Jordan Journal of Agricultural Sciences, Volume **8**, No.**4** 2012

Potence Ratio and Path Coefficient Analysis for Some Quantitative Traits Of Maize (*Zea mays* L.) Hybrids Developed in Syria

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ABSTRACT

Twenty-eight hybrids were created during 2008 cropping season. Hybrids were evaluated during 2009 cropping season for eight agronomic traits at the Agriculture Scientific Research Center. Homs, Syria. The present work aimed at determining the potence ratio and path analysis for grain yield (ton/ hectare), ear length (cm), ear diameter (cm), 100-kernel weight (g), number of kernel per row, starch, protein and oil content in grain (%). The potence ratio for most traits exceeded +1 except for starch, protein and oil content in grain; their potence ratios ranged from -1 and +1 indicated that the partial and over-dominance gene effects played major role in the inheritance of starch, protein and oil content in grain while over-dominance gene effects were the most importance in inheritance of grain yield, ear length, ear diameter, 100-kernel weight and number of kernel per row. Results showed that grain yield correlated positively and significantly correlated with ear diameter ($r=0.592^{**}$), oil content in grain ($r=0.337^{**}$), 100-kernel weight ($r=0.293^{**}$) and ear length ($r=0.222^{**}$). The path coefficient analysis estimates indicated that ear diameter, oil content in grain and ear length had high positive direct effects on grain yield indicating that indirect selection for these traits could lead to direct increase in grain yield.

Keywords: Maize, Grain yield, Potence ratio and Path Coefficient Analysis.

INTRODUCTION

Maize is the world's third leading cereal crop after wheat and rice (FAO, 2009). It is primarily used as a major food, feed grain for livestock and for industrial products (El-Hawary *et al*., 2003). In Syria, maize comes third after wheat and barley as per planted area (Agriculture statistics publication 2008). However, increasing grain yield of cereal crops is considered one of the important national goals to face the growing needs of the population therefore, it has become necessary to develop genotypes which consistently show superior performance. Plant breeder is interested in the estimation of gene effects in order to formulate the most advantageous breeding procedures for improvement of the attribute in question. Therefore, breeders need information about nature of gene action, phenotypic correlation and path analysis as well as other genetic parameters for yield, yield components and quality traits. Sprague, (1963) listed three major factors that must be considered and which may limit progress in the analysis of quantitative genetic variation: i. the number of genes involved. ii. the type of gene action. iii. the genotype-environment interaction.

Cockerham, (1961), Hallauer and Miranda Fo, (1981) and Eshghi and Akhundova, (2009) discussed the relation between type of gene action and the efficient breeding schemes; he concluded that all systems of selection are fruitful if gene action is entirely additive. El-Hosary and Abd El-Sattar, (1998); Khalil, (1999); Edward and Lamky, (2002) and Al-Kaddoussi *et al*.,

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Received on 3/4/2011 and Accepted for Publication on 29/5/2012.

(2004) found that over-dominance was involved in the inheritance of 100-kernel weight and grain yield per plant where potence ratio values were larger than (+1). Srdić *et al*., (2008) and Haq *et al*., (2010) reported that additive and non-additive gene effects were involved in determining the performance of genotypes. However, additive gene effects were more predominant for the inheritance of grain yield and oil content. Amit and Joshi (2007) concluded that non-additive gene action controlled the inheritance of oil, starch and protein contents in grain. Selvaraj *et al*., (2006) derived that additive gene action was more important than non-additive gene action in controlling grain yield and oil content, while non-additive controlled the inheritance of protein contents.

