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STABILITY ANALYSIS AND PROTEIN PATTERNS OF CANOLA GENOTYPES GROWN UNDER DIVERSE AGRO-ECOLOGICAL CONDITIONS

Clara R. Azzam[1], H. A. M. Moustafa[2] and I. M. Amer[2]

1- Cell Research Dept., Field Crops Research Institute, Agricultural Research Center.
2- Plant Res. Dept., Nuclear Res. Center. Atomic Energy Authority.

ABSTRACT

Six genotypes of Brassica napus (Three Egyptian cultivars and three exotics from Germany) were grown in five diverse environments to study genotype and environmental interaction and phenotypic stability for seed yield and its components, as well as, to study the differentiation of protein patterns of these genotypes under the various agro-ecological conditions. The study revealed that there was considerable variation due to the interaction between genotypes and environments for all studied characters, while, the genotype effects over all agro-ecological conditions were insignificant except for the two traits (height of first branches and oil content of seeds). The local cultivars: Serwo 6 and Pactol had the highest values for these traits, respectively. The genotypes differed as regards to the contribution of linear and non-linear variance components of GE interaction. The significant variance of GE reveals that the six canola genotypes are not fully adapted to the environments under study in the country. The study indicated that standard deviation from linearity (S^2_d) is the best parameter for stability but Coefficient of determination may be considered only in measuring seed yield. So, the recommendation of specific genotypes for specific regions is necessary such as Pactol and Evita genotypes for favourable productivity environments (Giza) and vice versa, Licosmos and Serwo 6 for poor environmental productivity (Fayoum). On the other hand, Star genotype proved to be relatively stable.

The SDS-PAGE protein analysis revealed that the six genotypes greatly differed in their protein patterns and the diverse agro-ecologies modified their proteins with appearance of new protein types in all genotypes, especially when grown in relatively saline soil.

Key words: ***Brassica napus, Agro-ecological conditions, Adaptation, GxE interaction, Electrophoresis, Protein finger printing, Environmental conditions.***

INTRODUCTION

The magnitude of the variance components associated with G x E interactions could be tested via combinations of years and locations, to determine the most efficient allocation of resources for cultivar testing. Different attempts have been made to solve the problems created by G x E interactions (Comstock and Moll 1963). Most of the estimates, however, only provide information on their existence and magnitude, but give no measurements of the individual genotypes with the environment. Interest has been focused on the regression analysis, an approach originally proposed by Yates and Cochran (1938) and later modified by Finlay and Wilkinson (1963) and Eberhart and Russell (1966).

Allard and Bardshaw (1964) have categorized environmental factors which lead to G x E interactions as predictable and unpredictable. The contribution of predictable environmental fluctuations to genotype x location interactions can be reduced by allocating specific cultivars to environments. Unpredictable environmental variation is more difficult and often leads to large genotype x year and genotype x year x location interactions. Selection of stable cultivars that perform consistently across environments can reduce the magnitude of these interactions.

The phenotypic performance of a genotype is not necessarily the same under diverse agro-ecological conditions. Some genotypes may perform far well in some environments but not so well in others. Such genotypes x environmental interactions have assumed greater importance in plant breeding as they reduce the stability of genotypic values under diverse environments (Dhillon *et al* 1999).

Rape-seed may be cultivated in winter in Egypt. Its seed contains more than 40% of excellent edible semi dry oil. Consequently, rape seed oil is considered a promising oil crop to decrease the gab between the production and the consumption. It grow well in newly reclaimed lands (Ghallab and Sharaan, 2002).

Protein markers, including seed storage protein and isozymes were among the first group of molecular markers exploited for genetic diversity assessment.

In the present investigation, an attempt has been made to study stability parameters of some local and exotic canola genotypes under different agro-ecological conditions, as well as, protein banding patterns and cluster analysis of these genotypes.

MATERIALS AND METHODS

Five experiments were carried out at the Agricultural Research Station Farm of Agricultural Research Center (Giza) for two seasons, Station Farm of Agricultural Research Center (Kom Oshim, El-Fayoum) and Agricultural Research Station of Atomic Energy Authority Farm (Inshas) Egypt for two seasons. Six genotypes were planted (three exotic genotypes; Evita Star and Licosmos from Germany and three local genotypes; Serwo 6, Pactol and Serwo 4) in a randomized complete block design with three replicates for each trail. Seeds were sown at 5 cm depth in hills, 10 cm apart within rows of 3 m long and 70 cm width. Plants were thinned, 21 days after emergence, to two plants/hill. Three rows were considered as an experimental plot. All other agricultural practices were applied as recommended for ordinary canola production in each location.

Soil samples were taken from the five experimental sites for physical and chemical analysis according to Jackson (1967) as shown in Table (1). While, Table (2) represents the other different agro-climatic conditions, which affected the studied traits, at the three sites in the two seasons.

Table 1. Soil mechanical and chemical analysis for the five experimental sites.

Analysis type	El-Fayoum 2002-2003	Giza 2002-2003	Inshas 2002-2003	Giza 2003-2004	Inshas 2003-2004
Mechanical analysis:					
Clay %	27.50	46.33	8.98	45.86	12.02
Silt %	20.00	36.81	46.53	38.47	42.76
Sand %	52.50	16.86	44.49	15.67	45.22
Texture	Sandy clay loam	Clay loam	Loam	Clay loam	Loam
Chemical analysis:					
Organic matter %	0.62	2.94	0.30	2.20	0.33
Calcium carbonate %	19.30	2.70	1.15	3.00	1.10
E. C. (Soil paste)	4.14	3.40	0.71	2.90	1.10
pH (1:2.5)	8.15	7.90	7.80	8.20	7.85

Samples of 30 plants/genotype were taken randomly for agronomic trait measurements; fruiting zone length (cm), first fruiting branch height (cm), No. of fruiting branches, No. of pods/plant, weight of pods / plant (g), seed yield/plant (g), seed index (weight of 1000 seeds, g), and seed oil content were determined using the procedure described by A.O.A.C. (1990).

