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RESULTS OF INHERITANCE EVALUATION OF AGRONOMICALLY IMPORTANT TRAITS IN SUNFLOWER

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SUMMARY

This contribution summarizes our knowledge on more complex cases of inheritance of the traits that affect the yield indirectly and that are of breeding and seed growing importance. Further on, it summarizes knowledge of genetic parameters of yield traits and results of their variability evaluation. Following traits are dealt with: pollen sterility conditioned by 4 genes, recessive ramification determined by 2 genes and dominant ramification determined also by 2 genes, head inclination conditioned by 12 genes. Genetic characteristics of the following polygenic traits are described: oil content and husk of achenes, weight and number of achenes, plant height and leaf area, self-fertility. In the yield components directional coefficients and variability as the proportion of additive and non-additive components of inheritance are presented.

INTRODUCTION

This paper summarizes our knowledge on more complex cases of inheritance of the traits that affect the yield indirectly and that are of importance for breeding and seed production. Furthermore it summarizes our knowledge of genetic parameters of yield traits and the results of the evalution of their variability.

1. EXAMPLES OF TRAITS CONDITIONNED BY INTERACTIONS OF 2 - 4 OLIGOGENES

For the inheritance of a single trait - genic pollen sterility - a large number of segregation ratios have been found. In the presence of a single ms gene, the segregation in the F_2 generation is 3 : 1. In two-gene combinations, different interactional segregation ratios may appear, namely 9 : 7, 15 : 3. Three-gene combinations segregate in the ratios 42 : 22 and 56: 8. Four-gene combination segregates in the ratio 215 : 41. Various combinations and segregation ratios are summarized in Table 1.

Table 1.

Segregation ratio	Abbreviated segregation ratio	Genes
9 : 7	1.3 : 1	ms_3 ms_4
42 : 22	1.9 : 1	ms_3 $ms_4 ms_{1\ (2)}$
3 : 1	3 : 1	ms_1
13 : 3	4.3 : 1	$ms_{3\ (4)} ms_{1\ (2)}$
215 : 41	5.2 : 1	$ms_1 ms_2 ms_3 ms_4$
56 : 8	7 : 1	$ms_1 ms_2 ms_{3\ (4)}$
15 : 1	15 : 1	$ms_1 ms_2$

When the trait is conditioned by 4 genes with 3 types of gene interactions, 7 segregation ratios occur in the F_2 generation, namely:

1 : 1; 2 : 1; 3 : 1; 4 : 1; 5 : 1; 7 : 1; 15 : 1.

This explains differences in the proportion of sterile plants when usually 25% are expected (which corresponds to an apparently simple inheritance).

Another case of a more complex oligogenic inheritance that we have studied is the inheritance of plant ramification.

In the ramification two basic categories can be differentiated from the point of inheritance: dominant ramification, conditioned by two genes, Br_1, and Br_2, and reccesive ramification conditioned also by two genes, b_1 and b_2. In the reccesive ramification both genes are in an interaction of complementarity type. It means, that in the F_2 generation 7 ramifying plants with the main head come to 9 non-ramifying plants. Gene combinations conditioning recessive ramification are presented in Table 2 (ramification designated by X).

Table 2.

	B_1B_2	B_1b_2	$b1B_2$	$b1b_2$
B_1B_2	0	0	0	0
B_1b_2	0	X	0	X
b_1B_2	0	0	X	X
b_1b_2	0	X	X	X

If dominant alleles of both genes are present in a genotype, the plant does not ramify. In the presence of a single B_1 or B_2 gene and also in the case of recessive genotype, b_1b_2 ramification on the plant appears. In consequence to this, ramifying plants may appear in the segregates, together with non-ramified plants (heterozygotes).

Dominant ramification has a substantially more complex inheritance because its phenotypic manifestation includes 4 basic categories segregating in the ratio (8 : 4) : 3 : 1 which corresponds to the interaction of dominant epistasis when the first, most frequent categories are fused (segregation ratio in the F_2 is 12 : 3 : 1).

Gene combinations conditioning dominant ramification are given in Table 3.

Hence, the progeny of a cross betwen two heterozygotes in both genes will contain 6 - 7 % (ratio 15 : 1) of the non-ramifying phenotype. Non-ramifying phenotype useful for breeding and partially ramifying phenotype will be present in 25% of the cases (ratio 3 : 1).

Table 3.

