

PROCEEDINGS OF THE

20th INTERNATIONAL SUNFLOWER CONFERENCE



Novi Sad, Serbia
June 20-23, 2022

Proceedings of the

20th International Sunflower Conference



Novi Sad, Vojvodina, Serbia
June 20-23, 2022

Sponsored by



The International Sunflower Association, Paris, France,

In cooperation with



**The Institute of Field and Vegetable Crops, National
Institute of Republic of Serbia, Novi Sad, Serbia**

Proceedings of the 20th International Sunflower Conference
Novi sad, Serbia, June 20-23, 2022

Editors: Sreten Terzić, Dragana Miladinović

Editorial committee:

Dr. Aleksandra Radanović
Dr. Boško Dedić
Dr. Dragana Miladinović
Dr. Igor Balalić

Dr. Nada Grahovac
Dr. Sandra Cvejić
Dr. Sonja Gvozdenac
Dr. Sreten Terzić

Scientific committee:

Dr. Dragana Miladinović,
IFVCNS, Serbia (Chair)
Dr. Daniel Álvarez, INTA, Argentina
Dr. Tatiana Antonova, VNIIMK, Russia
Dr. Kulpash Bulatova, KSRI, Kazakhstan
Dr. Miguel Cantamutto, INTA, Argentina
Prof. dr. Jovan Crnobarac, UNS, Serbia
Dr. Sandra Cvejić, IFVCNS, Serbia
Dr. Philippe Debaeke, INRA, France
Dr. Yakov Demurin, VNIIMK, Russia
Dr. Maria Duca, UASM, Moldova
Dr. Valentina Encheva, DAI, Bulgaria
Dr. László Hargitay, Agromag, Hungary
Dr. Nada Hladni, IFVCNS, Serbia
Dr. Brent Hulke, USDA ARS, USA
Dr. Chao-Chien Jan, China
Dr. Siniša Jocić, IFVCNS, Serbia
Dr. Yalcin Kaya, TUHM, Turkey
Prof. dr. Renate Horn, UR, Germany
Dr. Nicolas Langlade, INRA, France
Dr. Kateryna Makliak, NAAS, Ukraine
Prof. dr. Stevan Maširević, Serbia
Dr. Vladimir Miklič, IFVCNS, Serbia
Dr. Leire Molinero Ruiz, CSIC, Spain
Dr. Sujatha Mulpuri, DOR ICAR, India
Dr. Stéphane Muñoz, INRA, France
Dr. Maria Pacureanu-Joita, NARDI, Romania
Dr. Begoña Pérez-Vich, CSIC, Spain
Etienne Pilorge, Terres Inovia, France
Prof. dr. Loren Rieseberg, UBC, Canada
Dr. Gerald Seiler, USDA ARS, USA
Academician Dragan Škorić, SANU, Serbia
M.Sci. Mariano Sposaro, Syngenta, Argentina
Dr. Sreten Terzić, IFVCNS, Serbia
Dr. Gian Paolo Vannozzi, UDSU, Italy
Dr. Felicity Vear, France
Dr. Leonardo Velasco, CSIC, Spain
Prof. dr. Jun Zhao, IMAU, China

Organizing committee:

Chair: Dr. Vladimir Miklič
Co-chair: Dr. Siniša Jocić
Dr. Dragana Miladinović
Dr. Ana Marjanović Jeromela
Dr. Jelena Ovuka
Dr. Sreten Terzić
Dr. Sandra Cvejić
Dr. Sonja Gvozdenac
Dr. Goran Malidža
Dr. Nada Hladni
Dr. Nenad Dušanić
Dr. Igor Balalić
Dr. Velimir Radić
Dr. Aleksandra Radanović
Dr. Sonja Tančić Živanov
Dr. Boško Dedić
Dr. Milan Jocković
Dr. Nada Grahovac
Dr. Željko Milovac
MSc. Zvonimir Sakač
MSc. Brankica Babec
MSc. Nemanja Ćuk
MSc. Dragana Savin
BSc. Nada Lečić
BSc. Siniša Prole
BSc. Branislav Ostojić
BSc. Goran Jokić
BSc. Ilija Radeka
BSc. Daliborka Butaš
BSc. Miloš Krstić
BSc. Nedeljko Klisurić

