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Genetic Control of Oil and Saturated Fatty Acids in Maize (Zea mays L.) Populations

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Abstract: This study has been conducted in Çanakkale / Turkey during the years of 2011-2012. This research features six inbred lines and F_1 plants with half-diallel mating design. The aim is to determine the heredity of maize seed oil content and the content of maize seed saturated fatty acids. Accordingly, the additive and dominance gene variances have been determined for the heredity of oil content, palmitic acid content and stearic acid content effectively. The range of NSHD and BSHD for maize grain oil content is determined to be between 0.211 and 0.443. The W_r- V_r graphs about parents shows while there exists full dominance for inheritance of oil content and palmitic acid content, there exists partial dominance for inheritance of stearic acid content.

Keywords: Maize, maize oil, inheritance, dominance, saturated fatty acids

Mısır (*Zea mays* L.) Populasyonlarında Yağ ve Doymuş Asitlerin Genetik Kontrolü

Öz: Bu çalışma 2011 ve 2012 yılları içinde Çanakkale/Türkiye' de yürütülmüştür. Bu araştımada 6 kendilenmiş hat ve yarım diallel melezlemeden elde edilen F_1 bitkileri rol oynamaktadır. Amaç mısır tohumlarının içindeki yağın ve doymuş yağ asitlerinin kalıtımını belirlemektir. Bu doğrultuda yağ içeriği, palmitik asit içeriği ve stearik asit içeriği eklemeli ve dominans gen varyansları etkili bir şekilde belirlenmiştir. Mısır tanesi yağ içeriği için DAKD ve GAKD aralığı 0.211 ve 0.443 bulunmuştur. Wr- Vr grafiği ebeveynler hakkındaki yağ içeriği ve palmitik asit içeriği kalıtımı için tam dominatlık mevcut olduğunu gösterirken stearik asit içeriği kalıtımı için kısmi dominatlığın mevcut olduğunu göstermektedir.

Anahtar Kelimeler: Mısır, mısır yağı, kalıtım, dominansi, doymuş yağ asitleri

1.Introduction

Maize is a very valuable nutrition crop which has various functions in the conventional agriculture. Maize is consumed as feed and silage for animals besides it is being used as food and fuel for human being. Maize is a rich source for both agriculture and industry because maize is an important raw material for the production of medicine, oil, starch, glucose, flour, textile dyes and many other products. Like many other oil crops, the seed of maize hybrid includes approximately 4% of oil (Laurie et al., 2004). Maize oil has become popular recently as an important source of healthy vegetable oils. Maize oil is highly beneficial and it supplies high level of energy and fundamental unsaturated fatty acids. In this respect, maize oil is a high – quality plant oil owing to its high content of unsaturated fatty acids. Maize oil is very beneficial for human health because it reduces the level of blood cholesterol ratings since it prevents the hardening of the arteries (Orhun, 2011). The abundance of unsaturated fatty acids in maize oil makes it very high quality. Oil content and fatty acid content are quantitative traits, which are affected by multiple factors like genotype and environment. Many researchers have investigated the existence of higher oil and fatty acid content in the grain and its determinants. It is stated that heredity of maize grain fatty acids content rely on knowledge of the genetic events governing related traits. Jinks (1954) and Hayman (1954) developed a technique called diallel crossing that deduces data on the genes mechanism. Generally, many breeders use this technique when choosing the best genotypes. Generally, this technique is used to anticipate the types of gene action (El Badawy, 2013). This analysis provides a unique

chance to test a number of lines in all combinations. Dominance gene effect is desirable for developing hybrids and additive gene action implies that standard selection protocols would be effective enough in breeding to develop the character. (Edwards et al.,1976).

In this respect, this study examines the potential role of dominance and additive genes in determining of oil and saturated fatty acid content. This study is designed to investigate the heredity of oil content and fatty acid composition in maize grains. At the same time, this study allows to determine the superior parents and hybrids for oil content and fatty acids for further improvement of oil quality and quantity in maize. Last but not least, this study identifies gene activities that are responsible for the inheritance of oil content and saturated fatty acids content particularly.

