INSTITUT ZA RATARSTVO I POVRTARSTVO
INSTITUT OD NACIONALNOG ZNAČAJA ZA REPUBLIKU SRBIJU



Oplemenjivanje suncokreta



Univerzitet u Novom Sadu, Poljoprivredni fakultet
23.11.2022.

DR SANDRA CVEJIĆ

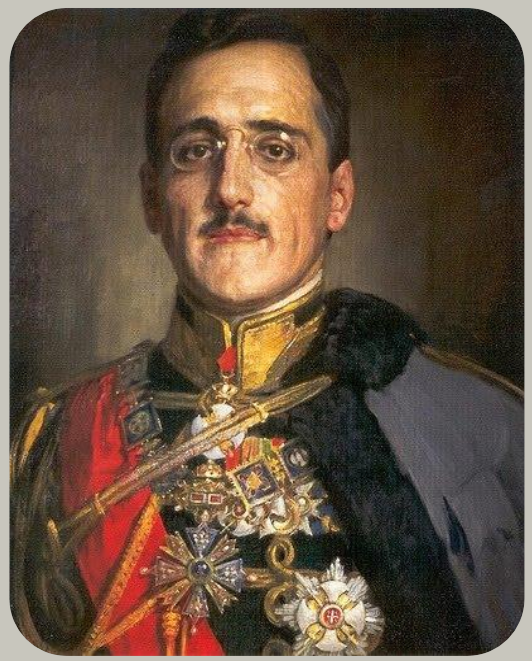
OSNIVANJE

1938.

Poljoprivredna ogledna i kontrolna stanica



Zgrada Instituta 1938.



Kralj Aleksandar I od Jugoslavije

2018.

Institut od nacionalnog značaja
Najveći u jugoistočnoj Evropi!

Institut je u vlasništvu republike Srbije

Finansiranje Instituta:

Institutska sredstva

96% iz sopstvenih izvora!!!

Ministarstvo prosvete, nauke i tehnološkog razvoja R. Srbije

Ministarstvo poljoprivrede, vodoprivrede i šumarstva R. Srbije

Pokrajinski sekretarijat za visoko obrazovanje i naučnoistraživačku delatnost Vojvodine

Pokrajinski sekretarijat za poljoprivredu, vodoprivredu i šumarstvo Vojvodine

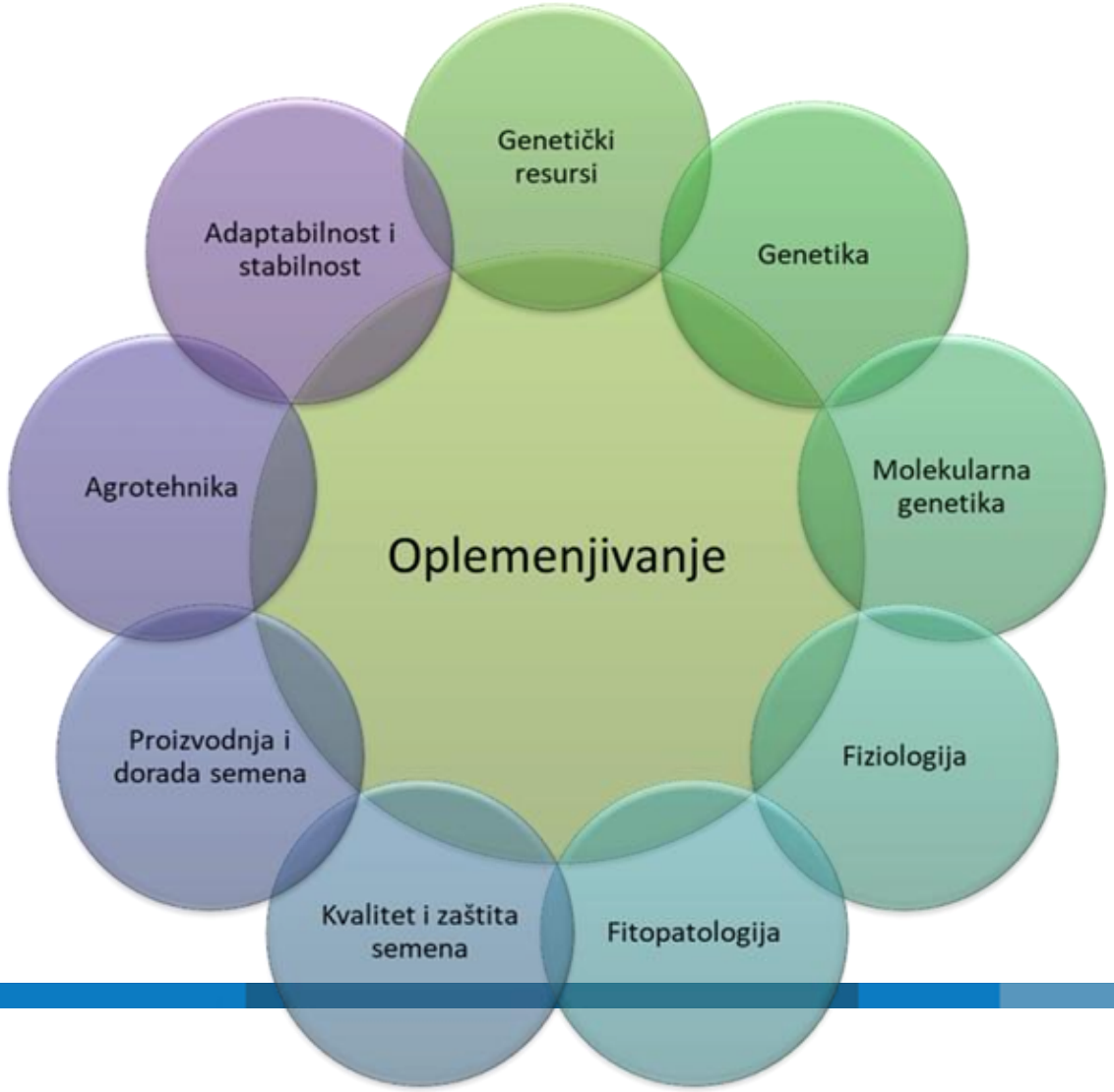
Naučni institut

Semenska kompanija





OBLASTI ISTRAŽIVANJA



504 ZAPOSLENIH, OD TOGA 96 NAUČNIH RADNIKA!

Research Assistant
9

Research Associate
24

Senior Research Associate
24

Principal Research Fellow
33

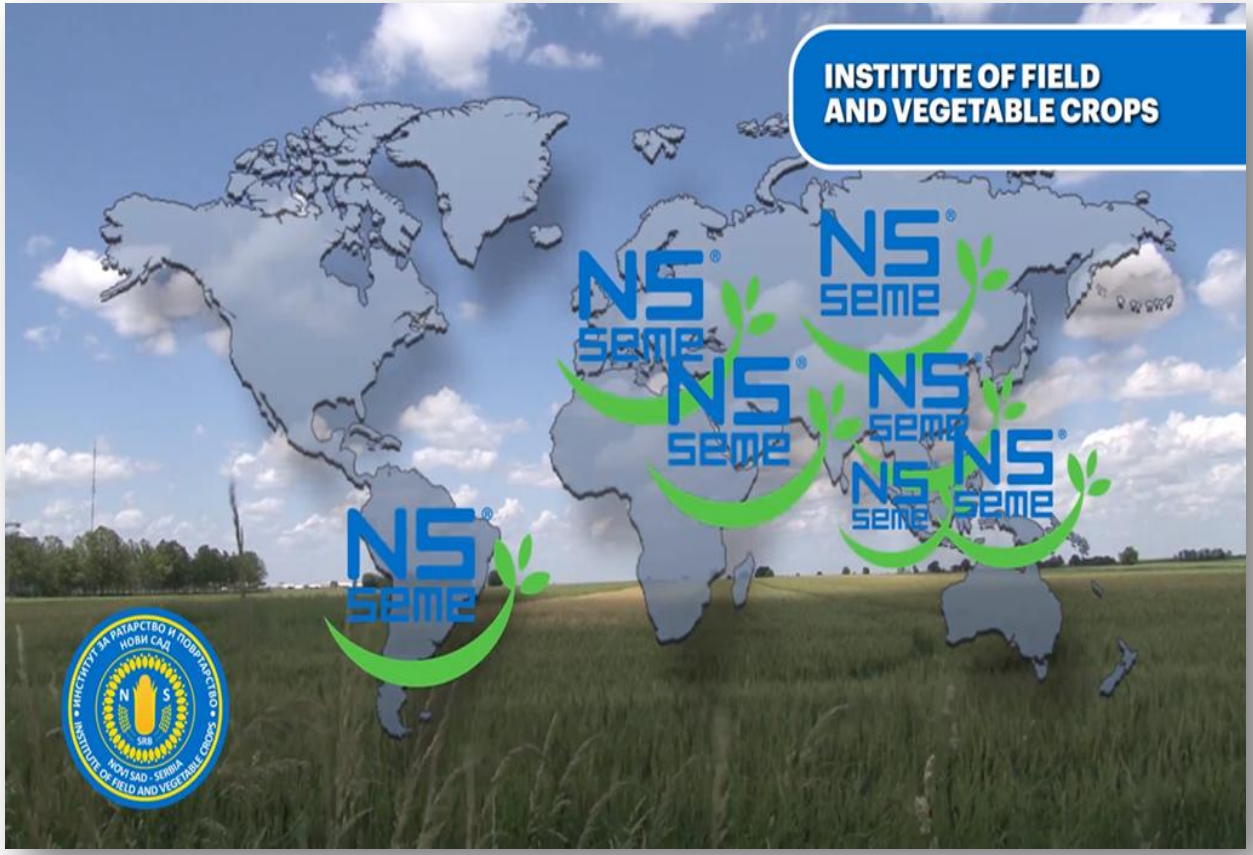
Research trainee
6





Naučna i komercijalna saradnja u celom svetu!

- ALBANIA
- ARGENTINA
- AUSTRIA
- BELARUS
- BULGARIA
- CANADA
- CHINA
- CROATIA
- CZECH REPUBLIC
- ENGLAND
- FRANCE
- MACEDONIA
- GREECE
- HUNGARY
- INDIA
- IRAN
- ITALY
- MOLDAVIA
- PORTUGAL
- ROMANIA
- RUSSIA
- SLOVAKIA
- SLOVENIA
- SPAIN
- SWITZERLAND
- TURKEY
- UKRAINE



Stvoreno preko 1400 sorata i hibrida u 26 zemalja sveta

Dani polja Instituta

Dani polja strnih žita, krmnog bilja i uljane repice



Dani polja prolećnih kultura (kukuruz, suncokret, soja…)



ORGANIZACIONA STRUKTURA

ODELJENJA



Strna žita



Kukuruz



Suncokret



Leguminoze



Povrće i alternativne kulture

ODSECI



Šećerna repa



Uljana repica

LABORATORIJE



Laboratorija za ispitivanje semena



Laboratorija za zemljište i agroekologiju



Laboratorija za biotehnologiju

ODELJENJE ZA SUNCOKRET

www.nsseme.com

NS program oplemenjivanja suncokreta istorijat

- Institut za ratarstvo i povrtarstvo iz Novog Sada je osnovan 1938.
- Odeljenje za suncokret (kasnije Zavod za uljane kulture) osnovan 01.01.1962.
- Prva stvorena sorta suncokreta Novosadski 4 (1948) a poslednje Novosadski 20, Novosadski 61 (1976)
- Prvi NS hibridi suncokreta registrovani 1978. (među prvima u svetu!)







NS SUNCOKRET

PRVI STVORENI U NOVOM SADU

- Hibridi suncokreta u svetu
- Izvor otpornosti na *Phomopsis*
- Clearfield hibrid u Evropi
- SUMO hibrid u Srbiji



Danas je NS program jedan od najvećih oplemenjivačkih programa suncokreta u svetu





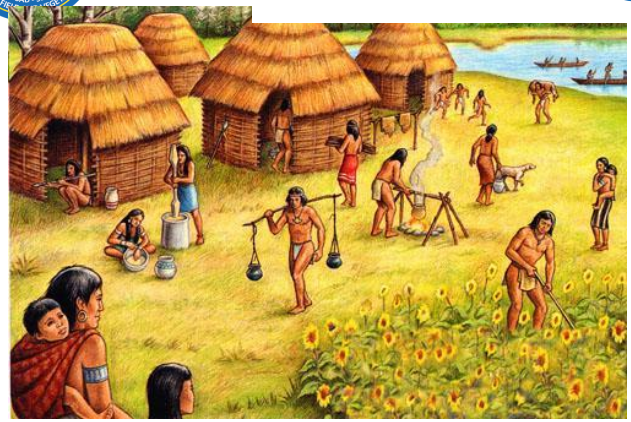


Istorija gajenja suncokreta

- Vodi poreklo iz Severne Amerike (2300 pne)
- Španski moreplovci preneli u Evropu (14. veku) (*Helianthus*-cvet sunca)
- U Rusiji počela da se koristi kao industrijska biljka (sredinom 18. veka)
- Raširila se po Balkanu (u 19. veku)

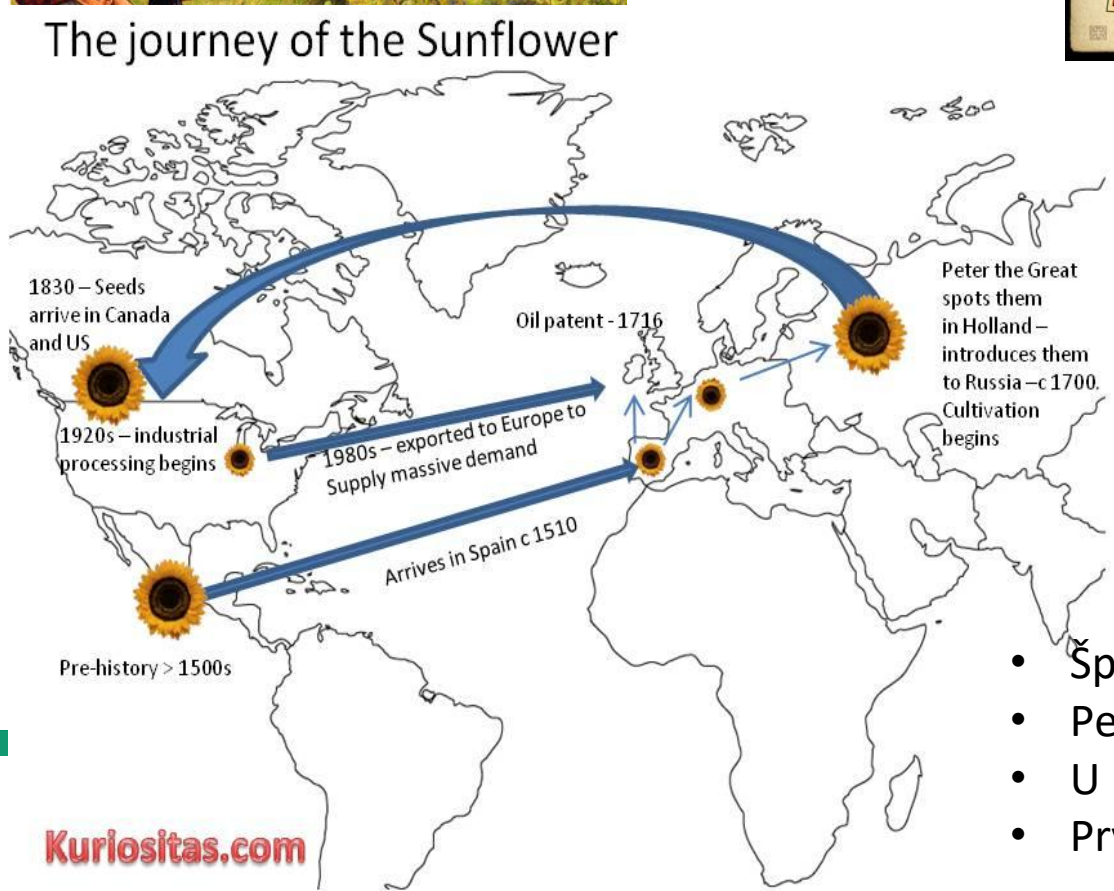


Istorija gajenja suncokreta



Prvi dokazi o gajenju suncokreta datiraju 2600 p.n.e.