Statistical analysis and stability parameters

All data in each trait were statistically combined analyzed using Mstatc statistics program and genotypes were compared by using L.S.D. at 0.05 level probability.

Stability parameters were estimated using the model proposed by Eberhart and Russell (1966). Each location in a given year was considered as an individual environment. Three stability parameters were measured: (1) the linear regression (b value) of variety mean in each environment on the environmental index of each environment (Table 3), (2) the deviation of mean square from the regression for each variety (S^2_d value).

Table 2. Different climatical conditions at the three sites in the two seasons, 2002-2003 and 2003-2004 (monthly report of the agricultural metrology from the Central Laboratory of Agricultural Climate, CLAC).

Month	Location	Different climatic conditions										
		1	2	3	4	5	6	7	8	9	10	11
Dec. 2002	El-Fayoum	2.5	0.0	19.4	19.1	19.7	62.0	38.0	86.0	16.7	9.5	23.8
Dec. 2002	Giza	2.0	0.0	19.6	21.6	18.6	44.0	36.0	53.0	14.0	7.2	20.8
Dec. 2002	Inshas	2.6	0.0	18.2	16.3	17.8	64.0	40.7	79.0	17.1	12.8	21.5
Dec. 2003	Giza	1.9	10.0	15.2	18.0	17.5	61.0	38.0	85.0	15.9	9.6	22.1
Dec. 2003	Inshas	1.9	12.0	21.0	17.2	18.2	63.0	55.0	82.0	16.9	12.5	21.3
Jan. 2003	El-Fayoum	1.6	4.0	19.0	19.1	20.5	62.0	39.0	86.0	16.6	9.2	23.9
Jan. 2003	Giza	2.2	0.0	17.3	15.9	15.2	63.0	47.0	82.0	17.4	6.2	28.7
Jan. 2003	Inshas	1.3	0.0	16.6	15.2	16.8	64.0	41.0	78.0	15.6	10.4	20.9
Jan. 2004	Giza	2.2	8.0	13.0	16.9	16.3	57.0	33.0	81.0	15.0	6.4	23.7
Jan. 2004	Inshas	1.8	18.0	17.9	14.3	17.3	61.3	42.9	80.0	15.3	10.9	19.8
Feb. 2003	El-Fayoum	2.6	0.0	17.5	19.2	19.2	58.0	31.0	85.0	14.6	7.6	21.5
Feb. 2003	Giza	2.0	0.0	18.5	20.4	17.6	50.0	30.0	70.0	14.9	7.6	22.0
Feb. 2003	Inshas	2.2	0.0	16.5	14.8	16.3	64.0	36.9	76.0	13.7	8.9	18.6
Feb. 2004	Giza	2.8	0.0	12.8	17.2	16.6	55.0	32.0	79.0	14.8	7.8	21.9
Feb. 2004	Inshas	2.4	10.0	18.3	15.9	15.6	66.0	48.0	85.0	15.7	10.3	21.1
Mar. 2003	El-Fayoum	3.0	0.0	21.2	22.6	24.2	58.0	30.0	85	16.8	9.4	24.3
Mar. 2003	Giza	3.1	0.0	11.4	14.2	15.5	49.0	28.0	69	16.9	12.6	21.2
Mar. 2003	Inshas	3.1	10	16.6	16.5	18.2	58.0	35.4	80	16.9	11.8	22.1
Mar. 2004	Giza	4.0	4.0	15.8	21.3	21.4	52.0	28.0	76.0	18.2	11.7	24.7
Mar. 2004	Inshas	3.4	0.0	22.5	19.0	20.4	64.0	43.0	85.0	18.1	13.1	23.0
Apr. 2003	El-Fayoum	5.4	0.0	26.3	28.7	30.3	53.0	24.0	83	24.1	15.4	32.7
Apr. 2003	Giza	5.1	0.0	18.8	20.1	19.4	48.0	26.0	70	21.1	13.4	28.8
Apr. 2003	Inshas	4.9	0.0	23.0	22.3	24.1	53.0	30.2	76	20.8	14.1	27.5
Apr. 2004	Giza	6.1	0.0	24.4	24.6	26.5	51.0	23.0	78.0	21.3	14.3	28.3
Apr. 2004	Inshas	4.9	0.0	26.2	23.3	24.4	59.0	32.0	86.0	20.9	14.6	27.2
May. 2003	El-Fayoum	6.7	0.0	31.3	34.2	25.7	49.0	19.0	78	29.0	19.6	38.5
May. 2003	Giza	6.3	0.0	23.0	27.6	26.7	42.0	35.0	49	26.1	17.9	34.2
May. 2003	Inshas	6.7	0.0	27.8	27.0	28.9	48.4	19.8	77.0	25.1	17.3	32.9
May. 2004	Giza	6.4	0.0	20.7	26.1	30.1	48.0	21.0	75.0	26.2	19.9	32.6
May. 2004	Inshas	7.5	0.0	29.7	26.5	28.4	57.0	31.0	84.0	25.6	19.1	32.1

Different climatic conditions : 1= Evaporation (mm^3/day) 2= Rain (mm^3) 3= Soil temperature 20 cm depth (average) 4= Soil temperature 10 cm depth (average) 5= Soil temperature 5 cm depth (average) 6= RH% (average) 7= RH% (min.) 8= RH% (max.) 9= Air temp. (average) 10= Air temp. (min.) 11= Air temp. (max.)

Table 3. Environmental indices for canola characteristics.

