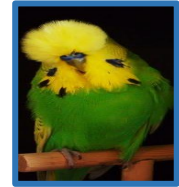


# CONFECTIONERY SUNFLOWER IN SERBIA



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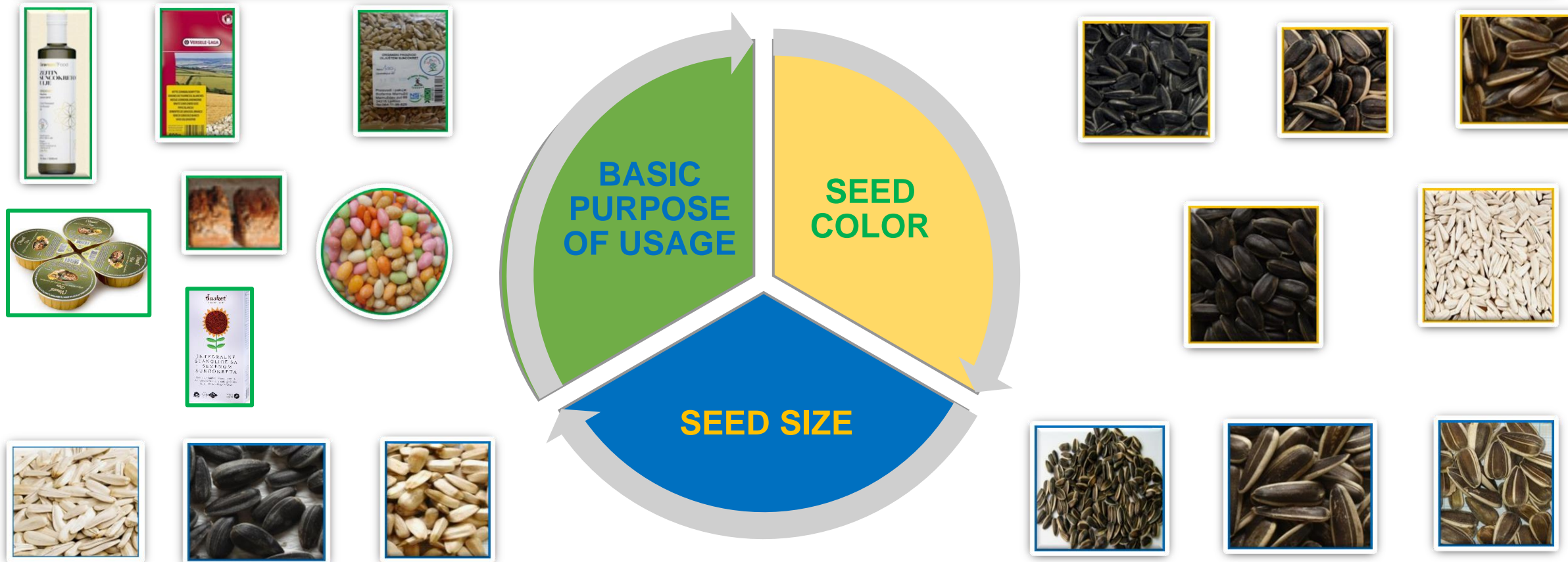
Serbia is one of the leading countries in the Balkans both in production and breeding of high-protein confectionery sunflower, although the area under this crop in Serbia is rather small.

High-protein or confectionery sunflower has a separate market from the oil type sunflower, as it is used in the food industry, roasted or dehulled and used as a whole seed or component of snacks and baker's wares, or as bird and pet feed (Hladni, 2016; Hladni and Miladinović, 2019).

Apart from proteins, confectionery high protein sunflower hybrids also contain significant oil quantities that used to obtain cold press oils and oil cake as a by-product (Hladni et al., 2021; Lužaić et al., 2021a).

