Phenotypic Correlation, Path Analysis and Genetic Parameters of Some Quantitative Characters in Rice Under Water Stress Environments

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ABSTRACT

The present investigation was conducted at the Experimental Farm of Faculty of Agriculture, Kafrelsheikh University during 2008 and 2009 seasons. The main objectives of this investigation were to study the association between some quantitative characters in rice, using path coefficient analysis to determine the relative importance of such characters to grain yield variation and estimation of some genetic parameters of twenty five rice genotypes under water stress environments (irrigation every 6, 9 or 12 days).

Grain yield was positively correlated with each of number of panicles/plant (under the two severely stressed environments), number of grains/panicle (under the first and the third water intervals) and with panicle length under all environments. Panicle length was positively correlated with number of grains/panicles under all treatments.

Fertility percentage was negatively correlated with number of panicles/plant under all environments and positively correlated with 1000-grain weight under the first and the third treatments. Meanwhile, number of panicles/plant was negatively correlated with 1000-grain weight, this may be due to their compensatory relationship.

Path coefficient analysis revealed that under the most stressed environments, number of panicles/plant had the largest direct effect on grain yield, while under slight stress (irrigation every 6 days), number of grains/panicle appeared to be the most important yield component followed by number of panicles/plant and panicle length.

Phenotypic coefficient of variability (PCV) was, in general, higher than genotypic (GCV) coefficient of variability for different traits, indicating less environmental influence in the expression of different traits.

Heritability estimates in broad sense were either relatively moderate or high for all studied traits. Such estimates ranged from 55 to 94% for grain yield and 1000-grain weight, respectively. Relatively higher genetic advance coupled with high heritability estimates was detected for 1000-grain weight and plant height.

INTRODUCTION

Grain yield is the most important character, it is the final outcome of the various metabolic activities occurred in the plant. The method most widely used in rice breeding is hybridization followed by selection in the segregated generation. Hence, the plant breeder needs to know what are the most important characters in selection for high yield. Some workers studied the relationships between grain yield and other agronomic traits.

Rice grain yield was positively correlated with each of heading date (Choudhury and Das, 1997); plant height (Takane, *et al.*, 1997); panicle length (El-Hity and El-Keredy, 1992 and Yolanda and Das, 1995); number of panicles/plant (Ashvani *et al.*, 1997); grain number/panicle (Anand, *et al.*, 1998 and Rao and Saxena, 1999); and 1000-grain weight (El-Hity, *et al.*, 1992).

Panicle length was positively correlated with each of plant height and number of spikelets/panicle (Chaubey and Singh, 1994) Also, plant height was positively correlated with number of grains/panicle (Gomez, *et al.*, 2005).

Correlation, simply measures mutual association without regard to causation, while path analysis specifies the causes and measures their relative importance. Many efforts were conducted to study path analysis in rice such as Mishra, *et al.*, (1973), Rao *et al.* (1976), Nigem and Eissa (1988), El-Hity and Keredy (1992), El-Hity (1994) and Samonte *et al.* (1998). The greatest direct positive effects for grain yield were recorded for number of panicles/plant followed by plant height (Chaubey, *et al.*, 1994), while Yolanda and Das (1995) indicated that grain number per panicle was the main component character affecting yield directly.

Estimation of variability, heritability and predicted genetic gains of quantitative traits are important for available rice germplasm in breeding programs, to judge whether the phenotypic variability is heritable or due to the environment. The present paper deals with such type of analysis and its objectives were to study:

1. The interrelationships between grain yield and other characters studied as phenotypic correlation coefficients under three water stressed environments.
2. Path analysis to detect the relative importance of some morphological characters to yield variations under three water stressed environments.
3. Phenotypic (PCV) and genotypic (GCV) coefficients of variability, heritability and genetic advance from selection for the studied characters.

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MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm of the Faculty of Agriculture, Kafrelsheikh University during 2008 and 2009 seasons. Twenty five rice genotypes, lines and hybrids having diverse morphobgical and agronomical traits were involved in this study. Such genotypes were: Giza 171, Suweon 287R, Milang, Agmi, Giza 159, IR 66R, pusa 150-9-3-IR, IR 4467-3-2-2R, Sakha 104, Giza 177, Giza 181, Giza 182, Giza 178, Giza 176, Sakha 102, Sakha 103, Riho, Giza 175, Sakha 101, hybrid rice 1, hybrid rice 2, Giza 172, Gz. 1368-5-4, G 46B and G 46A x Giza 178 (as a promising hybrid rice combination).

