T.A. Perestova, USSR

MORPHOLOGICAL AND ANATOMICAL TRAITS OF FRUITS OF HELIANTHUS SPECIES UTILIZED IN BREEDING

Sunflower seed huskness is widely utilized in breeding for high oil content. When the proportion of the pericarp is reduced below 20% there is a danger it looses its protective function. To solve this problem we have started a comparative analysis of the morphology and anatomy of wild species of Helianthus, of cultivated sunflower and of their interspecific hybrids.

Cultivated sunflower belongs to the plants of the determinant type, and all wild Helianthus species belong to the undeterminant type. The inflorescence growth of the cultivated sunflower is the more intensive in the period from the formation of heads till the beginning of flowering and in the flowering period. In wild species inflorescence mainly grows before flowering.

The inflorescence size determines the size and quantity of seeds. The productivity of the cultivated sunflower is much more than that of any of the wild Helianthus species. The length of the flowering stage of its head determines the heterogenity of the seeds, because they are formed in somewhat differing environmental conditions. As a result it became necessary to divide the head into marginal, middle and central the zones. The quantity of flowers set in each zone is almost the same but the actual productivity is the result of different seed setting in the zones. The main role belongs to the seeds of the marginal and middle zones (Table 1).

The morphological and physical traits of the fruit of cultivated sunflower and its development speed depend not only on conditions of growth but on the fruit position in the head as well. Thus, the weight of 1000 seeds and the propor-

Table 1

Head Morphology of H. annuus L.

Head zone	Quantity of		Seed setting, %	Seed mass, %
	flowers	seeds		
Marginal	509	475	93	61
Middle	489	343	70	30
Central	448	44	10	9

tion of their pericarp is reduced from the marginal zone to the centre. Physical properties of the seed are largely determined by the state of the pericarp (Table 2).

Fruits of wild species and interspecific hybrids of first generations differ in their morphological and physical properties from fruits of the cultivated sunflower and of interspecific hybrids of advanced generations; they have low 1000 seed weight, a high proportion of pericarp, and a high specific weight of the fruit and seed. The specific weight of the pericarp of wild species and of interspecific hybrids of early generations is over 1,000 g/cub.cm.

Seed filling is an essential trait of the physical structure of the fruit. In cultivated sunflower it increases from the marginal zone of the head towards the central zone. The higher the seed filling the closer is the kernel to the pericarp and the more difficult it is to separate them. However, the seed filling trait is unsufficient for technological estimation of the breaking ability of the pericarp. The pericarp thickness and its anatomical structure play the main role in solving this question.

The presence of phytomelane in the sunflower pericarp determines the resistance of the seed against injuries caused by sunflower moth caterpillars (Homoesoma nebulella Hb.). Most of

Table 2

Some Physical Properties of Sunflower Fruit

Species according to ploidy groups	1000 seeds weight, g	Pericarp proportion, %	Hardness of pericarp, g/cub.cm	Seed filling, %
H. annuus, 2n=34				
Head marginal zone	64.3	20.8	0.570	73.7
Head middle zone	58.9	18.3	0.637	75.8
Head central zone	48.5	16.0	0.752	82.3
Wild species				
2n=34, annuals	13.6	44.0	1.216	83.8
2n=34, perennials	3.4	30.7	1.091	78.6
2n=68	8.0	37.2	1.159	80.5
2n=102	5.0	36.1	1.279	76.9
H. tuberosus x VNIIMK 8931				
F_1-F_3	15.0	43.8	1.123	75.1
F_{12}	88.4	22.9	0.608	74.7

sunflower high oil varieties possess the pericarp with the thickness of about 150-250 mk. Pericarp thickness and its anatomical structure largely depend on the seed position on the head rather than on the conditions of growing. The thickness of the phytomelane layer also depends on seed position on the head: in the seeds of the central zone this layer may be discrete thus offering no protection against moth caterpillars (Fig. 1).

Pericarp thickness of the seeds of wild sunflower species varies from 70 to 150 mk, that is 2-3 times less than that of the cultivated sunflower. The pericarp of wild species seed is characterized by a large quantity of hypoderm cells, by a thick phytomelane layer situated at the border of hypoderm and spheric or polar-spheric (at transverse sections) masses of sclerenchyme cells. Resistance of wild species to sunflower moth gave hope that this feature would be inherited by interspecific hybrids. Studies have shown that in advanced generations the traits of wild species and hybrids of early generations disappear and the pericarp of the seed of the 6-12th generations shows a close affinity with the pericarp of cultivated sunflower. At such a rapid evolution of the pericarp the thickness of the phytomelane layer considerably varies in most hybrids of the higher generations, but it is quite sufficient to protect the seeds against moth even in the case when pericarp proportion is as low as 16-17% (Fig. 2).