Traits	Agro-ecological conditions				
	1	2	3	4	5
Fruiting zone (cm)	1	1.17	2.17	2.02	1.97
First branch height (cm)	1.61	3.95	1	3.25	1.45
No. of fruiting branches /plant	1	1.10	1.23	1.29	1.19
No. of pods/ plant	1	2.10	2.56	5.03	2.27
Seeds yield/ plant (g)	1	4.39	2.75	6.11	2.52
Seed index(g)	1	1.39	1.91	1.20	1.95

Agro-ecological conditions 1= Fayoum 2002-2003 2= Giza 2002-2003 3= Inshas 2002-2003 4= Giza 2003-2004 5= Inshas 2003-2004

Significance of regression coefficients (b values) was tested by the Student's t-test (Steel *et al.* 1997), (3) Coefficients of determination (R^2 values) were computed from individual linear regression analysis (Pinthus, 1973).

To demonstrate interrelationships of the stability statistics estimated, correlation coefficients (r) between pairs of stability parameters, as well as, between each parameter and the general mean yield of each genotype were calculated.

Sodium Dodesyl Sulfate-polyacrylamide gel electrophoresis (SDS-PAGE)

For direct visual protein comparisons of the six genotypes grown under three different agro-ecological conditions i.e., Fayoum, Giza and Inshas, proteins were size fractionated based on the molecular weight by SDS-PAGE performed as described by Laemmli (1970). 0.75 mm-thick vertical slab gels were cast and electrophoresed using the Bio Rad Mini-Protean II system. Gels were stained with commassie brilliant blue R-250 solution, photographed and scored using gel documentation system manufactured by Alpha Ease FC (Alphimager 2200), U.S.A. The similarity matrices and the relationships among the genotype under each agro-ecological condition were computed according to Nei and Li (1979). This are presented by dendrograms using SPSS windows (Version 10) program.

RESULTS AND DISCUSSION

Pooled analysis of variance revealed significant differences among the genotypes for two characters only; first fruiting branch height and oil content. Further, variance due to environment (linear) was significant for all characters (Table 4).

Table 4. Analysis of variance for different characters in canola grown under different environmental conditions.

SV	df	Fruiting zone (cm)	First branch height (cm)	No. of fruiting branches	No. of pods/plant	Seed yield/plant (g.)	Seed index (g.)	Oil content %
Varieties	5	9.842	552.61**	1.761	5260.1	11.284	0.641	105.21**
Env + (var x environ)	24	141.58**	1761.5**	6.219**	61618.1**	132.08**	6.008**	68.30**
Environment (Linear)	1	3042.4**	39468.4**	42.097**	1230865**	2816.33**	117.32**	1442.84**
Var x Env (Linear)	5	21.628*	183.23*	5.582**	21605.4**	28.779**	4.032**	28.63**
Pooled deviation	18	13.738*	105.12	4.402**	7774.7*	11.652*	0.372	2.95**
Deviation V1	3	43.08	57.85	0.995761	1286.351	19.9145*	0.463168	1.23
Deviation V2	3	36.71	2.10	5.93227**	7307.394	6.300323	0.67564	1.54
Deviation V3	3	36.83	137.04	7.001369**	19644.48**	8.237384	0.041551	0.18
Deviation V4	3	92.73	235.78*	6.228622**	1800.729	23.562*	0.104546	8.07**
Deviation V5	3	303.46*	52.09	3.442944*	16466.2*	4.75911	0.619513	0.04
Deviation V6	3	215.43	145.88	2.813628	142.786	7.138265	0.329428	6.64**
Pooled error	50	7.341	72.94	1.23	4099.7	5.914	0.435	1.23

V1=Pactol, V2= Serwo 4, V3= Serwo 6, V4= Evita, V5= Licosmos and V6= Star
*, ** indicate significant at 5 % and 1% level of probability, respectively

The variance due G x E was significant for all the characters indicated that performance of the genotypes can be changed across the different environments (Table 4).

Significant deviation from linearity was detected at exotic variety Evita for most of the studied traits (first branch height, No. of branches, seed yield and oil content); cv. Licosmos for fruiting zone length, No. of branches and No. of pods/plant; cv. Star for only oil content. Similar trend was also found in some cases for the local cultivars, Serwo 6 (No. of branches and No. of pods), Serwo 4 (No. of branches) and Pactol (seed yield/plant) as shown in Table (4). When individual variances for seed yield/plant were expressed as a percent of the total variance component as accounted by environment, genotype x environment and genotype they were 98.6, 1.0 and 0.4 %, respectively. Similarly, a high contribution of the non-genetic factors to the total variance was also reported by Brandle and McVetty (1988) and Ngeve *et al* (2005).

Regarding to seed yield and its related traits, the highest mean value was found at Giza in 2003-2004 cropping season with variety of Licosmos, Star, Evita and Pactol for fruiting zone length, No. of branches, No. of pods/plant and seed yield/plant, respectively. However, Evita exhibited the highest seed yield over all environments (Table 5).

The first branch height of genotypes varied from 33.8 cm for Pactol to 50.8 cm for Serwo 6. While the oil content ranged from 37.05% for Serwo 4 to 43.95% for Pactol variety (Table 5). Oil content as well as the other characters were also greatly influenced by the environments. The oil content ranged from 31.96% at Fayoum to 43.13% at Inshas in 2003-2004. G x E interaction for oil content was significant, which means different responses of genotypes to various environments. The lowest oil content (26%) was produced by Evita at Fayoum and the highest (48%) by Pactol at Inshas in 2003-2004 season. In contrast, Wani (1993) reported that oil content was a highly stable trait when genotypes grown across different environments.

Table 5. Mean values for studied characters of six canola genotypes as affected by five agro-ecological conditions.

