DESIRED MODEL OF HYBRID SUNFLOWER AND THE NEWLY DEVELOPED NS – HYBRIDS

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The progress of genetics and plant breeding in recent years has brought about the development of new varieties of domesticated plant species. These new varieties possess genetic potentials for high yields. New achievements in the fields of agrochemistry and cultural practices considerably changed the conditions for plant growing. This is vhy the presently grown crops have different conditions of growing not only from their wild forms but also from their predecessors grown 25 or 50 years ago (Borojević, 1971).

Wild sunflower forms which grow in association with other plant species or branching wild forms from America which grow at low density were used to develop varieties and hybrids which have only one stalk and which are grown at high density. The requirements towards the environmental factors of the populations of newly developed sunflower genotypes differ considerably from those of wild sunflower forms.

Genetić differences among individual plants have higher effects on yields in larger populations. A genetically homogeneous material is thus more desirable to be grown in dense populations. This is the advantage of growing pure inbred lines and F_1 generations (hybrid corn and sunflower). These are the reasons why the stem height, form and architecture of leaves and other plant parts of sunflower varieties and hybrids have to be different from the same characters of the wild sunflower forms.

The largest contribution to the development of a model of high-oil sunflower varieties was made by Soviet breeders Pustovoit and Jdanov. Besides high seed yields and oil content in seed, they also succeeded in incorporating into their model the resistance to sunflower moth (armored layer), rust, and broomrape as well as high tolerance to other diseases.

The discovery of suitable sources of male sterility offered the possibility of practical utilization of heterosis in sunflower. Leclercq (1969) made a notable achievement in this field by incorporating sterile cytoplasm from *H. petiolaris* into the domestic sunflower form.

The utilization of heterosis in sunflower is mostly done through single cross hybrids and, more recently, three-way hybrids. Sunflower hybrids are genetically narrower than the varietal population and thus each agroecological region requires a different type of hybrid. Kinman, Zimmer and Fick developed the model for the agroecological conditions of the U.S.A., Vrânceanu and Stoenescu designed and developed the model for the conditions of Romania.

In Yugoslavia, the largest hectarage under sunflower is found in Vojvodina — around 80%. Sunflowers are grown in an intensive rotation with wheat, corn, and sugar beet, less frequently with soybean, vegetables, and fodder crops. The intensive rotation requires a high-yielding hybrid type with a wide spectrum of disease resistance.

Components of seed and oil yield

As a phenotype is the result of an interaction between a genotype and the environmental conditions, it is important in the course of modelling a variety or a hybrid to define the characters which play the prevalent role in the formation of yields and the environmental factors which affect these characters. When breeding for high yields, it is important to determine the components which can easily be morphologically determined at different stages of ontogenesis. They have to be in correlation with yields so that the breeding for these components be at the same time the breeding for high yields (Borojević, 1971).

To show the main components of the hybrid model for the conditions of Vojvodina and their expression in dependance of the environmental factors, a schematic review of the hybrid model is given in Figure 1.

The final components of seed and oil yield are:

LE MODÈLE DE TOURNESOL HYBRIDE DÉSIRÉ ET LES HYBRIDES NS RÉCEMMENT OBTENUS

Résumé

L'auteur présente les composants principaux du type d'hybride de tournesol adapté aux conditions de milieu de Voïvodine, insistant sur le nombre de grains sur plante qui doit être plus de 1 500 à un peuplement de 45 000—50 000 plants/ha, le poids hectolitrique de 40—50 kg/hl, le poids de 1 000 grains plus de 80 g, le pourcentage en coques de 20—24 et la teneur en huile plus de 50%. Par la réalisation de ces composants on peut obtenir un rendement en huile plus de 2 000 kg/ha.

Une attention particulière est accordée à la projéction d'un modèle d'hybride qui réunisse la résistance complexe aux maladies principales qui diminuent le rendement du tournesol et la tolérance satisfaisante à la sécheresse. De même, un accent important est mis sur l'amélioration de l'architecture de l'appareil foliaire, afin d'utiliser plus efficacement la lumière et l'énergie solaire.

Une partie des desiderata de ce modèle d'hybride a été réalisée par la création et l'extention dans la culture des premiers hybrides de tournesol yougoslaves, obtenus à Novi Sad, comme par exemple NS-H-26-RM, NS-H-27-RM, NS-H-62-RM, NS-H-63-RM, qui ont dépassé la variété VNIIMK 8931 en moyenne pour deux ans, avec 29—34% concernant le rendement en huile.