2. Materials and Methods

This research performs 6x6 half diallel crossing without reciprocal population {n(n-1) |2} (n= number of parental lines) which contain 6 inbred parents and 15 F_1 hybrids. The field trials were performed by randomized block design with 4 replicates in Çanakkale during 2011-2012. The plots were composed of 4 rows with 5m in length. In the first year, we obtained 15 F_1 hybrids from 6 inbred lines using half diallel crossing method. During the second year, F_1 hybrids and inbred lines seeds have been planted with the same design. All the necessary cultural practices are applied for the production of maize at this region for 2 years. After maize ears were harvested at the maturation time their grains were threshed by hand. We determined the seed oil content and saturated fatty acids content from 15 F_1 hybrids seeds and 6 inbred lines seeds as 2 replicates. We prepared samples of 10 seeds from 15 F_1 hybrids and 6 inbred lines. Oil content of grains was obtained according to the method (TSE-973 EN ISO- 659 February 2000). We obtained the grain oil from each sample by using hexane as a solvent for the Gerhardt Soxhlet extraction.

We determined the grain fatty acids composition by using the Gas- Liquid Chromatography of UPAC model according to TSE-973 EN ISO (Anonymous, 2000). For statistical analyses, we utilized a computer program that applies the principles of Steel and Torrie (1960). Furthermore, half-diallel genetic parameters were estimated by using the Tarpopgen packaged program that applies the Jinks and Hayman (1953) method. (Özcan.1999).

3. Results and Discussion

Oil content

According to the oil content data, differences (F values) between parents and hybrids regarding the genotypes have been found highly significant (see Table 1). This situation results from genotypes. In relation to this, Jellum and Marion (1996) stated that genotypes are the main determinants of oil content of grain and it is considered as a trait with high heritability. As it is clear from Figure 1, over-dominance exists since the regression line cut the Wr axis below the origin line. With respect to the (%) grain oil content, while inbred lines number 1 and 2 involve more dominant genes, line 3 and line 5 involve more recessive genes. These results are in accordance with those of Jellum and Widstrom (1970, 1975). Yet the other parameters about dominance (H1, H2) are significantly different from zero (Table 2). This result might be observed since the grain oil content is under the control of dominance gene action and the additive gene action. Since the mean dominance influence of the heterozygote locus (h2) is significant, high heterotic values would be anticipated for oil content among crosses. E (environment) variance is not found to have major importance in inheritance of oil content (see Table 2). In accordance with this result, Jellum and Marion (1996) and Werle et.al. (2014) stated that the impact of genotype x environment interaction was not significant for the oil content. Dominant genes are more influential than recessive alleles for this feature because F value is negative (see Table2).

NSH and BSH degrees of oil content are determined 0.211 and 0.443, respectively.

Palmitic acid content

Figure 2 shows the heredity of palmitic acid content in the Vr-Wr graph format. As before, since the regression line cuts the Wr axis under the origin, over-dominance is considered. With respect to the grain palmitic acid content (%), while inbred line number 1 have more dominant genes, number 6

have more recessive genes. Moreover, H1 and H2 parameters that are related to dominance effects are different from zero significantly (see Table 2). This may be due to the fact that palmitic acid content is controlled largely by dominance gene effects as well as by the additive gene effects like the oil content.