Thirty days old seedlings of each genotypes were individually transplanted in seven rows, 5.8 m long and 20 cm apart. Each row contained twenty-nine hills. Sowing date were on 3 and 5 May in the two seasons, respectively. The seeds of G 46A x Giza 178 rice hybrid were produced in the summer season of 2007 through crossing the promising cytoplasmic male sterile line (G46A) with the indica rice cultivar (Giza 178). While, the two other hybrid rice combinations; hybrid rice 1 and hybrid rice 2, were kindly provided by Rice Research and Training Center, Sakha Kafr El-Sheikh, Egypt. All the genotypes were grown under three intervals of irrigation; watering every 6, 9 or 12 days. A randomized complete block design with three replications was employed for each water interval.

The stress was applied after two weeks from transplanting till harvest. The package of all other recommendations of rice planting was followed.

Readings for individual characters were recorded on five center rows excluding the two outer rows from each plot. Ten guarded hills were randomly chosen and used for collecting data on yield components and some agronomic characters. The following characters were measured.

1. Days to 50% heading (day).
2. Plant height (cm).
3. Panicle length (cm).
4. Number of grains/panicle.
5. Fertility percentage (%).
6. Number of panicles/plant.
7. 1000-grain weight (g).
8. Grain yield (ton/fed.).

Grain yield was calculated from the total weight of grains from each plot (five center rows) and then converted to calculate grain yield (ton/fed.).

Analysis of variance was computed for each season according to Snedecor and Cochran (1967). Error variances from separate analysis of the data were tested for homogeneity using Bartlett's Test (Bartlett, 1937). As such error was homogeneous the combined analysis was calculated for the data of the two seasons according to Cochran and Cox (1957). Phenotypic (PCV) and genotypic (GCV) of variability were estimated according to the method suggested by Burton (1952). The expected genetic advance from selection (Δg) for a given trait as well as the phenotypic correlation between any pairs of traits was calculated as stated by Johnson *et al.* (1955). Moreover, path analysis was calculated as illustrated by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The knowledge of degree and direction of correlation among different traits of rice are of great importance. It may be useful indicator for indirect selection programs as it help in identifying traits that have more, little or no importance in the selection programs. The phenotypic correlation coefficient between grain yield and the seven characters on one side, and among the agronomic characters themselves on the other side, are presented in Table 1. Obviously, grain yield was positive and highly significant correlated with number of panicles/plant under the second and the third water intervals (0.505 and 0.424, respectively) and with number of grains/panicle and panicle length under all environments.

Previous papers have mentioned that rice grain yield as a function of number of sipkelets/panicle, grain weight, percentage of filled spikelets (Yoshida and Parao, 1976) and number of panicles per square meter (Miller *et al.*, 1991) or number of filled grain per panicle (Samonte *et al.*, 1998). Grain yield was positively correlated with number of spikelets/panicle and panicle length (Geethadevi *et al.*, 2000).

Other inter-character correlations revealed that number of days to 50% heading was significantly and positively correlated with plant height under all environments. Such estimates were 0.379, 0.392 and 0.348 for T_1, T_2, and T_3, respectively. While, it was negatively correlated with fertility percentage and number of panicles/plant. These results were in general agreement with those reported by El-Hity (1994) who reported that heading date was positively correlated with culm length and negatively correlated with number of panicles per m^2. Plant height exhibited positive and highly significant phenotypic correlation coefficients with fertility percentage under all environments.

Panicle length gave positive and significant correlation coefficient with number of grains/panicles under all environments.