Character	Environment	Genotypes						X`	LSD 5%		
		Pactol	Serwo 4	Serwo 6	Evita	Licosmos	Star		E	G	E x G
Fruiting zone (cm)	1	54.60	45.97	50.97	43.17	66.11	49.87	51.78	11.34	N.S.	21.20
	2	66.47	62.82	58.58	63.63	52.22	59.93	60.61			
	3	107.33	116.00	110.33	112.67	113.00	115.67	112.50			
	4	94.17	104.40	94.50	111.42	100.22	122.08	104.46			
	5	99.33	101.00	95.67	108.00	108.67	99.67	102.06			
	X`	84.38	86.04	82.01	87.78	88.04	89.44	86.28			
First branch height (cm)	1	22.30	26.03	34.90	24.77	28.00	41.12	29.52	8.68	6.26	14.00
	2	62.35	69.78	78.87	65.60	77.04	81.57	72.53			
	3	9.00	13.00	27.67	33.67	11.33	15.67	18.39			
	4	48.83	55.61	80.00	48.89	65.83	58.89	59.68			
	5	26.67	21.33	32.67	21.33	30.33	27.33	26.61			
	X`	33.83	37.15	50.82	38.85	42.51	44.92	41.35			
No. of fruiting branches / plant	1	6.97	6.07	6.43	6.87	8.95	5.77	6.84	1.13	N.S.	1.82
	2	8.30	6.87	6.86	8.40	8.02	6.87	7.55			
	3	7.67	7.67	7.33	9.67	8.67	9.33	8.39			
	4	7.77	7.58	7.07	9.83	9.39	11.14	8.80			
	5	8.33	10.00	10.00	6.33	7.00	7.33	8.17			
	X`	7.81	7.64	7.54	8.22	8.40	8.09	7.95			
No. of pods/ plant	1	85.02	80.19	101.35	63.42	152.83	45.87	88.11	58.70	N.S.	104.98
	2	170.66	246.46	138.48	219.67	171.47	164.03	185.13			
	3	269.33	174.67	340.33	256.33	110.33	204.33	225.89			
	4	506.90	329.00	332.40	546.83	450.97	491.64	442.96			
	5	209.33	205.67	230.00	181.67	194.33	181.00	200.33			
	X`	248.25	207.20	228.51	253.58	215.99	217.37	228.48			
Seeds yield/ plant (gm)	1	3.02	2.87	4.47	1.85	5.54	1.45	3.20	1.90	N.S.	3.99
	2	12.67	16.16	13.30	12.22	14.46	15.40	14.03			
	3	8.23	7.99	5.71	11.92	9.21	9.72	8.80			
	4	25.68	19.17	16.70	22.27	15.00	18.56	19.56			
	5	6.96	6.74	6.28	11.08	8.57	8.80	8.07			
	X`	11.31	10.59	9.29	11.87	10.55	10.79	10.73			
Seed index (gm)	1	2.86	3.08	4.03	2.38	2.90	2.91	3.03	0.94	N.S.	1.08
	2	3.86	4.31	4.13	4.08	4.42	4.40	4.20			
	3	6.36	5.17	4.84	5.46	6.51	6.35	5.78			
	4	4.12	4.57	4.07	3.28	2.74	3.02	3.63			
	5	6.37	5.13	4.77	5.70	6.53	6.67	5.86			
	X`	4.71	4.45	4.37	4.18	4.62	4.67	4.50			
Oil %	1	35.50	33.75	35.25	26.00	29.50	31.75	31.96	0.08	0.27	0.60
	2	44.00	36.75	42.25	40.00	39.50	38.00	40.08			
	3	47.25	37.50	43.75	39.75	42.00	42.25	42.08			
	4	45.00	38.75	43.25	40.75	41.25	39.00	41.33			
	5	48.00	38.50	44.25	41.00	43.50	43.50	43.13			
	X`	43.95	37.05	41.75	37.50	39.15	38.90	39.72			

Environments: 1= Fayoum 2002-2003 2= Giza 2002-2003 3= Inshas 2002-2003
4= Giza 2003-2004 5= Inshas 2003-2004

Also, the genotypes responded differentially to one or more of the environmental factors, which differed between locations and years. The relative importance of location as a factor affecting G x E interaction has been noticed (Table 5). However, Brandle and McVetty (1988) and Gebeyehu and Assefa (2003) on different crops reported that performances of cultivars were less consistent over years than over locations. This contrast may be due to the different response of different crops even genotypes to different agro-ecological factors. In Egypt, however, the agro-climatic conditions (seasons) may not greatly affect on G x E interaction.

Although, the genotype Evita followed by Pactol showed high mean values of seed yield/plant along with non stable performance across different environments and positively regression coefficient, but significance of deviation from linear regression (Table 6).

Table 6. Stability parameters for six canola genotypes under five agro-ecological conditions

Traits	Stability parameters	Genotypes					
		Pactol	Serwo 4	Serwo 6	Evita	Licosmos	Star
Fruiting zone (cm)	bx.y	0.804**	1.070**	0.917**	1.142**	0.923	1.144**
	R^2	0.979	0.990	0.986	0.978	0.898	0.950
	S^2_d	43.077	36.707	36.828	92.730	303.455*	215.434
First branch height (cm)	bx.y	0.901**	1.038**	1.093**	0.712*	1.173**	1.083**
	R^2	0.969	0.999	0.950	0.825	0.983	0.946
	S^2_d	57.848	2.098	137.041	235.781*	52.090	145.884
No. of fruiting branches /plant	bx.y	0.321	1.074	0.657	1.290	0.085	2.572*
	R^2	0.196	0.315	0.128	0.382	0.005	0.845
	S^2_d	0.996	5.932**	7.001**	6.229**	3.443*	2.814
No. of pods/ plant	bx.y	1.211**	0.620*	0.639	1.361**	0.908*	1.262**
	R^2	0.987	0.782	0.570	0.986	0.774	0.999
	S^2_d	1286.35	7307.39	19644.5**	1800.729	16466.2*	142.786
Seeds yield/ plant (g)	bx.y	1.351**	1.071**	0.831**	1.090*	0.625**	1.033**
	R^2	0.935	0.966	0.929	0.887	0.928	0.959
	S^2_d	19.915*	6.300	8.237	23.562*	4.759	7.138
Seed index (g)	bx.y	1.214**	0.576*	0.310	1.101	1.413**	1.385
	R^2	0.954	0.760	0.938	0.987	0.955	0.975
	S^2_d	0.463	0.676	0.042	0.105	0.620	0.329

This indicated that the genotypes did not exhibit the same level of performance over all the environments. Similar interaction was also reported by Wani (1992) and Dhillon *et al* (1999). Meanwhile, the seed yield per plant of the other four genotypes with medium average exhibited positively significant regression coefficient and non significant deviation from linear regression as well as coefficient of determination near to the unit (R^2 =1). So, these genotypes linearity responded to the improved agro-ecological conditions. The significant variance of G x E obtained in this study revealed that the canola genotypes are not fully adapted to all locations under study that leads to a recommendation of specific genotypes for specific regions.