Tabassum *et al*., (2007) revealed that dominance absence and over dominance controlled the inheritance of 100- kernel weight. Sumathi *et al*., (2007) mentioned that oil content had consistent negative and significant correlation with grain yield. On the other hand, Mittelmann *et al*., (2003) found positive and significant correlation between grain yield and oil content, but this correlation was negative with protein content, however protein content exhibited significant positive correlation with oil content. Positive and significant correlation between 100-kernel weight and grain yield was reported by Shamim *et al*., (2010). Many researchers revealed that the most important sources of variation in plant yield was the direct effects of 100-kernel weight (Abd El-Sattar and Motawea, 1999; Amin *et al*., 2003 and Rafiq *et al*., 2010). The main objectives were to estimate of potence ratio and path analysis for yield, its components and quality traits of 28 F_1's hybrids of maize.

Materials and Methods

Eight inbred lines of yellow maize were used in this study i. e IL.256-06 (P_1), IL.136-06 (P_2), IL.840-06 (P_3), IL.291-06 (P_4), IL.322-06 (P_5), IL.233-06 (P_6), IL.767-06 (P_7) IL.257-06 (P_8) and were kindly provided by the Department of Maize Researches, General Commission for Scientific Agricultural Research (GCSAR), Ministry of Agriculture and Agrarian Reform, Damascus. Syria. The eight parental inbred lines crossed in a half diallel fashion (Griffing's, 1956 method 4), in 2008 and evaluated in 2009 season at the Agriculture Scientific Research Center. Homs, Syria. The experiment was designed in randomized complete blocks (R.C.B.D) with three replications. Each, plot consisted of four ridges, 6m long and 70 cm width. Plants were spaced at 25 cm within ridge and thinned at one plant per hill after about 21 days of planting. Recommended cultural practices for maize production were applied during the growing season. Observations and measurements were recorded on 10 guarded plants chosen at random from each plot for grain yield (ton/hectare), ear length (cm), ear diameter (cm), 100-kernel weight (g), number of kernel per row, starch, protein and oil content in grain (%). Mather (1949) and Smith (1952) approaches used to estimate potence ratio (P) as follows:

$P = (F_1 – MP) / [0.5 \times (P_2 – P_1)]$ where: F_1 = the first generation mean, P_1 = the mean of the first parent, P_2 = the mean of the better parent and MP = mid parents value. Complete dominance is indicated when potence ratio is equal to (+1) or (-1). Partial dominance is the case when ratio between (+1) and (-1). Over-dominance indicated if ratio exceeds (± 1). The phenotypic correlation coefficients calculated as described by Snedecor and Cochran, (1981) .

$$r_{ph} = \sigma_{p_i p_j} / \sqrt{\sigma^2_{p_i} \times \sigma^2_{p_j}}$$

Where: r_{ph} is phenotypic correlation coefficient; $\sigma_{p_i p_j}$ is the phenotypic covariance for the trait (i^{th}) and trait (j^{th}); $\sigma^2_{p_i}$ and $\sigma^2_{p_j}$ are the respective phenotypic standard deviation.

The path coefficient analysis was performed using the method proposed by Wright, (1934) and utilized by Dewey and Lu, (1959)

$$1 = P^2_{y0} + P^2_{y1} + P^2_{y3} + (2P_{y1r12}P_{y2}) + (2P_{y1r13}P_{y3}) + (2P_{y2r23}P_{y3})$$

$$RI = |CD_i| / \sum_i |CD_i| \times 100$$

Where: p is the path coefficient analysis (direct effect for trait); y is the grain yield; r is the phenotypic correlation coefficients; CDi is the coefficient of determination and

RI% is the relative importance. The PLAB STAT program was used for all calculations.

Results and Discussion

Potence Ratio Estimates

Potence ratios of grain yield, ear length, ear diameter, 100-kernel weight and number of kernel per row (Table 1) were larger than unity for most crosses indicating over-dominance gene effects played a major role in inheritance of these traits. This result is in agreement with Amer and Mosa, (2004), El-Shouny *et al*., (2005), Tabassum *et al*., (2007) and Srdić *et al*., (2008).

Table (1). Potence ratio of grain yield, ear length, ear diameter and 100-kernel weight for 28 F_1 hybrids.