Table 1. Phenotypic simple correlation coefficient among the studied characters under three water intervals averaged over 25 rice genotypes and the two seasons

Characters	Water intervals	No. of days to 50% heading	Plant height	Panicle length	No. of grains/ panicle	Fertility percentage	No. of panicles/ plant	1000 grain weight
		Parametrs						
Grain yield	T_1	-0.248*	-0.080	0.383**	0.448**	-0.058	0.133	-0.053
	T_2	-0.042	-0.010	0.203*	-0.069	-0.363**	0.505**	-0.086
	T_3	0.141	0.183	0.261*	0.404**	-0.333**	0.424**	-0.164
No. of days to 50% heading	T_1		0.379**	0.060	-0.058	-0.128	-0.166	-0.120
	T_2		0.392**	0.051	-0.127	-0.233*	-0.266*	-0.038
	T_3		0.348**	-0.026	0.005	-0.381**	-0.105	-0.010
Plant height	T_1			-0.139	-0.130	0.482**	-0.069	0.117
	T_2			-0.037	-0.239*	0.481**	-0.237*	0.111
	T_3			0.042	-0.024	0.305**	-0.248*	0.101
Panicle length	T_1				0.467**	-0.098	0.084	0.017
	T_2				0.250*	-0.056	0.115	0.185
	T_3				0.445**	0.015	-0.006	0.088
No. of grains/ panicle	T_1					-0.094	-0.178	0.097
	T_2					-0.190	0.061	0.38
	T_3					-0.213	0.011	0.058
Fertility percentage	T_1						-0.279*	0.291*
	T_2						-0.342**	0.180
	T_3						-0.335**	0.382**
No. of panicles	T_1							-0.412**
	T_2							-0.441**
	T_3							-0.232*

T_1, T_2, T_3: refers to irrigation every 6, 9 or 12 days, respectively.
* and ** significant at 0.05 and 0.01 levels, respectively.

Previous results showed, that panicle length was positively correlated with number of productive tillers/m^2 (El-Hity and El-Keredy, 1992).

Fertility percentage showed negative and significant correlations with number of panicles/plant under all environments but, it was positively correlated with 1000-grain weight in case of the first water interval and the third one. While, number of panicles/plant and 1000-grain weight were negatively correlated due to their compensatory relationship.

From the previous results of correlations, it is obvious that relationships between most pairs of traits were approximately constant and showed the same direction under all environments, suggesting the possibility of selection for common traits for genetic improvement of yield under wide range of environments (El-Marakby *et al.*, 2007). Also, selection of genotypes with high mean performance for panicle length, number of grains/panicle and number of panicles/plant will lead to high yielding genotypes.

Path coefficient analysis:

Information on the interrelationship among the studied characters was obtained by path coefficient analysis of the phenotypic correlations. Path coefficient analysis was practiced in order to find out the relative importance for the studied characters towards grain yield variations. Grain yield was considered the resultant variable and the other characters the causal variables.

Each component had a direct influence acting alone, and an indirect influence acting in combination with the other variables. Path coefficient analysis between grain yield and each one of the specified characters are presented in Table 2. It is clear from the results that plant height, panicle length, number of grains/panicle and number of panicles/plant showed positive direct effects on grain yield.

The direct effect of plant height was positive and moderate on grain yield under the three water intervals. The direct effects showing greater values with increasing water intervals, which amounted to 0.176, 0.359 and 0.382 for the three water intervals, respectively. On the other hand, all the indirect effects of plant height were low or had negative values.

The positive correlation of panicle length with grain yield could mainly be attributed to its direct effect of grain yield. Such estimates were 0.252, 0.18 and 0.117 for the three water intervals, respectively.

Table 2. Path coefficient analysis of direct and indirect effects on grain yield for three water intervals averaged over 25 rice genotypes and the two seasons