	Br_2 Br_1	Br_2 br_1	$br2$ Br_1	br_2 br_1
Br_2 Br_1 Br_2 br_1	Ramification along the whole stem by long branches 4x		Ramification along the whole stem by short branches 4x	
br_2 Br_1 br_2 br_1	Ramification along the whole stem by short branches 4x		Ramification only on a part of the stem 3x	absence of ramification 1x

2. EXAMPLE OF A TRAIT GOVERNED BY 5 - 12 OLIGOGENES.

Of this category of traits we studied the inheritance of head inclination. Basically, this trait can be differentiated into 4 basic categories according to the angle of inclination, 0^o - 45^o, 45^o - 90^o, 90^o - 135^o, 135^o - 180^o. The whole range of inclination 0^o - 180^o appears to be conditioned by 12 genes, out of which each of the given categories by three genes. Additivity prevails between single genes while dominance or interactions of the type of cumulative duplicity (segregation ratio 27 : 27 : 9 : 1) prevail within groups of genes.

Relations between the genes are given in Table 4.

Table 4.

Degree of inclination	0–45°	45°–90°	90°–135°	135°–180°
Dominance ↓	Hb_{a1}	Hb_{b1}	Hb_{c1}	Hb_{d1}
	Hb_{a2}	Hbb2	Hb_{c2}	Hb_{d2}
	Hb_{a3}	Hbb3	Hb_{c3}	Hb_{d3}
	← Additivity →			

Each of the three genes conditioning one of the categories affects the head inclination independetly for about 15^o. When two genes are present the inclination increases to 30^o and three genes enhance the inclination to 45^o. A summary of 3-gene combinations acting within one category is presented in Table 5.

Table 5.

hb_1	hb_2	hb3	–	0°
Hb_1	hb2	hb3	–	15°
hb_1	Hb2	hb3		
hb_1	hb2	Hb3		
Hb_1	Hb2	hb_3	–	30°
Hb_1	hb2	Hb3		
hb_1	Hb2	Hb3		
Hb_1	Hb2	Hb3	–	45°

In the system of inheritance of head inclination two basic principles are in action ; there is also a modifying principle, determining the hierarchy of dominance of the categories in the sequence $0^o < 45^o < 90^o < 135^o > 180^o$.

Hence the most suitable head inclination of 135^o, dominantes over all others.

3. SHORT SUMMARY OF THE DATA OBTAINED ON GENETIC AND HYBRIDIZATION CHARACTERISTICS OF POLYGENIC TRAITS

Oil content in achenes - parental genotypes have a marked effect, combining ability has also a certain importance, but mostly just modifies the result of the evalution of the level of parental genotypes. The prevailing principle of inheritance is incomplete dominance with superiority of the parent with the higher oil content. The minimum oil content requirement in the parent with the lower oil content is 40%. Female line should have a higher oil content. The hybrid vigour manifests only in a small number of hybrids.

It reaches only 2%, on average. Correlation between the value of the parents and of the hybrid is rather high (r = 0.71). Heritability does not exceed the value of 0.4. Average value of the directional coefficient to the oil yield is 0.40.

HUSK CONTENT OF ACHENES

The value of the trait in the hybrid is defined to a significant degree by the level of parental genotypes, their combining ability having only a negligible importance. The prevailing genetic principle is additivity which is manifested by intermediate result of the cross. Husk content in both parents should not exceed 25%. Hybrid vigour bears no effect on this trait. Correlation between parents and hybrids is even higher than for oil content (r = 0.84). Heritability varies between 0.4 and 0.6. Average value of the directional coefficient to the achene weight is 0.35. Its complementary component of seed weight reaches the value of the directional coefficient to the achene weight, 0.75.

ACHENE WEIGHT (TKW)

The value of this trait depends on combining ability as well as on the trait level in parental lines. Prevailing principles of inheritance are incomplete dominance passing to dominance and overdominance. Hybrid vigour reaches 5 - 10%. Correlation between lines and hybrids is medium high (r = 0.63). Trait heritability has the value 0.2 - 0.4. The final value of the trait in the hybrids depends to a large measure on the level of the second main yield component - number of achenes. An increase of the value level of either one of these two traits results in a significant increase of the value of the other one. Average value of the directional coefficient to the yield of achenes is 0.40.

NUMBER OF ACHENES PER HEAD

This trait depends substantially on combining ability of the lines. Overdominance is the prevailing principle. Hybrid vigour varies between 40 and 60%. Correlation between parents and progeny is low (r = 0.30). Heritability does not exceed the value of 0.2. Average value of the directional coefficient to the yield of achenes is 0.95.

YIELD OF ACHENES PER PLANT

It is determined almost entirely by combining ability. Hybrid vigour over the more productive parent reaches 50 - 70%. Correlation between the yield of lines and hybrids is very low (r = 0.1 - 0.2). Heritability does not exceed 0.2. Directional coefficient to the oil yield reaches 0.85.

PLANT HEIGHT

Trait value of the hybrid depends on both the combining ability and the level of the trait in the lines. Dominance to overdominance is the prevaling principle of inheritance. The taller inbred line should be about 40 cm shorter than the desired height of the hybrid. Hybrid vigour varies around 20%.

LEAF AREA

It usually increases in accordance with increases in plant height and is conditioned by the same principles. Minimum index of the leaf area in lines should reach 2.5 m^2 per square meter of soil surface. In hybrids it is enhanced to 3 - 4 m^2 per square meter of soil surface.