MODELO DESEADO DE GIRASOL E HÍBRIDOS NS RECIENTEMENTE CREADOS

Resúmen

El autor presenta los principales componentes del tipo de híbrido de girasol adaptado a las condiciones de medio de Vojvodina, con insistencia en el número de semillas por planta, el cual debe sobrepasar 1 500 a una densidad de 45 000—50 000 plantas por hectárea, peso hectolítrico de 45—50 kg/hl, el peso de 1 000 semillas de más de 80 g, el porcentaje de cortezas de 20—24 por ciento y el contenido de aceite de más del 50 por ciento Si se realizan estas componentes se puede obtener una producción de aceite de más de 2 000 kg/ha. Atención destacada está prestada a la proyectación de un modelo híbrido que llegue a una resistencia compleja frente a las principales enfermedades disminuyen la producción de girasol, así como una tolerancia adecuada a la sequia. Asimismo, un acento importante se pone sobre la remodelación de la arquitectura del aparato fotosintético, para utilizar con máxima eficacia la luz y la energia solar.

Parte de los desideratos de este modelo de híbrido han sido realizados creando e introduciendo a la producción los primeros híbridos de girasol yugoslavos, obtenidos en Novi Sad, NS-H-26-RM, NS-H-27-RM, NS-H-62-RM, NS-H-63-RM los cuales han sobrepasado la variedad VNIIMK 8931 por unos dos años, con 29—34 por ciento en la producción de aceite.

— No. of plant per ha (45,000—50,000).
— No. of seeds per plant (> 1,500).
— Hectoliter weight (45—50 kg/hl).
— Weight of 1,000 seeds (> 80 g).
— Low husk perecentage (20—24%).
— High oil content in seed (> 50%).

If the above figure are achieved, it is reasonable to expect to reach the desired goal, i.e. to obtain more than 2,000 kg/ha oil. To reach this goal, it is important to breed the lines for the above characters. It is also necessary to know the manifestation of the effect of heterosis for these characters as well as to know the correlations among the characters.

Fig. 1. — Schematic review of the model of the NS-sunflower hybrid genotype

GENES FOR MEDIUM VEGETATION LENGTH (120—130 days)

GENES FOR MEDIUM STEM HEIGHT (160—180 cm)

GENES FOR MEDIUM LEAF SIZE (6,000—7,000 sq. cm/plant)

GENES FOR INCREASED NO. OF FLOWERS (> 1,500/plant)

GENES FOR DISEASE RESISTANCE:

— OROBANCHE CUMANA
— PLASMOPARA HELIANTHI
— SCLEROTINIA SCLEROTIORUM *(S. libertiana)*
— SCLEROTINIA BATATICOLA *(M. phaseoli)*
— VERTICILLIUM DAHLIAE
— BOTRYTIS CINEREA
— ALTERNARIA HELIANTHI
— PUCCINIA HELIANTHI
— PHOMA SP.
— SEPTORIA HELIANTHI

GENES FOR RESISTANCE TO SUNFLOWER MOTH (armored layer)

GENES FOR SMALL INLCINE OF THE HEAD

GENES FOR DROUGHT RESISTANCE

GENES FOR LONG DURATION OF GREEN AREA

GENES FOR EFFICIENT NAR

GENES FOR EFFICIENT TRANSLOCATION OF ASSIMILATED SUBSTANCES INTO SEEDS (high oil and protein content)

GENES FOR HIGH QUALITY OF OIL AND PROTEINS

GENES FOR LARGE AND HEAVY SEEDS

GENES FOR TOLERANCE TO DATE OF HARVESTING

YIELD COMPONENTS

NO. OF PLANTS/HA 45,000—50,000

NO. OF SEEDS/HA > 1,500

WEIGHT OF 1,000 SEEDS > 80 G

HECTOLITER WEIGHT 45—50 KG/HL

LOW HUSK PCTG. < 25%

HIGH OIL CONTENT IN SEEDS > 50%

OIL YIELD > 2,000 KG/HA

ENVIRONMENT

CROP ROTATION IN WHICH SUNFLOWER IS PLANTED EACH 6—7 YEARS

GOOD LAND BEDDING

MINERAL NUTRITION FOR 45,000—50,000 PLANTS/HA

TIMELY CULTURAL PRACTICES

NITROGEN TOPDRESSING BEFORE THE PHASE OF INTENSIVE GROWTH

SUFFICIENT PRECIPITATION DURING GROWING SEASON (about 300 mm)