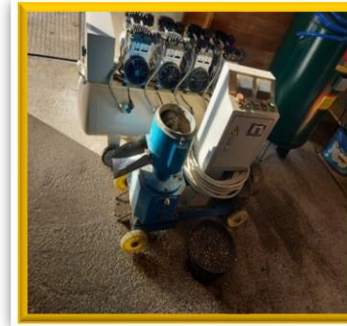


# HIGH-PROTEIN NS SUNFLOWER HYBRIDS ARE DIVIDED INTO GROUPS BASED ON :



Large open-pollinated confectionery varieties, with large black seeds, have been grown in the past, but in the last few years they start to be replaced by NS confectionery hybrids, which led to the increase of their use in the production, processing industry and smaller processing factories.

Large seed fractions are roasted and packed individually, while smaller seed fractions are used in the production of cold-pressed sunflower seed oil (Hladni and Miladinović 2019).



# GENETIC RESOURCES – STATUS AND TOOLS DIVERSITY ANALYSIS SERBIA

Knowledge of genetic diversity of confectionary sunflower can have a large impact on its use in breeding programs, so characterization of the existing sunflower collections is essential for breeders (Tan et al., 2016).

Levels and distribution of genetic variation within the confectionary sunflower gene pool are still not adequately explored. Adequate selection of traits used in confectionary germplasm evaluation can improve the efficiency of breeding programs.



# GENETIC RESOURCES – STATUS AND TOOLS DIVERSITY ANALYSIS SERBIA

Local populations have huge genetic variation and are well-adapted to local soil types and climatic conditions, as well as other environmental factors. They are the source of many desirable genes, especially those addressing higher adaptability to environmental conditions and resistance to certain diseases



**IFVCNS COLLECTION OF 30  
HIGH PROTEIN LOCAL  
SUNFLOWER POPULATIONS  
FROM THE WORLD**



# GENETIC RESOURCES – STATUS AND TOOLS DIVERSITY ANALYSIS SERBIA



LOCAL SUNFLOWER POPULATION



LOCAL SUNFLOWER POPULATION

Self-pollination local sunflower population for creating new lines

## GENETIC RESOURCES – STATUS AND TOOLS DIVERSITY ANALYSIS SERBIA

Hladni et al. (2017a) used the Shannon diversity index (H) to evaluate the variability of 68 confectionary sunflower genotypes based on 32 morphological descriptors. The high diversity index value (0.7) suggests that the evaluated material is a representative confectionary sunflower germplasm collection.

HOMALS analysis indicates the importance of descriptor selection for germplasm evaluation. Based on this, the most informative trait was coloration of stigma (DFIA), seed color of stripes (SCS), and seed main color (SMC). These had both the highest variability and the highest discriminative power among genotypes.



Fig. 1. Confectionary sunflower genotypes representative for seed descriptor categories (a) size (small, medium, large), (b) shape (elongated, narrow ovoid, broad ovoid, rounded) (c) main color (grey, light brown, medium brown, dark brown, black) and (d) color of stripes (white, grey, brown, black).

Hladni N, Terzić S, Mutavdžić B, Zorić M (2017) Classification of confectionary sunflower genotypes based on morphological characters. *The Journal of Agricultural Science*, Cambridge University Press, 155: 10, pp. 1594-1609.

<https://doi.org/10.1017/S0021859617000739>



## BREEDING – PROGRAMS AND INTRODUCTION OF HYBRIDS

Breeding program for confectionery sunflower in Serbia has been established at: Centre for Agricultural and Technological Research in Zaječar and Institute of Field and Vegetable Crops in Novi Sad (IFVCNS) during the 1980s.

Specific breeding goals for confectionery sunflower are high mass per 1000 seeds, low content of hull, high content of proteins, and low oil content (Dozet and Jovanović, 1997; Jovanović, 2001; Dijanović et al., 2003).

Since the results of a number of researchers show that the protein content of sunflower seeds varies in a wide range from 13% to 28% (Stanojević et al., 1992; Jovanović and Stanojević, 1996), higher and more stable protein yield is an ultimate objective of confectionery sunflower breeders.