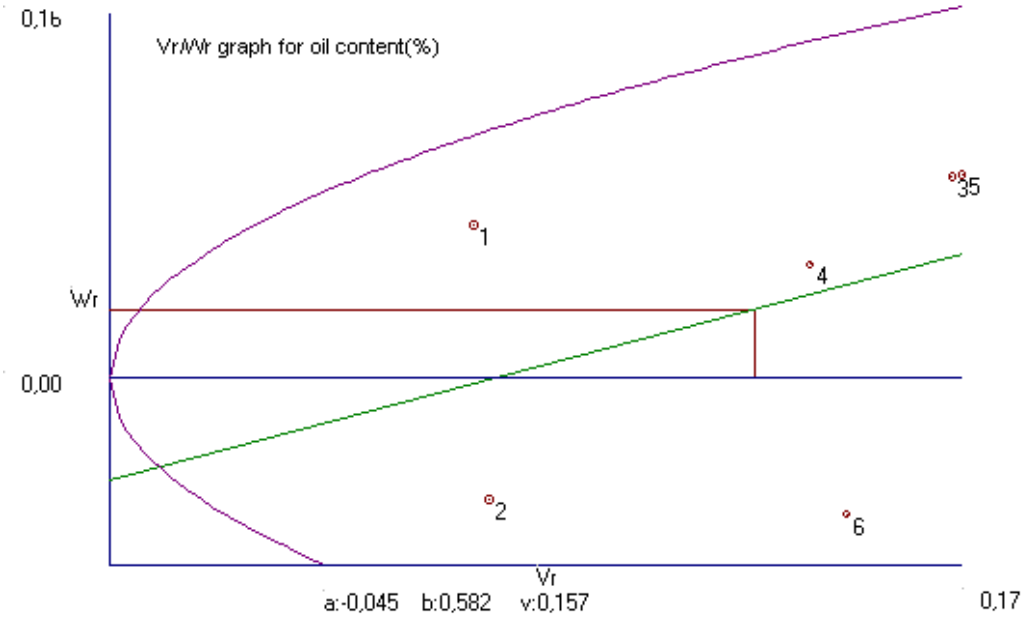

Figure 1. Vr/Wr graph for oil content
Şekil 1. *Yağ içeriği için Vr/Wr grafiği*

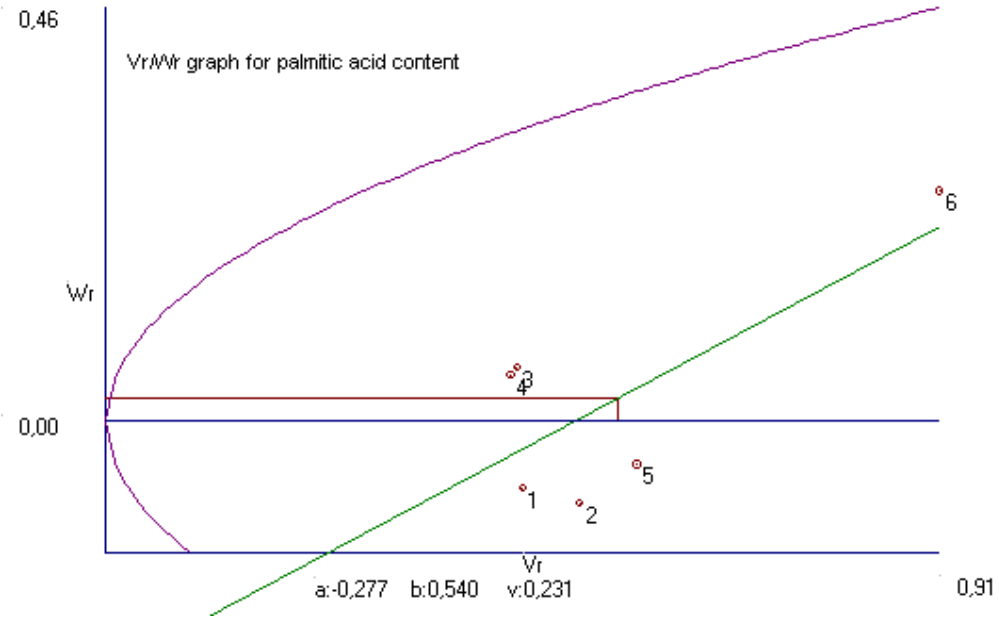

Figure 2. Vr/Wr graph for palmitic acid content
Şekil 2. *Palmitik asit içeriği için Vr/Wr grafiği*

Because the mean dominance effect of the heterozygote locus (h2) is found to be significant, high heterotic effect values would be expected for palmitic acid content among crosses. Last but not least, E (environment) variance is not significant in the inheritance of palmitic acid content (see Table 2).

Dominant alleles are more effective than recessive alleles in the formation of this trait because F value is negative (see Table 2).
We have estimated narrow sense and broad sense heritability degree of palmitic acid as 0.039 and 0.540, respectively.