TIMELY HARVEST

The stand density is the first step towards securing high yields. This is why it is necessary to plant and maintain the optimal number of plants per area unit. When developing a hybrid model, emphasis should be placed on genotypes which are tolerant to the change of environmental conditions at the stage of sprouting and initial stages of development. The maintenance of the optimal density is connected with the wider spectrum of disease resistance and this is the reason why disease resistance is an important character in a hybrid model. On the basis of the studies of different genotypes grown in Vojvodina it was concluded that the optimal density is 45,000—50,000 plants/ha. To be grown at this density, the plants have to be 160—180 cm tall and their vegetation length should be medium (120—130 days).

In order to obtain more than 1,500 seeds par plant it is necessary to breed inbred lines for increased number of flowers. It is important to find lines which have a high effect of heterosis for this character in a hybrid combination. It is difficult to find a hybrid combination which has both a high value for the weight of 1,000 seeds and a high value for the hectoliter weight, but such a combination should nevertheless be searched for. In this case, the hectoliter weight is more important of the two characters. If the breeder places an emphasis from the beginning of his work on low husk percentage and high oil content, it is possible to develop the desired hybrids.

Resistance to diseases and pests

To grow a hybrid in an intensive crop rotation which should secure high and stable yields, it is necessary that the hybrid possess resistance to the dominant diseases and pests of the region of cultivation. When incorporating resistance into a hybrid model the follwing points should be carefully observed:

a) Development of a wide spectrum of resistance to several parasite species.

b) Development of a wide spectrum of resistance to a single parasite. In case of the sunflower, it is possible to achieve resistance to the following diseases: *Plasmopara helianthi* (so far, four dominant genes which control this disease have been determined), *Orobanche cumana* (Or_A, Or_B, and Or_M genes), and *Puccinia helianthi* (R_1 and R_2).

c) Development of tolerance to the pathogenes towards which there are no genetic sources of resistance (*Sclerotinia sclerotiorum, Sclerotium bataticola,* etc.).

d) Utilization of passive resistance to the diseases causing leaf and stem spot, by strengthening the basic plant parts.

It is difficult to achieve resistance to all diseases listed in the schematic review of the hybrid model. Wild sunflower forms should be used to secure a higher degree of resistance. At the moment, it is possible to incorporate genetic resistance to the following diseases: *Plasmopara helianthi, Orobanche cumana, Verticillium dahliae,* and *Puccinia helianthi.* The incorporation of resistance to other diseases should be considered as a gradual process, the course of which depends on the determination of sources of resistance in wild sunflower forms and their introduction into the domestic sunflower form.

Sunflower moth (*Homoeosoma nebulella* Hb.) is the most important pest on sunflower seed in Yugoslavia. It is simple to achieve genetic resistance to this pest as a large number of lines with good combining ability possess the carbon layer in the husk.

Position of the head on the stem

The severity of attack of certain diseases of sunflower head is directly related to the position of the head on the stem. Those sunflower genotypes the stems of which bend after the flowering have the heads inside the leaves which favors the occurrence of diseases. In the NS-hybrid model, the stem should be firm from top to bottom in order to hold the head inclined at the angle of 45° above the leaves.

Resistance to drought

It is our experience that drought may be a limiting factor for the realization of yielding potentials of sunflower hybrids. Drought occurs as a limiting factor in sandy and "higher" locations in Vojvodina, some regions of Serbia, and particularly in Macedonia.

Sunflower hybrids have to be resistant to soil and air drought, i.e. high tempertures at the stage of seed filling. To achieve drought resistance it is necessary to secure:

— more efficient root system,

— certain architecture of the basic plant parts,

— early maturation, and

— resistance to diseases *(Sclerotinia bataticola).*

Besides an efficient utilization of soil moisture, the root system also has to be efficient in nutrient uptake.

Architecture of the photosynthetic apparatus

Shorter stem of sunflower hybrids and an intensive production technology required a change in the stand density. Increased number of plants (to 45,000—50,000) set forth different requirements regarding the role and size of leaf area.