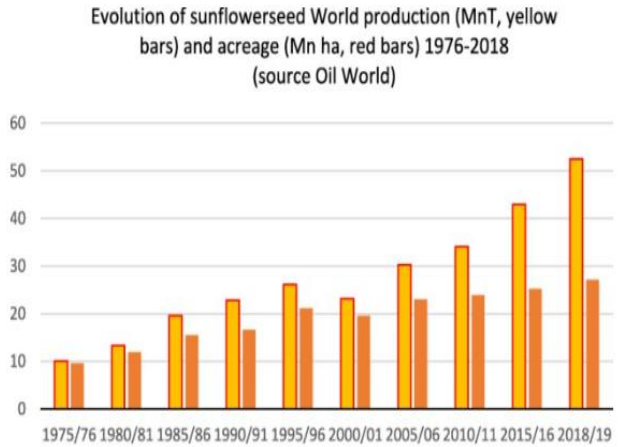


Anthony van Dyck – autoportret sa suncokretom 1632.

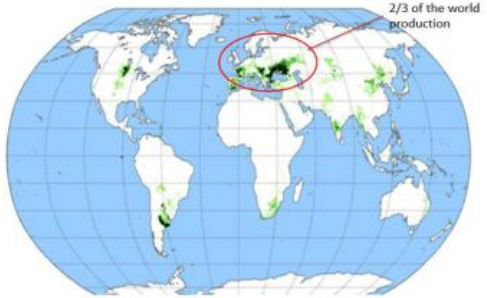
- Španci ga doneli iz Amerike 1510.
- Petar Veliki ga doneo u Rusiju 1700.
- U Rusiji kao uljana biljka od 1818.
- Prve stvorene sorte u Rusiji 1912.

Rasprostranjenost

- Suncokret je četvrta po važnosti uljarica u svetu, uglavnom se gaji u umerenim, polusuvim regionima.
- Gaji se na preko 27 miliona hektara (FAO 2017). Projekcije OECD-FAO Agricultural Outlook 2021-2031 su da će se površina suncokreta u EU povećati do 4,5 miliona ha.
- Najveći proizvođači: Rusija, Ukrajina, Argentina, Kina, Rumunija, Francuska...





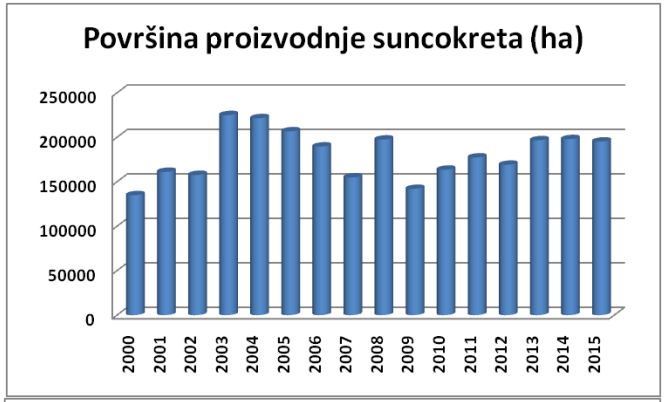


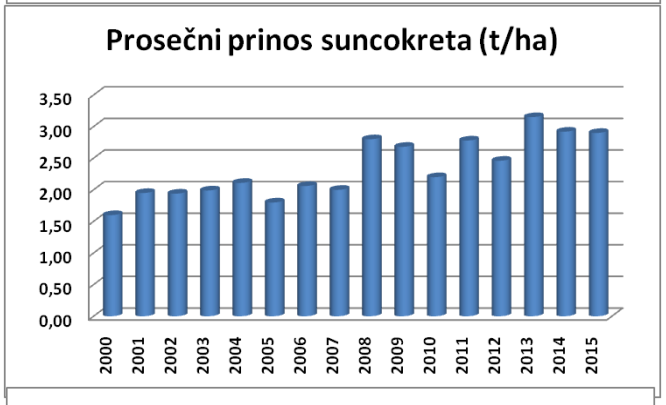
Pilorgé E. 2020. Sunflower in the global vegetable oil system: situation, specificities and perspectives. OCL 27: 34.

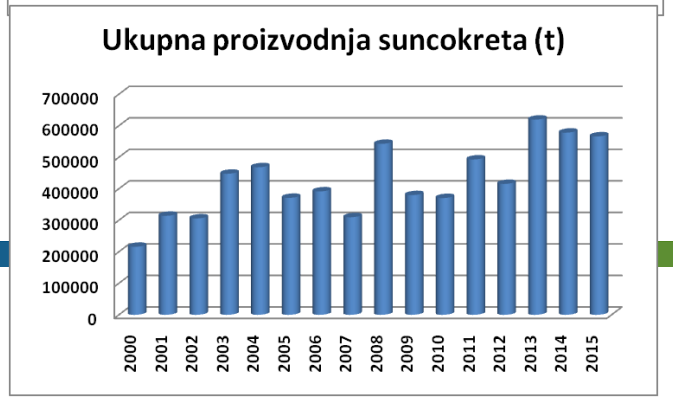
Proizvodnja suncokreta u Srbiji

- Najvažnija uljana kultura u Srbija (85% biljnih ulja potiče od suncokreta)
- Površine u Srbiji 150-220 000 ha
- Prosečan prinos (2006-2020.) = 2,43 t/ha









Taksonomija

- Fam. *Composite* (*Asteraceae*)
- Rod. *Helianthus*

  14 jednogodišnjih

  37 višegodišnjih
- Vrsta. *Helianthus annuus* L.

  kulturni suncokret









Botanika

- Cvetovi skupljeni u cvast – glavicu
- Plod: ahenija (jezgro (75%) + ljuska)
- Jednogodišnja jara kultura
- Fotoperiodizam: neutralna
- Heliotropna
- Dobro razvijen korenov sistem
- Visoke performanse fotosinteze - C3-fotosinteza, 40-50 mg CO_2/dm2 površine lista na sat,do 200 kg/ha suve materije dnevno, koeficijent transpiracije cca. 600 l/kg suve materije.







Biologija cvasti

- Cvast:

Jezičasti cvetovi (sterilni, na obodu)

Trubasti cvetovi (fertilni, u spirali, od 600-4000 u glavici)

- Formiranje cvasti počinje u fazi 5-7 pari listova

Izrazito stranooplodna biljka



1 – žig; 2 – pet sraslih prašnika; 3 – pet sraslih kruničnih listića, 4 – nektarski prsten; 5 – plodnik; 6 – čašični listići; 7 – brakteje; 8 – stubić tučka; 9 – polenova zrnca.

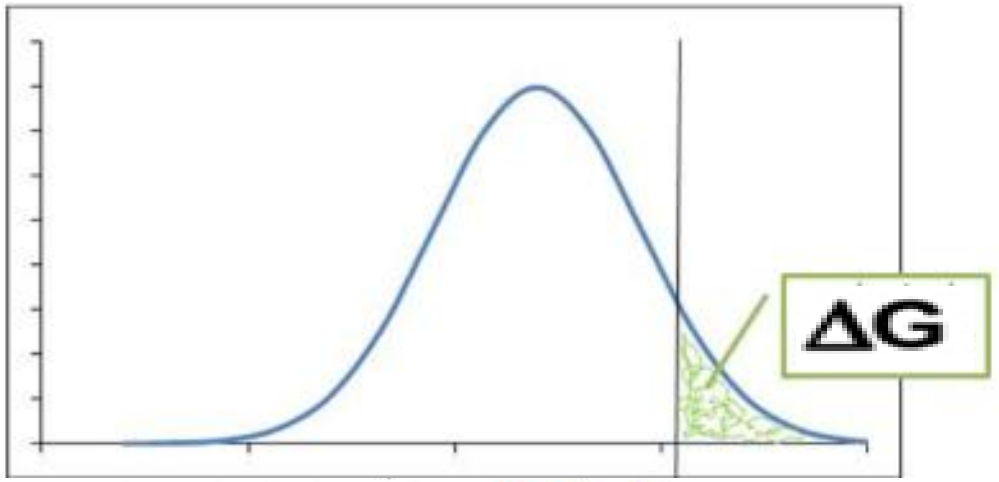
Oplemenjivanje suncokreta

- rad na stvaranju novih i poboljšanju postojećih sorti (hibrida) suncokreta.
- ciljevi: povećanje produktivnosti, kvaliteta i drugih osobina komercijalne vrednosti.
- razvojem i primenom biotehnologije uspostavili su se novi alati za stvaranje i razvoja novih sorti.
- molekularno oplemenjivanje je trenutno standardna praksa kod mnogih rataskih kultura.



Genetska dobit od selekcije

Dobit usled povećanja performansi kvantitativnih osobina koji se ostvaruje godišnje kroz selekciju.



$$\text{Genetic Gain} = \Delta G = h^2 \, \sigma_P \, i / L$$

h^2 → heritability

σ_P → phenotypic variability in population

i → Selection Intensity: proportion of population selected to produce the next generation

L → length of cycle interval (usually 1 generation)

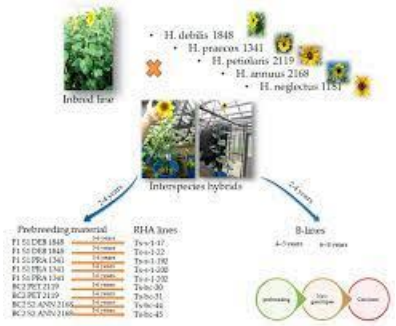
$$\frac{\sigma^2_{Genotype} - \sigma^2_{Dominance} - \sigma^2_{Epistasis}}{\sigma^2_{Genotype} + \sigma^2_{Environment} + \sigma^2_{GxE} + \sigma^2_{error}} = \frac{\sigma^2_{Additive}}{\sigma^2_P}$$

Moose and Mumm, 2008

Koraci u oplemenjivanju

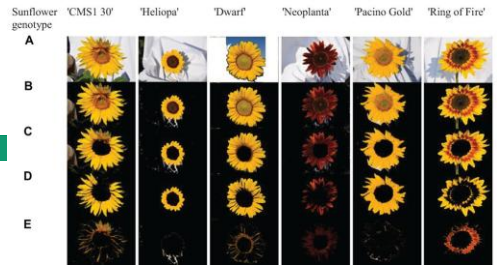


Izvori varijabilnosti (sorte, linije, indukovane mutacije, divlji srodnici...)



Metodi oplemenjivanja

Analiza svojstva (fenotipizacija)



Odabir genotipova

Genetska varijabilnost suncokreta

- Uska genetska varijabilnost kulturnog suncokreta
- Deficit u poželjnim genima



Povećanje genetske varijabilnosti:

- Gen banke iz drugih instituta
- Sorte
- „Target crossings“
- Mutacije



NEW GENETIC VARIABILITY IN SUNFLOWER INBRED LINES CREATED BY MUTAGENESIS

ABSTRACT

The challenges of maintaining a collection of wild sunflower (*Helianthus*) species

Scientia Horticulturae

Genetic variability for concentrations of essential elements in tubers and leaves of Jerusalem artichoke (*Helianthus tuberosus* L.)

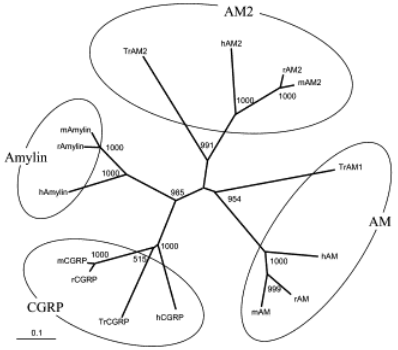
Genetski resursi

- Divlji srodnici
- Interspecies hibridi
- Sorte
- „Public lines“
- Inbred linije drugih instituta
- Populacije
- Mutacije









Kolekcija divljih vrsta suncokreta

Najveća kolekcija u Europi!!!

21 višegodišnja vrsta
7 jednogodišnjih vrsta
Preko 500 populacija
Sakupljene uglavnom u SAD





Gene pool gajenog suncokreta

- Ukupno 7000 inbred linija, razvijenih u IFVCNS
- Selekcioni napori su tradicionalno bili fokusirani na prinos semena i komponente prinosa, otpornost na bolesti, ranu zrelost, kvalitet ulja...
- Međunarodno poreklo – Rusija, Francuska, Rumunija...



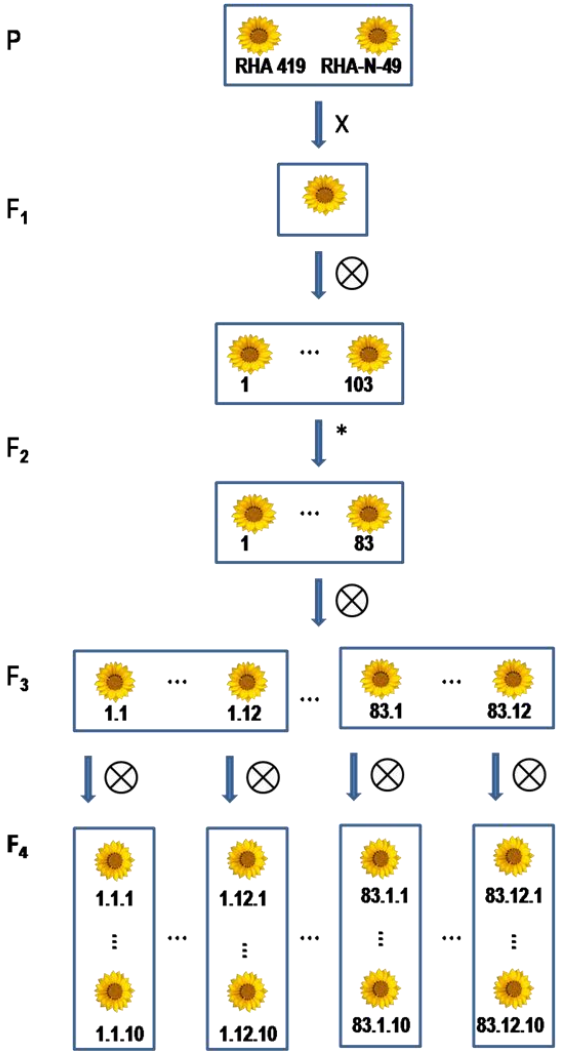


Target crossing

Biparental populations

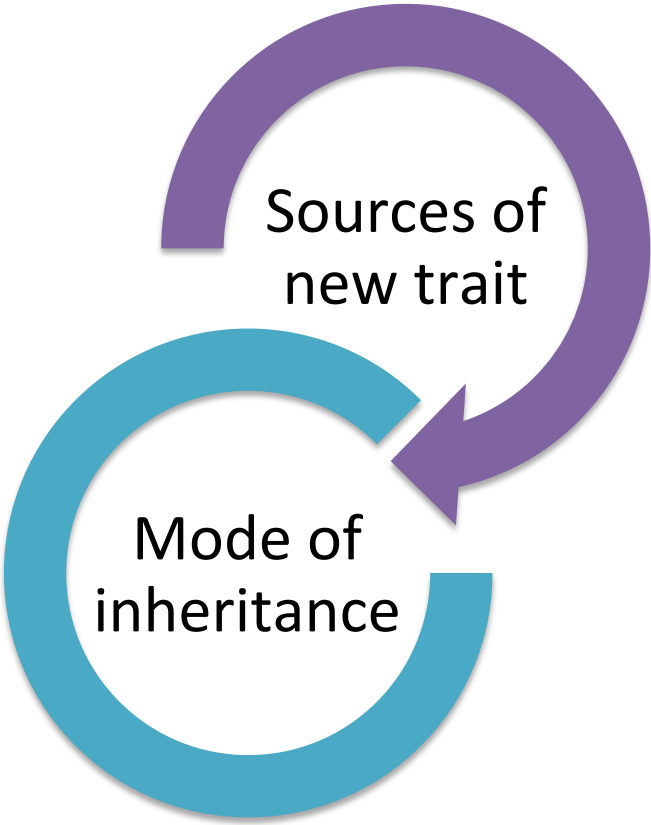
- Elite x elite
- Elite x donor





Prioritetne grupe

- Elite inbred lines
- Inbred line gene pool
- Interspecies gene pools
- Wild species

