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PHENOTYPIC CORRELATION AND PATH COEFFICIENT ANALYSIS ON CANOLA UNDER DROUGHT STRESS CONDITIONS

Abdalla. A. F.; Morad, S. S.; Hggag. E. E. and Mahfouz, M.M.

Department Of Agronomy, Faculty Of Agriculture,
Al-Azhar University. Nasr City, Cairo, Egypt.

ABSTRACT: Correlation coefficients and path coefficient analysis were computed among all pairs of studied characters i.e., Days to 50% flowering, Plant height (cm), Number of branches/plant, No. of heads/plant, No. of silliqua/plant, 1000-seed weight (g), Seed yield/plant (g), Seed yield t/fed., Seed oil content (%), Oil yield (t/ fed.) and water use efficiency. Six parents and 15 F_1 genotypes of canola grown under water stress conditions in 2004/2005 season at Regwa Company Farm, 62 Kilometers, from Cairo Desert road, under three watering regimes intervals(irrigation every 3, 6 and 9 days). Path coefficient analysis was made on the basis of correlation coefficient taking seed yield/plant as y and the rest characters as x1,x2,xn. Results from the correlation showed that the following traits; number of branches/plant, number of heads/plant, 1000 seed weight, oil yield t./fed. and water use efficiency are the most effective characters and could be used in breeding programs for screening and identifying the most drought tolerant genotypes, since these traits are positively correlated with grain yield under the three irrigation intervals used. While, path coefficient analysis studied under different irrigation treatments indicated that number of siliqua/plant, number of heads/plant and 1000 seed weight could be used as selection criteria for screening and isolating high yielding and tolerant genotypes under stress conditions, while selection to grain yield is difficult due to its low heritability resulting from variation in intensity of stress.

INTRODUCTION

Drought is a problem and specially in countries with low rainfall and high temperatures. Such countries have modern irrigation practices and the farmers try to get the maximum efficiency from irrigation system. The increase in the human population of the world raised the demands of food production while land deterioration causing significant of decrease in yield. Irrigated agriculture contributes significantly toward meeting world food and fiber needs but at the same time faces problem of limited water supplies. Irrigation can often be used successfully without hazardous effects to crop or soils under adoption of new crop and water management strategies. (Ahmad *et al.,* 1986). Breeding for high yielding genotypes under drought conditions, requires information on the nature and magnitude of variation in the available materials, association of characters with yield and among themselves and the extent of environmental influence on these characters (Salwa Soliman and Mona Soliman 2003).

Experiments were carried out to study the effect of different irrigation intervals on the seed yield and it is component of canola (*Brassica napus* L.) genotypes and their F_{1s}. The association between different characters and seed yield using path co-efficient analysis to detect the best characters as selection criteria for improving canola yield under stress conditions.

MATERIAS AND METHODS

The genetic material used in this study as a parental varieties of canola were; Serw 4 (P1), Sedo (P2), L5 (P3), L16/56 (P4), LC 101 (P5) and L3 (P6 or lines). All seeds of canola genotypes were obtained from Plant Genetic Resources Department, Desert Research Center (DRC) except Serw4 which were from. Names and origin of the parental genotypes is presented in Table (1).

Table (1): Name, origin of the six divergent Canola genotypes.

No.	Name	Origin
1	Serw.4 (P1)	NRV-ARC(Egypt) [I]
2	Sedo (P2)	Germany
3	Line- L5 (P3)	NBL-DRC (Egypt)[II]
4	Line-16/56 (P4)	NBL-DRC (Egypt)[II]
5	Line-C 101 (P5)	NBL-DRC (Egypt)[II]
6	Line-L3 (P6)	NBL-DRC (Egypt)[II]

I NRV-ARC: Newly released variety through Agriculture Research Center- Oil Crops Department

II NBL – DRC: Newly bred line released through Desert Research Center (Canola Breeding Program).

Field trials:

In 2003/2004 season, 6 parents were used and crossed to form a non-reciprocal diallel set of 15 F_1 hybrids. Crosses were made in the farm of Regwa Company area, Kilometr62, Desert road, Cairo-Alexandria. In 2004/2005 season, a field trial included the 15 F_1 hybrids and their respective parents were conducted to assess the performance and variability among Canola genotypes for some morphological traits and to estimate genetic parameters of the studied traits under normal and water stress conditions. Sowing date was on 15th of November. The physical and chemical properties of soil samples taken from the experimental site to depth 0-30cm were analyzed mechanically (Piper, 1950), and chemically (Black *et al.* 1965). Analysis of irrigation water (average over five irrigations) during each growing season was made. The results of analysis are presented in Table (2) which showed that soil texture is characterized as loamy sand.