Two genotypes; Licosmos and Serwo 6 had positive regression coefficient but it was less than 1.0 with higher seed yield per plant than the lowest environment (Fayoum). These genotypes were relatively better adapted to poor environments.

According to Eberhart and Russell (1966) a variety considered as stable should meet criteria of high mean yields, with regression coefficient equal to unity and S^2_d approaching zero. It could be considered widely adapted and stable, it have the ability to express its yield potential in a range of environmental conditions. Using these criteria, no single genotype is stable for seed yield/plant (Table 6). This is in agreement with results of Wani (1992), Wani (1993), Verma *et al* (1994) and Dhillon *et al* (1999). However, with respect to seed index, Evita was found to be stable for this trait as indicated via coefficient of determination (R^2) near unity and least deviation from regression (0.1).

Star genotype seems to be relatively stable in the most of studied traits as compared to the other genotypes. Meanwhile, Pactol followed by Evita exhibited the maximum seed mean values under the best environmental productivity. The two genotypes showed sensitivity to environmental changes and hence could be cultivated under relatively good productivity environments like Giza. In Egypt, however, we are looking for a variety adapted to new reclaimed area (poor environments), lick cv. Licosmos which had b_i = 0.63, R^2 near linearity and insignificant deviation from linearity (S^2d) = 4.7. For all studied characters of the other genotypes, as shown in Table (6), there is no one genotype that had a high stability in terms of higher mean value than the grand mean and that had a regression coefficient significantly greater than 1.0.

The correlation of R^2 with S^2d was negative and significant in most cases. It means that the increase in coefficient of determination associated with the decrease in the deviation from linearity. The R^2 and S^2d could be considered as the stability parameters for these traits.

Correlation between mean values and the three stability parameters varied considerably (Table 7). The non significant correlation between the mean values and b indicated that genotypes with high mean did not respond linearity for increasing environmental productivity.

Table 7. Correlation among the stability parameters, as well as, the mean of the studied traits for six canola genotypes.

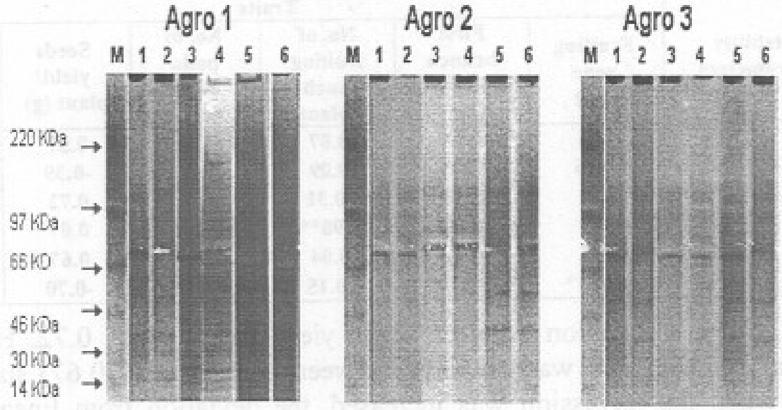
Stability parameters		Traits					
		Fruiting zone (cm)	First branch height (cm)	No. of fruiting branches /plant	No. of pods/ plant	Seeds yield/ plant (g)	Seed index (g)
$X^{\cdot}$	bx.y	0.65	0.53	0.07	0.64	0.57	0.51
	R^2	-0.56	-0.01	0.09	0.43	-0.39	0.06
	S^2_d	0.72	0.33	-0.31	-0.37	0.72	0.58
b_i	R^2	0.09	0.80	0.98**	0.90*	0.07	0.55
	S^2_d	0.15	-0.56	0.04	-0.77	0.67	0.30
R^2	S^2_d	-0.96**	-0.92**	-0.15	-0.94**	-0.70	-0.57

The association between mean yield and S^2_d was 0.72. However, negative correlation was obtained between b_i and S^2_d (-0.67) suggesting that when the regression was increased, the deviation from linearity was decreased and the seed yield was increased by increasing deviation from linearity response or at specific agro-ecological conditions. However, the correlation between mean yield and R^2 was negative (-0.40) with a weak correlation between R^2 and b_i (0.07). So, R^2 shall be considered only in measuring dimensions of seed yield per plant but could not adequately detect wide adaptability and stability for seed yield. The same result was obtained by (Gebeyehu and Assefa, 2003) but in navy bean yield.

SDS-PAGE protein banding patterns

Leaf storage protein (water-soluble fraction) was used in this study to assess polymorphism of the six canola genotypes under three agro-ecological conditions. Electrophoretic separation of water soluble extracted protein in the studied genotypes is shown in Figure 1 (Agro 1, Agro 2 and Agro 3) and their densitometric analysis as described by Nei and Li (1979) are illustrated in Table (8), where the presence and absence of bands were assessed with (1) and (0), respectively.

From the protein banding patterns and densitometric analysis of SDS-PAGE for water soluble protein fraction of canola genotypes (Fig. 1) and Table (8), 41 bands were obtained with different molecular weights ranging from 286 to 17 KDa. The first agro-ecological condition (Fayoum) produced the highest number of bands for all genotypes except for Pactol and Serwo 4 genotypes, followed by the third agro-ecological conditions (Inshas), which indicated that the soil structure and composition highly affected number of protein bands. Similar conclusion was revealed by G x E analysis in the previous phenotypic analysis in the present study.