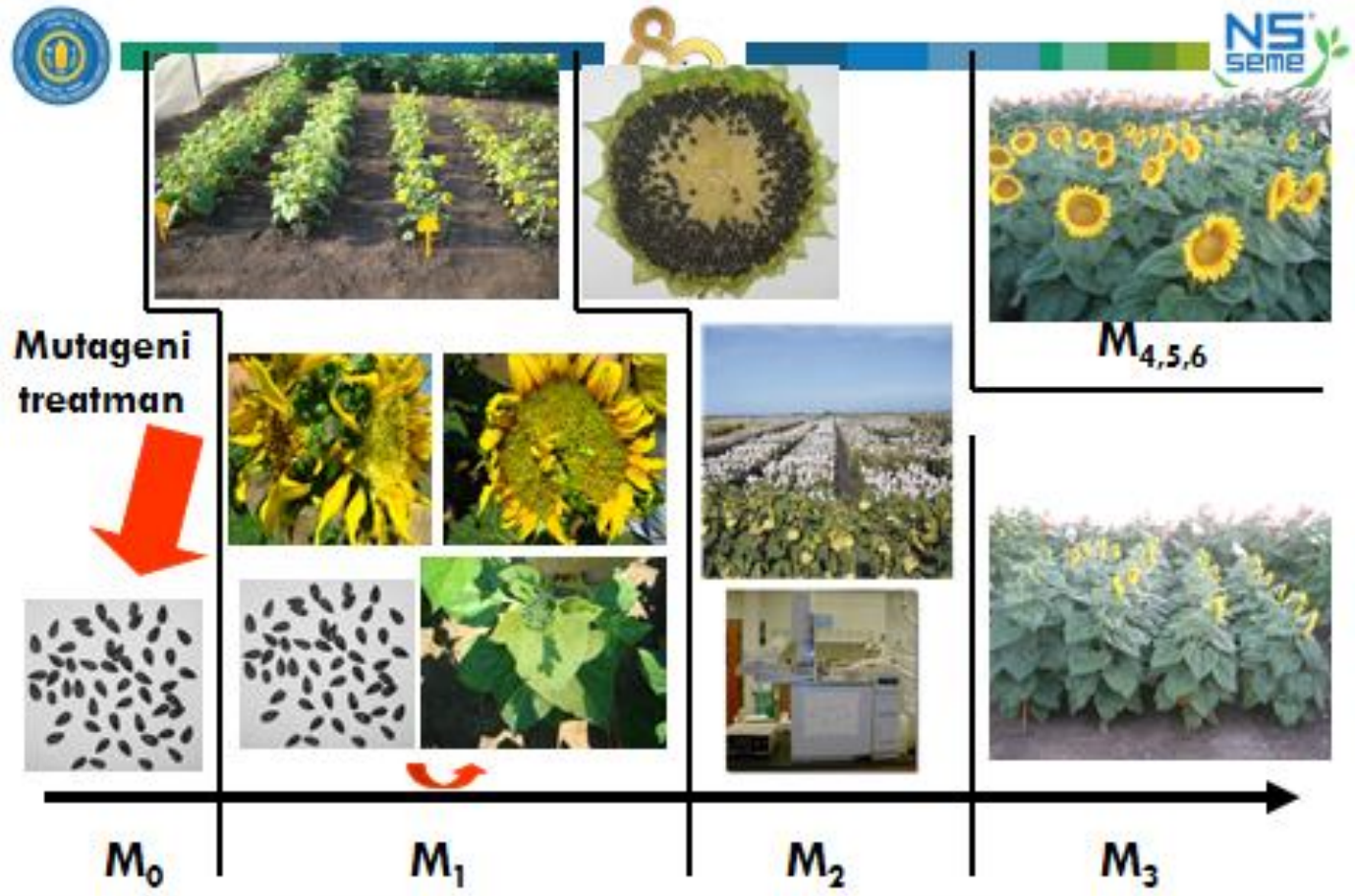


Mutacije

- nasledne promene u genetičkom materijalu koje su izazvane različitim hemijskim ili fizičkim sredstvima
- mutaciono oplemenjivanje (mutation breeding)
- makromutacije i mikromutacije
- genetske mutacije (gene mutation, point mutation) i hromozomske mutacije
- mutagena sredstva (mutagensi) - fizička (X, γ, neutroni...)

  - hemijska (ems, dms, sa)
- analize pojave mutacija; od fenotipa do gena (Forward genetics) ili od gena do fenotipa (Reverse genetics)

Mutacije



Mutacije

Early flowering

	Earliness (days)	Plant height (cm)	Head diameter (cm)	Seed yield (g)	Oil content (%)	Oil yield (g)
L3	63.00(±0.18)	122.45(±0.34)	16.57(±0.45)	17.90(±0.23)	35.41(±0.56)	6.38(±0.17)
RANI-1	57.33**(±0.38)	123.84(±0.33)	16.28(±0.09)	14.38(±0.49)	37.00(±0.26)	5.30(±0.14)



High statue mutant



	Earliness (days)	Plant height (cm)	Head diameter (cm)	Seed yield (g)	Oil content (%)	Oil yield (g)
R3	55.33(±0.28)	47.20(±0.62)	6.70(±0.07)	15.13(±0.06)	41.43(±0.28)	6.27(±0.06)
VISOKI-2	65.33**(±0.28)	73.51**(±0.52)	9.14**(±0.08)	20.48**(±0.27)	37.50(±0.43)	7.68(±0.15)

Short statue mutants



	Earliness (days)	Plant height (cm)	Head diameter (cm)	Seed yield (g)	Oil content (%)	Oil yield (g)
L2	75.33(±0.38)	160.43(±0.14)	17.08(±0.04)	33.48(±0.08)	36.78(±0.09)	12.31(±0.05)
NISKI-5	74.67(±28)	146.59**(±0.23)	14.49*(±0.19)	36.99**(±0.13)	37.37(±0.27)	13.83(±0.14)
R1	72.33(±0.28)	109.20(±0.56)	12.59(±0.06)	19.47(±0.61)	49.20(±0.15)	9.59(±0.32)
NISKI-9	63.67**(±0.42)	97.93*(±0.61)	11.48*(±0.07)	19.70(±0.16)	48.19(±0.17)	9.49(±0.05)

Branching mutant



Oil quality

Mutant	Alteration	Wild type	Treatment
MU-1	Mid-oleic	V-8931	*ems* 0,25 %
MU-2	Mid-oleic	V-8931	γ 80 Gy
MU-4	Higher content of saturated fatty acid	RHA-SEL	N_f 3 Gy
MU-6	Higher content of stearic fa	RHA-R-27	γ 150 Gy

Mutants with higher oil content

	Earliness (days)	Plant height (cm)	Head diameter (cm)	Seed yield (g)	Oil content (%)	Oil yield (g)
L1	72.33(±0.33)	99.60(±0.74)	17.18(±0.21)	24.67(±0.05)	44.62(±0.36)	9.78(±0.11)
MUL-3	69.00(±0.48)	92.75(±0.29)	16.49(±0.04)	25.06(±0.32)	48.69**(±0.20)	10.69(±0.14)
R2	73.67(±0.28)	126.63(±0.15)	12.97(±0.10)	23.41(±0.25)	35.97(±0.15)	8.41(±0.06)
MURF-7	74.33(±0.11)	102.23**(±0.62)	10.88*(±0.14)	22.55(±0.24)	46.13**(±0.29)	10.40*(±0.14)



Sorte

Increasing the genetic variability using open pollinated varieties

Some of the most popular Russian varieties:

Zelenka

Kruglik A-41

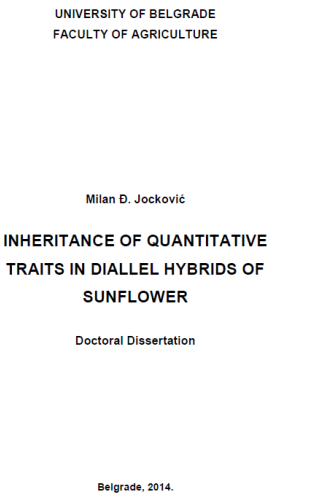
Ždanovski 8281

Peredovik

Armavirski 3497

Seed yield
Oil content




UNIVERSITY OF BELGRADE
FACULTY OF AGRICULTURE

Milan Đ. Jocković

INHERITANCE OF QUANTITATIVE TRAITS IN DIALLEL HYBRIDS OF SUNFLOWER

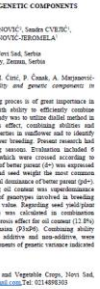
Doctoral Dissertation

Belgrade, 2014.


original scientific paper/ originalni naučni članak

Gene Effects and Combining Abilities for Oil Content in Sunflower

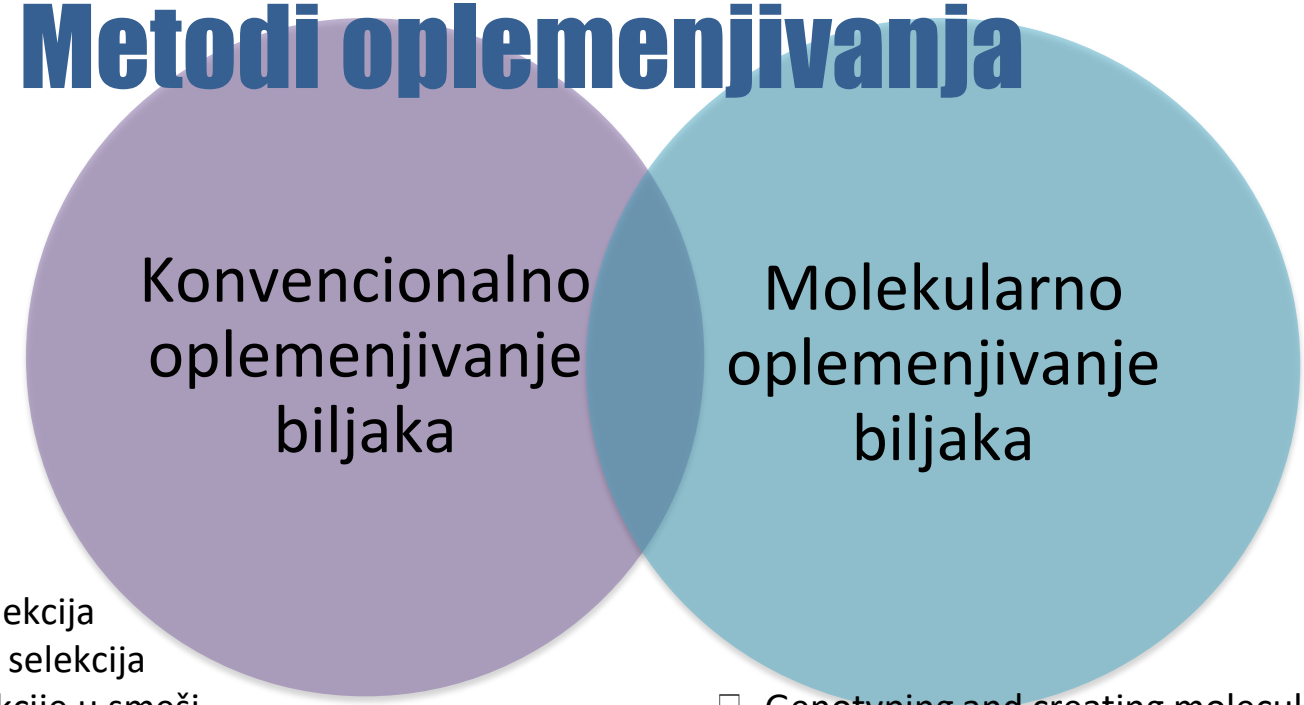



VALUATION OF COMBINING ABILITY AND GENETIC COMPONENTS IN SUNFLOWER

- Azovski – used as a gene donor for broomrape resistance
- Kazački – mid height, strong stem – tolerant to lodging
- Harkovski – short stem, high seed yield, Or5
- Lider – oil content >50%, resistant to Fusarium sp.
- Rodnik – drought tolerance, still in production (VNIIMK)
- Amaian 444 – tolerant to lodging

Jocković M. 2015. Inheritance of quantitative traits in diallel hybrids of sunflower. Doctoral dissertation, Faculty of agriculture, University of Belgrade.

Metodi oplemenjivanja



- ❑ Masovna selekcija
- ❑ Individualna selekcija
- ☐ Metod selekcije u smeši
- ☐ Pedigre metod
- ☐ Metod potomstva jednog semena
- ☐ Metod povratnog ukrštanja

- Za stvaranje sorti
- Za stvaranje hibrida
- Za stvaranje nove varijabilnosti
- Za poboljšanje populacija

- ☐ Genotyping and creating molecular maps - genomics
- ☐ Phenotyping - phenomics
- ☐ Marker assisted selection (MAS)
- ☐ QTL mapping or association mapping
- ☐ Genomic selection (GS)
- ☐ Genome editing

Gregor Mendel

„otac genetike“
1822 - 1884.



200 година Менделовог рођења

150 година Менделових правила (2016)



Mendelovi zakoni: primena

1. Mendelovo pravilo

F_1: Uniformnost **=> F1-hibridi**

2. Mendelovo pravilo

F_2: Razdvajanje gena **=> Mogućnost ranog odabira**

3. Mendelovo pravilo

F_2: Slobodno kombinovanje **=> Kombinaciono oplemenjivanje**

gmgw Gregor Mendel Gesellschaft Wien
Gregor Mendel Society of Vienna
http://gregormendelgesellschaft.at

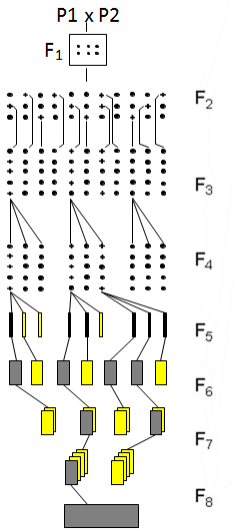
Celebrations of 200th anniversary of G. J. Mendel' s birth [*20th July 1822]
https://www.mendel22.cz/

Stvaranje hibrida suncokreta

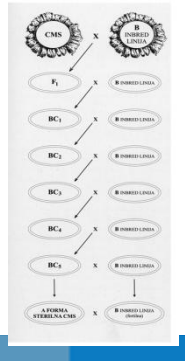
Traje 12-15 godina

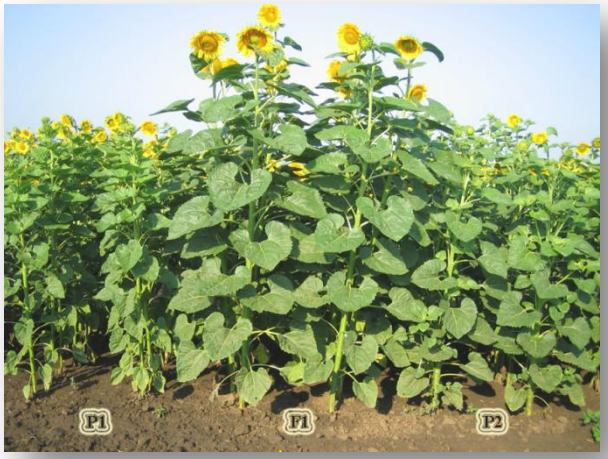
CMS linija

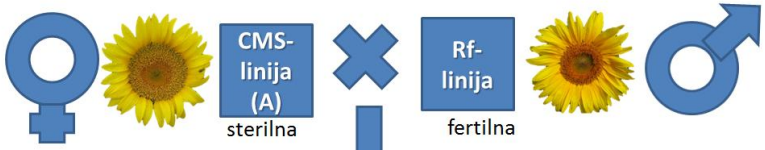
Pedigree method



6-8 generacija
+
6 generacija
unošenje
CMS-a







F1 HIBRID

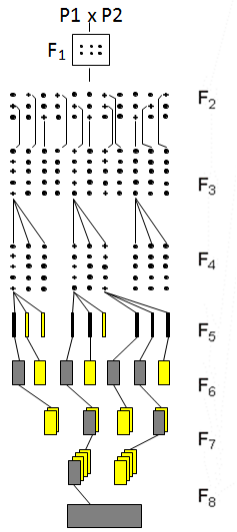
Testiranje kombinacionih sposobnosti
3-4 godine

Registracija hibrida

Rf linija

6-8 generacija

Pedigree method



Stvaranje hibrida

- Koristi se fenomen heterozisa (hibridna snaga F1 generacije)
- Prvi registrovani hibridi u Rumuniji, Jugoslaviji i Francuskoj
- Majka mora imati ugrađenu CMS a otac gen za restauraciju fertilnosti

Prednost hibrida nad sortama ogleda se u iskorišćavanju fenomena heterozisa (bujnost F_1 generacije), većim genetskim potencijalom za prinos semena, lakšem unošenju gena za otpornost prema bolestima, većoj uniformnosti useva što omogućava lakše kombajniranje i dobijanje semena jednake vlažnosti i podesnijeg za čuvanje.