Source of variation	Water intervals (days)		
	6	9	12
Heading date (X_1) and grain yield			
Direct effect (Py_1)	-0.32	-0.22	-0.04
Indirect effect via plant height	0.067	0.141	0.133
Indirect effect via panicle length	0.015	0.009	-0.003
Indirect effect via number of grains/panicle	-0.02	0.023	0.002
Indirect effect via fertility percentage	0.01	0.115	0.093
Indirect effect via number of panicles/plant	-0.012	-0.106	-0.044
Indirect effect via 1000-grain weight	0.012	-0.004	0.001
Total correlation: $r(x_1, y)$	-0.248	-0.042	0.141
Plant height (X_2) and grain yield			
Direct effect (Py_2)	0.176	0.359	0.382
Indirect effect via heading date	-0.121	-0.086	-0.014
Indirect effect via panicle length	-0.035	-0.007	0.005
Indirect effect via number of grains/panicle	-0.045	0.043	-0.007
Indirect effect via fertility percentage	-0.038	-0.237	-0.074
Indirect effect via number of panicles/plant	-0.005	-0.094	-0.104
Indirect effect via 1000-grain weight	-0.011	0.012	-0.004
Total correlation: $r(x_2, y)$	-0.080	-0.01	0.163
Panicle length (X_3) and grain yield			
Direct effect (Py_3)	0.252	0.180	0.117
Indirect effect via heading date	-0.019	-0.010	0.001
Indirect effect via plant height	-0.024	-0.014	0.016
Indirect effect via number of grains/panicle	0.163	-0.046	0.137
Indirect effect via fertility percentage	0.009	0.028	-0.004
Indirect effect via number of panicles/plant	0.006	0.046	-0.003
Indirect effect via 1000-grain weight	-0.002	0.019	-0.004
Total correlation: $r(x_3, y)$	0.383	0.203	0.261
No. of grains/panicle (X_4) and grain yield			
Direct effect (Py_4)	0.348	-0.178	0.307
Indirect effect via heading date	0.019	-0.028	0.000
Indirect effect via plant height	-0.022	-0.086	-0.009
Indirect effect via panicle length	0.118	0.095	0.052
Indirect effect via fertility percentage	0.008	0.093	0.052
Indirect effect via number of panicles/plant	-0.013	0.024	0.005
Indirect effect via 1000-grain weight	-0.01	0.004	-0.002
Total correlation: $r(x_4, y)$	0.448	-0.069	0.404
Fertility percentage (X_5) and grain yield			
Direct effect (Py_5)	-0.078	-0.492	-0.244
Indirect effect via heading date	0.040	0.051	0.015
Indirect effect via plant height	0.085	0.173	0.117
Indirect effect via panicle length	-0.025	-0.012	0.002
Indirect effect via number of grains/panicle	-0.033	0.034	-0.065
Indirect effect via number of panicles/plant	-0.020	-0.136	-0.141
Indirect effect via 1000-grain weight	-0.029	0.019	-0.015
Total correlation: $r(x_5, y)$	-0.058	-0.363	-0.333
No. of panicles/plant (x6) and grain yield			
Direct effect (Py_6)	0.071	0.399	0.420
Indirect effect via heading date	0.053	0.059	0.004
Indirect effect via plant height	-0.012	-0.085	-0.095
Indirect effect via panicle length	0.021	-0.021	-0.001
Indirect effect via number of grains/panicle	-0.062	-0.011	0.003
Indirect effect via fertility percentage	0.022	0.168	0.082
Indirect effect via 1000-grain weight	0.040	-0.046	0.009
Total correlation: $r(x_6, y)$	0.133	0.505	0.424
1000-grain weight (x_7) and grain yield			
Direct effect (Py_7)	-0.098	0.104	-0.040
Indirect effect via heading date	0.038	0.008	0.000
Indirect effect via plant height	0.021	0.040	0.039
Indirect effect via panicle length	0.004	0.033	0.010
Indirect effect via number of grains/panicle	0.034	-0.007	0.018
Indirect effect via fertility percentage	-0.023	-0.089	-0.093
Indirect effect via number of panicles/plant	-0.029	-0.176	-0.097
Total correlation: $r(x_7, y)$	-0.053	-0.086	-0.164

The direct effects of this trait were very low via fertility percentage and number of panicles/plant under the first and the second water intervals and under the third water intervals via heading date and plant height. Previous results showed a positive direct effect of panicle length on grain yield (El-Hity and El-Keredy, 1992).

Number of grains/panicle had the largest direct effect on grain yield, as confirmed by the highly significant and positive phenotypic correlation coefficient between the two characters (0.448). The indirect effect of number of grains/panicle via panicle length was low (0.118) under the first water interval and very low or had negative values via the other traits and the other environments. The indirect effect via number of panicles/plant and 1000-grain weight was negative.

The negative indirect effects obtained between number of grains/panicle and number of panicles/plant, this could be due to the masking action on direct effect influence (El-Hity *et al.*, 1992).

Number of grains/panicle proved to have a sizable effect on grain yield, while the indirect effect via the other characters were low and being negative (Nigem and Eissa, 1988). This results were in accordance with those also obtained by Samonte *et al.* (1998).