SELF-FERTILITY

This trait is determined exclusively by parental qualities; combining ability has no importance. Usualy it shows an intermediate level. The system of fertilization plays a certain role. In the case of geitonogamy (fertilization between flowers of the same head) the trend to incomplete dominance of the self-fertile parent increases. Then self-fertility in the hybrid is higher by 20 - 40% than the average expression of the trait in the parents. In the case of absolute geitonogamy (fertilization within the same flower) the trend to self-fertility declines in the hybrid by as much as 40% in comparisen with the average value of the parents. If at least one line with a high capacity for self-fertilization (over 80%) is used for crossing, the self-fertility level of the hybrid will vary between 20 and 80% depending on the system of fertilization. Heritability fluctuates around the value of 0.4.

Basically, all genetic parameters of polygenic traits show a considerale variability depending on environmental conditions, mainly climatic factors. As an example illustrating this fact, here are the results of a study of variability of directional coefficient values under the conditions of Europe in the following three traits: oil yield per plant, oil content and oil yield of achenes per plant. The value of directional coefficients between achene yield and oil yield varied from 0.685 to 0.996 and between oil content and oil yield from 0.225 to 0.553.

The share of the sum of both directional coefficients, for achene yield and oil yield, varied from 55.3 to80.9% with respect to oil content and from 19.1 to 44.7% with respect to oil yield.

Dependence between the northern latitude in Europe and share of oil content in oil yield indicates that oil content contributes to oil yield to the maximum extent in areas between 37° and 43° northern latitude. Then the share of oil content on oil yield declines drastically while the share of achene yield on oil yield increases accordingly. Distinct enhancement of the share of achene yield is obvious from 47° northern latitude, as shown in Figure 1. Another example is a change of the share of basic elements of genetic variability which contributes to a large extent to the materialization of this trait. In Central Europe, the share of additive and non-additive component is almost in perfect balance, as shown in Table 6.

Table 6.

	Share of additive and non-additive component	
	in %	in the ratio
Spain	18. 8 : 81.2	1 : 4.3
Romania	28.9 : 71.1	1 : 2.5
Yugoslavia	31.2 : 68.8	1 : 2.2
Czechoslovakia	40.7 : 59.3	1 : 1.5

From the standpoint of interpretation of the relation of the share of genetic variability components to the manifestation of hybrid vigour, potentially equal hybrid vigour materializes more in Southern than in Central Europe.

The examples offered show that the values of genetic parameters obtained in one locality or more localites within the same geographical area cannot be generalized because variability of these parameters can be considerable within Europe. To make separately obtained results objective, trends (relations) between the values of genetic parametrs and geographical-climatic conditions of environment have to be evaluated first.

Good preconditions for this postulation are offered by the widely dispersed network of experimental localities of the FAO subnetwork "Sunflower genetics and breeding". New organization of relations in coordination among the participants of the cooperation in obtaining and evaluating the results of methodically uniform trials will be developed.

RESULTATS CONCERNANT L'HERATIBILITE D'IMPORTANT CARACTERES AGRONOMIQUES CHEZ LE TOURNESOL

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Cette publication résume nos connaissances sur les cas les plus complexes d'héritabilité concernant des caractéres contrôlant indirectement le rendement et possédant un effet important sur la sélection et la croissance des graines. Par la suite, nous présentons des données concernant les parametres génétiques contrôlant le rendement et des résultats de l'évaluation de leur variabilité. Les caractéres suivants sont traités: stérilité du pollen contrôlée par 4 génes, le caractére réccssif "ramification" controlé par deux génes et sa forme dominante conditionne par également deux génes, la position de la tête (inclinaison) controlé par 12 génes. Les caractéristiques génétiques des caractéres suivants sont décrits: contenu en huile, hauteur des plantes, surface folaire, auto-fertilité.

RESULTADOS CONCERNIENTES A LA HEREDABILIDAD DE CARACTERES DE INPORTANCIA AGRONOMICA EN EL GIRASOL

Kovačik, A. & Škaloud, V.

Esta publicación resume nuestros conocimientos sobre los casos más complejos de herencia concercientes a caracteres que controlan / indirectamente el rendimiento y poseen un efecto importante sobre la selección y crecimiento de los granos. En lo que sigue, presentamos los datos concernientes a los parámetros genéticos que controlan el rendimiento y los resultados de evaluación de su variabilidad. Los siguientes carácteres son considerados; esterilidad del polen controlada por 4 genes, el caracter de ramificación recesiva controlado por dos genes y su forma dominante controlado asimismo por dos genes, la posición del capítulo (inclinación) controlado pos 12 genes. Las características genéticas de los carácteres siguientes son descritos: contenido en aceite, altura de las plantas, area floliar y autofertilidad.