Table (2): Soil and irrigation water analysis for the experimental site at Regwa region over two seasons.

A) Soil mechanical analysis					
Depth (cm)	Coarse sand %	Fine sand %	Silt %	Clay %	Texture
0-30	27.04	47.65	12.18	13.13	Loamy Sand

B) Soil chemical analysis											
Depth (cm)	pH	ECe dSm^{-1}	$CaCo_3$	Soluble cations (mg/100g)				Soluble anions (mg/100g)			
				Na^+	Ca^{++}	Mg^{++}	K^+	$Co3^-$	HCO_3^-	Cl^-	So_4^{--}
0-30	7.19	7.45	45.62	30.04	39.21	10.86	5.62	-----	10.85	33.8	35.2

C) Irrigation water chemical analysis									
pH	EC dSm^{-1}	Soluble cations (mg/100g)				Soluble anions (mg/100g)			
		Na^+	Ca^{++}	Mg^{++}	K^+	$Co3^-$	HCO_3^-	Cl^-	So_4^{--}
7.05	6.98	30.38	30.73	25.17	0.41	-----	2.65	52.75	31.29

Each field trial was subjected to three irrigation regimes applied with drip irrigation system in a form of irrigation intervals. Irrigation intervals were carried out for 60 minutes, through a drip irrigation system, where drippers of GR type were used. Such dripper discharges 4.0 L./hr, number of drippers/fed. was 16800. The irrigation treatments began 30 days after sowing in the two seasons where plants were became established and constant amount of water per irrigation was given for all irrigation treatments. The irrigation treatments were as follows: a) Irrigation every 3 days b) Irrigation every 6 days c) Irrigation every 9 days. 10 guarded plants were randomly collected from each plot where the different irrigation treatments coincided with each other for recording a set of traits for drought tolerance assessments. The following data were recorded i.e., Days to 50% flowering, Plant height (cm), Number of branches/plant, No. of heads/plant, No. of silliqua/plant,1000-seed weight (g), Seed yield/plant (g), Seed yield t/fed., Seed oil content (%), Oil yield (t/ fed.).

Phenotypic (r_p) correlation coefficient were calculated between five traits in F_1 generation under different water regimes according to Snedecor and Cochran (1982). However, partitioning correlation coefficient into direct and indirect effects at phenotypic level was made by determining path coefficients under the three irrigation intervals treatments using method proposed by Wright (1921) and utilized by Dewey and Lu (1959).

The involved characters in this analysis were:

(y) Seed yield/plant, (x_1) Number of branches/plant, (x_2) No. of heads/plant, (x_3) No. of siliqua/plant, (x_4) 1000- seed weight, and (x_5) Seed oil content

The path coefficients were obtained by the simultaneous solution of the following equations, which express the basic relationship between correlation and path coefficients. The relative importance (RI%) of each variables to the total variation was estimated according to the following formula:

$RI\% = |CD_i| / \Sigma_i |CD_i| \times 100$

Where: CD_i : the coefficient of determination

RI% : the relative importance.

RESULTS AND DISCUSSION

Phenotypic Correlation and path co-efficient analysis:

The relationship between traits plays an important role in breeding programs which studying associated changes in two traits caused by environmental factors such as water supply, fertilizer, plant density, sowing date…etc, are useful in obtaining reliable information on the nature, extent and directions of selection. However, the knowledge of associations between traits measured under both non-stress drought and stress drought conditions enable the breeder in predicting genotypic performance under drought and water conditions. Correlation coefficient values among all the studied traits along with water use efficiency are recorded in Tables (3 ,4 and 5).

Table (3): Values of phenotypic correlation coefficients estimated between different pairs of traits under control (irrigation every 3 days interval) treatment.

characters	(1) Flowering date 50%	(2) Plant height (cm)	(3) No. of Branches/	(4) No. of heads/ plant	(5) No. of siliqua/ plant	(6) 1000 seed weight (g)	(7) Seed oil content	(8) Oil yield (t/ fed.)	(9) Water use efficiency	(10) Seed yield/plant (gm)	(11) Seed yield/fed. (t.)
1		0.737**	-0.032	-0.032	-0.100	0.330	-0.500*	0.056	0.226	0.212	0.230
2			-0.006	-0.155	0.082	0.395	-0.434*	0.195	0.360	0.354	0.348
3				0.839**	0.705**	-0.06	-0.007	0.535*	0.562**	0.558**	0.574**
4					0.708**	-0.074	0.194	0.431	0.364	0.383	0.372
5						-0.212	0.119	0.778**	0.779**	0.774**	0.782**
6							-0.105	0.182	0.240	0.239	0.228
7								0.316	-0.014	-0.017	-0.010
8									0.951**	0.939**	0.944**
9										0.998**	0.984**
10											0.996**

* and ** : Denote significance at P ≤ 0.05 and 0.01 probability levels, respectively.