P1
F1
P2

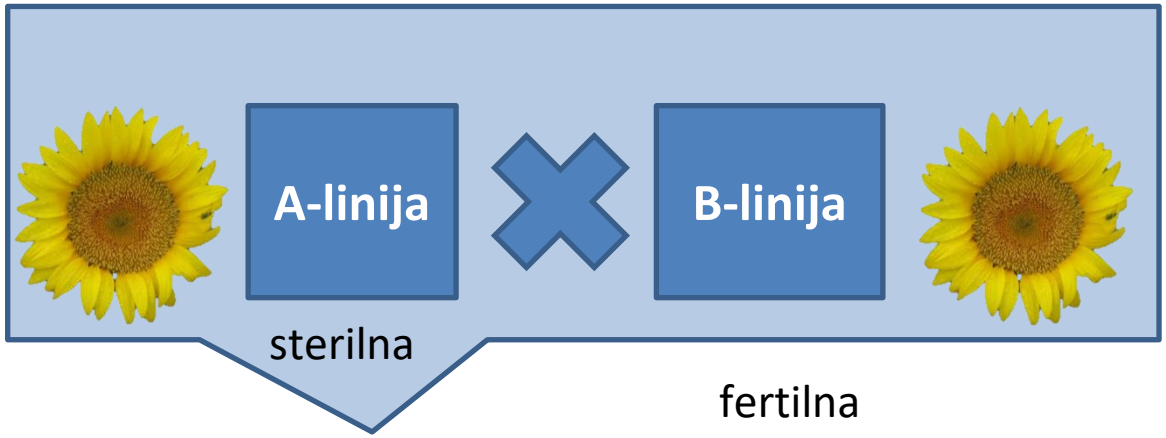
Muška sterilnost

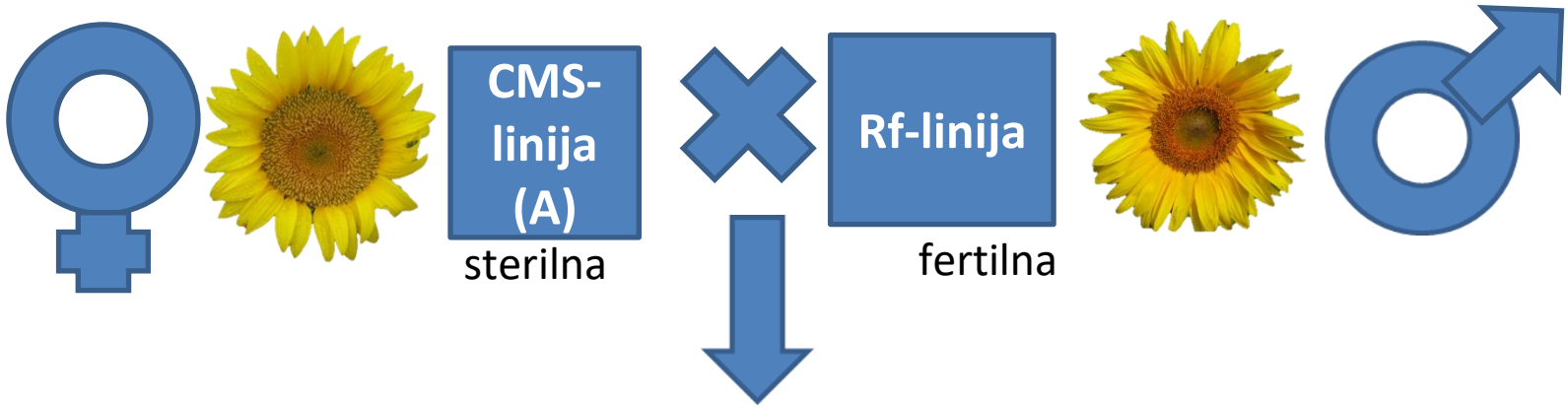
- Omogućeno otkrivanjem izvora CMS-a iz divljeg suncokreta
- PET1: CMS iz ukrštanja sa *H. petiolaris* (Leclercq, 1969).



Fertilna i sterilna linija

Stvaranje hibrida





F1

HIBRID

Stvaranje inbred linija

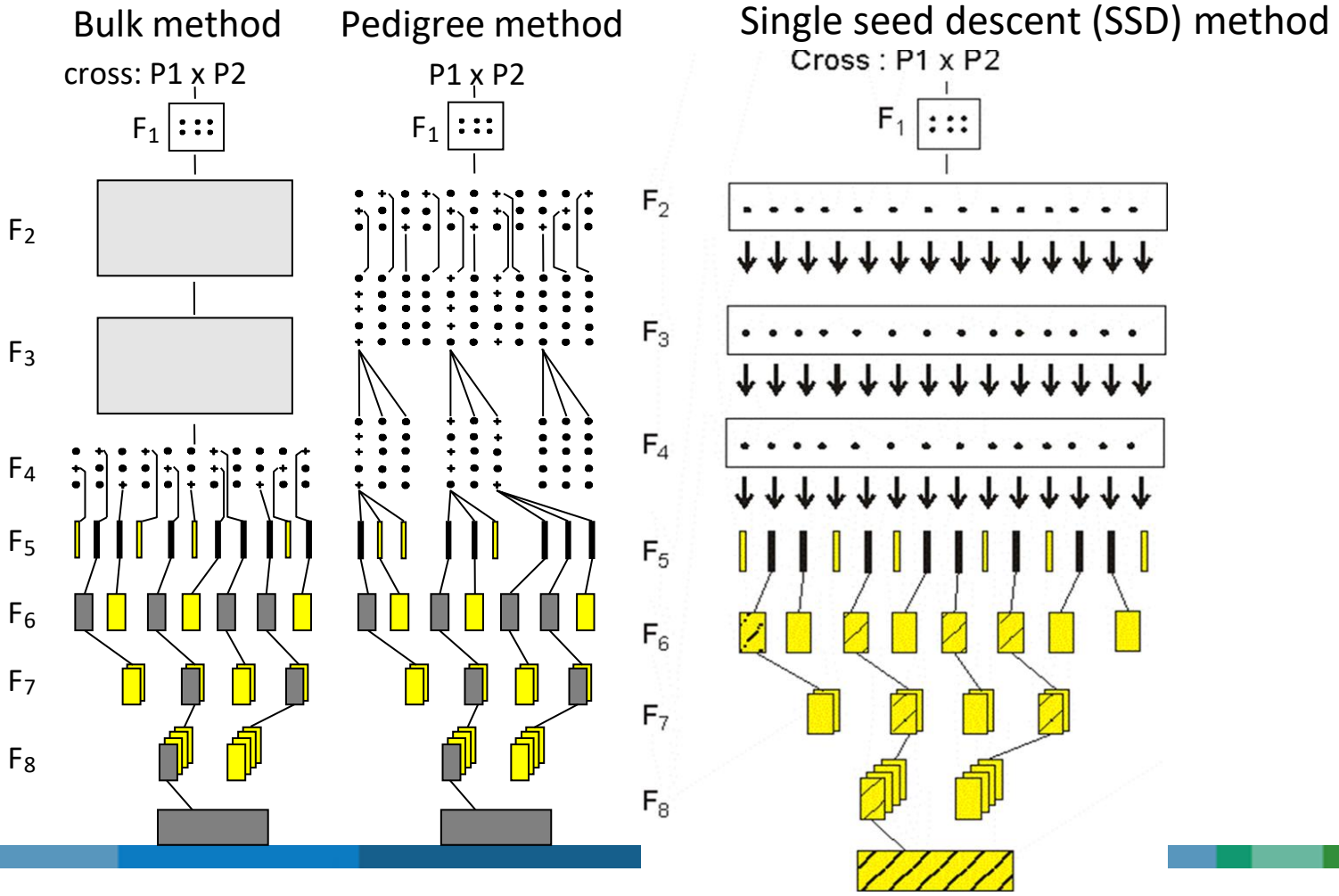
Početni materijal:
Populacije, sorte, dve ukrštene linije (target crossing)....

Inbred depresija: prinos semena (40-60%), visina biljke idr.

Pedigre metod selekcije: samooplodnja, individualna selekcija biljaka za agronomska svojstva, otpornost..., ponavlja se proces 4-5 generacija.
SSD metod
Bulk metod



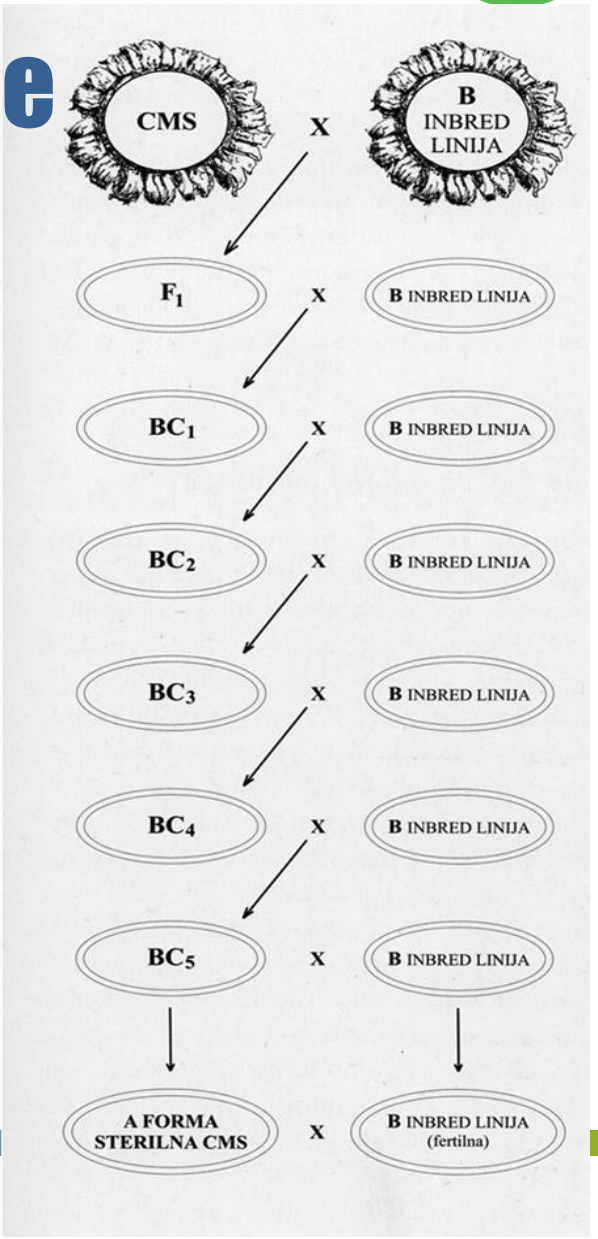
Stvaranje inbred linija



Transfer CMS-a u inbred linije

Metod povrathih ukrštanja:
Donor CMS je već poznata sterilna linija koja se ukršta sa novostvorenom inbred linijom, nakon 5 povratnih ukrštanja 98% gena novostvorene inbred linije se povrati

Restorer transfer:
U liniju oca se unost gen restauracije fertilnosti serijom povratnih ukrštanja. Testira se ukrštanjem sa CMS linijom (potomstvo mora biti fertilno).
Restorer linije se granate kako bi cvetanje što duže trajalo.



Kombinacione sposobnosti

- opšte OKS
- posebne PKS

Opšta kombinaciona sposobnost predstavlja prosečnu vrednost jednog roditelja (linije) na osnovu njegovog ponašanja u ukrštanjima sa drugim linijama.

Posebna kombinaciona sposobnost je ponašanje roditelja X u ukrštanju sa roditeljem Y. Prosečna vrednost te kombinacije mora da
odstupa od proseka opšte kombinacione sposobnosti tih roditelja u poređenju sa nekim drugim roditeljima

Dialelna ukrštanja

Sample testing scheme					
sterile	R-lines (restorer inbred lines, male fertile pollinators)				
CMS lines	**m**	**n**	**o**	**p**	**q**
a	a x m	a x n	a x o	a x p	a x q
b	b x m	b x n	b x o	b x p	b x q
c	c x m	c x n	c x o	c x p	c x q
d	d x m	d x n	d x o	d x p	d x q

Linija x tester

Multi-lokacijski ogledi

- Svake godine se testira preko 3000 novih hibridnih kombinacija
- Predkomisijski i postkomisijski ogledi



DE GRUYTER HELIA 2015; 38(63): 189–199

Milan Jocković*, Siniša Jocić, Ana Marjanović-Jeromela, Mihajlo Ćirić, Petar Čanak, Vladimir Miklič and Sandra Cvejić

Biomorphological Association and Path Analysis in Sunflower (*Helianthus annuus* L.)

Research Article

Characterization of sunflower testing environments in Serbia

Author's personal copy

Field Crops Research

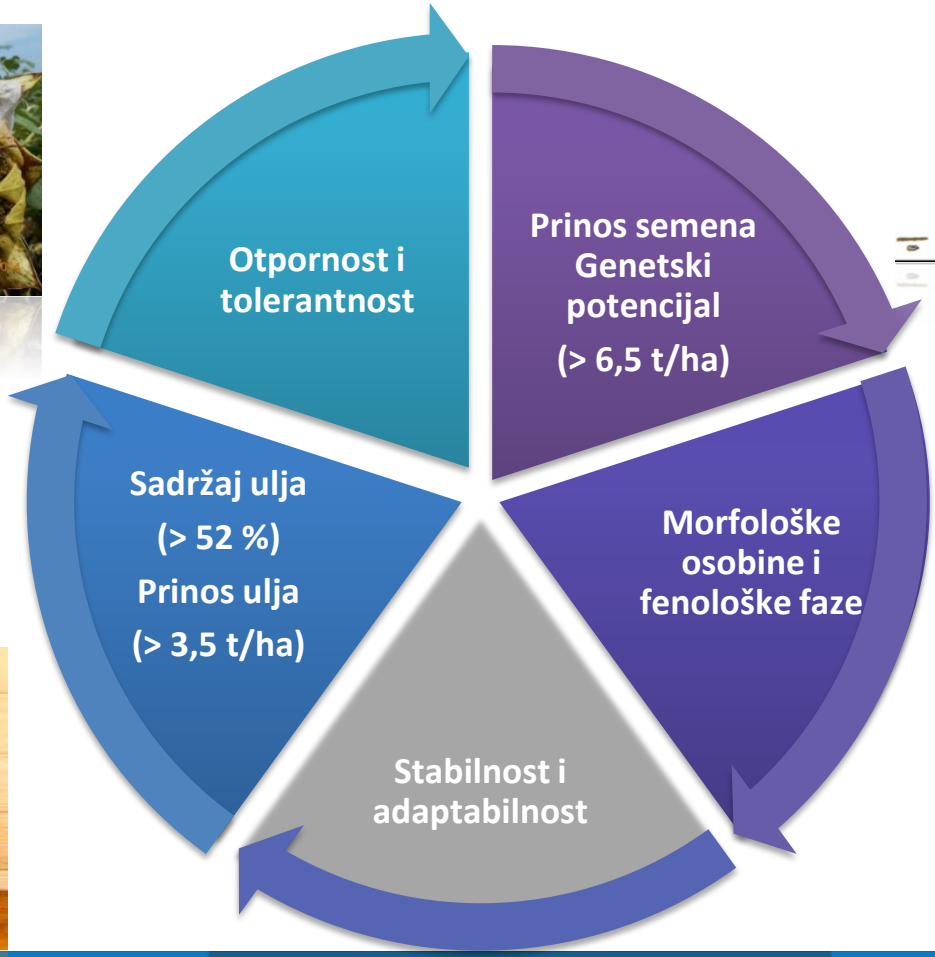
journal homepage: www.elsevier.com/locate/fcr

Interpretation of hybrid × sowing date interaction for oil content and oil yield in sunflower



Ciljevi oplemenjivanja











Oplemenjivanje na povećan prinos semena i ulja

- Prinos semena je bila i ostala najznačanija osobina u oplemenjivanju i proizvodnji suncokreta.
- Prinos semena je složena osobina, poligenog karaktera koje zavisi i od uslova spoljašnje sredine.
- prilikom odabira početnog materijala za stvaranje hibrida sa visokim genetičkim potencijalom za prinos semena i ulja treba imati informacije o načinu nasleđivanja, manifestovanju heterozisa u F_1 generaciji, heritabilnosti i korelacijama sa drugim osobinama
- Zbog važnosti faktora spoljašnje sredine, heritabilnost za prinos semena je relativno mala u odnosu na druge agronomske osobine
- Stvaranje visokoproduktivnih hibrida zavisi od prinosa semena i njegovih komponenti, a to su broj biljaka po jedinici površine (55 – 60 hiljada biljaka po hektaru), broj semena po biljci (preko 1500), masa 1000 semena (preko 80g), hektolitarska masa (45-50 kg), nizak sadržaj ljuske (20-24%). Ako se ove vrednosti postignu dobija se prinos semena od preko 5 tona po hektaru.





