MORPHOLOGICAL FEATURES OF VEGETATIVE ORGANS IN SUNFLOWER LINES AND DIFFERENT TYPES OF GENETIC CONTROL OF DWARFNESS

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Summary:
Morphological analysis of such characters as plant height, internode length, and size of all leaves on the stem of dwarf sunflower lines established that dimensions of each leaf and the related internode are genetically determined and show the least degree of variation in years. A correspondence between the stem morphological structure and the genetic type of dwarfness control was revealed. The first type of dwarfness is characterized by strong and *even* shortening of internodes, increased number of internodes and leaves, and the vegetative period extention. This dwarfness is controlled by genes - *i* and *dw* - with an intermediate inheritance and the recessive epistasis type of genes' interaction. This type of dwarfness is characteristic of the lines VIR 272 and VIR 434. Dwarfness of the second type is determined by the additive interaction of recessive alleles of no less than 3 genes – *sht*1, *sht*2, and *sht*3 (short stem) in VIR 319 and VIR 328. Dwarfness of the third type was found in VIR 253, VIR 500, VIR 501 and VIR 648. Control of this character in the lines is based on the polygenic action of no less than 3 *sd* (semidwarf) genes with incomplete dominance. The second and third types of dwarfness are associated with *shortening of internodes of the leaves of the medium and upper types*, and reduction of their number. In this case, the second type is characterized by the maximum shortening of internodes of the medium type leaves, while the third type – by even shortening of all leaves.

The creation of dwarf plants in agriculture became one of the largest achievement of our century. Due to the development of dwarf wheat and rye cultivars, yields per area unit have sharply increased in many countries of the world (Allan et al.,1968, Fick, 1973, Merezhko,1986; Kobylyanskii,1983). As a rule, dwarf sunflowers are more early, resistant to lodging and crowdedness of crop, and take out less nutrients from soil (Schneiter,1992, Feoli et al., 1993). The available references describe for sunflower only the dw gene that reduces plant height; its has a pleiotropic morphological effect and extends the vegetative period (Tolmachev, 1992). However, there are sunflower lines in the VIR collection which are dwarf and ultra-early at the same time (the sprouting to flowering period makes 48 - 53 days). The use of dwarf lines makes it possible to obtain dwarf, early, heterotic hybrids. From this point of view, a comprehensive study of dwarf sunflower lines is of interest.

Observations were carried out from 1995 through 1999 on experimental fields of VIR's Pushkin Laboratories and the Kuban Experiment station of VIR in the Krasnodar Territory. The following dwarf lines from VIR have been studied: VIR 171, VIR 253, VIR 319, VIR 328, VIR 434, VIR 500, VIR 501, VIR 648, VIR 649, an accession of ornamental type from the VIR collection, 3 Finnish dwarf hybrids: MDA 3410, SAM 461, Ex81. The standard tall cv. Peredovik was used as a reference. Plants were spaced at 40 by 30 cm. Every 7 to 9 days during the vegetative period size of all leaves on the stem (length, width, petiole), plant height, internode length, and head diameter were measured. In three years, 256 plants have been studied. The genetic analysis of the characters of plant height and the internode length was carried out when crossing the dwarf VIR lines VIR 253, VIR 272, VIR 434, VIR 500, VIR 501, VIR 648, and VIR 649 with the tall cv. Peredovik. The hybrids from F1, F2, F3 and Fb(BC) were analyzed.

During ontogenesis, all leaves on the stem differ by the rate and duration of their growth, and as a result - by the correlation of the length, the width and the petiole of the leaf. By a complex of morpho-physiological characters, F.M. Kuperman et al. (1961) distinguished the following groups of sunflower leaves:

a) cotyledonous leaves;
b) first two leaves are the embryo leaves;
c) from the 3rd up to the 12th are the bottom type leaves;
d) from the 12th up to the 20th –23rd are true cauline leaves of the medium type;
e) from the 21st –24th up to the 25th –27th and in individual plants up to the 30th –31st, leaves should be attributed to the top type. In our research we ran into the problem, that not all investigated lines and hybrids complied with this leaf division. The most typical illustration of this classification is the standard cv. Peredovik, which has the maximum height, the internode length, the sizes and the number of leaves (27-38 pieces) among the investigated plants (Fig. 2-1).