The International Sunflower Association Board of Directors:

Dr Vladimir MIKLIČ, Serbia (President & Representative of ISA Sponsors)

Mr Etienne PILORGE, France (Secretary-Treasurer)

Dr Yakov DEMURIN, Russia

Dr Maria DUCA, Moldova

Dr Valentina ENCHEVA, Bulgaria

Dr Laszlo HARGITAY, Hungary

Dr Brent HULKE, USA

Dr Maria JOITA-PACUREANU, Romania

Dr Yalcin KAYA, Turkey

Dr Nicolas LANGLADE, France

Dr Stevan MAŠIREVIĆ, Serbia

Dr Mulpuri SUJATHA, India

Dr Gian Paolo VANNOZZI, Italy

Dr Leonardo VELASCO, Spain

Pr Jun ZHAO, PR China

Dr Katerina Makliak, Ukraine

Guillermo Pozzi (as subsidiary of Carlos Feoli) Argentina

The proceedings of the 20th International Sunflower Conference contain 153 contributions from scientists of 30 countries. They include plenary lectures, oral talks and regular communications presented with posters, among which, selected contributions were emphasized with short oral talks. The manuscripts are classified by research areas in ten separate sections. They offer a thorough review of the current state of the art of sunflower research and production around the world. The Organizing Committee is grateful to Tanja Vunjak and Aleksandar Vojisavljević for their excellent editorial assistance in the preparation of these Proceedings.

ISC2022 Organizing committee



Conference program

Sunday, 19 June

16.00-21.00	Registration
19.00-21.00	Welcome Reception

Monday, 20 June

8.00-17.00	Registration	
9.00-9.30	Opening Ceremony	
9.30- 10.15	Invited talk Section 1: Dr. Felicity Vear (France)	
10.15-11.00	Coffee break	
11.00-12.00	Section 1: Breeding – New/old breeding goals and challenges	Section 2: Oils and proteins – Innovations for increased quality and feedstock supply
	Oral and short oral presentations	Oral and short oral presentations
12.00-13.30	Lunch	
13.30-14.30	Invited talks Section 3: Dr. C.C. Jan (China) Section 4: Dr. Sreten Terzić (IFVCNS, Serbia)	
14.30-15.00	Coffee break	
15.00-16.00	Section 3: Confectionery sunflower – Emerging crop	Section 4: Genetic resources – Investment for the future
	Oral and short oral presentations	Oral and short oral presentations
16.00-17.00	Poster session – Sections 1, 2, 3, 4	
18.00-21.00	Novi Sad and Petrovaradin fortress tour	

Tuesday, 21 June

8.30-17.00	Registration	
9.30-10.30	Invited talks Section 5: Dr. Leire Molinero Ruiz (CISC, Spain) Section 6: Dr. Philippe Debaeke (INRAE, France)	
10.30-11.00	Coffee break	
11.00-12.00	Section 5: Biotic stress resistance – New and emerging pests and diseases	Section 6: Crop production and modeling – Yield stability in changing environment
	Oral and short oral presentations	Oral and short oral presentations
12.00-13.30	Lunch	
13.30-14.30	Invited talks Section 7: Dr. Nicolas Langlade (INRAE, France) Section 8: Etienne Pilorgé (Terres Inovia, France)	
14.30-15.00	Coffee break	
15.00-16.00	Section 7: Abiotic stress resistance – Challenges of changing environment	Section 8: Economy and market – Trends and prospects
	Oral and short oral presentations	Oral and short oral presentations
16.00-17.00	Poster session – Sections 5, 6, 7, 8	

Wednesday, 22 June

8.30-17.00	Registration	
9.30-10.30	Invited talks Section 9: Dr. Stéphane Muños (INRAE, France) Section 10: Dr. Nicole Creux (FABI, South Africa)	
10.30-11.00	Coffee break	
11.00-12.00	Section 9: Broomrape – Constant challenge	Section 10: Bees and seeds – Exploring new venues for increased yield and seed production
	Oral and short oral presentations	Oral and short oral presentations
12.00-13.30	Lunch	
13.30-14.30	Panel: Sunflower in a changing environment – Trends and prospects	
14.30-15.00	Coffee break	
14.30-15.30	Poster session – Sections 9, 10	
15.00-16.30	ISA Assembly	
16.30-17.00	Closing ceremony	
20.00-24.00	Gala Dinner Pustavoit Award Presentation Ceremony IFVCNS Best Poster Award Presentation	