Oplemenjivanje na otpornost prema patogenima

- Bolesti predstavljaju limitirajući faktor u proizvodnji suncokreta na svim kontinentima gde se on gaji
- Poznato je da preko 30 različitih patogena napada suncokret i prouzrokuje bolesti koje nanose ekonomske štete
- Veliki problem u oplemenjivanju na otpornost prema bolestima predstavlja postojanje više rasa kod određenih patogena

1. Genetska otpornost:	2. Visok stepen tolerantnosti:
Plasmopara helianthi	***Phomopsis/Diaporthe helianthi***
Puccinia helianthi	***Macrophomina phaseolina***
Verticillium albo-altrum	***Albugo eragopogonis***
Verticillium dahliae	
Erysiphe cichoracearum	
3. Određen stepen tolerantnosti:	**4. Nedovoljna tolerantnosti:**
Sclerotinia sclerotiorum	***Alternaria ssp.***
Phoma macdonaldii	***Rhizopus ssp.***
	Botrytis cinerea etc.

Oplemenjivanje na otpornost prema plamenjači

- Plamenjača je oboljenje suncokreta koje uzrokuje gljiva *Plasmopara halstedii* (Farl.) Berl. et de Toni.
- Do sada identifikovano oko 40 rasa
- Otpornost prema plamenjači je kontrolisana dominantnim genima, označenim kao *Pl* geni (Pl_1-Pl_{20}, Pl_{ARG}), koji obezbeđuju otpornost prema jednoj ili više rasa plamenjače.
- Testiranje se vrši u laboratoriji i poljskim uslovima
- Stvara se veliki broj novih linija i hibrida sa *Pl* genima različitog porekla
- Prevođenje komercijalnih linija u forme otporne na plamenjaču
- MAS za *Pl6* i *Plarg*

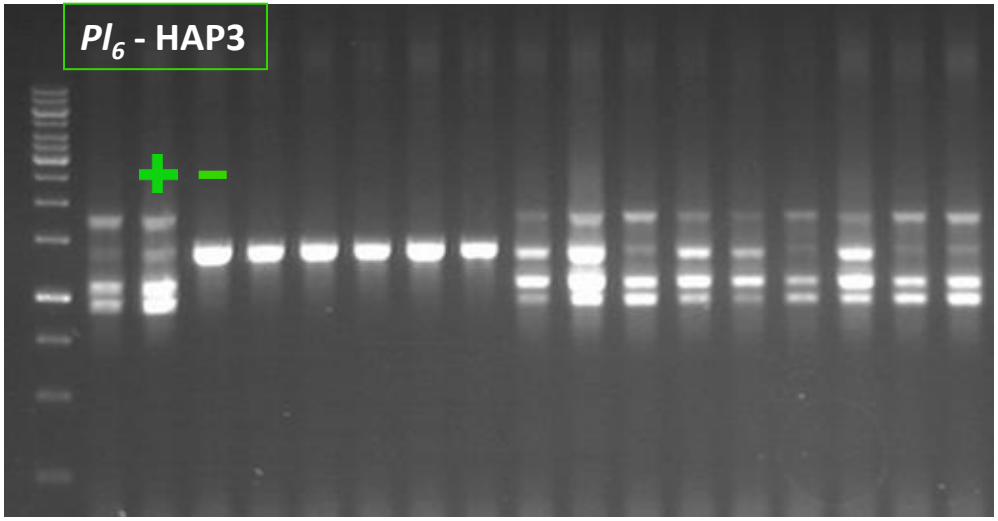


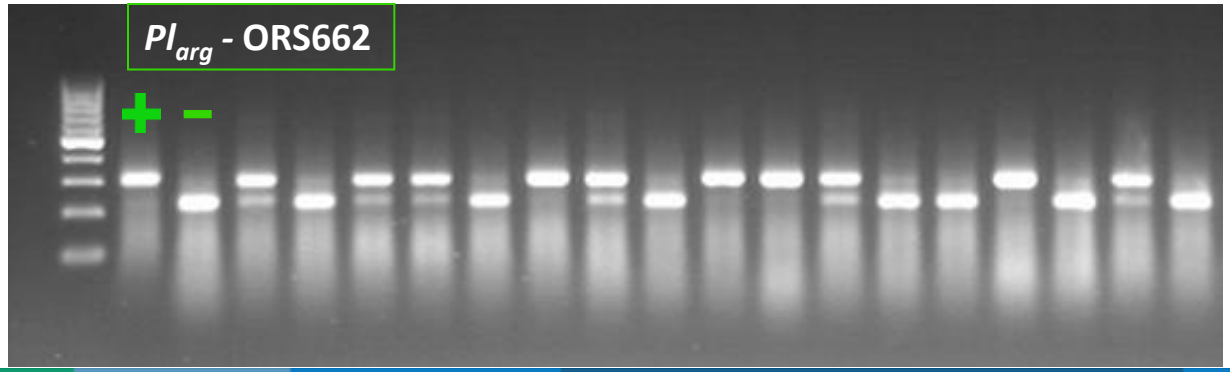






MAS





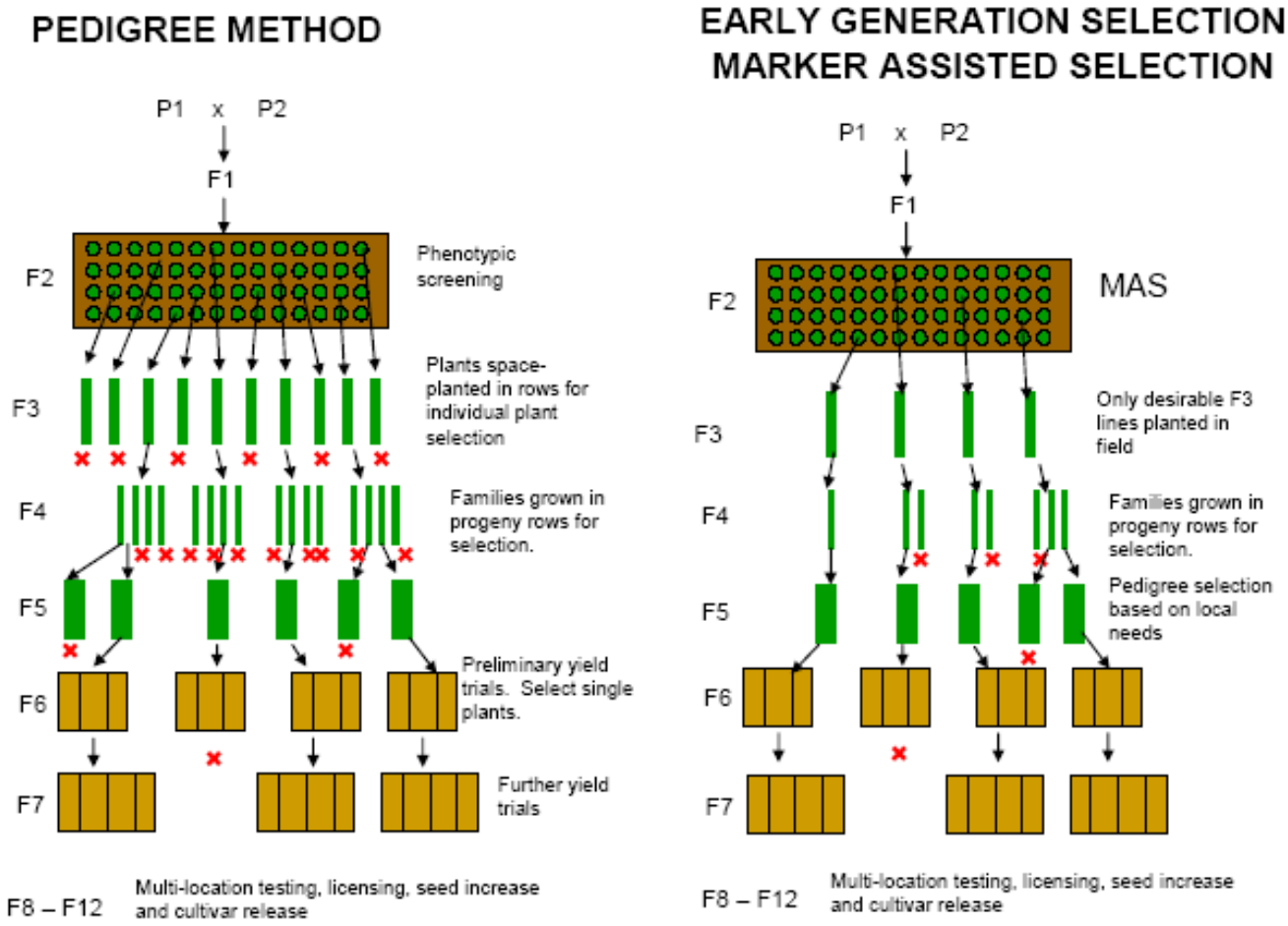




Identification and validation of breeder-friendly DNA markers for Pl_{arg} gene in sunflower

Imerovski et al. (2014) Mol Breeding 34(3):779-788

MAS – identifikacija genotipova sa PI genom

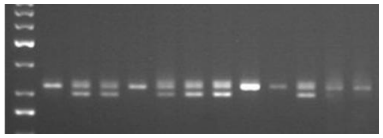


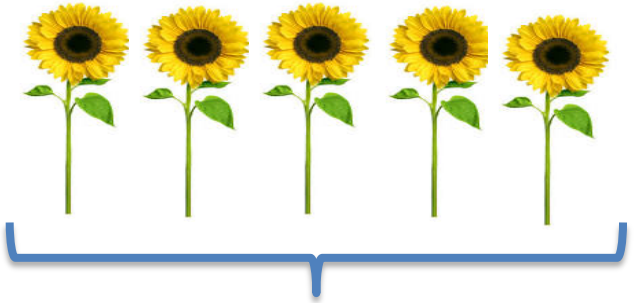
MABC – unošenje Pl gena



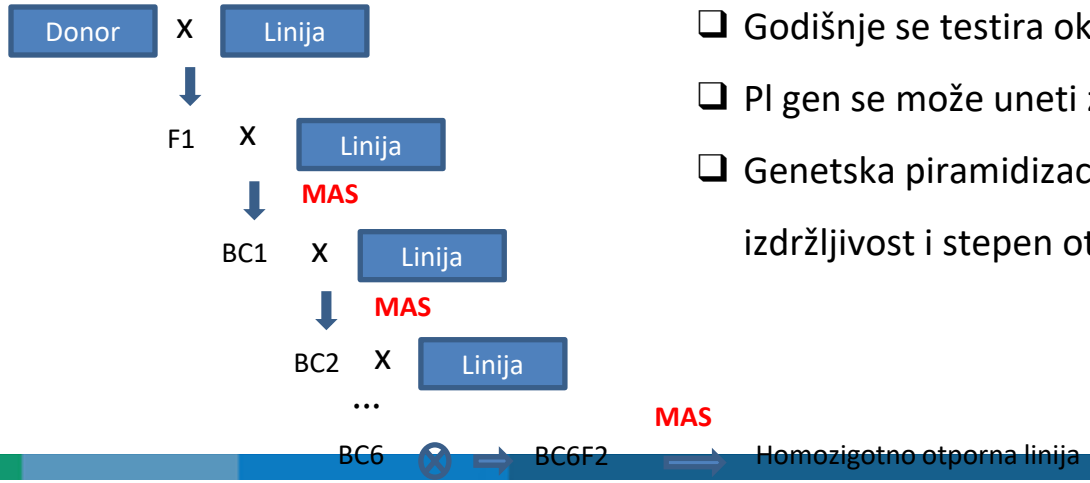
Elitne IFVCNS linije osetljive na plamenjaču

MAS





Homozigotne otporne linije



- Godišnje se testira oko 5000 uzoraka.
- Pl gen se može uneti za 3 godine.
- Genetska piramidizacija pomaže poboljšanje izdržljivost i stepen otpornosti na plamenjaču.

Istraživanja na *Orobanche cumana*

- Parazitska cvetinica - volovod
- Osam rasa (A-H) publikovano
- Otpornost se kontroliše *Or* genima (*Or*$_1$-*Or*$_5$, *Or*$_6$, *Or*$_7$...)



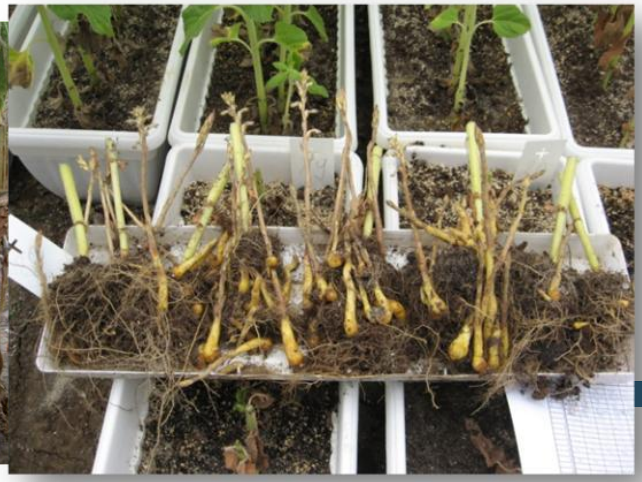


Oplemenjivanje na otpornost na nove rase

- **Testiranje 2011-2022.**
- **Lokaliteti:**
  - **Srbija (Sever Bačke, 2 lokaliteta),**
  - **Rumunija (Crnomorski region, 4 llokaliteta),**
  - **Španija (Andaluzija, 4 lokaliteta),**
  - **Turska (Trakija, 2 lokaliteta),**
  - **Ukrajina (Zaporozhye, 2 lokaliteta),**
  - **Rusija (Rostovska oblast, 2 lokaliteta).**
- **Testirano preko 1500 NS genotipova**







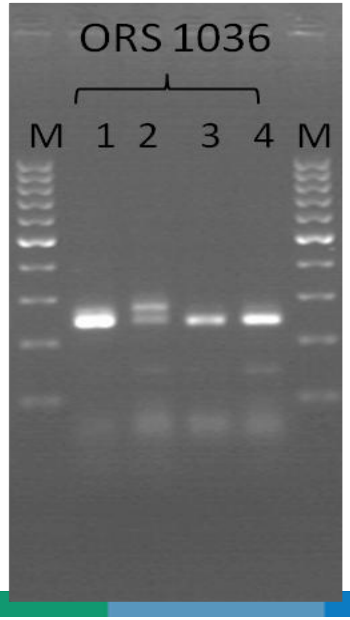
Rezultat: inbred linije otporne na rase preko F

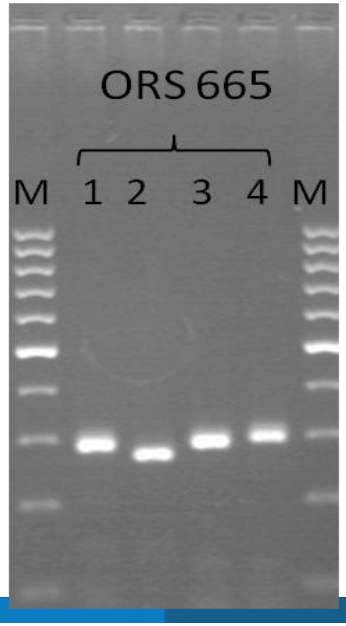
GENOTYPE	SERBIA	SPAIN	ROMANIA	TURKEY	UKRAINE	RUSSIA
GP:RHA-ROM	0 (R)	0 (R)	0 (R)	0 (R)	0 (R)	0 (R)
GP: RHA-BOS	0 (R)	0 (R)	0 (R)	0 (R)	0 (R)	0 (R)
HA 267	0 (R)	0 (R)	0 (R)	0 (R)	0 (R)	0 (R)
LIV-10	0 (R)	0 (R)	20 (MR)	10 (MR)	10 (MR)	0 (R)
LIV-17	0 (R)	0 (R)	20 (MR)	10 (MR)	10 (MR)	0 (R)
AB-VL-8	0 (R)	0 (R)	10 (MR)	0 (R)	10 (MR)	0 (R)
Differentals						
LC-1093 (Or_6)	0 (R)	10 (MR)	100 (S)	100 (S)	100 (S)	100 (S)
LC-1003 (Or_5)	0 (R)	100 (S)	100 (S)	100 (S)	100 (S)	100 (S)
LC-1002 (Or_4)	100 (S)	100 (S)	100 (S)	100 (S)	100 (S)	100 (S)
LC-231 (Or_3)	100 (S)	100 (S)	100 (S)	100 (S)	100 (S)	100 (S)
LC-215 (Or_2)	100 (S)	100 (S)	100 (S)	100 (S)	100 (S)	100 (S)
AD-66	100 (S)	100 (S)	100 (S)	100 (S)	100 (S)	100 (S)