Fertility percentage showed a negligible direct effect on grain yield under the three water intervals as it showed negative values. The indirect effects of fertility percentage via plant height was positive and relatively low under the second and the third water intervals. Meantime, the indirect effect of this trait was very low via heading date and plant height under the first water intervals and under the second one via heading date, number of grains/panicle and 1000-grain weight. The indirect effect was mostly equal zero via panicle length (0.002). These results were generally in agreement with those of El-Hity and El-Keredy (1992) who reported that fertility percentage exhibited a negative direct effect on grain yield.

The direct effect of number of panicles/plant was positive and low under the first water intervals (0.071), relatively high (0.399 and 0.42) under the two other intervals, respectively. The indirect effect of this trait was relatively low (0.168) via fertility percentage and very low via the other combination or had negative values.

The direct effect of 1000-grain weight was positive and low under the intermediate water interval. While such estimates were inferior and negative (-0.098 and -0.04) under the first and the third water intervals, respectively. The indirect effects of 1000-grain weight via heading date, plant height and panicle length were very low under the three environments and via number of grains/panicle under the third water interval. Meanwhile, all the other indirect effects of 1000-grain weight had negative values.

The aforementioned results indicated that a plant type for increased yield should have large panicles, high number of grains/panicle and high number of panicles/plant as it have a possible consideration for the indirect selection for grain yield.

Genetic Parameters:

Estimates of variance components, phenotypic (PCV) and genotypic (GCV) coefficient of variability and genetic advance are presented in Table 3. The results showed that genotypic variance ($\delta^2 g$) were highly significant for all the studied characters, indicating wide range of genetic variability among rice genotypes. Also, genotype by environment interaction was highly significant for all the studied characters indicated that the genotypes interacted considerably with environmental changes.

Phenotypic coefficient of variability was, in general, higher than genotypic coefficient of variability. The small differences between PCV and GCV indicating less environmental influence on the expression of different traits. Such estimates were (17.0 and 13.62) for number of panicles/plant, (14.72 and 13.62) for number of panicles/plant and (14.72 and 10.47) for grain yield for PCV and GCV, respectively. The relatively high genetic coefficients of variability for grain yield and number of panicles/plant indicated that these traits might be more genotypically predominant and it would be possible to achieve further improvement from them. Choudhary and Das (1998) found that grain yield per plant had a high genotypic coefficient of variability.

Results in Table 3 showed that heritability estimates in broad sense, were either relatively moderate or high for the studied traits. Such estimates was high in case of 1000-grain weight (94%). while, it was relatively high for days to 50% heading (87.64%), plant height (88.4%) and fertility percentage (83.52%). Moderate heritability estimates were recorded for panicle length, number of grains/panicle, number of panicles/plant and grain yield (56.1, 66.07, 64.57 and 55%, respectively).

Results in Table 3 showed that the expected genetic advance (GS) from selection, as percentage of mean, ranged from 10.71 to 23.72% for fertility percentage and plant height, respectively, while such values were relatively moderate for grain yield, 1000-grain weight and number of panicles/plant. The desirable genetic gain was found to be associated with high heritability estimates in case of 1000-grain weight or with moderate heritability estimates in case of grain yield.

Table 3. Genetic parameters for eight agronomic rice characters averaged over 25 rice genotypes, the three water intervals and the two seasons

Parameters	No. of days to 50% heading	Plant height	Panicle length	No. of grains/ panicle	Fertility percentage	No. of panicles/ plant	1000 grain weight	Grain yield
Grand mean	103.63	94.37	21.77	124.82	86.07	17.17	24.70	2.93
σ^2g	66.41	133.54	4.00	81.99	23.98	5.51	4.69	0.11
σ^2gE	6.67	12.64	2.23	38.10	3.68	2.37	0.28	0.08
σ^2e	2.70	4.88	0.90	4.00	1.05	0.70	0.01	0.01
P.C.V.%	8.40	13.03	12.24	8.92	6.22	17.00	9.02	14.72
G.C.V.%	7.86	12.25	9.17	7.25	5.69	13.62	8.75	10.47
$h^2_{b.s}$	87.64	88.40	56.10	66.07	83.52	64.57	94.00	55.0
Δg	15.78	22.38	3.09	15.16	9.22	3.90	4.32	0.51
g(% of mean)	15.23	23.72	14.17	12.15	10.71	22.63	17.46	16.72

Previous studies showed that heritability estimates were recorded for plant height (Saravanan and Senthil,1997).