## BREEDING – PROGRAMS AND INTRODUCTION OF HYBRIDS

### THE AIM OF CONFECTIONARY SUNFLOWER BREEDING

- Different shape and seed size
- Uniformity of seed size
- Different look and hull color
- High protein content
- Low oil content
- High oleic acid content + beta or gamma tocopherols
- Easy dehulling



In the breeding process it is important to identify traits which could be used as selection criteria for increased protein content in seeds and develop efficient methods and tools for predicting oil and protein yields depending on parameters of cultivation, such as artificial neural networks (ANNs) (Hladni et al., 2015; Hladni et al., 2017b; Hladni et al., 2021; Lužajić et al., 2021b).



# CONFESTIONARY HYBRID BREEDING FACILITIES IN IFVCNS



Breeding nursery



Greenhouse



Cages



Experimental hybrid testing



Irrigations fields for disease resistance testing



Winter nurseries in Argentina



For production of experimental hybrids

## BREEDING – PROGRAMS AND INTRODUCTION OF HYBRIDS

Years of breeding work on confectionery sunflower in IFVCNS led to creation of new NS confectionery hybrids, which are registered in Serbia, EU, and Russia. NS confectionery hybrids respond to a great extent to production and market demands of EU, Russia and Balkan countries. They also maintain their presence in the Iranian, Albanian and Chinese markets (Hladni and Miladinović, 2019).



## BREEDING – PROGRAMS AND INTRODUCTION OF HYBRIDS

Confectionery hybrids have significantly higher seed yield than open-pollinated varieties, as well as resistance to biotic and abiotic stresses (Hladni et al., 2018).

The advantage of confectionery sunflower in comparison to varieties are crop uniformity, suitability for mechanized harvesting, optimal plant density for achieving the desired size, seed quality and color.



# NS CONFESTIONERY HIBRIDS ARE REGISTERED IN

## EU

MAHELAN  
BORNEO  
RIO  
STRIAL  
NS COLONEL  
NS GOLIAT  
NS IVAN  
NS ARGONAUT  
NS DIMITRI  
NS TEZEJ

NS VIKING  
NS COPERNICUS  
NS TOR  
NS LEVIATHAN

## EU

FOR BIRD FEED

NS LACTAL  
NS PAPAGENO  
NS KANARINO

## RUSSIA

HC 6316  
HC 6318  
HC 6320  
HC 1111

## UKRAIN

НС ГОЛІАТ  
НС ДІВ  
НС КОЛОНЕЛ  
ВРАНАЦ

## SERBIA

VRANAC  
CEPKO  
NS GARAVI  
NS GRICKO  
NS SLATKI  
NS DIMITRI  
NS IVAN  
NS VITEZ  
NS GOLIAT  
NS LEVIATHAN  
NS VIKING  
NS ARGONAUT

FOR BIRD FEED

LABUD  
NS PAPAGENO  
NS KANARINO

EU 14,  
Russia 4,  
Ukraine 4,  
Serbia 11  
confectionery  
hybrids and 3  
hybrids for  
bird feed in EU  
and Serbia

## PURPOSE OF USAGE OF NS HIGH PROTEIN HYBRIDS



### HUMAN NUTRITION

NS Colonel,  
Borneo  
NS Leviathan,  
NS Goliat,  
NS Mahelan



### HUMAN AND BIRD NUTRITION

NS Argonaut



### BIRD FEED

NS Papageno,  
NS Kanarino,  
Labud  
Experimental hybrids  
NS Blanka and NS  
Albus