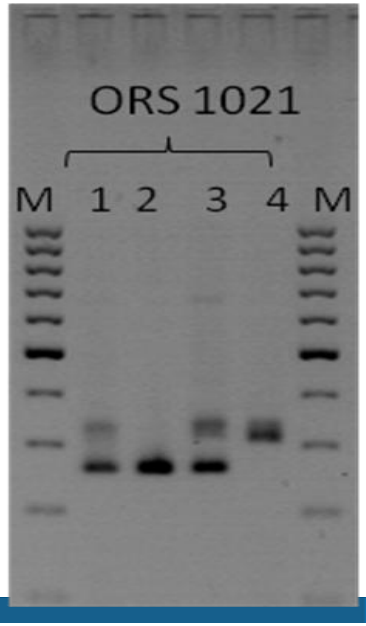
Genotyping by SSR

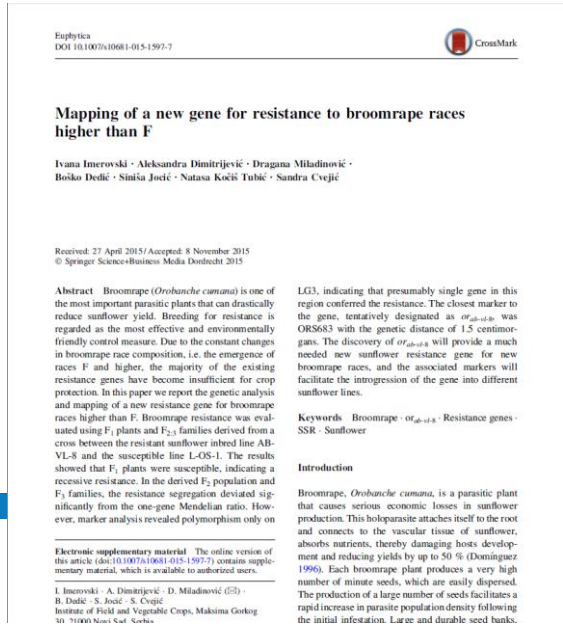
Mapiranje novog gena koji kontroliše otpornost na volovod, rase preko F

LG3 – novi gen otpornosti









Euphytica
DOI 10.1007/s10681-015-1597-7

CrossMark

Mapping of a new gene for resistance to broomrape races higher than F

Ivana Imerovski · Aleksandra Dimitrijević · Dragana Miladinović · Boško Dedić · Siniša Jocić · Natasa Kočiš Tubić · Sandra Cvejić

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Abstract Broomrape (*Orobanche cumana*) is one of the most important parasitic plants that can drastically reduce sunflower yield. Breeding for resistance is regarded as the most effective and environmentally friendly control measure. Due to the constant changes in broomrape race composition, i.e. the emergence of races F and higher, the majority of the existing resistance genes have become insufficient for crop protection. In this paper we report the genetic analysis and mapping of a new resistance gene for broomrape races higher than F. Broomrape resistance was evaluated using F_1 plants and $F_{2:3}$ families derived from a cross between the resistant sunflower inbred line AB-VL-8 and the susceptible line L-OS-1. The results showed that F_1 plants were susceptible, indicating a recessive resistance. In the derived F_2 population and F_3 families, the resistance segregation deviated significantly from the one-gene Mendelian ratio. However, marker analysis revealed polymorphism only on LG3, indicating that presumably single gene in this region conferred the resistance. The closest marker to the gene, tentatively designated as $or_{ab\text{-}vl\text{-}8}$, was ORS683 with the genetic distance of 1.5 centimorgans. The discovery of $or_{ab\text{-}vl\text{-}8}$ will provide a much needed new sunflower resistance gene for new broomrape races, and the associated markers will facilitate the introgression of the gene into different sunflower lines.

Keywords Broomrape · $or_{ab\text{-}vl\text{-}8}$ · Resistance genes · SSR · Sunflower

Introduction

Broomrape, *Orobanche cumana*, is a parasitic plant that causes serious economic losses in sunflower production. This holoparasite attaches itself to the root and connects to the vascular tissue of sunflower, absorbs nutrients, thereby damaging hosts development and reducing yields by up to 50 % (Domínguez 1996). Each broomrape plant produces a very high number of minute seeds, which are easily dispersed. The production of a large number of seeds facilitates a rapid increase in parasite population density following the initial infestation. Large and durable seed banks

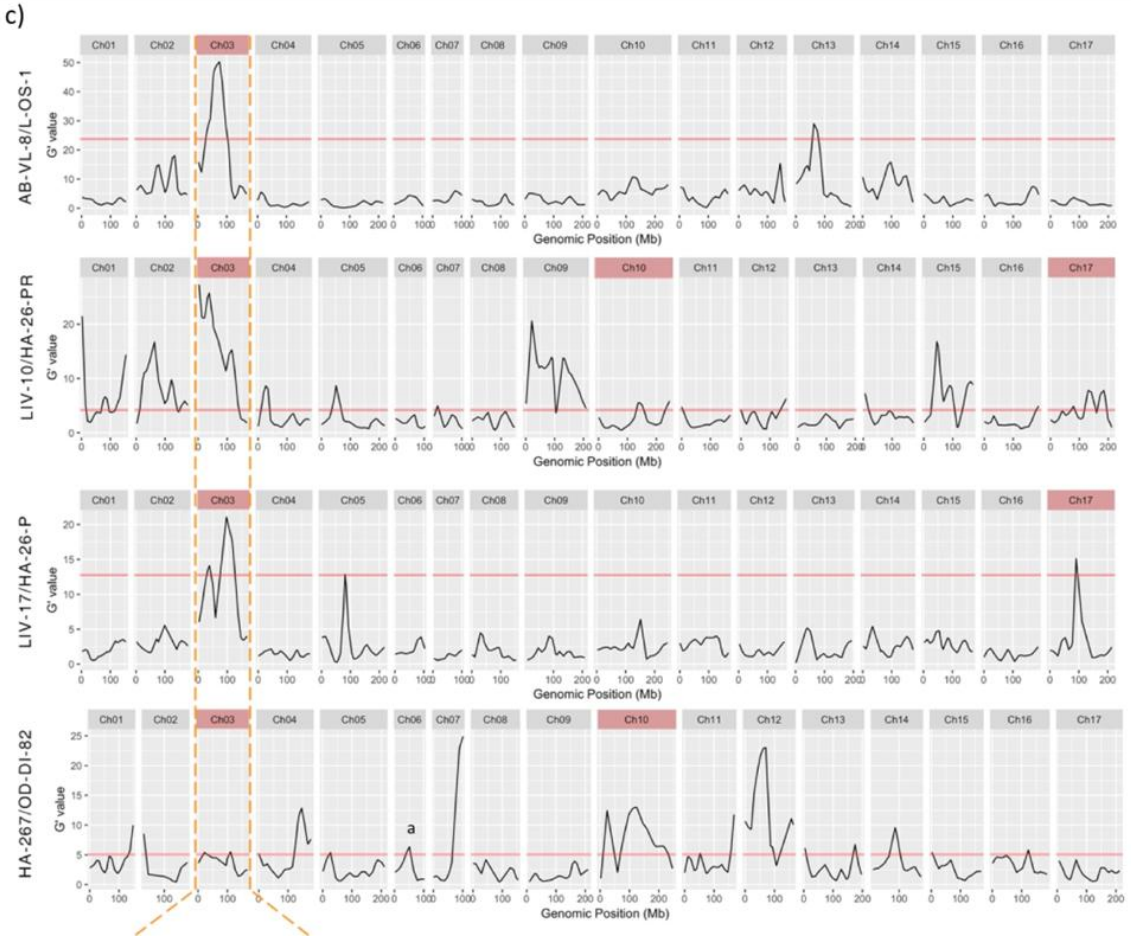
Electronic supplementary material The online version of this article (doi:10.1007/s10681-015-1597-7) contains supplementary material, which is available to authorized users.

I. Imerovski · A. Dimitrijević · D. Miladinović (✉) · B. Dedić · S. Jocić · S. Cvejić
Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21000 Novi Sad, Serbia

Genotyping by sequencing

- QTL mapping
- SNP markeri







DEKORATIVNI SUNCOKRET



HIBRIDI SA VISOKIM PRINOSOM SEMENA I ULJA, OTPORNI NA NAJVAŽNIJE BOLESTI I TOLERANTNI NA SUŠU

HIBRIDI TOLERANTNI HERBICIDE

Clearfield® Production System

Clearfield® Plus Production System

SUMO

HIBRIDI SA PROMENJENIM KVALITETOM ULJA



KONZUMNI HIBRIDI



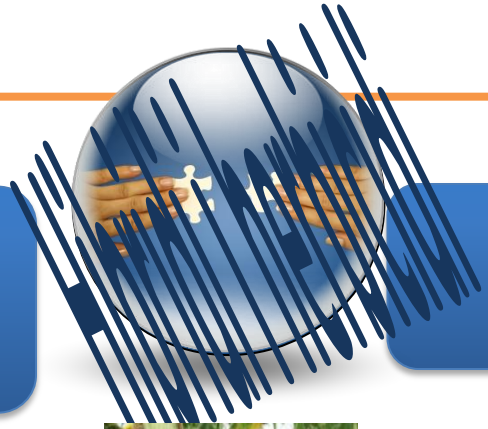
HIBRIDI ZA HRANU PTICA



GLAVNI PRAVCI U OPLEMENJIVANJU NS SUNCOKRETA

OPLEMENJIVANJE NA TOLERANTOST PREMA HERBICIDIMA

IMAZAMOX
(Pulsar® 40 and Passat®)
IMAZAMOX + IMAZAPYR
(Euro-Lightning®)



TRIBENURON-METIL
(Express® 50 SX)

Clearfield®
Sistem Proizvodnje

Clearfield® Plus
Production System



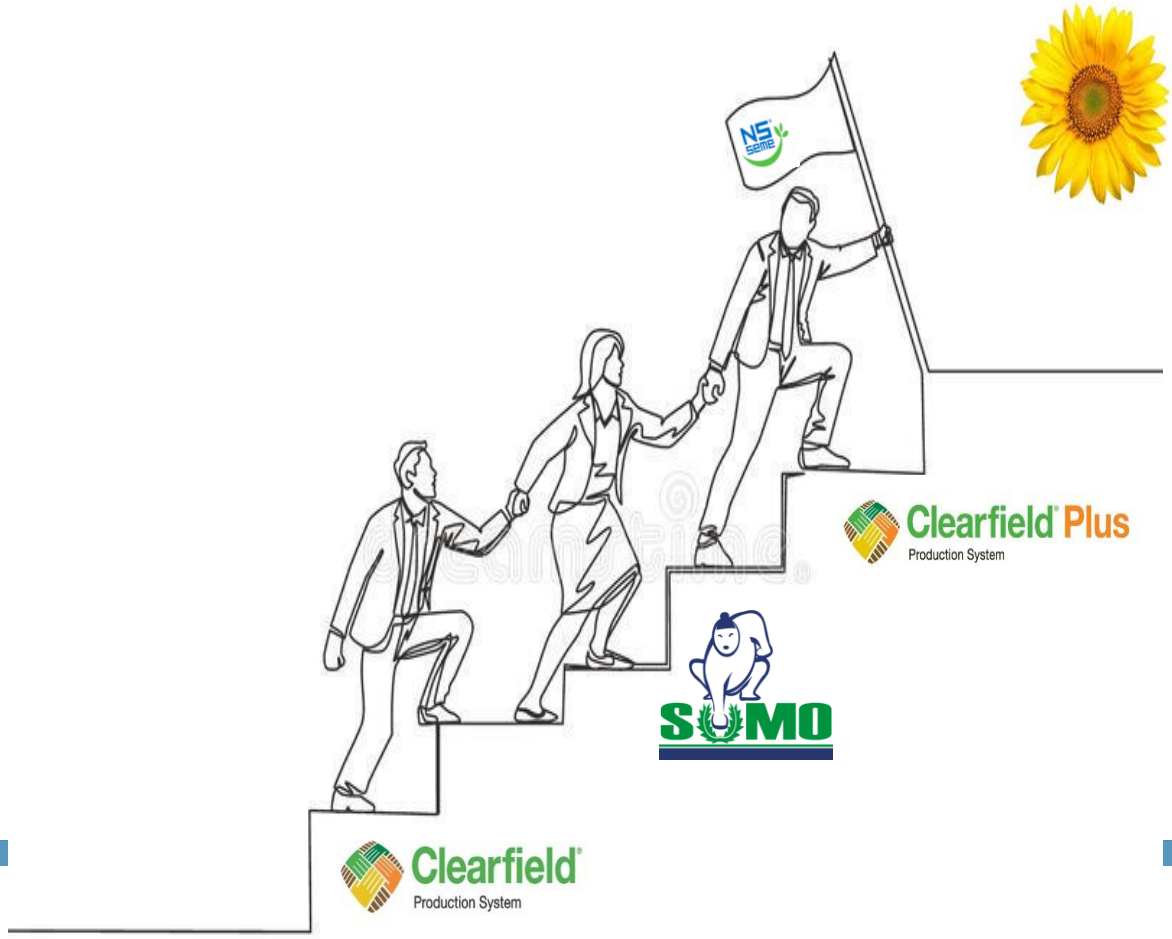
volovod

SOMO



Cirsium arvense

NS Institut je uvek među liderima u uvođenju novih tehnologija - primer suncokreta!



Oplemenjivanje na promenjen kvalitet ulja

Seme suncokreta sadrži u proseku 40-50 % ulja

Suncokretovo ulje - visoko kvalitetno



Standardni tip:

Naziv masne kiseline	Simbol	Nutritivan karakter	Fizičko stanje	Oksidativna stabilnost	Standardni sadržaj (%)
Palmitinska	16:0	hiperholesterolemski	čvrsto	visoka	6
Stearinska	18:0	neutralan	čvrsto	visoka	5
Oleinska	18:1	hipoholesterolemski	tečno	visoka	21
Linolna	18:2	hipoholesterolemski	tečno	niska	68

VISOKO-OLEINSKI TIP

- Sadržaja oleinske kiseline je preko 80%
- Pervenec - prva visokooleinska sorta suncokreta dobijena indukovanim mutacijama (*Soldatov*, 1976)
- Donor *Ol* gena
- Način nasleđivanja



Oplemenjivanje konzumnog suncokreta

Suncokret čije se seme i jezgro direktno koriste za ishranu ljudi zove se konzumni

- Visok sadržaj proteina (preko 25%)
- Oblik i veličina semena
- Uniformnost semena
- Izgled i boja semana
- Duže trajanje semena
- Lako ljuštenje semena



Ukrasni suncokret







rezano cveće

za baštensku proizvodnju

za saksijsku proizvodnju

Ukrasni suncokret - istraživanja

- **Diversity study:** Mladenović E, Cvejić S, Jocić S, Čukanović J, Jocković M, Malidža G (2017) Variability of morphological characters among ornamental sunflower collection. Genetika 49 (2): 573 -582.
- **Combining ability:** Cvejić S, Jocić S, Mladenović E, Jocković M, Miladinović D, Imerovski I, Dimitrijević A (2017) Evaluation of combining ability in ornamental sunflower for floral and morphological traits. Czech J. Genet. Plant Breed., 53: 83–88.
- **The inheritance study:** Cvejić S, Jocić M, Mladenović E (2016) Inheritance of floral colour and type in four new inbred lines of ornamental sunflower (*Helianthus annuus* L.). The Journal of Horticultural Science & Biotechnology, 91(1):30-35.