Hybrids	Grain yield g	Ear length cm	Ear diameter cm	100-kernel weight g
$P_1 \times P_2$	5.64	3.87	3.12	4.38
$P_1 \times P_3$	4.56	6.84	3.54	7.37
$P_1 \times P_4$	17.81	3.04	8.57	11.04
$P_1 \times P_5$	5.26	2.43	20.14	2.38
$P_1 \times P_6$	18.18	3.58	2.40	4.16
$P_1 \times P_7$	10.19	2.65	10.76	2.94
$P_1 \times P_8$	2.45	0.01	-0.18	-6.00
$P_2 \times P_3$	41.75	23.35	15.92	3.24
$P_2 \times P_4$	7.12	5.76	2.84	10.20
$P_2 \times P_5$	27.74	2.59	3.65	2.13
$P_2 \times P_6$	5.79	26.45	52.33	10.58
$P_2 \times P_7$	27.26	4.89	7.06	1.55
$P_2 \times P_8$	7.72	6.92	2.19	5.59
$P_3 \times P_4$	7.28	7.08	2.26	4.41
$P_3 \times P_5$	18.98	3.87	4.46	14.25
$P_3 \times P_6$	4.80	14.89	8.12	6.42
$P_3 \times P_7$	15.40	5.00	4.22	37.36
$P_3 \times P_8$	8.87	11.62	2.65	7.70
$P_4 \times P_5$	11.07	5.99	6.13	2.23
$P_4 \times P_6$	41.27	8.21	1.69	18.25
$P_4 \times P_7$	17.15	97.60	5.20	2.82
$P_4 \times P_8$	70.42	4.66	30.00	18.72
$P_5 \times P_6$	6.26	3.54	2.50	1.84
$P_5 \times P_7$	68.70	5.37	17.80	14.87
$P_5 \times P_8$	13.67	3.03	6.83	3.34
$P_6 \times P_7$	8.46	9.78	3.93	1.24
$P_6 \times P_8$	21.44	5.82	1.31	8.82
$P_7 \times P_8$	22.14	3.33	5.12	2.51

P_1, P_2, P_3, P_4, P_5, P_6, P_7 and P_8 denote to IL.256-06, IL.136-06, IL.840-06, IL.291-06, IL.322-06, IL.233-06, IL.767-06 and IL.257-06 respectively.

On the other hand, Potence ratio values of starch, protein and oil content in grain (Table 2) were between

±1 in some crosses however, partial dominance and over dominance effects played a major role in inheritance of these traits. Our results support the conclusion of [Tabassum, (2004), Selvaraj *et al*., (2006) and Amit and Joshi., (2007)] who reported that partial dominance and over dominance controlled with inheritance of starch, protein and oil content in grain.

Table (2). Potence ratio of number of kernel/ row, starch, protein and oil content in grain for 28 F_1 hybrids.

Hybrids	Kernels per row k	Starch mg	Protein mg	Oil mg
$P_1 \times P_2$	2.93	16.00	-1.00	0.25
$P_1 \times P_3$	1.76	1.30	0.45	2.39
$P_1 \times P_4$	4.89	1.55	-0.57	4.82
$P_1 \times P_5$	1.73	3.36	-0.23	23.00
$P_1 \times P_6$	2.49	-0.95	0.40	0.20
$P_1 \times P_7$	1.45	-2.54	0.04	0.68
$P_1 \times P_8$	1.76	-1.06	1.16	-0.25
$P_2 \times P_3$	8.39	-0.38	-0.10	0.14
$P_2 \times P_4$	7.95	0.54	-2.30	-0.14
$P_2 \times P_5$	6.82	0.81	-3.70	-0.34
$P_2 \times P_6$	18.20	-1.67	0.45	0.01
$P_2 \times P_7$	5.37	5.67	-0.37	4.71
$P_2 \times P_8$	6.06	-0.84	1.18	0.09
$P_3 \times P_4$	4.14	0.75	0.30	0.01
$P_3 \times P_5$	61.67	2.37	-0.36	1.00
$P_3 \times P_6$	4.83	6.92	-1.00	-0.60
$P_3 \times P_7$	227.62	5.93	-13.00	1.15
$P_3 \times P_8$	3.01	0.84	0.63	2.53
$P_4 \times P_5$	3.81	-17.29	0	0.13
$P_4 \times P_6$	18.25	0.39	-0.73	-0.14
$P_4 \times P_7$	3.39	0.20	-0.20	0.66
$P_4 \times P_8$	14.52	10.23	0.31	4.18
$P_5 \times P_6$	4.60	1.00	-0.44	-0.18
$P_5 \times P_7$	37.52	3.43	-0.41	-0.07
$P_5 \times P_8$	3.07	-7.40	0.61	4.69
$P_6 \times P_7$	3.57	0.50	3.80	1.86
$P_6 \times P_8$	6.93	1.14	-0.25	-0.42
$P_7 \times P_8$	2.78	0.22	-0.02	0.35