1- Correlation between traits under 3 days intervals treatment:

Positive and significant correlation was found between plant height and flowering date (50%) (0.737); number of branches/plant with each of number of heads/plant (0.839), number of siliqua/plant (0.705), oil yield (t/fed.) (0.535), water use efficiency (0.562), seed yield/plant (0.558) and seed yield t./fed.(0.574). as well as, between number of siliqua/plant and each of number of heads/plant (0.708), oil yield (t/fed.) (0.778) water use efficiency (0.779), seed yield/plant (0.774) and seed yield t./fed. (0.782); and, between oil yield (t./fed.) and each of water use efficiency (0.951), seed yield/plant (0.939) and seed yield t./fed. (0.944); water use efficiency and seed yield/plant (0.998) and seed yield t./fed (0.984), and between seed yield/plant and seed yield t./fed. (0.996). While significant negative correlation was found between seed oil content and each of flowering date (50%) (-0.5) and plant height (-0.434) (Table,3).

Table (4): Values of phenotypic correlation coefficients estimated between different pairs of traits under mild stress (irrigation every 6 days interval) treatment.

characters	(1) Flowering date 50%	(2) Plant height	(3) No. of Branches/	(4) No. of heads/ plant	(5) No. of siliqua/ plant	(6) 1000 seed weight (g)	(7) Seed oil content	(8) Oil yield (t/ fed.)	(9) Water use efficiency	(10) Seed yield/plant (gm)	(11) Seed yield/fed. (t)
1		0.161	-0.101	-0.131	0.067	0.377	-0.227	0.117	0.284	0.264	0.252
2			0.081	0.056	0.207	0.034	-0.011	0.128	0.140	0.132	0.136
3				0.890**	0.652**	-0.154	0.093	0.513*	0.488*	0.482*	0.475*
4					0.635**	-0.158	0.136	0.437*	0.388	0.374	0.380
5						0.191	-0.199	0.643**	0.737**	0.747**	0.708**
6							-0.211	0.401	0.483*	0.484*	0.495*
7								0.248	-0.143	-0.172	0.133
8									0.928**	0.917**	0.923**
9										0.984**	0.997**
10											0.989**

* and ** : Denote significance at $P \leq 0.05$ and 0.01 probability levels, respectively.

2- Correlation between traits under 6 days intervals treatment:

Positive and significant correlation was found between number of branches/plant with each of number of heads/plant (0.890) , number of siliqua/plant (0.652), oil yield (t/fed.) (0.513), water use efficiency (0.488), seed yield/plant (0.482) and seed yield t./fed.(0.475). Also, significant positive correlation was obtained between number of heads/plant with each of number of siliqua/plant (0.635), oil yield (t/fed.) (0.437), and between number of siliqua/plant and each of, oil yield (t/fed.) (0.643) water use efficiency (0.737), seed yield/plant (0.747) and seed yield t./fed (0.708), and between 1000 seed weight and each of water use efficiency (0.483), seed yield/plant (0.484) and seed yield t./fed. (0.495); water use efficiency with seed yield/plant (0.984) and seed yield t./fed. (0.997) and between seed yield/plant and water and seed yield t./fed. (0.989)(Table, 4).

Table (5): Values of phenotypic correlation coefficients estimated between different pairs of traits under severe stress (irrigation every 9 days interval) treatment.

characters	(1) Flowering date 50%	(2) Plant height (cm.)	(3) No. of Branches/	(4) No. of heads/ plant	(5) No. of siliqua/	(6) 1000 seed weight (g)	(7) Seed oil content	(8) Oil yield (t/ fed.)	(9) Water use efficiency	(10) Seed yield/plant (gm.)	(11) Seed yield/fed. (t.)
1		0.014	0.304	0.536*	0.265	0.169	-0.092	0.262	0.321	0.320	0.315
2			0.297	0.085	0.293	0.137	-0.009	0.443*	0.546*	0.502*	0.534*
3				0.683**	0.478*	0.304	0.100	0.609**	0.625**	0.640**	0.638**
4					0.381	0.201	-0.133	0.381	0.485*	0.484*	0.478*
5						-0.120	0.079	0.602**	0.642**	0.641**	0.639**
6							-0.064	0.396	0.445*	0.470*	0.465*
7								0.462*	-0.108	-0.123	-0.106
8									0.918**	0.938**	0.968**
9										0.991**	0.985**
10											0.993**