Digital image: Zorić, M., Cvejić, S., Mladenović, E., Jocić, S., Babić, Z., Marjanović Jeromela, A., & Miladinović, D. (2020). Digital Image Analysis Using FloCIA Software for Ornamental Sunflower Ray Floret Color Evaluation. *Frontiers in Plant Science*, *11*, 584822.



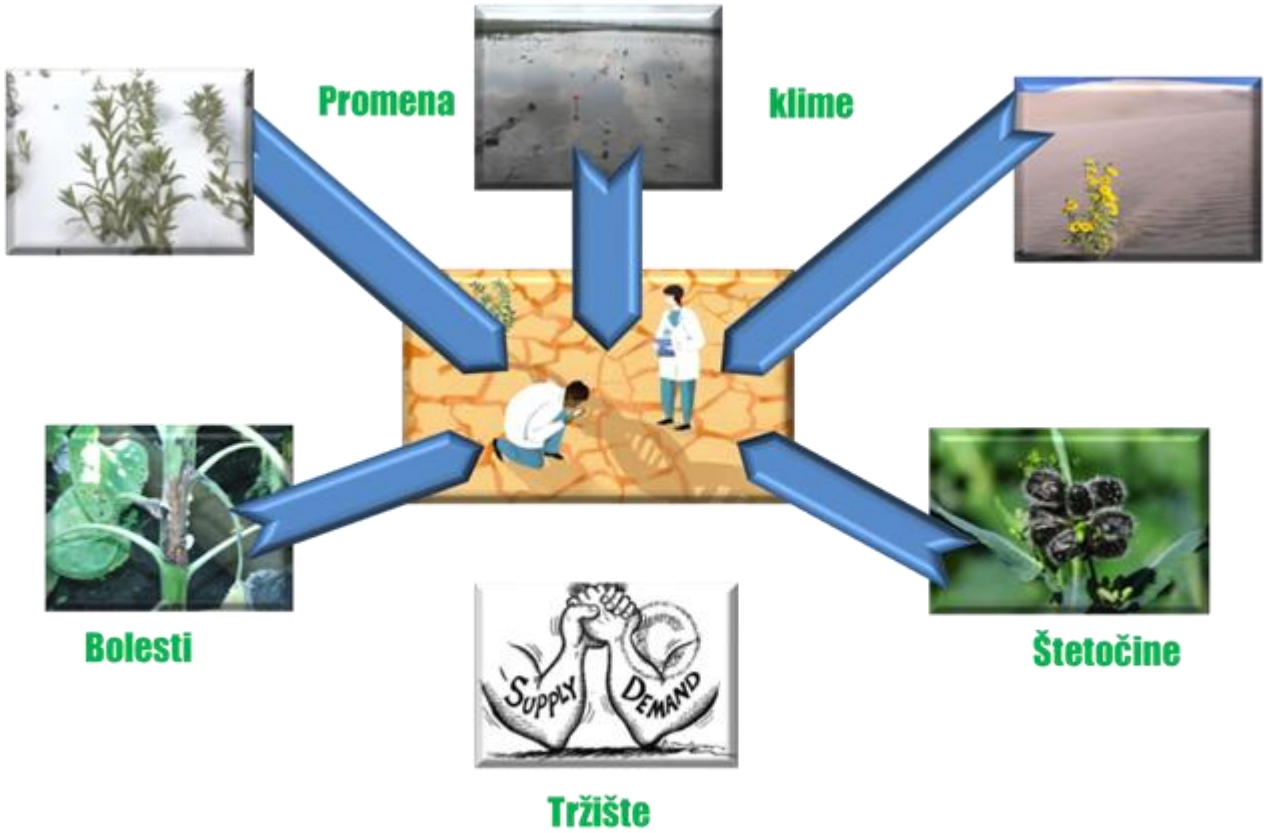
Test sunflower



Image segmentation



Novi izazovi u oplemenjivanju suncokreta



Novi momenti – globalno otopljenje

PROSEČNE MESEČNE TEMPERATURE

- Višegodišnji prosek
- Ispod v.p.
- Ispod v. p. >1°C
- Iznad v.p.
- Iznad v.p. >1°C

Mesec	1964-2015	1964-1975	1976-1985	1986-1995	1996-2005	2006-2015	2016-2021
April	11,7	11,3	10,6	11,7	11,7	13,1	13,7
Maj	17,0	16,7	16,5	16,5	17,7	17,5	17,2
Jun	20,0	19,7	19,3	19,6	20,8	20,9	22,1
Jul	21,7	21,1	20,6	22,2	21,7	23,1	23,1
Avgust	21,2	20,4	20,0	21,8	21,7	22,5	23,7
Septembar	16,9	16,8	16,7	17,3	16,3	17,5	18,4
Godišnje	11,4	10,9	10,8	11,3	11,6	12,3	13,0
Vegetacione	18,1	17,7	17,3	18,2	18,3	19,1	19,7

Adaptabilnost na abiotski stres

Glavni efekti

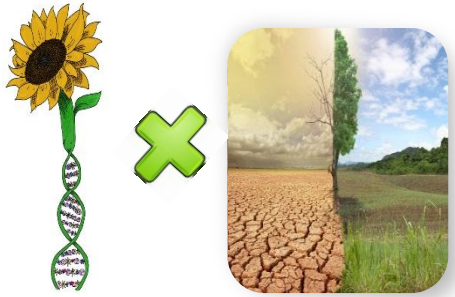
Efekat genotipa

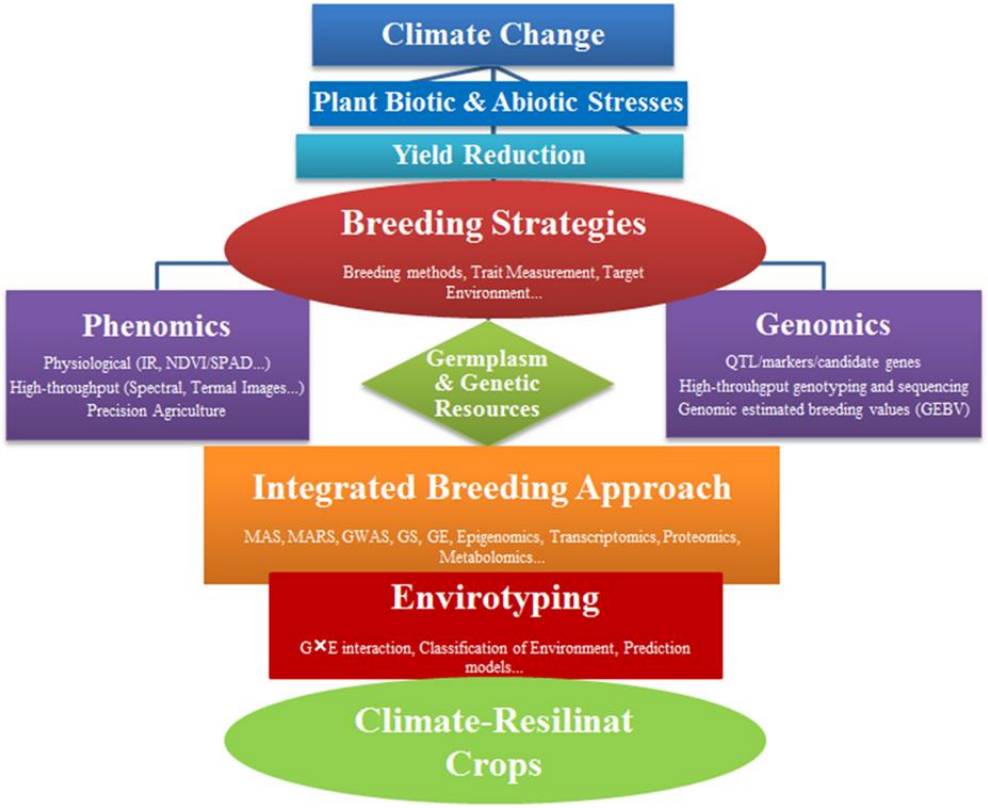


Efekat sredine



Interakcija G x E





Characterization of abiotic stress tolerance and traits related to it is very complex and interrelated to many factors.

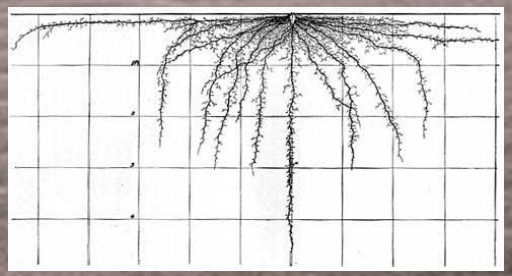
Tolerantnost suncokreta na sušu

✔Biljka suncokreta je tolerantna na sušu pošto ima ekstenzivni, jako razgranat korenov sistem koji joj omogućava da crpi vodu iz dubljih slojeva zemlje.

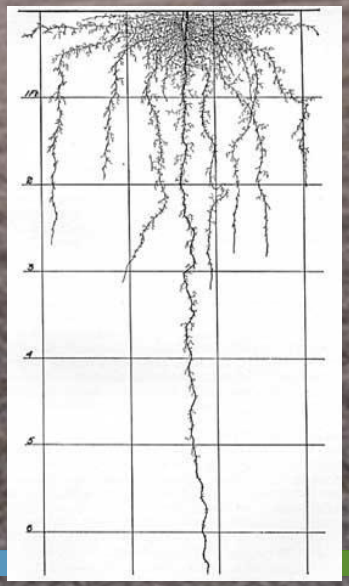
✔Kratki periodi suše možda neće značajno smanjiti prinos semena jer su usevi manje pod stresom zbog velike zapremine korena.



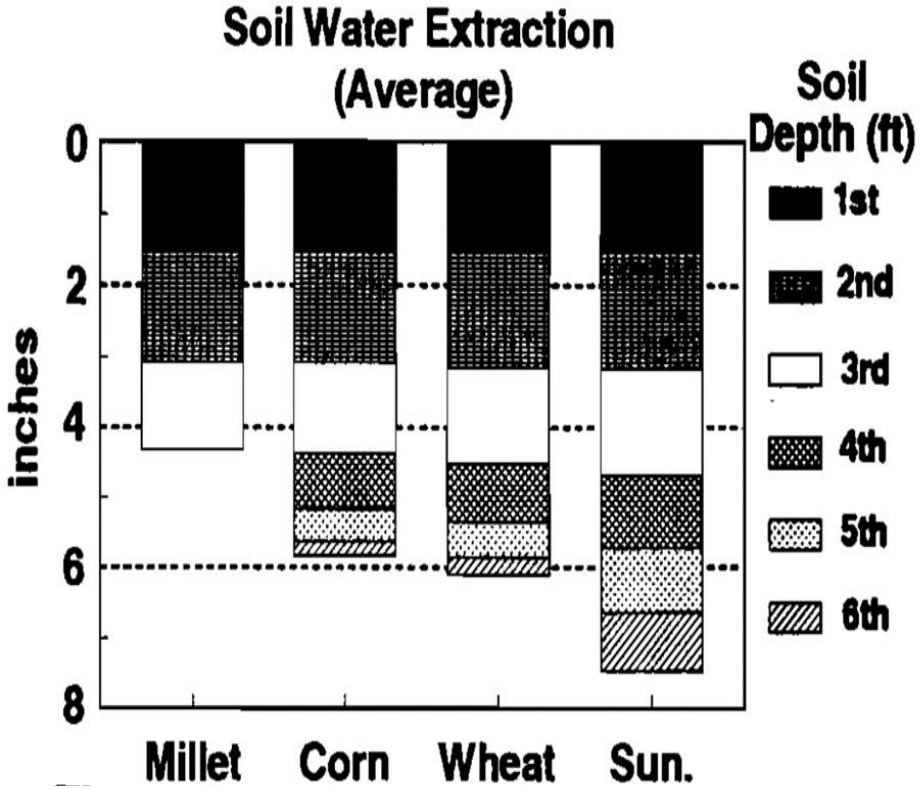
Maize root

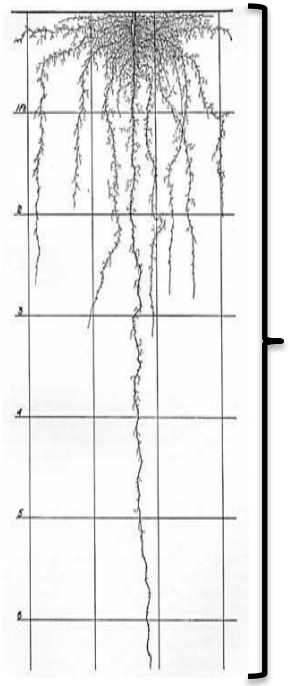


Sunflower root



Moćan korenov sistem suncokreta



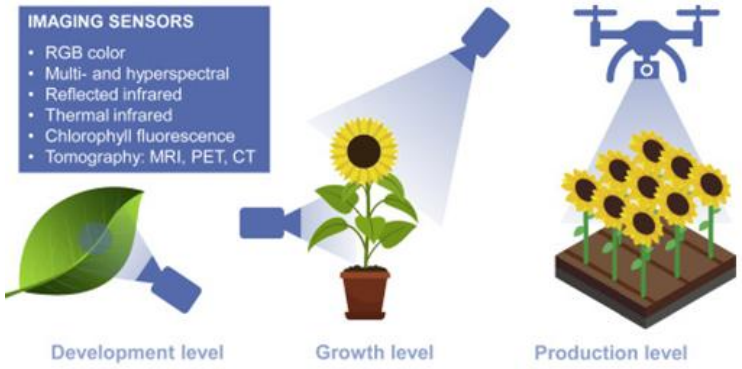


180 cm
(270cm
?)

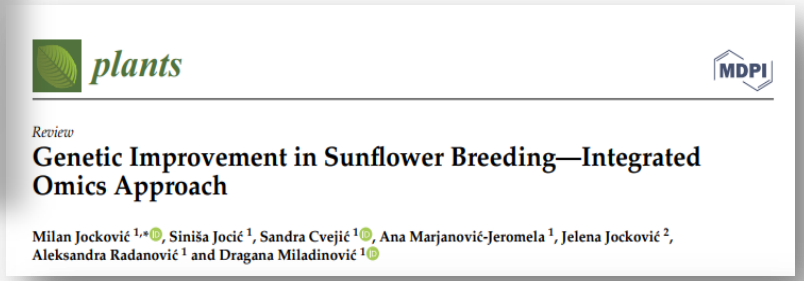
Извор: USDA

Fenomika

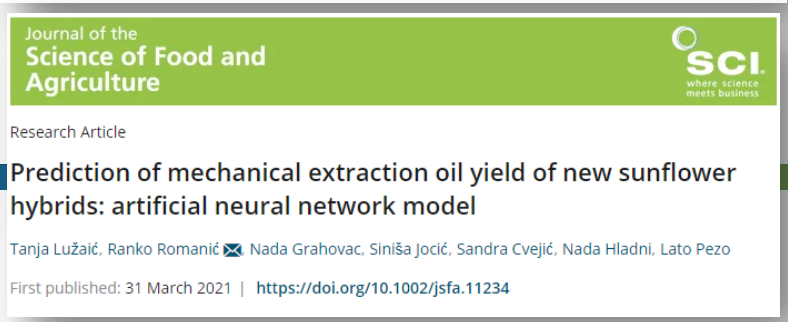
- Phenomics is a new field of science that connects genomics with plant ecophysiology and agronomy.
- Plant phenotyping is a an diverse field of research aiming to describe and quantify plant traits expression.