P_1, P_2, P_3, P_4, P_5, P_6, P_7 and P_8 denote to IL.256-06, IL.136-06, IL.840-06, IL.291-06, IL.322-06, IL.233-06, IL.767-06 and IL.257-06 respectively.

Phenotypic correlation

The phenotypic correlation coefficients estimated among the eight studied characters including grain yield are presented in Table (3).

Table (3). Phenotypic correlation between studied traits and grain yield.

Traits	GYP
Ear length	0.222**
Ear diameter	0.592**
100-kernel weight	0.293**
Kernels per row	0.021
Starch content in grain	0.103
protein content in grain	-0.077
oil content in grain	0.337**

** indicated to significant at P= 0.01 respectively.

It is worthy noting that grain yield showed significant positive correlations with each of ear length (r=0.222**), ear diameter (r=0.592**), 100-kernel weight (r=0.293**) and oil content in grain (r=0.337**). This result indicates that selection, considering any of all these characters simultaneously may be effective in improving grain yield, especially if those characters had high heritability estimates. However, non-significant correlations were observed between grain yield and other traits. Some of these results were reported by Al-Ahmad, (2004), Sadek *et al*., (2006), Soengas *et al*., (2006), Aydin *et al*., (2007), Najeeb *et al*., (2009), Rafiq *et al*., (2010), Shamim *et al.,* (2010) and Wannows *et al.,* (2010).

Path Coefficient Analysis

Path coefficient analysis was performed to identify the important yield attributes by estimating the direct effects of traits contributing to yield and separating the direct from the indirect effects through other related traits by partitioning the correlation coefficient and finding out the relative importance of different characters as selection criteria. The estimates of direct and indirect effects of the three yield related traits viz. ear diameter, oil content in grain and ear length on grain yield are presented in Table (4).

Table (4). Direct and indirect effects of ear diameter, oil content of grain ear length vs. grain yield.

Source of variation	Effects
1.Ear diameter vs. Grain yield	
Direct effect	0.510
Indirect effect via Oil content in grain	0.022
Indirect effect via Ear length	0.049
Total	0.581
2.Oil content in grain vs. Grain yield	
Direct effect	0.318
Indirect effect via Ear diameter	0.036
Indirect effect via Ear length	-0.023
Total	0.331
3.Ear length vs. Grain yield	
Direct effect	0.186
Indirect effect via Ear diameter	0.134
Indirect effect via Oil content in grain	-0.040
Total	0.280