The period of the formation of the maximum leaf area of parental components and hybrids should be as short as possible. The area should be then kept at this level as long as possible (LAD). The vertical and horisontal position of leaves and their relation with the quality and intensity of light indicates that the leaves differ among themselves regarding their physiological and biochemical activity during the day. Top leaves have a higher photosynthetic activity when sunrays fall at an angle (early morning and late afternoon). Medium leaves have the highest activity around noon. The horisontal and vertical position of leaves in the hybrid model should ensure an intensive absorption of light during day, efficient utilization of CO_2 from the air, and the optimal air circulation in the plot. Sunflower leaves should be corrugated (to increase the active area) and should slope downwards. The maximum leaf area of a hybrid should be 6,000—7,000 sq. cm/plant. The hybrid genotype should possess genes for an efficient NAR, thus ensuring a high intensity and productivity of photosynthesis and an intensive transportation of assimilated matter into the seeds.

Since the activity and duration of leaf area are directly correlated with the resistance to pathogenic organisms, particularly those causing spot and wilt of leaves and stems, there is a need of developing hybrids with a wide spectrum of resistance.

Chemical compositions of seeds and oil

When formulating a hybrid model, we should define not only the content of oil and proteins in seed but also the quality of these characters. The biological value of oil is estimated on the basis of the composition of fatty acids as well as on the basis of the content of lyposoluble vitamins, particularly the vitamin E. The sunflower oil should contain large quantities of linoleic acid and alpha-tocopherol. The ratio alpha-tocopherol: linoleic acid should be higher than 0.7 mg/g.

Evaluation of first NS-sunflower hybrids

Our long-term breeding work resulted in the development of a number of sunflower hybrids. First domestic hybrids started to be grown in commercial production in 1977. These hybrids correspond partially with the planned hybrid model.

The value of the first domestic sunflower hybrids may be illustrated by the average seed yields obtained in commercial production in Vojvodina, the main sunflower growing region of the country. In 1977, the average seed yield on 140,000 ha was 26.3 q/ha. In 1978, which was an unfavourable year, sunflowers were grown in Vojvodina on 183,000 ha with the average seed yield of 24.3 q/ha. Long-term average seed yield of Soviet varieties which had been grown in Vojvodina before the introduction of the domestic hybrids was 18.0 q/ha. The maximum annual average seed yield of Soviet varieties was 20 q/ha.

The genetic potentials of the new sunflower hybrids are not fully utilized in commercial production, as may be concluded from the fact that considerably higher yields that the average were obtained in some plots. The maximum seed yield in commercial production of 46 q/ha was obtained in a 40 ha plot planted by NS-H-26-RM. Improved cultural practices and incorporation of a wider spectrum of disease resistance should enable sunflower hybrids to produce average seed yields of over 30 q/ha.

In order to correctly regionalize new sunflower hybrids in different regions of Vojvodina (Srem, Banat, Bačka), large plot trials are conducted annually in 40—34 localities. The size of the basic plots in these trials is 1 ha each hybrid (variety).

The results obtained in large-plot trials are similar to those obtained in commercial production and may be used for the evaluation of the new hybrids.

The results of large-plot trials show that the hybrid NS-H-26-RM was the most plastic. Its two-year average seed yield was 33.93 q/ha, 8.8 q/ha higher than the yield of the control variety VNIIMK 8931. Regarding seed yield, NS-H-27-RM was in the second place, NS-H-62 RM and NS-H-63-RM in the third and fourth, respectively (Table 1). An increased variability in seed yields of the last two hybrids resulted from the susceptibility of their leaves and stems to infection by ascospores of *Sclerotinia libertiana.*

The hybrid NS-H-26-RM had a slightly lower oil content in seed than the Soviet variety VNIIMK 8931; the other hybrids had significantly higher oil contents in seed than the control variety (Table 2).

Two-year research results show that the hybrid NS-H-27-RM had the highest oil yield per hactare. It was 1,545 kg/ha or 38% higher than the yield of the control variety VNIIMK 8931. The hybrid NS-H-26-RM was in the second place, NS-H-62-RM and NS-H-63-RM in the third and fourth place, respectively (Table 3).