Further breeding may lead to an appearance of biotypes with even a lower proportion of pericarp; anatomical control is therefore necessary to screen biotypes with thin and interrupted phytomelane layer. Some biotypes may be observed with an altered correlation between the proportion of the pericarp and the thickness of the phytomelane layer, that is, at 15-17% of pericarp content or under, the phytomelane

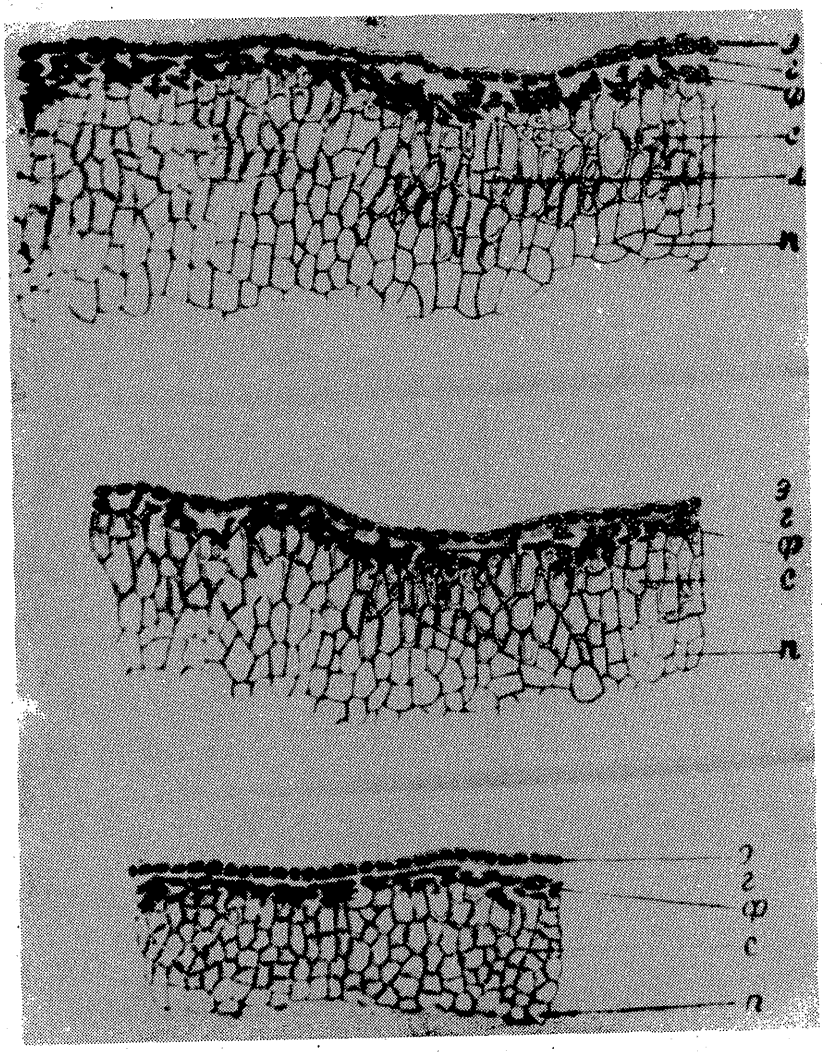

Fig. 1. Anatomocal structure of pericarp of Helianthus annuus L. fruit (cross section)
Upper picture: marginal zone of a head; central - middle zone; lower - central zone of a head
Conventional marks:
Э - epidermis with cuticula; Г - hypoderma; Ф -phytomelane layer; с - sclerenchyma; П - parenchyma rays; П - parenchyma with thin walls