The data in Table (4) indicated that the ear diameter had the highest positive direct effect 0.510 followed by oil content in grain (0.318) and low direct effects for ear length (0.186). However, the indirect effects of ear diameter through either oil content in grain or ear length were negligible values (0.022 and 0.049, respectively). The indirect effect for oil content in grain through ear diameter was negligible value (0.036), also via ear length was negative and negligible value (-0.023). Ear length gave through oil content in grain, a negative and negligible indirect effect (-0.040). On the other hand, the indirect effect of ear length through ear diameter was positive and relatively low (0.134). The direct and joint effects for each of ear diameter, oil content in grain and ear length on grain yield variation are presented in Table (5). Data indicated that the main sources of grain yield variation in order of relative importance (RI%) of direct effect for ear diameter was 26.01%, followed by the relative importance of direct effect for oil content in grain 10.11% and the relative importance for ear diameter through ear length 4.99%, followed by the relative importance of direct effect for ear length 3.46%, then the relative importance for ear diameter through oil content in grain 2.27%. The relative importance of total contribution of these mentioned traits reached 45.36% while the residual effects were 54.64% of the total phenotypic variation of grain yield.

Table (5). Relative importance (direct and joint effects) in percent of grain yield.

Source of variation		CD	RI%
1Ear diameter	(X_1)	0.2601	26.01
2Oil content in grain	(X_2)	0.1011	10.11
3Ear length	(X_3)	0.0346	3.46
4	$(X_1) \times (X_2)$	0.0227	2.27
5	$(X_1) \times (X_3)$	0.0499	4.99
6	$(X_2) \times (X_3)$	-0.0148	-1.48
Residual		0.5464	54.64
Total relative importance			**45.36%**

CD denote coefficient of determination. RI% denotes relative importance.

It is worthy to note that the direct effect of ear diameter as well as oil content in grain proved to be the major grain yield contributors. Some of these results mentioned by other workers [Amin *et al*., (2003), Al-Ahmad, (2004), Sadek *et al*., (2006), Fabijianac *et al*., (2006), Abou- Deif, (2007), Wannows *et al.,* (2010), Rafiq *et al*., (2010) who revealed that ear diameter and/or oil content in grain are considered as the main component of grain yield variation].

Conclusion

It can be concluded from our results that the partial and over-dominance gene effects played a major role in inheritance of starch, protein and oil content in grain while over-dominance gene effects were the most importance in inheritance of grain yield, ear length, ear diameter, 100-kernel weight and number of kernel per row. On the other hand, ear diameter as well as oil content in grain proved to be the most effective selection criteria in maize breeding programs aiming high grain yield capacity.

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درجة السيادة وتحليل المسار لبعض الصفات الكمية في هجن من الذرة الصفراء مستنبطة في سورية

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ملخـص

تم تكوين ثمانية وعشرين هجيناً فردياً خلال عام 2008 وقيمت هذه الهجن في عام 2009 في مركز البحوث العلمية الزراعية في حمص بهدف تقدير درجة السيادة ومعامل تحليل المسار لصفات الغلّة الحبية (طن/ هكتار)، طول وقطر العرنوس (سم)، وزن المئة حبة (غرام)، عدد الحبوب بالصف ومحتوى الحبوب من النشاء والبروتين والزيت (%) وأظهرت النتائج سيطرة السيادة الفائقة ($P_R > +1$) على معظم الصفات المدروسة ما عدا صفات محتوى الحبوب من النشاء والبروتين والزيت التي أظهرت سيادة وراثية جزئية ($-1 < P_R < +1$)، وأظهرت صفة الغلّة الحبية سيادة فائقة ($P_R > +1$). ارتبطت الغلّة الحبية ارتباطاً مظهرياً موجباً ومعنوياً مع صفات قطر العرنوس (0.592)، محتوى الحبوب من الزيت (0.337)، وزن المئة حبة (0.293) وطول العرنوس (0.222)، وبينت دراسة تحليل المسار أن صفات قطر العرنوس، محتوى الحبوب من الزيت وطول العرنوس على الترتيب هي أكثر الصفات المدروسة مساهمةً في تباين الغلّة الحبية.

الكلمات الدالة: الذرة، درجة السيادة ومعامل تحليل المسار.

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تاريخ استلام البحث 2008/4/28 وتاريخ قبوله 2009/12/10.