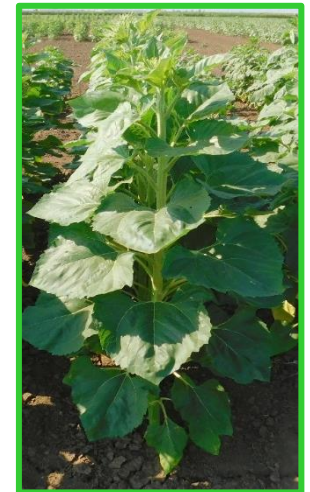


## NS LEVIATHAN

## LARGE STRIPE SEEDS

### HYBRID DESCRIPTION

- Confectionary hybrid suitable for nutrition and de-hulling.
- Medium late hybrid.
- Hybrid is genetically resistant to rust and the sunflower moth.
- Genetic potential for seed yield is over 5.8 t/ha.
- Excellent seed size, length and color.
- Thousand seed weight is 120-140 g, seed with stripes.
- The oil content is less than 35%.
- The content of protein in the seed is 27% which makes this hybrid suitable for food consumption.
- It has a low hull percentage and seed is easy for de-hulling.
- This hybrid is attractive to pollinators and well adapted to different ecological conditions and soil types.
- Optimal plant density at harvesting time is from 35,000 to 42,000 plants per hectare.



NS-GOLIAT

## HYBRID DESCRIPTION

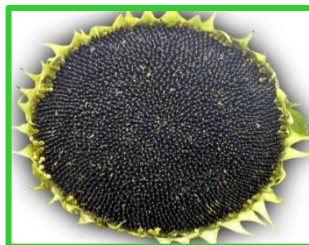
## LARGE STRIPE SEEDS

- Confectionery sunflower hybrid for nutrition and de-hulling
- Medium early hybrid
- Genetic potential for seed yield over 4.5 t/ha
- Mass of 1000 seeds 105-120g
- Oil content in seed less than 33%
- Kernel protein content 23%
- Low husk content
- Resistant to sunflower rust (*Puccinia helianthi*), sunflower moth tolerant to *Phomopsis*
- Attractive to pollinators, adapted to different ecological conditions and soil types
- Optimum plant density 35,000 to 42,000 plants/ha



**MAHELAN**

**LARGE DARK SEEDS**



## HYBRID DESCRIPTION

- Confectionery sunflower hybrid for nutrition and de-hulling
- Medium early hybrid
- Genetic potential for seed yield is over 4.5 t/ha
- Oil content in the seed under 35%
- Kernel protein content is over 26%
- It has a low hull percentage
- Mass if 1000 seeds from 95 to 110g
- Resistant to rust and sunflower moth
- Tolerant to *Phomopsis* and *Phoma*
- Stands stress conditions well
- Attractive to pollinators
- Optimum plant density at harvesting time is 35,000-42,000 plants per hectare



**NS ARGONAUT**

## HUMAN AND BIRD NUTRITION MEDIUM STRIPE SEEDS

### HYBRID DESCRIPTION

### FOUND ITS PLACE IN THE EU MARKET

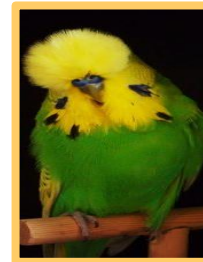
- Confectionary hybrid suitable for nutrition and machine de-hulling.
- It can also be used for bird feed.
- Medium early hybrid.
- Genetic potential for seed yield is over 4.5 t/ha.
- Thousand seed weight is 110-120 g, seed with stripes.
- Oil content in the seed is lower than 35%.
- The content of protein is 25%, which makes this hybrid suitable for food consumption.
- Resistant to the rust and sunflower moth.
- Because of its good adaptability, it can be successfully grown on different soil types.
- Attractive to pollinators.
- Optimal plant density at harvesting time is from 35,000 to 42,000 plants per hectare.



## NUTRITION FOR BIRDS

It has been tested over the period of several years in trials with producers in Serbia and EU and has found its place in the market as feed for pigeons and parrots.

NS Papageno and NS Laktal are registered in the EU and NS Albus is in the process of registration in the EU.