Agro-ecological conditions Agro1=Fayoum, 2002-2003 Agro 2= Giza, 2002-2003 Agro 3= Inshas, 2002-2003

Fig. 1. Protein banding patterns for leaf storage protein of six canola genotypes grown under three agro-ecological conditions.

Band with MW of 242 KDa (genotype 6), 121 KDa (genotypes 4 and 5), 118 KDa (genotypes 3 and 6) and 49 KDa (genotypes 3 and 4) were expressed only under the relatively high salt conditions with 4.14 EC (Fayoum), as shown in Tables (1 and 8).

The development of new bands and absence of others, represented by different genotypes, under salt condition stress, would indicate either the enhancement or repression of gene expression in those plants. Jain *et al* (1993) reported that salt stress induced distinct genotype-specific changes in polypeptide patterns. These polypeptides may be essential for some osmo-regulator proteins.

On the other hand, band with MW 214 KDa (genotype 6), 147 KDa (genotypes 2 and 5), 107 KDa (genotypes1, 2, 3 and 5), 42 KDa (genotypes 1, 2, 3, 4 and 6), 30 KDa (genotypes 1, 2, 4 and 6), 18 KDa, (genotype 6) and 17 KDa, (genotype, 2) were expressed only under Inshas conditions, which showed the lowest EC (salt concentration). These results are in agreement with Mohan *et al* (1997) and Azzam and Abbas (2005) who reported that SDS-PAGE was widely used to separate proteins, which are directly related to genetic background.

Table 8. **Densitometric analysis of SDS-PAGE for leaf storage protein (water soluble protein fraction) of six canola genotypes grown under three agro-ecological conditions in 2002/2003 season.**

No. of bands	Env.	Fayoum 2002-2003						Giza 2002-2003						Inshas 2002-2003					
	MW. KDa	Genotypes						Genotypes						Genotypes					
		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1	286	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2	242	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
3	230	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
4	214	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
5	196	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1
6	176	0	0	1	0	1	1	0	0	0	0	1	0	0	1	0	1	1	0
7	166	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0
8	150	0	0	1	1	0	0	0	0	0	0	1	1	1	1	0	1	0	1
9	147	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	0
10	127	0	0	0	1	0	0	0	0	1	1	0	0	1	0	0	1	1	1
11	121	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
12	118	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
13	112	0	1	0	0	0	0	1	1	1	1	1	1	0	0	0	1	0	1
14	107	1	0	0	1	1	0	0	0	0	0	0	0	1	1	1	0	1	0
15	101	0	0	1	0	0	1	1	1	1	1	1	0	0	1	1	0	0	0
16	98	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	1	0	0
17	91	0	0	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1
18	83	0	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	1
19	76	0	1	0	1	0	0	1	1	0	0	0	0	0	1	1	0	1	0
20	74	0	0	1	0	1	1	0	0	1	1	1	1	0	0	0	1	0	0
21	67	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1
22	63	0	0	1	0	0	1	0	1	0	0	0	0	1	1	1	0	0	0
23	61	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0
24	58	0	1	0	0	1	1	0	0	0	1	0	1	0	0	1	0	0	1
25	53	1	0	1	1	1	1	0	0	1	1	0	0	1	1	1	1	1	1
26	49	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	48	0	0	0	0	1	1	0	1	0	1	1	1	1	0	0	0	0	0
28	45	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0
29	42	0	0	0	1	1	1	0	0	0	0	0	0	1	1	1	1	0	1
30	40	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0
31	36	0	0	0	1	1	0	0	0	0	1	0	1	0	1	0	0	0	1
32	34	0	0	1	1	0	1	1	1	1	0	1	0	0	0	1	1	0	0
33	32	1	1	0	0	1	0	0	0	0	1	0	1	1	0	0	0	1	0
34	30	0	0	1	0	1	1	0	1	1	0	1	0	1	1	0	1	0	1
35	28	0	1	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0
36	26	1	0	0	1	1	1	0	0	1	0	1	0	0	1	0	0	1	1
37	23	0	0	1	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0
38	21	1	0	0	1	1	1	0	1	0	0	1	1	1	0	1	0	1	1
39	19	0	0	1	1	0	1	0	0	0	0	1	0	0	1	0	1	0	0
40	18	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
41	17	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Total No. of band		8	7	17	21	24	26	7	10	9	10	14	15	14	16	11	14	14	16

Genotypes: 1 = Pactol 2= Serwo 4 3= Serwo 6 4 = Evita 5= Licosmos 6= Star

Similarity indices among the six canola genotypes grown under three different agro-ecological conditions based on protein analysis are presented in Table (9).

Table 9. The similarity indices (pair wise comparison) of SDS-protein data among six canola genotypes grown under three agro-ecological conditions.

Agro-ecological conditions	Cases	Genotypes					
		Pactol	Serwo 4	Serwo 6	Evita	Licosmos	Star
Agro 1	Pactol	1					
	Serwo 4	0.40	1				
	Serwo 6	0.24	0.08	1			
	Evita	0.35	0.21	0.42	1		
	Licosmos	0.44	0.19	0.39	0.58	1	
	Star	0.29	0.18	0.64	0.50	0.67	1
Agro 2	Pactol	1					
	Serwo 4	0.59	1				
	Serwo 6	0.38	0.42	1			
	Evita	0.24	0.30	0.63	1		
	Licosmos	0.29	0.50	0.61	0.42	1	
	Star	0.18	0.40	0.25	0.56	0.48	1
Agro 3	Pactol	1					
	Serwo 4	0.47	1				
	Serwo 6	0.48	0.52	1			
	Evita	0.43	0.53	0.32	1		
	Licosmos	0.36	0.47	0.40	0.36	1	
	Star	0.47	0.44	0.37	0.47	0.33	1

Environments: Agro 1= Fayoum 2002-2003 Agro 2= Giza 2002-2003
Agro 3= Inshas 2002-2003

In Agro 1 (Fayoum), the highest similarity indices (0.67 and 0.64) were recorded between Star and each of Licosmos or Serwo 6, respectively, while the lowest similarity index (0.08) was recorded between Serwo 4 and Serwo 6, as shown in Table (9).