Thursday, 23 June

9.00-15.00	Field day
------------	-----------

Table of contents

PLENARY

Old and New breeding goals and challenges	
Felicity Vear	1
Sunflower improvement in seed and oil quality in Russia	
Yakov Demurin	8
Confectionery sunflower as an emerging crop	
Chao-Chien Jan	13
From conservation to introgression breeding - from conservation to introgression breeding	
Sreten Terzić	18
Biological control agents against sunflower pathogens	
Carmen Gómez-Lama Cabanás, Pedro Miranda-Fuentes, Jesús Mercado-Blanco, Mercedes Romero-Cuadrado, Leire Molinero-Ruiz	25
New cropping systems and growing environments for sunflower: consequences on target traits and ideotypes	
Philippe Debaeke	26
Prediction of sunflower tolerance to drought using quantitative genetics and crop modelling	
Langlade Nicolas, Casadebaig Pierre, Gosseau Florie, Mangin Brigitte, The SUNRISE consortium	27
Sunflower in the global vegetable oil system: situation, specificities and perspectives	
Etienne Pilorgé	28
Resistance to <i>Orobanche cumana</i>: “We will keep on fighting until the end”	
Muños Stéphane	29
The delicate balancing act of climate control during flowering, pollination and seed development in sunflower	
Nicky Creux, Carine Marshall, Uyabongeka Memela, Phrasia Mapfumo, Stacey Harmer	30

ORAL TALKS

Applying genomic tools to accelerate and facilitate downy mildew resistance breeding in sunflower	
Guojia Ma, Xuehui Li, Lili Q	31
¿Does white rot resistance penalize seed-yield in sunflower?	
M Antonella Giussani, Fernando Castaño, Santiago G. Delgado	35
The impact of the Ahas1-4 herbicide tolerance allele over different agronomic traits in sunflower	
Emiliano Altieri, Raquel Sensolini, Mariano Sposaro, Federico Bock, Mariano Bulos	40
Developing and Comparing the Yield Potential of Single Cross and Three Way Cross Sunflower Hybrids for Uganda Condition.	
Walter O. Anyanga, Pius Elobu	41
A multi-year survey on sunflower meal quality produced in france	
Sylvie Dauguet, Elodie Tormo, Mohammed Krouti, Alain Quinsac	48
Improvement of the nutritional value of sunflower meal by sifting technology	
Alain Quinsac, Justine Danel, Sylvie Dauguet, Corinne Peyronnet, Mohammed Krouti, Patrick Carré, François Brionnet, Maria Vilarino	49
Confectionery sunflower in Serbia	
Nada Hladni, Ranko Romanić, Brankica Babec, Siniša Jocić, Vladimir Miklič, Veljko Petrović,	