The lines VIR 171,VIR 253, VIR 319, VIR 328, VIR 500, VIR 648, VIR 649 are close to cv. Peredovik by the number of leaves, but their plants are shorter and size of leaves is smaller. In the lines VIR 319, VIR 328, the width never exceeds the lengths of the leaf, and the same refers to most plants of the line VIR 171, but in some plants width of the medium type leaves exceeds their length a little. In the lines VIR 253, VIR 500, VIR 648, VIR 649, the leaves from the 9th up to the 21st – 28th have the width that is equal to the length, or in some cases slightly larger or less than the length.

A different classification of leaves should be applied to other lines and hybrids. For instance, in the line VIR 501, the hybrids MDA 3410, SAM 461, Ex81 the number of leaves sharply

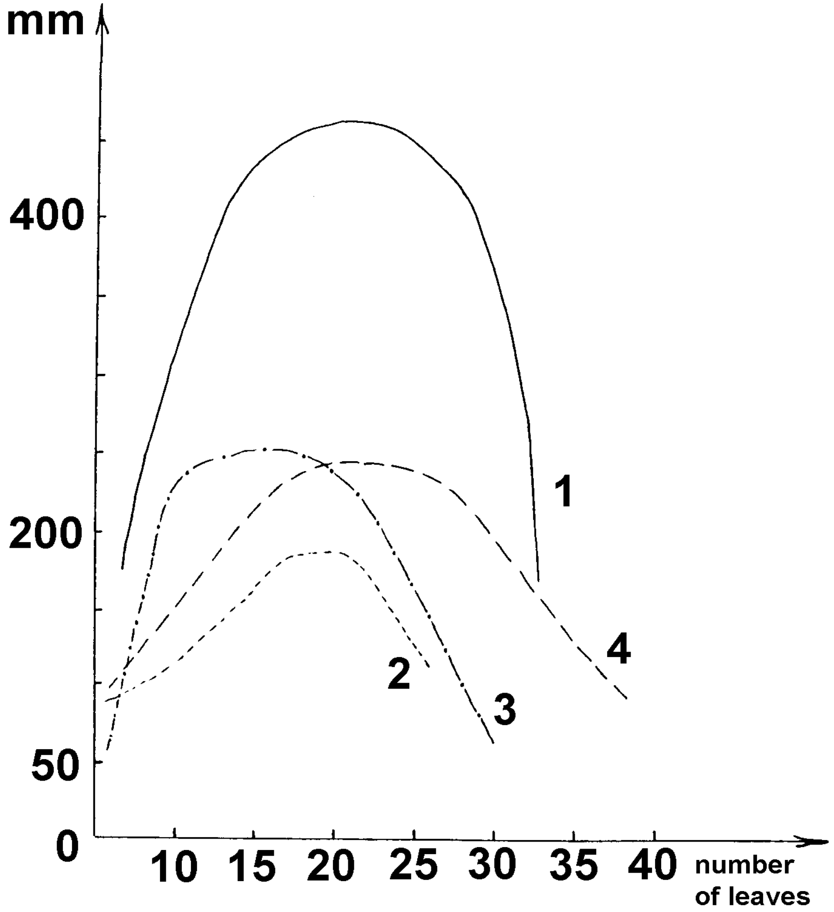

Fig.1. Distribution of leaf lengths on the stem
1 – cv. Peredovik, tall
2 – Dwarf line VIR 501
3 – Dwarf Finnish hybrid MDA 3410
4 – Dwarf line VIR 434