Methods:
Physiological (IR, NDVI/SPAD...)
High-throughput (Spectral, Termal Images...)
Precision Agriculture


plants
MDPI
Review
Genetic Improvement in Sunflower Breeding—Integrated Omics Approach
Milan Jocković [1,*], Siniša Jocić [1], Sandra Cvejić [1], Ana Marjanović-Jeromela [1], Jelena Jocković [2], Aleksandra Radanović [1] and Dragana Miladinović [1]


ORIGINAL RESEARCH article
Front. Plant Sci., 09 November 2020 | https://doi.org/10.3389/fpls.2020.584822
Digital Image Analysis Using *FloCIA* Software for Ornamental Sunflower Ray Floret Color Evaluation
Martina Zorić[1], Sandra Cvejić[2*], Emina Mladenović[3], Siniša Jocić[2], Zdenka Babić[4], Ana Marjanović Jeromela[2] and Dragana Miladinović[2]


Journal of the Science of Food and Agriculture
SCI where science meets business
Research Article
Prediction of mechanical extraction oil yield of new sunflower hybrids: artificial neural network model
Tanja Lužaić, Ranko Romanić, Nada Grahovac, Siniša Jocić, Sandra Cvejić, Nada Hladni, Lato Pezo
First published: 31 March 2021 | https://doi.org/10.1002/jsfa.11234

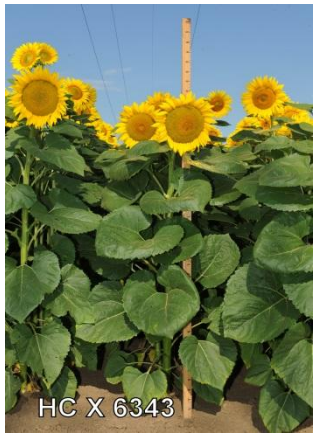
Fenotipizacija kod suncokreta

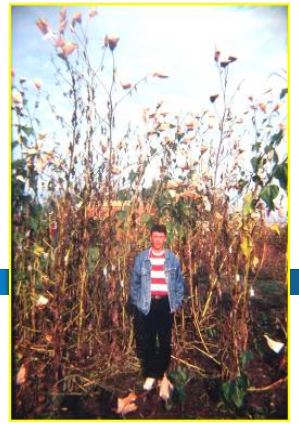
Classical methods











New methods









SmartSun - Creating climate smart sunflower for future challenges

Фонд за науку
Републике Србије

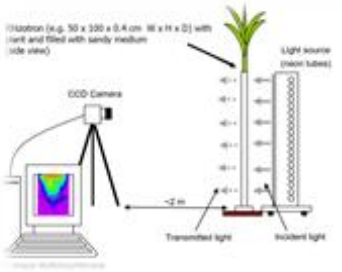
Broj projekta: 7732457
Tip projekta: Fond za nauku Republike Srbije – program IDEJE
Period realizacije: januar 2022 – decembar 2024.

Phenotyping → **Genotyping Epigenetic** → **Biometric**

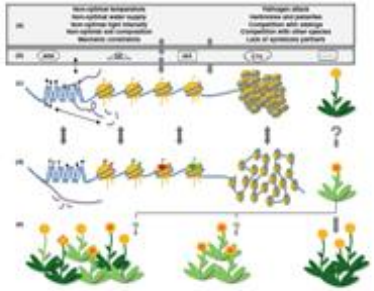
- Quick test for drought tolerance
- Digital root analysis in rhizotrons
- Anatomic characterisation

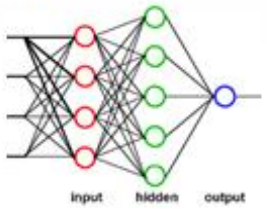
- Meta-analysis for gene discovery - RT-PCR analysis
- Epigenetic analysis – small RNA and lncRNA expression profile differences

- Root analysis (DART andWhinRhizo)
- Anatomic data - PAST 3.16
- Epigenetics - GGplot2 package for analyze multiple RNA-Seq datasets
- integration of obtained data - machine learning methods









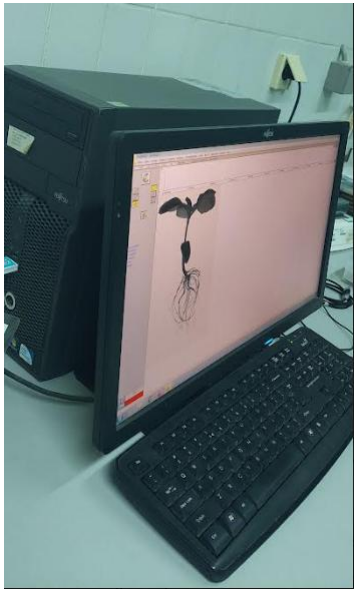
Root phenotyping

Root phenotyping - less studied due to methodological difficulties in measuring root growth and development



Rhizotrons are set of system for plant growth with ability to monitor and measure root growth repeatedly in non-destructive manner
Rhizotron for continuous root growth monitoring consists of two plates of which one is transparent
Plant is grown in thin layer between plates in specific medium (soil, treset...)
Rhizotron is placed under a various angles to increase the percentage of root visible on transparent plate





Rhizotron setup

- Sunflower root phenotyping in rhizotrons
- Two-week growth period
- Repeated measures
- Stress induced changes monitoring
- Main aim - root architectural traits measurement in genotypes tolerant to drought



day 1 day 6 day 13

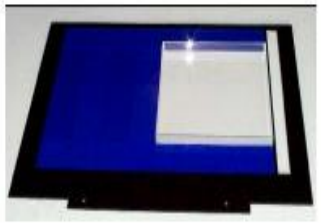
Primary and lateral sunflower root growth in rhizotron

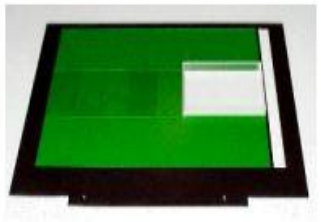
Techniques/softwares

Two-step data collection

1. Photographing root in predetermined time intervals





2. Scanning whole or parts of washed root

WinRHIZO Pro STD4800



Scanning device




Positioning system
saving 10-20 seconds by bypassing scanner preview step

NOVI MOMENTI - PROTEINI SUNCOKRETA
NOVE PERSPEKTIVE – KVALITET!

- SADRŽAJ PROTEINA U SEMENU SUNCOKRETA I PREKO 23% (PRIMER NS OLIVA)
- PRINOS PROTEINA/HA NA NIVOU NEKIH PROTEINSKIH BILJNIH VRSTA (>1T/HA)
- SUNCOKRET KAO ULJANO-PROTEINSKA BILJNA VRSTA
- PROTEINI SUNCOKRETA - NON-GMO











Suncokret- proteinska biljka

Seme	Latinski naziv	Sadržaj proteina (%)
Soja	*Glycine max (L.)*	36,49
Bob	*Vicia faba*	26,12
Sočivo	*Lens culinaris*	25,80
Crni gram pasulj	*Vigna mungo*	25,21
Mungo pasulj	*Vigna radiata*	23,86
Crni pasulj	*Phaseolus vulgaris*	23,58
Suncokret- NS Oliva	*Helianthus annuus*	23,05
Golubiji grašak	*Cajanus cajan*	21,70
Šareni pasulj	*Phaseolus vulgaris*	21,42
Lima pasulj	*Phaseolus lunatus*	20,62
Adzuki pasulj	*Vigna angularis*	19,87
Leblebija	*Cicer arietinum*	19,30





NS suncokret u Japanu!

Već nekoliko godina novosadski institut izvozi suncokret u Japan!





Glavni ciljevi gajenja:

- Zelenišno đubrenje
- Fitoremedijacija – za zemljišta zagađena radijacijom!!!



NS suncokret u Finskoj!!!









Hrana za polinatore!

SEMENARSTVO U SRBIJI I INOSTRANSTVU



CELOKUPNA DORADA SEMENA JE U NAJSAVREMENIJIM NS POSTROJENJIMA





Prvi kolor sorter u Srbiji

Zimske generacije

1. **Ubrzanje procesa oplemenjivanja**

1. **Umnožavanje linija i hibrida**

1. **Postkontrolni testovi svih kategorija semena proizvedenih u prethodnoj sezoni**

Čile



Argentina







Meksiko

Indija



FINALNI REZULTAT OPLEMENJIVANJA



NEGDE U IRANU....

NS hibridi suncokreta u svetu

Blizu 700 registrovanih hibrida suncokreta
Proizvode se na preko 3 000 000 ha u svetu (svaki 8. ha)



NO.	ZEMLJA	NS HIBRIDI	ZAJEDNIČKI HIBRIDI
1	RUSSIA	39	38
2	UKRAINE	85	48
3	FRANCE	3	35
4	HUNGARY	11	6
5	ITALY	27	45
6	SPAIN	4	11
7	TURKEY	1	-
8	MOLDOVA	16	9
9	BELARUS	3	4
10	KAZAHSTAN	6	-
11	CHINA	-	4
12	BULGARIA	8	10
13	CROATIA	5	5
14	CZECH REPUBLIC	6	2
15	SLOVAKIA	18	7
16	ROMANIA	44	9
17	ENGLAND	-	2
18	PORTUGAL	-	1
19	ARGENTINA	7	1
20	INDIA	2	-
21	ALBANIA	6	-
22	MACEDONIA	23	-
23	UZBEKISTAN	5	-
24	MOROCCO	3	2
25	SERBIA	117	-
	SVEGA	439	239

NS RONIN

- Srednje rani hibrid.
- Novi hibid pune vegetacije i rekordno visokih prinosa.
- Genetski otporan na volovod (rase A, B, C, D i E), rđu i suncokretov moljac.
- Visoko-tolerantan prema *Phomopsis*-u i *Macrophomina*. Tolerantan je na *Sclerotinia sclerotiorum* i to na forme koje se javljaju na korenu, stablu i glavi.
- Biljke imaju bujan habitus i otporne su na poleganje.
- Genetski potencijal za prinos semena preko 5,5 t/ha.
- Sadržaj ulja 48-50%.
- Adaptibilan i može se gajiti u različitim agroekološkim uslovima.
- Preporučeni (optimalni) sklop u žetvi: 55.000-60.000 biljaka po hektaru.

NS KRUNA

- Rani hibrid nove generacije.
- Jedan od najprinosnijih hibrida u ogledima u Srbiji, Rusiji i Ukrajni.
- Odlikuje se značajno nižim stablom sa krupnim glavama. Položaj glave je polupovijen sa ravnim stablom.
- Genetski je otporan na plamenjaču (Pl_6 gen), volovod rase od A do E, rđu i suncokretov moljac.
- Visoko tolerantnosti prema *Phomopsis*, *Macrophomina*, bolestima koje izazivaju pegavost lista i stabla i prema beloj truleži (korenske i stabljične forme).
- Genetski potencijal za prinos semena preko 5,5 t/ha.
- Sadržaj ulja 46-48%.
- Visoko tolerantan na sušu
- Izuzetne otpornosti na sušu, atraktivan je prema polinatorima i odlikuje se visokim stepenom oplodnje.
- Preporučeni (optimalni) sklop u žetvi: 55.000-60.000 biljaka po hektaru.

NS KIRIL

MORFOLOŠKE OSOBINE I FENOLOŠKE FAZE	• SREDNJE RANI HIBRID • SREDNJE VISINE
GENETSKI POTENCIJAL ZA PRINOS SEMENA	• PREKO 5,5 t/ha
SADRŽAJ ULJA SADRŽAJ OLEINSKE K.	• 47-48%
OTPORNOST	• VOLOVOD (Or5 gen)
TOLERANTNOST	• *Phomopsis helianthi* • *Macrophomina phaseolina* • *Sclerotinia sclerotiorum*
ADAPTABILNOST	• STABILAN U RAZLIČITIM AGROEKOLOŠKIM USLOVIMA • OPTIMALAN SKLOP 50 000-55 000 BILJAKA/HA



NS H 8005

MORFOLOŠKE OSOBINE I FENOLOŠKE FAZE	• SREDNJE RANI HIBRID • PROSEČNE VISINE, OTPORNO NA POLEGANJE
GENETSKI POTENCIJAL ZA PRINOS SEMENA	• PREKO 5,5 t/ha
SADRŽAJ ULJA	• 48-49%
OTPORNOST	• VOLOVOD (rase do E)
TOLERANTNOST	• *Visoko tolerantan na tribenuron-metil* • *Phomopsis helianthi* • *Macrophomina phaseolina* • *Sclerotinia sclerotiorum*
ADAPTABILNOST	• ZA RAZLIČITE AGROEKOLOŠKE USLOVE • OPTIMALAN SKLOP 55 000-60 000 BILJAKA/HA



NS H 8002

- Srednje rani hibrid.
- Visoko tolerantan na tribenuron-metil.
- Prosečna visina biljke, visoko otporan na poleganje.
- Genetski otporan na plamenjaču (*Pl6* gen), volovod (rase A, B, C, D i E), rđu i suncokretovog moljca.
- Visoko tolerantan na *Phomopsis helianthi, Macrophomina, Sclerotinia sclerotiorum*.
- Genetski potencijal za prinos semena preko 5,5 t/ha.
- Sadržaj ulja u semenu 47- 48%.
- Visoko tolerantan na susne i stresne uslove kao i uslove prekomerne vlaznosti.
- Rešava problem većine širokolisnih korova kao što je palamida (*Cirsium arvense*) uz obaveznu upotrebu herbicida.
- Dobre performanse u uslovima stresa.
- Preporučen (optimalan) sklop u žetvi 55 000-60 000 biljaka/ha.

NS SMARAGD CLP

Clearfield® Plus
Production System

- Srednje rani hibrid.
- Prosečna visina biljke, visoko tolerantan na poleganje.
- Tolerantan na herbicide iz grupe imidazolinona (za Clearfield®Plus proizvodni sistem).
- Rešava problem širokolisnih korova i volovoda uz obaveznu upotrebu herbicida.
- Otporan na plamenjaču (Pl_6 gen), volovod (races A, B, C, D and E), rđu i suncokretovog moljca.
- Tolerantan na *Phomopsis*, *Macrophomina*, *Sclerotinia sclerotiorum*.
- Genetski potencijal za prinos semena preko 5.5 t/ha.
- Sadržaj ulja u semenu 47-48%.
- Adaptivan i stabilan u različitim agroekološkim uslovima.
- Preporučen (optimalan) sklop u žetvi 55 000-60 000 biljaka po hektaru.

NS LEVIATHAN



- Srednje kasni hibrid.
- Konzumni suncokret pogodan za ljudsku ishranu i ljuštenje.
- Genetski otporan na rđu i suncokretovog moljca, tolerantan na *Phomopsis*.
- Genetski potencijal za prinos semena preko 6 t/ha.
- Odlična veličina, dužina i boja semena.
- Masa 1000 semena 120-140 g, šareno seme.
- Sadržaj ulja manji od 35%.
- Sadržaj proteina u semenu 27% što ga čini pogodnim za konzumaciju.
- Nizak procenat ljuske, lako se ljušti.
- Atraktivan za oprašivače i dobro prilagođen različitim ekološkim uslovima i tipovima zemljišta.
- Optimalan sklop tokom žetve 35.000-42.000 biljaka po hektaru.

NS hibridi suncokreta



KLASIČNI ULJANI HIBRIDI

- NS KRUNA
- NS RONIN
- NS ROMEO
- NS KIRIL

Novo!!!





VRLO RANI HIBRIDI

- NS DUKAT
- NS H 7749

Novo!!!

VISOKOOLEINSKI

- NS OLIVA
- NS SANO

Novo!!!





KONZUMNI

- NS LEVIATHAN
- NS GRICKO

IMI HIBRIDI

- RIMI PR
- PEGAZ
- NS TAURUS

Clearfield® Production System

Clearfield® Plus Production System



SUMO HIBRIDI

- SUMO 1 PR
- SUMO 2 OR
- NS SUMO ORFEJ
- NS SUMO SUN

CLP HIBRIDI

- NS SMARAGD CLP
- NS SAMURAJ CLP

SUMO

NS TIM NA SUNCOKRETU



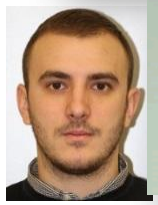

Oplemenjivanje:
dr Siniša **JOCIĆ**
dr Sandra **CVEJIĆ**
dr Milan **JOCKOVIĆ**
dr Nada **HLADNI**
Nemanja **ĆUK**, master
Jelena **JOCKOVIĆ,** master

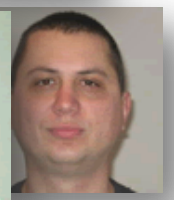







Semenarstvo:
dr Vladimir **MIKLIČ**
dr Jelena **OVUKA**
dr Velimir **RADIĆ**
Miloš **KRSTIĆ**, master
Branislav **OSTOJIĆ**, dipl.inž..
Goran **JOKIĆ**, dipl. inž.
Daliborka **BUTAŠ**, dipl. inž.











Biotehnologija:
dr Dragana **MILADINOVIĆ**
dr Aleksandra **RADANOVIĆ**













Ogledi:
Brankica **BABEC**, master
Ilija **RADEKA** – dipl.inž.
Nedeljko **KLISURIĆ** – dipl.inž.





Analize ulja i oleinske kiseline:
dr Nada **GRAHOVAC**




Zaštita suncokreta
dr Boško **DEDIĆ**
dr Sonja **GVOZDENAC**

International Sunflower Association i NS Institut
20. International Sunflower Conference u Novom Sadu, 20-23. jun 2022.





Hvala na pažnji!