Table 1. Variance analyses table of characters in maize genotypes
Çizelge 1. *Mısır genotipleri karakterlerinin varyans analiz tablosu*

Source of variation	**D.F**	**Oil Content**		**Palmitic acid Content**		**Stearic Acid Content (%)**	
		Mean Squares	**F Value**	**Mean Squares**	**F Value**	**Mean Squares**	**F Value**
Replication	1	0.068		0.495		0.003	
Genotypes	20	0.200	2.885*	0.697	2.259*	0.123	2.153*
Error	20	0.069		0.308		0.057	

Table 2. Genetic parameters table of characters in maize genotypes
Çizelge 2. *Mısır genotipleri için genetic parametreler tablosu*

Genetic Parameters	**Oil Content**	**Palmitic Acid**	**Stearic Acid**
D (additive genetic variance)	0.123±0.103	0.072± 0.182	0.053± 0.064
H_1 (dominance variance)	0.466±0.261*	1.947± 0.461	0.236± 0.162
H_2 (corrected dominance variance)	0.388± 0.233	1.634± 0.412	0.209± 0.144
F	0.146± 0.251	0.146± 0.444	0.027± 0.156
h	0.050± 0.157	0.038± 0.277	-0.002± 0.097
E (environment effect)	0.035± 0.039	0.159± 0.069	0.027± 0.024
D-H_1	-0.343± 0.229	-1.875± 0.405	-0.183± 0.142
$(H_1/D)^{1/2}$	1.947	5.191	2.102
$H_2/4H_1$	0.208	0.210	0.221
KD/KR	1.877	1.484	1.271
Heritability (broad sense)	0.443	0.430	0.499
Heritability degree (narrow sense)	0.211	0.029	0.144
K (gene number)	0.130	0.023	-0.007
Yr, Wr+Vr	r=0.163	r=0.025	r=-0.522

Stearic acid content

The data differences among the genotypes regarding the stearic acid content are found to be highly significant (Table 1). Figure 3 illustrates that the regression line passes through a point that is above of the origin which implies the existence of partial-dominance with additive type of gene action for the stearic acid content. Similarly, Jellum and Widstrom (1970) identifies the same result by conluding the inheritance of stearic acid content is controlled by additive genes. Figure 3 also predicts that inbred line number 2 involves more dominant genes, whereas line number 6 involves more recessive genes. However, H1 and H2 parameters have been found very close to zero (Table 2). This may lead us to conclude that the stearic acid content is controlled heavily by the additive gene effects. In addition, the E (environment) variance is not found to be important in inheritance of stearic acid content (Table 2). Matching with our conclusion, Dunlap et

al. (1995a) argued that genetic factors play more important role on fatty acid composition than environmental factors. Recessive alleles are less effective than dominance alleles for this feature because F value is negative (Table 2).

NS and BS heritability degree of palmitic acid have been estimated 0.144 and 0.499, respectively.