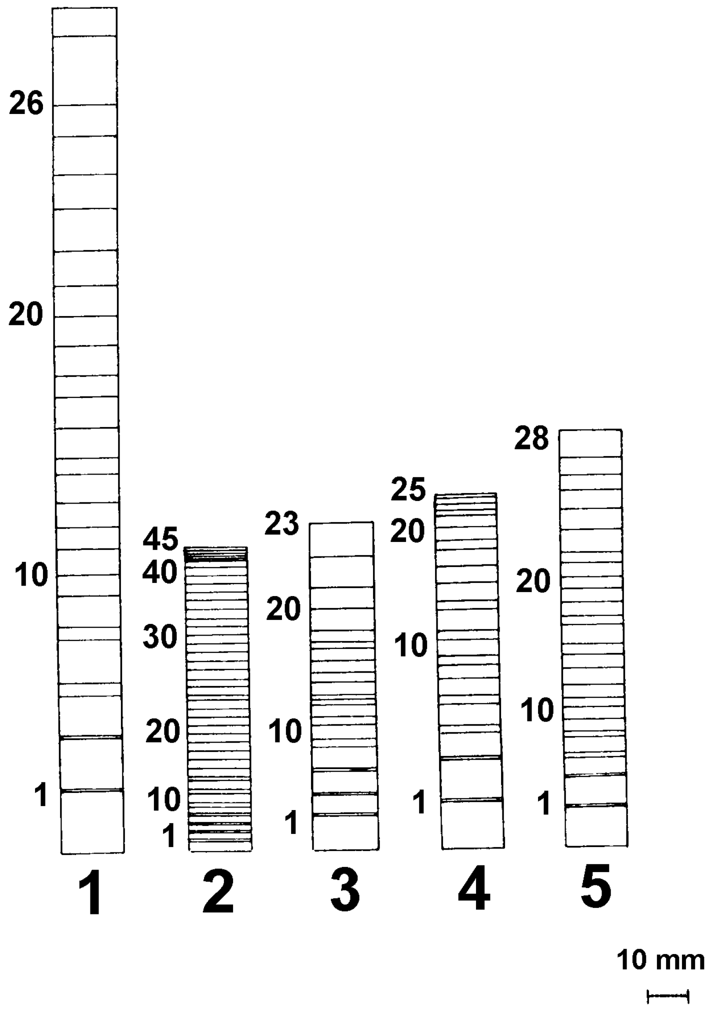

Fig.2. Diagram of internode lengths in sunflower
1 – cv. Peredovik, tall
2 – Dwarf line VIR 434
3 – Dwarf line VIR 319
4 – Dwarf Finnish hybrid MDA 3410
5 - Dwarf line VIR 253

decreases down to 20-27, while the line VIR 434 shows a sharp increase up to 40-45 leaves. Of the hybrids MDA 3410, SAM 461 and Ex 81, it is characteristic that the length exceeds the width up to the 7^{th} –10^{th} leaf, and the length is either equal to the width or the width slightly exceeds the length starting from the 8^{th} up to the 14^{th} –18^{th} leaf, and the length exceeds the width again in the leaves that follow. For the lines VIR 501, VIR 434 it is characteristic, that the width never exceeds the length of the leaf; the exception is the line VIR 434 in 1999, in which the width was either equal to the length or exceeded it a little from the 12^{th} – 13^{th} up to the 17^{th} leaf. Embryo leaves are the first to appear on the plant, and they are the first to stop growing; then appear the bottom type leaves (from the 3^{rd} up to the 5^{th}), and the last to appear are the top type leaves. The bottom type leaves have the shortest period of growth, the top type leaves grow a little bit longer, and the medium type leaves have the longest growth.

So, the observed features of size and growth rate of leaves in the lines and hybrids from VIR allow the following grouping. In the hybrids MDA 3410, SAM 461 and Ex 81, the bottom type leaves decrease in size up to the 5^{th} leaf; in SAM 461, Ex 81 the leaves from the 6^{th} up to the 12^{th}, and in MDA 3410 up to the 14^{th} are the medium type leaves, and from the 15^{th} up to the 22^{nd} – 27^{th} are the top type leaves. In the line VIR 501 the leaves from the 3^{rd} up to the 8^{th} are the bottom type leaves, from the 9^{th} up to the 17^{th} are the medium type leaves, and from the 18^{th} up to the 21^{st} – 26^{th} are the top type leaves. Thus, in the line VIR 501 and hybrids the the bottom type leaves' number decreases, and the leaves of the medium and the top type maintain the same number as in cv. Peredovik. In the line VIR 434, on the contrary, the bottom type leaves stay the same (up to the 12^{th} leaf), and from the 13^{th} up to the 24^{th} – 26^{th} these are the medium type leaves, and thus the number of the medium and top type leaves increases slightly (Fig.1.).