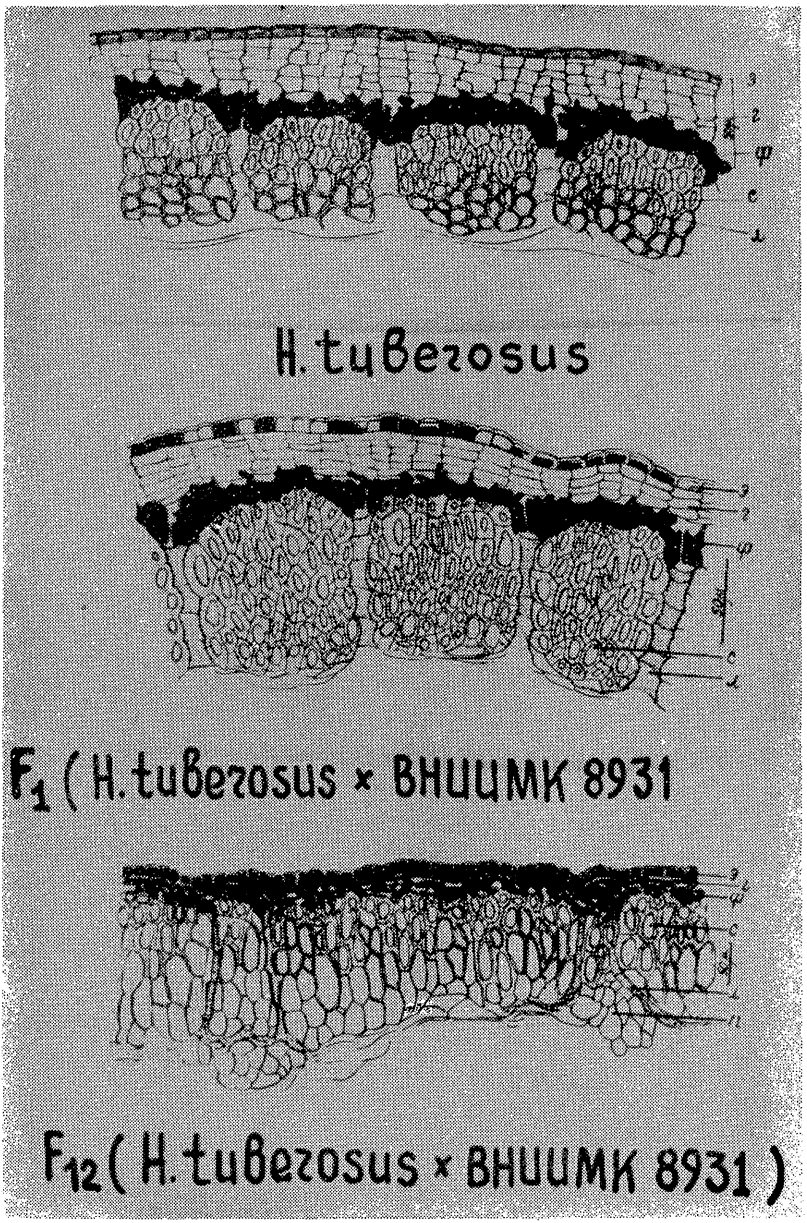

Fig. 2. Anatomical structure of pericarp of a wild species fruit and interspecific hybrids (cross section)
Conventional marks:
э - epidermis with cuticula; г - hypoderma; ф - phytomelane layer; с - sclerenchyma; п - parenchyma rays; п - parenchyma with thin walls

layer may have thickness about 25-50 mk. At present such biotypes have been observed among intra-specific (Troinoi 24, Prostoi 30) and inter-specific (H. tuberosus x VNIIMK 8931 and H. rigidus x VNIIMK 8931) hybrids and among mutants obtained with the help of nitroso etyl urea.

We have proved that phytomelane is absent in the embryo wall. It is formed after fecundation in a quantity sufficient to protect the seeds against moth in 3 days in the case of wild species, and in 7-10 days in the seeds of the marginal zone of the head of cultivated sunflower. The lack of uniformity of seeds in the head of cultivated sunflower is reflected in the reduced speed of phytomelane formation and in a slow formation of the pericarp in the middle and central parts of the head.

Formation of pericarp tissues and lignification of sclerenchyme fibres in the fruits of wild sunflower species is completed in 10 days and in cultivated sunflower only in 30 days after fecundation.

There is a reverse relationship between hypoderm development and the quantity of phytomelane in the pericarp of cultivated sunflower: maximal hypoderm development is observed in 7-10 days after fecundation; the hypoderm is obliterated by the 20-30th day and exactly by this period the phytomelane layer reaches its maximal value. As phytomelane possesses no cell structure, and as by the moment of its appearance the sclerenchyme cells of the adjacent layer have been lignified, we suppose that it develops as a result of destruction of hypoderm cells.