NS ALBUS



NS LACTAL



NS PAPAGENO



## NS PAPAGENO

## NUTRITION FOR BIRDS

### SMALL STRIPE SEEDS

## HYBRID DESCRIPTION

- High protein hybrid best food for birds
- Medium hybrid.
- Genetic potential for seed yield is over 5 t/ha.
- Thousand seed weight is 90-100 g, seed with stripes
- Oil content in the seed is 30-33%
- Protein content is 27%, which makes this hybrid suitable for bird food consumption.
- Resistant to the rust and sunflower moth, tolerant to *Phomopsis*.
- This hybrid is attractive to pollinators and well adapted to different ecological conditions and soil types
- Optimal plant density at harvesting time is 45.000-50.000 plants per hectare.



In Serbia yield of confectionery hybrids is on the same level as the yield of oil hybrids, over 4 t/ha, selected seed 3.5 t/ha, and the price is significantly higher per kg, sometimes even double, depending on the seed fraction.



Many small farmers in Serbia are producing NS confectionery hybrids such as NS Gricko, NS Leviathan, NS Slatki, NS Garavi and NS Goliat. NS confectionery hybrids can be used to obtain edible unrefined cold pressed oil (Romanić et al., 2020; Lužanić et al., 2019; Lužanić et al., 2021a).

## FUTURE DIRECTIONS IN SUNFLOWER BREEDING IN SERBIA

In order to achieve high and stable confectionery hybrid yield it is important to create a model of a sunflower plant which would enable an increase of the number of plants per hectare in the conditions of intensive cultivation practices and mechanized harvesting (**Hladni and Miladinović, 2019**).

It is necessary to pay more attention to the architecture of plant organs, like petiole angle, petiole length, plant height and number of leaves per plant, which directly influence the change of the photosynthesis.





## FUTURE DIRECTIONS IN SUNFLOWER BREEDING IN SERBIA

One of the goals in confectionery sunflower breeding, besides high protein content, is the creation of hybrids with high oleic acid and tocopherol content.



Organic fertilizers could be used for improvement of fatty acid composition and tocopherol content in organic cultivation of sunflower (Babec et al., 2019).



## FUTURE DIRECTIONS IN SUNFLOWER BREEDING IN SERBIA

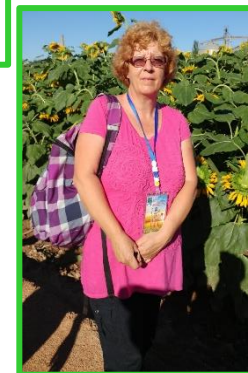
In the future, confectionery sunflower breeding will be focused on an integrated multidisciplinary approach based on genetics and genomics, physiology, and modelling, along with the application of modern breeding tools, should be used for designing novel sunflower varieties, more resilient to abiotic stresses and extreme environmental conditions, particularly drought tolerance (Hladni et al., 2022).



## FUTURE DIRECTIONS IN SUNFLOWER BREEDING IN SERBIA

The cooperation and exchange of breeding material from different breeding centers, as well as creation of joint hybrids, has gained importance in recent years as a tool for creation of new, more resilient and productive confectionery hybrids, ready to face both challenges from the market in Serbia and other countries (Hladni et al., 2018).

Goals of particular importance in breeding are the creation of hybrids resistant or tolerant to diseases and broomrape while also incorporating herbicide-tolerant traits, especially to Imidazolinones (IMI) and Sulfonyl Urea (SU).



## FUTURE DIRECTIONS IN SUNFLOWER BREEDING IN SERBIA

The combination of confectionery sunflower and legumes, while rarely used in practice, promises to improve not only sustainability of the production system but also yield (Babec et al., 2021).

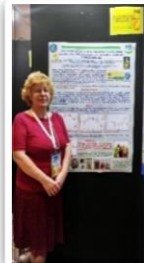


## The WuYuan symposium on Confection Sunflower Technology and Production, August 2018



IFVCNS is an institute of national importance for the Republic of Serbia. We are current with all the world trends when it comes to high protein confectionery sunflower breeding and production.

## World Congress on Oils and Fats. Sydney, Australia, February 2020



**THANK YOU  
FOR YOUR  
ATTENTION**