INHERITANCE OF SOME HETEROMORPHIC CHARACTERS IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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Sunflower is a crop manifesting a very high morphological variability. Investigating inheritance of morphological characters is considered to be important from four points of view.

Some morphological characters the inheritance of which is conditioned by major genes are of direct importance for agriculture while others, when connected with certain agriculturally important characters, can be exploited as marker genes.

Hitherto, studying morphological characters for purposes of determining the complex system of inheritance in sunflower has been of theoretical importance; its ultimate goal is to devise the chromosomal map of sunflower. Finally the fourth view of investigating morphological characters in sunflower is to exploit them for genetic modelling characters that are expressed more distinctly in this plant as in other crops. Inheritance of some morphological characters was studied by various authors. A survey on present knowledge has been presented mainly in papers by P. Leclercq (1968), Rudorf W. (1961), Zimmermann (1958), Stoenescu F. (1972), Hockett E. A. and Knowles P. F. (1970), Kováčik A. (1970) and others.

MATERIAL AND METHODS

The paper discusses the inheritance of some morphological characters in sunflower which are expressed in more than two alternative phenotypes. We studied interrelations between yellow, respective yellow-orange colour of ligulate flowers, which are common in sunflower, and sulphur — yellow colour which occurs in populations of *Helianthus annuus* in a markedly lower frequency. At the same time, the relation was analyzed between mentioned three phenotypes of ligulate — flower colour and anthocyanin or normal colour of tubular flowers.

In order to reveal inheritance of those characters inbred lines were crossed; lines carrying sulphur — yellow flowers were derived from the population of cv.

Primrose and those with yellow and yellow orange colour from cv. Bučanská olejná. Lines were homozygous in given characters. Reciprocal crossing was made and segregation ratios were analyzed in F_2 generation obtained from selfing F_1 individuals. What concerns the leaves, there were examined three phenotypical expressions of leaf-blade border, namely sharply crenated, finely crenated, and almost uncrenated which appears in spoonshaped leaves. This character was studied in crosses of lines originated from the cv. Karlik.

Also the surface of leaf-blade exhibits several phenotype expressions one of them being the less common type of glossy brownish tinge of the leaf surface. Inheritance of this character was examined in crosses of lines derived from the population cv. VNIIMK 6540. The same cultivar served as a source of lines with multiple leaf-whorls.

The last morphological character, namely palmette-like branching was investigated in its relation to non-branching as well as wildly branching phenotype.

Palmette-like branching was studied in lines derived from the population Ruzyňská No. 9. Wildly branching type appeared in lines from cv. Primrose while non-branching type in one line developed from the population cv. Slovenská sivá.

RESULTS AND DISCUSSION

The relation between inheritance of yellow colour and yellow-orange colour of sunflower ligulate flowers has been considered as monofactorially conditioned (Leclercq, 1968), the yellow colour being dominant over yellow-orange.

In our experiments lines carrying sulphur-yellow ligulate and anthocyanin tubular flowers were crossed with those in which ligulate flowers were yellow-orange and tubular flowers yellow.

F_1 was represented by only one type of plants namely with yellow - orange ligulate and anthocyanin tubular flowers. Uniformity as well as the phenotype of F_1 generation prove the dominance of yellow-orange over sulphur-yellow colour of ligulate flowers. In generation F_2 dihybrid segregation into three categories took place. There occurred plants carrying yellow-orange ligulate and anthycianin tubular flowers, further on plants with yellow-orange ligulate and yellow tubular flowers, and finally, plants with sulphur-yellow ligulate and anthocyanin tubulur flowers. Segregation of the mentioned categories responded approximately to 2 : 1 : 1 ratio. Each character being examined separately in F_2, segregating of orange-yellow to sulphur-yellow ligulate flowers was close to 3 : 1 ; similarly anthocyanin and yellow colours of tubular flowers segregated in 3 : 1 ratio.

Phenotypic combination of sulphur-yellow ligulate with yellow tubular flowers did not occur. F_1 crosses between a line carrying yellow ligulate and yellow tubular flowers and a line with sulphur-yellow ligulate and anthocyanin tubular flowers comprised only plants with yellow ligulate and anthocyanin tubular flowers. From this, dominance of yellow colour over sulphur-yellow colour of ligulate flowers may be deduced. In F_2 generation obtained by selfing F_1 plants all four possible phenotype combinations segregated out. Ratio between the group of plants manifesting yellow ligulate and anthocyanin tubular flowers, and plants whose phenotypes repeated individual parents was also 2 : 1 : 1. The fourth phenotypes represented by sulphur-yellow ligulate and yellow tubular flowers occurred only once among 128 plants examined. Apparently this combination resulted from breaking the linkage of the recessive factor (sulphur-yellow colour of ligulate flowers) and the dominant one (anthocyanin colour of tubular flowers). Both characters being examined separately in F_2, yellow colour of ligulate flowers was dominant over sulphur-yellow in the ratio 3 : 1 ; similarly the anthocyanin to yellow colour of tubular flowers segregated in the ratio 3 : 1.

Hybrid plants with wellow ligulate and anthocyanian tubular flowers, when back-crossed to a parental line carrying yellow ligulate and yellow tubular flowers, segregated out in B_1 two phenotype categories one of them being identical to F_1 and the second one to a yellow flowering parent, namely in 1 : 1 ratio.