Sadhukhan and Chattopadhyay (200) reported that grain yield had high phenotypic and genotypic coefficients of variation. El-Mowafi and Abou Shousha (2003) reported that heritability estimates were high for 1000-grain weight and moderate for number of spikelets/panicle, while grain yield exhibited low heritability estimates. High heritability estimates coupled with high genetic advances were recorded for plant height. (Gomez and Kalamani, 2003).

From the aforementioned results it is clear that the relationships between most pairs of traits were approximately constant and showed the same directions under all environments, suggesting the possibility of selection for common traits for genetic improvement of yield under wide range of environments.

Also, a plant type for increasing grain yield should have large panicles, high number of grains/panicle and high number of panicles/plant as it have a sizable effect on grain yield.

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الملخص العربي

التلازم المظهرى ومعامل المرور والمقاييس الوراثية لبعض الصفات الكمية فى الأرز تحت بيئات من الإجهاد المائى

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أقيمت هذه الدراسة بالمزرعة التجريبية بكلية الزراعة- جامعة كفرالشيخ خلال موسمى ٢٠٠٨-٢٠٠٩م. وتهدف هذه الدراسة إلى تقدير معامل الارتباط المظهرى لبعض الصفات الكمية فى الأرز وكذلك معامل المرور لتحديد الأهمية النسبية لبعض الصفات فى تباين صفة المحصول بالإضافة لدراسة بعض المقاييس الوراثية.

واشتملت هذه الدراسة على خمسة وعشرون صنفا وسلالة محلية ومستوردة من الأرز منهما صنفين من الأرز الهجين (هجين ١، هجين ٢) وأيضا أحد تراكيب الأرز الهجين المبشرة (G 46A x Giza 178).

تم زراعة هذه التراكيب الوراثية الخمس والعشرون تحت ثلاث معاملات من الرى (٦، ٩، ١٢يوم) ونفذت هذه المعاملات بعد الشتل بأسبوعين واستخدم فى التجربة تصميم القطاعات الكاملة العشوائية فى ثلاث مكررات.

وكانت أهم النتائج المتحصل عليها هى:

- ظهر أن التباين الوراثى كان عالى المعنوية لكل الصفات موضع الدراسة.
- كان هناك تلازما موجبا ومعنويا بين كمية المحصول وبين صفة عدد الداليات/ نبات (تحت ظروف الرى كل ٩، ١٢ يوم) وعدد الحبوب بالدالية (فى المعاملتين الأولى والثالثة، أى عند الرى كل ٦، ١٢ يوم)، فى حين كان التلازم معنويا وسالبا بين صفة عدد الداليات لكل نبات وصفتى نسبة العقم ووزن الـ ١٠٠٠ حبة تحت كل البيئات.

كذلك أظهرت النتائج وجود إرتباط معنوى موجب بين طول الدالية وعدد الحبوب بالدالية تحت معاملات الرى الثلاث.

- أظهر تحليل معامل المرور أنه تحت ظروف شدة الجفاف (الرى كل ٩، ١٢ يوم) أن صفة عدد الداليات لكل نبات كانت هى الأكثر تأثيرا مباشرا فى تباين كمية المحصول فى حين ظهر أنه تحت نظام الرى كل٦ أيام أن صفة عدد الحبوب بالدالية هى الأكثر مساهمة وتلى ذلك عدد الداليات/نبات وطول الدالية.
- كان معامل الاختلاف المظهرى أعلى من معامل الاختلاف الوراثى ولكن كان الفرق بينهما قليل وتراوحت قيم معامل الاختلاف الوراثى من ٥,٦٩ إلى ١٣,٦٢% لصفتى نسبة الخصوبة وعدد الداليات/نبات على التوالى.
- كانت قيم المكافئ الوراثى بصفة عامة إما متوسطة نسبيا أو عالية لكل الصفات موضع الدراسة وتراوحت من ٥٥% إلى ٩٤% لصفتى المحصول ووزن الـ١٠٠٠حبة على التوالى. وقد ارتبط التحسين الوراثى المتوقع بالقيم العالية لمعامل التوريث لصفتى وزن الألف حبة وارتفاع النبات.