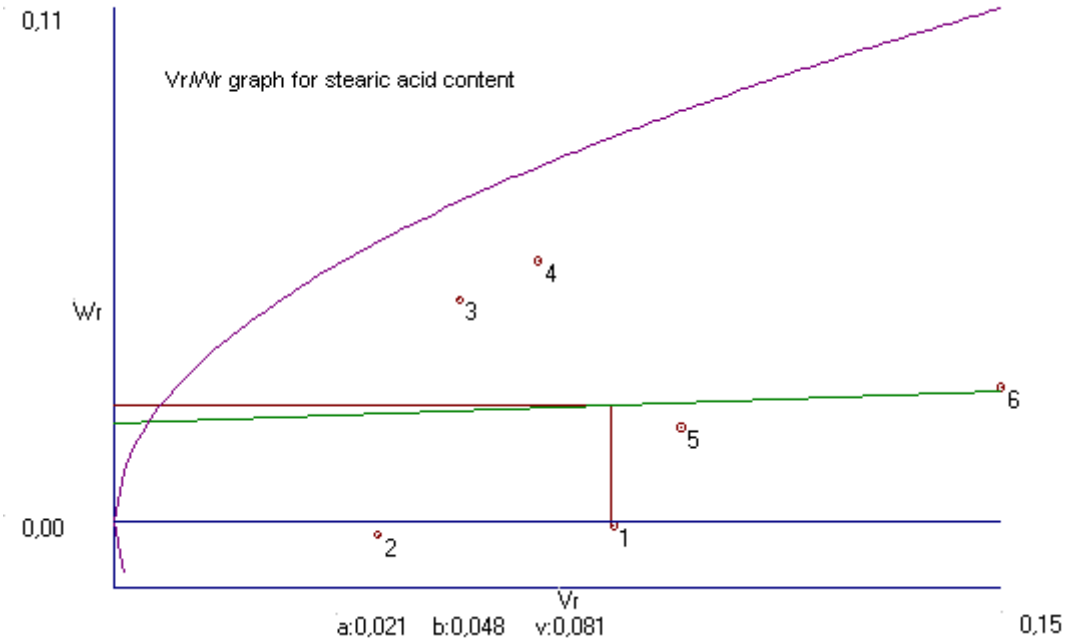

Figure 3. Vr/Wr graph for stearic acid content
Şekil 3. *Stearik asit içeriği için Vr/Wr grafiği*

References

Anonymous (2000). Animal and vegetables fats and oils-analysis by gas chromatography of methyl esters of fatty acids. TS 4664, EN ISO 5508. Turkish Standards Institute Publications, Ankara.

Dunlap, F. G.; White, P. J.; Pollak, L. M.1995 Fatty acid composition of oil from exotic corn breeding materials. Journal of the American Oil Chemist Society, v. 72, n. 9, p. 989-993.

Dupont J., White P.J, Carpenter M.P., Schaefer E.J., Meddani S.N., Elson C.E., Woods M. And Gorbach S.L. (1990). Food uses and health effects of corn oil. Food and Nutrition Science Consulting, Fort Collins, CO 80524.Journal of the American College of Nutrition, Vol:9 (5) :438-470.

Edwards JH, Barber SA 1976). Nitrogen uptake characteristics of corn roots at low N concentration as influenced by plant age. Agron. J., 68, 17-19.

El-Badawy MELM (2013). Heterosis and Combining Ability in Maize using Diallel Crosses among Seven New Inbred Lines. Asian Journal Crop Sciences 5(1):1-13

Hayman B I 1954. The teory and analysis of diallel cross-I. Genetics, 32: 789-809.

Jellum MD, Marion JE, (1966) Factors affecting oil content and oil composition of corn (Zea mays L.) kernels. Crop Sci 6:41–42

Jellum MD, Widstrom NW (1970). Inheritance of stearic acid composition of maize oil. J. Agric. Food. Chem., 18: 365-370.

Jinks, J. L. 1954. The analysis of continuous variation in a diallel crosses of Nicotiana rustica varieties. Genetics,39, 767–788

Jinks, J.L and Hayman, B. I. 1953. The analysis of diallel crosses. Maize Genetics Cooperation NewsLetter 27: (48-54).

Laurie CC, Chasalow SD, Ledeaux JR, Mc Carrolla R, Bush D, Hange B, Lai C, Clark D, Rocheford TR, Dudly (2004). The genetic architecture of response to long-term artificial selection for oil concentration in the maize kernel. Genetics, 168: 2141-2155.

Orhun G. E and Korkut K. Z 2011. Interrelatıonshıps among the Oil and Fatty Acids in Maize. African Journal of Agricultural Research. Vol: 6 (9), pp: 2115-2117

Özcan K. and N. Açıkgöz. 1999. A statistical analysis program for population genetics. 3. the symposisum of

computer applications for agriculture. 3-6 October, Çukurova University, Adana-Turkey.

Steel R.G.D., J. H.Torrie 1960. Principles and Procedures of statistics. McGraw Hill Book Co. Inc. NewYork, USA, pp. 107-109

Widstrom N.W., M.D. Jellum, 1975 Inheritance of kernel fatty acid composition among six maize inbreds. Crop Sci. 15: 44-46

Werle A., Ferreira F., Pinto R., Mangolin C., Scapim C. and Gonçalves L., 2014. Diallel analysis of maize inbred lines for grain yield, oil and protein content. Crop Breedıng and Applied Biotechnology.14:23-28.