In comparison with cv. Peredovik, a considerable decrease in the internode length is observed in dwarf forms and hybrids of sunflower (Table). Internodes shortening and, thus, realization of dwarfness may be achieved by different ways. In different lines from VIR and hybrids shortening of internodes of definite leaves takes place. For instance, in the lines VIR 171 and VIR 434 significant shortening of internodes of all leaf types occurs (Fig.2). It should be stressed that these lines show the minimum internode size in comparison with all other lines from VIR and Finnish hybrids. At the same time, the line VIR 434 has the maximum number of leaves (Fig.2-2). Likewise, even shortening of all internodes was observed in the line VIR 328, but its internodes were larger and leaves were fewer, if compared to VIR 434. The development of internodes of the embryo and lower type leaves in the studied lines from VIR and hybrids follows the pattern of cv. Peredovik. However, the length of internodes of the medium and top type leaves differs in these lines. The shortest internodes were recorded for the medium type leaves in the line VIR 319, while internodes of the top type leaves are longer and may be compared in length with the internodes of the lower type leaves (Fig. 2-3). In the Finnish hybrid MDA 3410 (Fig. 2-4), on the contrary, shortening of internodes of the medium and especially of the top type leaves occurs. In the lines VIR 253, VIR 500, VIR 501, VIR 648 and the hybrid Ex 81 internodes of the medium and top type leaves become shortened equally.

The results obtained allow a supposition that dimensions of each leaf and the related internode are genetically determined and show the least degree of variation in years. Morphological diversity of the sunflower stem structure is ensured by action of different dwarfness genes. These results are corroborated by the genetic researches by A.L. Yesaev (1998).

As a result of this genetic analysis of the character of dwarfness in crosses of dwarf lines from the VIR collection among themselves and with the tall cv. Peredovik we have identified three types of dwarfness (Yesaev, 1998, Gavrilova, Yesaev, 1998). By the morphological manifestation and the pleiotropic action, the first type is similar to the dwarfness described earlier by Yenson, and by Tolmachev. The genes' action in our research is expressed in strong and even shortening of internodes, increasing of their number and the number of leaves, and the vegetative period extention. This dwarfness is controlled by 2 genes – i and dw - with an intermediate inheritance and the recessive epistasis type of genes' interaction. It is characteristic of the lines VIR 272 and VIR 434. Dwarfness of the second type is determined by the additive interaction of recessive alleles of no less than 3 genes – sht1, sht2, and sht3 (short stem) in VIR 319 and VIR 328. Dwarfness of the third type was found in VIR 253, VIR 500, VIR 501 and VIR 648. Control of this character in the lines is based on the polygenic action of no less than 3 sd (semidwarf) genes with incomplete dominance. The second and third types of dwarfness are associated with shortening of internodes of the leaves of the medium and upper types, and reduction of their number. In this case, the second type is characterized by the maximum shortening of internodes of the medium type leaves, while the third type – by even shortening of all leaves.

Table. Characteristics of dwarf lines and cv. Peredovik, Kuban Exp.St. VIR, 1995

Form	Plant height, cm	Internode length, cm	Vegetative period, days
VIR 501	60 ± 0.6	2.9 ± 0.03	80
VIR 272	62 ± 1.8	1.4 ± 0.04	108
VIR 648	66 ± 0.7	2.8 ± 0.03	82
VIR 328	68 ± 0.9	2.4 ± 0.04	90
VIR 319	75 ± 1.4	2.9 ± 0.07	90
VIR 253	82 ± 0.7	2.9 ± 0.03	88
VIR 500	105 ± 1.0	3.4 ± 0.05	90
VIR 649	106 ± 1.3	5.7 ± 0.07	92
cv. Peredovik	200 ± 2.0	6.3 ± 0.07	94

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