On the other hand, in Agro 2 (Giza), the highest similarity indices (0.63 and 0.61) were recorded between Serwo 6 and each of Evita or Licosmos, respectively, while the lowest one was recorded between Star and Pactol (0.18).

While, under the third agro-ecological condition (Inshas), the highest similarity indices (0.53 and 0.52) were recorded between Serwo 4 and each of Evita or Serwo 6, respectively, while the lowest one was recorded between Serwo 6 and Evita (0.32), suggesting that the distance between the six canola genotypes differed according to their leaf storage protein banding patterns and affected by environmental conditions.

The dendrogram of the six canola genotypes showing the genetic relationships under three different agro-ecologies are presented in Figure (2).

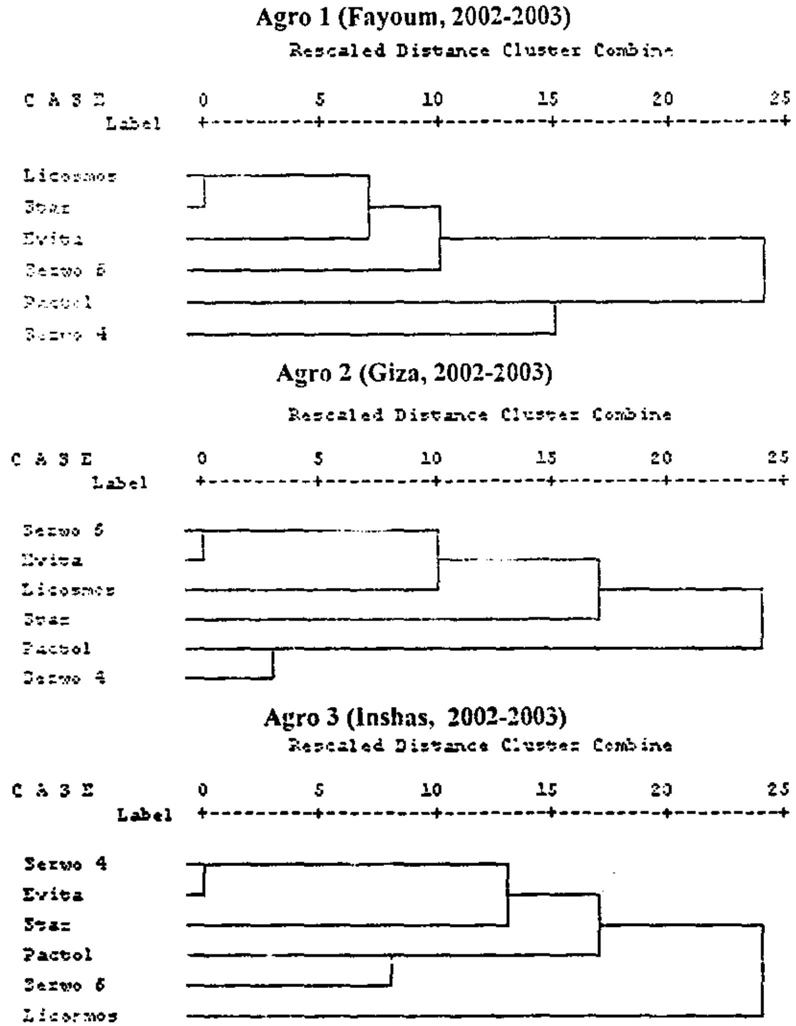


Fig.2. Dendrogram showing the genetic distance among six canola genotypes grown under three agro-ecological conditions using SDS-protein data.

The genotypes were separated into two clusters under each agro-ecological condition; cluster 1 included Licosmosm, Star. Evita and Serwo 6 (under both Agro1 and Agro 2), while the first cluster included all the canola genotypes except Licosmos under Agro 3 conditions. On the other hand, the second cluster under the Agro 1 and 2 included Pactol and Serwo 4 (the local cultivars). These results indicated that the genetic distance between the previous genotype is narrow than the other genotypes in Fayoum and Giza. The dendrogram (Fig. 2) showed that the expressions of relationship between genotypes were modified by agro-ecological conditions. These results are in agreement with Mohan *et al* (1997), Jaramillo *et al* (1999) and Azzam and Abbas (2005), who reported that SDS-PAGE can be used to certify the genetic makeup of wild cultivars, or newly derived plants.

REFERENCES

A.O.A.C. (1990). Official Methods of Analysis. Association of Official Analysis Chemist, 15th Ed. Washington, U. S. A.

Allard, R. W. and A. D. Bradshaw (1964). Implications of genotype-environment interactions in applied plant breeding. Crop Sci. 4: 503-508.

Azzam, Clara R. and Salwa M. Abbas (2005): Improvement of some economic characters through variation induced via irradiation in canola (*Brassica napus* L.). Egypt. J. Plant Breed. 9(2): 277-302.

Brandle, J. E. and P. B. E. McVetty (1988). Genotype x environment interactions and stability analysis of seed yield of oilseed rape in Manitoba. Canadian J. Plant Sci. 68: 381-388.

Comstock, R. E. and R. H. Moll (1963). Genotype x environment interaction. In: Hanson, W. D. and Robinson, H. F. (Eds.), pp. 164-198. Statistical Genetics and Plant Breeding. NAD-NRC Publ. No. 912.