*** and ** : Denote significance at P ≤ 0.05 and 0.01 probability levels, respectively.**

3- Correlation between traits under 9days intervals treatment:

Positive and significant correlation coefficient was found between flowering date 50% and number of heads/plant (0.536); plant height with each of oil yield (t/fed.) (0.443) water use efficiency (0.546), seed yield/plant (0.502) and seed yield t./fed.(0.534); number of branches/plant with each of number of heads/plant (0.683), number of siliqua/plant (0.478), oil yield (t/fed.) (0.609), water use efficiency (0.625), seed yield/plant (0.640) and seed yield t./fed.(0.638); between number of heads/plant with each of water use efficiency (0.485), seed yield/plant (0.484) and seed yield t./fed.(0.478) and between number of siliqua/plant and each of oil yield (t/fed.) (0.602), water use efficiency (0.642), seed yield/plant (0.641) and seed yield t./fed. (0.639) Also, it significant positive was obtained between 1000 seed weight and each of water use efficiency (0.445), seed yield/plant (0.470) and seed yield t./fed. (0.465) and between seed oil content % with oil yield (t./fed.) (0.462); oil yield content with each of water use efficiency (0.918), seed yield/plant (0.938) and seed yield t./fed. (0.968); water use efficiency with each of seed yield/plant (0.991) and seed yield t./fed. (0.985) and between seed yield/plant and seed yield t./fed. (0.993) (Table, 5).

The obtained results from the different studied correlation groups lead to conclude that the following traits; number of branches/plant, number of heads/plant, 1000-seed weight, oil yield t./fed. and water use efficiency could be used effectively in breeding programs as useful selection criteria for screening and identifying the most drought tolerant genotypes, since these traits are highly positively correlated with grain yield under the three irrigation intervals or both water stress treatments used in the present study. The obtained results agreed with many investigators (Clarke and Simpaon (1978), Ghobadi, *et al* (2006) and Salwa Soliman and Mona Soliman (2003).

Path coefficient analysis:

The components of the total seed yield variation determines directly and jointly by each factor are presented in table (6). Under irrigation every 3 days treatment the main sources of variation in order of importance were the direct effect of number of siliqua/plant (24.56%) and its joint effect with number of heads/plant (22.92%) then with number of branches/plant (13.90%) and with 1000-seed weight (4.35%) as well as the direct effect of number of heads/plant (10.66%) and its joint effect with number of branches/plant (10. 90) followed by the direct effect of 1000 seed weight (4.28%) and number of heads/plant (3.96%). The total contribution of five traits studied was 97.63%, while the residual effect assumed to be about 2.37% of total phenotypic variation.

Under irrigation every 6 days treatment the main sources of yield variation in order of importance were the direct effect of number of siliqua/plant (15.13%) and its joint effect with number of heads/plant (12.46%) then with number of branches/plant (15.90%) and with 1000 seed weight (3.68%) as well as the direct effect of number of branches / plant (9.82%) and number of heads/plant (6.36%) and its joint effect with number of branches/plant (14.07) followed by the direct effect of 1000 seed weight (6.13%). The total contribution of five traits studied was 88.94%, while the residual effect assumed to be about 11.06% of total phenotypic variation.

Under irrigation every 9 days interval the main sources of yield variation in order of importance were the direct effect of number of siliqua/plant (29.0213%) and its joint effect with number of branches/plant (11.56%) and with 1000-seed weight (5.34%) as well as the direct effect of 1000 seed weight (17.05%), and its joint effect with number of branches/plant (5.63) followed by the direct effect of number of branches/plant (5.04%). The total contribution of five traits studied was 81.50%, while the residual effect assumed to be about 18.50% of total phenotypic variation.

Table (6): components (direct and joint effects) in percentage of contribution due to grain yield and number of branches/plant, number of heads/plant, number of siliqua/plant, 1000 seed weight and seed oil content in canola under the three irrigation treatments.