Table 1

Two-year seed yields of new sunflower hybrids. Large-plot trials conducted in Vojvodina, in 1977 and 1978, in q/ha

No.	Hybrid (Variety)	Absolute minimum seed yield	Absolute maximum seed yield	Two-year average seed yield			
				Srem	Bačka	Banat	Vojvodina
1	VNIIMK 8931, cotrol	9.1	41.1	25.9	25.4	24.0	25.1
2	NS-H-26-RM	20.0	43.4	34.2	34.6	33.1	33.9
3	NS-H-27-RM	22.3	42.6	33.5	33.1	32.4	33.0
4	NS-H-62-RM	13.2	44.3	33.2	31.3	31.1	31.8
5	NS-H-63-RM	10.5	44.9	32.5	31.1	29.8	31.2

L.S.D.	*For hybrids:*	*For regions:*	*Hybrid × region:*
	5% = 0.8 q/ha	5% = 0.5 q/ha	5% = 1.1 q/ha
	1% = 1.0 q/ha	1% = 0.6 q/ha	1% = 1.5 q/ha

In 1979, the hybrids NS-H-26-RM, NS-H-27-RM, NS-H-62-RM, and NS-H-63-RM were planted in Yugoslavia on over 250,000 ha. The hybrids differ considerably regarding the agronomic characters. That is why they were planted in different regions.

The hybrid NS-H-26-RM was planted on the largest area, on account of its high adaptability, shortest vegetation period (less than 120 days), short and firm stem which makes it resistant to lodging and suitable for combine harvesting, genetic resistance to downy mildew, rust, broomrape, and sunflower moth, and tolerance to the agents of leaf spot. This hybrid should be grown in thicker stands, from 50,000 to 55,000 plants/ha. A short vegetation period makes it possible for this hybrid to be planted in those plots which are swamped in early spring.

The hybrid NS-H-27-RM is similar to NS-H-26-RM regarding vegetation period and plant height. Its specific trait is tolerance to drought. NS-H-27-RM is a high-oil hybrid, its oil content in seed reaching 55%. It equals NS-H-26-RM in respect to disease resistance. NS-H-27-RM efficiently takes up nutrietns from the soil and is suitable for growing in thicker stands (50,000—55,000 plants/ha.

The hybrids NS-H-62-RM and NS-H-63-RM are similar. They have a medium vegetation period and plant height from 180 to 210 cm. Their genetic potentials for seed yield are high. However, a high susceptibility of their medium leaves and stems to ascospores of *Sclerotinia libertiana* limits their area of growing. NS-H-63-RM has higher oil content in seed Both hybrids are genetically resistant to downy mildew. NS-H-62-RM better stands poorer soils, NS-H-63-RM is more tolerant to drought. The optimal density for these hybrids is 45,000 plants/ha.

The stabilization of sunflower seed yields in commercial production at the level above 30 q/ha requires the incorporation of a wider spectrum of disease resistance into the new hybrids from the wild sunflower forms. This model of NS-sunflower hybrid is being worked out in the second cycle of breeding.

Table 2

Two-year averange oil content (%) in seed in different regions of Vojvodina

No.	Cultivar	Srem		Banat		Bačka		Average for Vojvodina			Relative oil content %
		1977	1978	1977	1978	1977	1978	1977	1978	$\bar{x}$	
1	VNIIMK 8931, control	51.1	51.3	48.5	49.1	49.9	50.6	49.8	50.3	50.1	100
2	NS-H-26-RM	50.2	50.4	49.9	49.4	49.1	49.5	49.7	49.7	49.8	99
3	NS-H-27-RM	52.8	53.9	52.3	52.2	52.2	52.5	52.4	52.9	52.7	105
4	NS-H-62-RM	51.5	52.4	51.4	51.2	50.9	51.6	51.3	51.7	51.5	102
5	NS-H-63-RM	52.3	52.4	52.6	51.1	52.4	51.7	52.4	51.7	52.1	104

L.S.D. *For hybrids:* 5% = 0.4%, 1% = 0.5%; *For years:* 5% = 0.2%, 1% = 0.3%; *Hybrid × year:* 5% = 0.5%, 1% = 0.7%

Table 3

Two-year oil yields of new sunflower hybrids grown in large-plot trials in Vojvodina, q/ha

No.	Cultivar	Year		Average $\bar{x}$	Relative oil yield %
		1977	1978		
1	VNIIMK 8931, control	12.6	9.8	11.2	100
2	NS-H-26-RM	15.9	14.1	15.0	134
3	NS-H-27-RM	15.8	15.2	15.5	138
4	NS-H-62-RM	16.2	13.0	14.6	130
5	NS-H-63-RM	16.6	12.4	14.5	129

L.S.D. *For hybrids:* 5% = 2.7 q/ha, 1% = 4.5 q/ha

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