The rare double recessive combination that segregated out in F_2 generation was subsequently crossed with all four phenotypes occurred. In all F_1 generations obtained this combination proved recessive.

In general the results may be summarized in the following way. Yellow colour of ligulate flowers is dominant over orange-yellow as well as sulphur-yellow. Further, orange-yellow is dominant over sulphur-yellow. Yellow and orange-yellow colour of ligulate flowers is linked with yellow colour of tubular flowers while sulphur-yellow colour of ligulate flowers is linked with the anthocyanin colour of tubular flowers. The strength of linkage could not be determined precisely from F_2 generation. As concerned the morphological characters of leaves, inheritance of leaf-blade border was studied in generation F_2 and B_1, namely on crosses between plants with sharply or finely crenated leaves. Plants of generation F_1 were uniform in the character sharply crenated leaf ; in generation F_2 276 plants with sharply crenated leaf border and 116 plants with finely crenated leaves segregated out. Their empiric ratio was very close to the theoretical one 3 : 1. Similarly, in B_1 generation from crossing individuals of generation F_1 with the finely crenated parent, we stated the empiric segregation ratio 52 : 49 which corresponds to the 1 : 1 ratio of sharply and finely crenated borders of leaf blade.

Segregation proves a monofactorial inheritance, finely crenated leaf border being recessive to sharply crenated one. It has to be noted, however, that in F_2 a small amount of interstage types occurred which could be ranged into any of both basic phenotypical categories even after a detailed distinguishing.

One of test-crosses maifested segregation ratio 15 : 17 in generation B_1 ; among 17 plants carrying finely crenated leaf-border, 5 plants with almost uncrenated leaves and spoonshaped leaf blade occurred. In relation to finely crenated leaf border, this phenotype that was described by Kováčik and Škaloud (1973) proved monofactorial recessive and was linked with pollen sterility of plants.

There exists a rarely occurring colour of leaf surface, namely glossy brownish tinge. According to results of crossing homozygous in this character line with a line carrying normal green leaves, brownish colour may be considered an inherited character ; F_1 generation is uniform in green colour while in F_2 generation segregation of 90 green to 19 plants with glossy brownish leaf colour takes place. Regarding the value $\chi^2(1) = 3{,}33$ the empiri ratio may be considered coincident with the theoretical ratio 3 : 1.

In relation to normal green colour, the character of glossy brownish leaf blade which can be shortly marked as „leather leaf", is thus inherited as monofactorial recessive. The same type of inheritance was ascertained also in the character multiple whorl of leaves. If a simplified distinguishing of all phenotypes into two basic categories is made, there occurs a segregation ratio 51 : 16 which is close to the 3 : 1 ratio in favour of normally shaped whorl with two counterinserted leaves against multiple whorls. In general, the multiple whorl may be considered a monofactorial recessive character in relation to the normal whorl. Within the range of multiple whorl, as in the triple as in quadruple leaf whorl, it is possible to distinguish five phenotype categories which differ by the depth of bifurcation of one or both basic leaves. Various intensity of this character is supposed to be conditioned by modifying genes the number and interrelation of which could not be determined yet.

The special type of palmete-like branching was selected from the population which manifested various types of branching except for that as called „wildly branching type". As a result of several years lasting inbreeding, palmette-like branching was stabilized in the form of two vigorous counterinserted branches appearing between cotyledons even in the first weeks after plants emerged. Besides two basic branches whose growth intensity did not differ from the main stem, no further branching was manifested in plants.

Crossing lines carrying palmette-like branching with those with wild type of branching segregation resulted even in F_1 generation, though both parental lines were homozygous for those characters. There occurred two phenotypes one of which repeated the parental wild type of branching while the second one represented a combination of both parental phenotypes. In generation F_1, the empiric segregation ratio was 78 : 12 in favour of the wildly branching type and opposite to that carrying vigorous branches after cotyledonal leaves and wildly branching in the upper part of plant.

The original parental type with palmette-like branching did not occur in F_1 at all. Also crosses between lines with palmette- like branching and non-branching lines proved segregation in F_1 generation. Three phenotype categories segregated out among which the non-branching type was the most frequent. The second phenotype was represented by the most common form of branching in sunflower plants, namely irregular inserting of short shoots in various parts of the stem. The third phenotype was a combination of palmette-like branching with the second type.

Again, the pure palmette-like type of branching did not occur in the F_1 generation. The empiric segregation ratio 46 : 16 : 5 (non-branching, normal branching, and combination of normal with palmette-like branchin, respectively) indicates some relation between palmette-like branching and other types that occurred.

From both crossings it is apparent that palmette-like branching is recessive to wild branching, non-branching as well as normal branching in sunflower. The occurence of phenotypes that did not participate in crossing in F_1 generation, may be explained by involving more genes as well as their interaction in hybrid genotype.

Interaction of genes for wild as well as palmette-like branching exhibits intermediate expression while the genic interaction between non-branching and palmette-like branching results or in normal branching or in intermediate stage between normal and palmette-like branching of the plant.

Identification of genes that condition palmette-like branching and also determination of interactions of individual genes that condition various forms of branching will be carried out on the basis of future analyses.

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