Source of variation	Irrigation every 3 days		Irrigation every 6 days		Irrigation every 9 days	
	CD	RI%	CD	RI%	CD	RI%
No. of branches/plant (X_1)	0.180	3.96	0.242	9.82	0.063	5.04
No. of heads/plant (X_2)	0.485	10.66	0.157	6.36	0.001	0.08
No. of siliqua/plant (X_3)	1.116	24.56	0.374	15.13	0.363	29.02
1000 seed weight (X_4)	0.195	4.28	0.151	6.13	0.213	17.05
Seed oil content (%) (X_5)	0.002	0.04	0.002	0.06	0.029	2.32
(X_1) x (X_2)	-0.495	10.90	-0.347	14.07	-0.011	0.88
(X_1) x (X_3)	0.632	13.90	0.392	15.90	0.144	11.56
(X_1) x (X_4)	-0.022	0.49	-0.059	2.39	0.070	5.63
(X_1) x (X_5)	0.000	0.01	0.004	0.15	-0.009	0.68
(X_2) x (X_3)	-1.041	22.92	-0.308	12.46	-0.015	1.18
(X_2) x (X_4)	0.045	1.00	0.049	1.97	-0.006	0.48
(X_2) x (X_5)	-0.011	0.25	-0.004	0.17	-0.001	0.12
(X_3) x (X_4)	-0.198	4.35	0.091	3.68	-0.067	5.34
(X_3) x (X_5)	0.010	0.23	-0.010	0.39	-0.016	1.30
(X_4) x (X_5)	-0.004	0.08	-0.007	0.26	0.010	0.81
Residual	0.108	2.37	0.273	11.06	0.231	18.50
Total	1.000	100	1.000	100	1.00	100

CD: Coefficient of determination, RI% : Relative importance

Results obtained from path coefficient analysis studied under different irrigation treatments indicated that number of siliqua/plant, number of heads/plant and 1000 seed weight could be used effectively as selection criteria for screening and isolating high yielding and tolerant genotypes under stress conditions, especially selection mainly to seed yield is difficult due to its low heritability resulting from variation in intensity of stress. In this connection, Salwa Soliman and Mona Soliman

(2003) reported that path coefficient analysis declared that number of silique/plant and 1000-seed weight directly, indirectly and totally relative contribution affected seed yield by 53.39, 16.25 and 69.64 and 2.75, 0.51 and 3.26% for both traits respectively.

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الارتباط المظهري ومعامل المرور في الكانولا تحت ظروف الإجهاد الرطوبي

أحمد فتحي عبد الله سمير سيد مراد
عز الدين حجاج مدحت محفوظ محفوظ
قسم المحاصيل- كلية زراعة- جامعة الأزهر- مدينة نصر- القاهرة- جمهورية مصر العربية.

الملخص العربي

أقيمت تجربة حقلية بمزرعة رجوا الكيلو ٦٢ طريق مصر الإسكندرية الصحراوي حيث تم إجراء مجموعة من التهجينات النصف دائرية بين ستة تراكيب وراثية من الكانولا في الموسم الأول للحصول على الجيل الأول ١٥ (هجين) خلال موسمين ٢٠٠٣/٢٠٠٤ و٢٠٠٤/٢٠٠٥. وتم اختبار الآباء والهجن الناتجة تحت ثلاث معاملات ري وهى الري كل ٣ و٦و٩ أيام وتم دراسة الارتباط المظهري ومعامل المرور بين صفات تاريخ طرد٥٠% ، ارتفاع النبات ، عدد الفروع/نبات ، عدد النورات/نبات ، عدد القرون/نبات ، وزن ١٠٠٠ بذرة و محصول البذور /نبات ومحصول البذور طن/فدان ونسبة الزيت و محصول الزيت طن/فدان و كفاءة استخدام الماء تحت معاملات الإجهاد الجفافى في الموسم الثاني (٢٠٠٤/٢٠٠٥).أوضحت النتائج مايلى:

١- أظهرت نتائج الارتباط تحت معاملات الري المختلفة وجود ارتباط موجب و معنوي بين محصول الحبوب و عدد الفروع/نبات ، وزن١٠٠٠ بذرة ومحصول الزيت طن/ فدان وكفاءة استخدام الماء التي يمكن استخدامها في برامج الانتخاب وغربلة التراكيب الوراثية المختلفة.

٢- أظهرت نتائج معامل المرور أن صفات عدد النورات /نبات وعدد القرون/نبات وزن ال١٠٠٠ بذرة يمكن استخدامها في غربلة التراكيب الوراثية المختلفة و الحصول على تراكيب وراثية عالية المحصول.