Dhillon, S. S., K. Singh and K. S. Brar (1999). Stability analysis of elite strain in Indian Mustard. 10th International Rapeseed Congress, Canberra, Australia, 434-438.

Eberhart, S. A. and W. A. Russell (1966). Stability parameters for comparing varieties. Crop Sci. 6: 36-40.

Finlay, K. W. and G. N. Wilkinson (1963). The analysis of adaptation in plant breeding programme. Australian J. Agric. Res. 14: 742-754.

Gebeyehu, S. and H. Assefa (2003). Genotype x environment interaction and stability analysis of seed yield in Navy bean genotypes. African Crop Sci. J. 11(1): 1-7.

Ghallab, K. H. and A. N. Sharaan (2002). Selection in canola (*Brassica napus* L) germplasm under conditions of newly reclaimed land. 2. Salt-tolerant selection. Egypt. J. Plant Breed. 6(2): 15-30.

Jackson M. L. (1967). Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi.

Jain, S., H. S. Nainawatee, R. K. Jain and J. B. Chaudhury (1993): Salt tolerance in *Brassica juncea* L. II. Salt stress induced changes in polypeptide pattern of *in vitro* selected NaCl-tolerant plants. Euphytica 65 (2): 107-112.

Jaramillo, S. G., O. J. Medina, W. A. Rogriques, G. A. Tosello and P. Lopez (1999). Evaluation of some cereals, plants and tubers through protein composition. Journal of Protein Chemistry 18 : 6, 687-693.

Laemmli, U. K. (1970). Cleavage of structural proteins during assembly of the head of bacteriophage T4. Nature 227: 680-685.

Mohan, M., S. Mair, A. Bahgwat, T. G. Krishna and M. Yana (1997). Genomic mapping molecular markers and maker-assisted selection in crop plants. Molecular Breeding 3: 87-103.

Nei , M. and W. H. Li (1979). Mathematical model for studying genetic variation in terms of restriction of endonucleases. Proc. Natl. Acad. Sci. USA. 76:5269-5273.

Ngeve, J. M., A. G. O. Dixon and E. N. Nukenine (2005). The influence of host genotype x environment interactions on the response of cassava anthracnose disease in diverse agro-ecologies in Nigeria. African Crop Science Journal. 13(1): 176-185.

Pinthus, M. J. (1973). Estimates of genotypic value: a proposed method. Euphytica 22: 345-351.

Steel, R. D. G., M. J. H. Torrie and D. A. Dickey (1997). Principles and Procedures of Statistics. A biometrical approach. 3rd ed. McGraw-Hill, New York. 665 pp.

Verma, A. K., J. L. Matho and P. K. Sinha (1994). Stability for yield and yield attributing traits in Toria under rainfed conditions. Indians J. Agric. Sci. 1: 59-61

Wani, S. A. (1992). Genotype x environment interaction for yield and its components in Indian mustard. Adv. Plant Sci. 5: 421-425.

Wani, S. A. (1993). Stability for oil content and harvest index in Indian mustard. Adv. Plant Sci. 6:65-69.

Yates, F. and W. G. Cochran (1938). The analysis of groups of experiments. J. of Agric. Sci. 28: 556-580.

تحليل درجة الثبات ونماذج البروتين لتراكيب وراثية من الكانولا النامية تحت ظروف بيئية مختلفة

كلارا رضا عزام [١] ، حمدى عبد السميع محمد مصطفى[٢] وإبراهيم محمد عامر[٢]
١ - قسم بحوث دراسة الخلية – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية.
٢- قسم البحوث النباتية – مركز البحوث النووية _ هيئة الطاقة الذرية.

تم زراعة ست تراكيب وراثية (ثلاث أصناف محلية وثلاثة أصناف المانية) فى خمسة تجارب حقلية تمثل بيئات زراعية مختلفة (الفيوم – الجيزة – انشاص) لدراسة التفاعل بين التراكيب الوراثية والبيئات و درجة الثبات المظهرى لمحصول البذور ومكوناته، كما تم دراسة نماذج البروتين المختلفة لهذه الاصناف تحت الظروف البيئية المختلفة. وتوصلت النتائج الى وجود تباين كبير لتفاعل التركيب الوراثى مع البيئة لكل الصفات المدروسة ولكن لا يوجد تأثير معنوى للأصناف ماعدا صفة إرتفاع أول فرع ومحتوى الزيت. وتفوق الصنف المحلى سرو ٦ وباكتول فى هذه الصفات على التوالى. ومن جهة أخرى أختلفت التراكيب الوراثية فى مدى مساهمتها فى مكونات التباين الخطى وغير الخطى الراجع الى التفاعل بين الأصناف والبيئات، والتباين العالى لهذا التفاعل يشير الى أن الأصناف المستخدمة ليست لها قدرة كاملة على التأقلم لمدى واسع من الظروف البيئية المصرية. كما أوضحت النتائج ان الانحراف عن خط الانحدار S^2_d هو أفضل مقاييس لدرجة الثبات ولكن معامل التحديد R^2 يفيد فى قياس مصدر تباين المحصول. ويخلص البحث الى ضرورة إستخدام أصناف معينة لمناطق محددة مثل الصنف المستورد ايفيتا والمحلى باكتول يزرع فى الاراضى التى تستجيب لعوامل الانتاجية العالية والصنف المستورد ليكوزموس والمحلى سرو ٦ يزرع فى الاراضى منخفضة الانتاجية (الاراضى الملحية مثل الفيوم). بينما الصنف المستورد ستار أظهر درجة ثبات متوسطة.

وأوضح تحليل البروتين أن الاصناف السته تختلف فى نماذج البروتين المفصولة ولقد أوضح تحليل البروتين ودرجة التشابه أن إختلاف البيئات الزراعية أدى الى تحوير فى نماذج البروتين الصنفى وظهور أنواع من البروتينات الجديدة خصوصا تحت تأثير الزراعة فى أرض ملحية نسبيا.

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