Dragana Miladinović	50
Recent situation of confectionery sunflower production in Turkey	
Yalcin Kaya	55
A germplasm collection of confectionery sunflower landraces from Spain	
Leonardo Velasco, José M. Fernández-Martínez, Begoña Pérez-Vich	59
Stability in seed yield over years in confectionery sunflower	
Veli Pekcan, Mehmet Sezgin, Hatice Tezcan, Mehmet Ibrahim Yilmaz, Necmi Beser, Goksel Evcı, Yalcin Kaya	68
Current status of sunflower genetic resources in India	
M.Y. Dudhe, M. Sujatha, H.P. Meena, K. Alivelu, A. Vishnuvardhan Reddy	72
Resistances to <i>Orobanche cumana</i> by exploiting helianthus genetic diversity.	
Chabaud Mireille, Folletti Tifaine, Boniface Marie-Claude, Pérez-Vich- Begoña, Legendre Alexandra, Delavault Philippe, Simier Philippe, Pouvreau Jean-Bernard, Velasco Leonardo, Muños Stéphane	73
Genomic prediction of yield tolerance to drought in sunflower genetic resources	
Duhnen Alexandra, Blanchet Nicolas, Boniface Marie-Claude, Pouilly Nicolas, Langlade Nicolas, Mangin Brigitte	74
Lumisena™: A new seed treatment fungicide for downy mildew control in sunflower	
Shevchuk Oleg, Fernandes Nilceli, Papageorgiou Kalliopi, Troisi Marco	75
Downy Mildew of Sunflower – Innovative control with the seed applied technologies	
PLENARIS™ and Acibenzolar-S-Methyl	
Domenico di Bianco, Jennifer Foster, Franz Brandl, Julien Fourmont	76
Viballa™: A new effective herbicide for broadleaf weed control in sunflower crops	
Salas Maria, Apostolidis Vasilis	77
Sunflower yield prediction based on high resolution satellite imagery	
Branislav Pejak, Oskar Marko, Tatjana Lončar-Turukalo, Predrag Lugonja, Nataša Ljubičić, Vladimir Crnojević	78
Organic foliar fertilization of sunflower enhanced sunflower yield attributes and seed yield in the humid tropics	
Victor Olowe, James Fadeyi, Patience Odueme, Olabisi Somefun	79
Genetic, transcriptomic and physiological characterization of cold tolerance in sunflower	
Jean Lecomte, Nicolas Langlade, Nicolas Pouilly, Nicolas Blanchet	80
Sunflower drought: QTLs discovery in semi controlled conditions	
Marlene Mazas, Virginie Mirleau-Thebaud	81
Genetic control of sunflower metabolome in a dry agronomic environment	
Marco Moroldo, Annick Moing, Stéphane Bernillon, Vincent Segura, Gabriela Bindea, Nicolas Blanchet, Nicolas Langlade, SUNRISE consortium	86
Commercial launch of A.I.R.™ in Europe, a new herbicide-tolerant production system for Sunflower from Syngenta	
Gilles Grée, Attila Kovács	87
Cultural practices of sunflower in France analysis and rooms for progress	
Lecomte Vincent, Martin Monjaret Claire	88
Sunflower bird damage: is the research up to the challenges?	
Christophe Sausse, Corentin Barbu, Alice Baux, Sonia B. Canavelli, Page E. Klug, Fernando Pellegrini, Sebastian G. Zuil	89
Applied research & development for French sunflower –priorities to contribute to France’s national protein strategy	
David Gouache, Vincent Lecomte, Christophe Sausse, Dominique Wagner, Sylvie Dauguet, Claire Martin-Monjaret	93
Novel Sources of Resistance to <i>Orobanche cumana</i> Wallr. in Sunflower	
Irina Čalić, Anna Finkers-Tomczak, Rui Peng-Wang, Saskia Jacobs-Oomen, Evert-Jan Blom, Roy Gorkink, Marcel van Verk, Mireille Chabaud, Martin de Vos, Arjen van Tunen, Stephane Muños, Wilco Ligterink	94

miPEPs: new tools to study and control the sunflower broomrape	
Sabine Tourneur, Jean-Philippe Combier, Stéphane Munos, Thomas Laurent, Philippe Delavault	95
Some characteristics of <i>Orobanche cumana</i> from different countries	
Maria Duca, Angela Port, Steliana Clapco	96
The genetic interaction between sunflower inbred lines in the process of developing <i>Orobanche cumana</i> resistance hybrids	
Onisan Emilian, Petrescu Irina.....	97
Insect pollination is necessary to achieve maximum seed yield and oil content in sunflower, but a low bee density is enough	
Stan Chabert, Christopher Sénéchal, André Fougeroux, Olivier Geist, Vincent Guillemard, Solenne Leylavergne, Constance Malard, Jérémy Pousse, Gabriel Carré, Édith Caumes, Charlotte Cenier, Alain Treil, Bernard E. Vaissière.....	98
Contamination of Sunflower Seeds by Fungi and Its Control Using Fungicide Treatments	
Mandela E. Addrach, Yuan Zhang, Jian Zhang, Lin Liu, HongYou Zhou, Jun Zhao	103
Association studies and marker development for the fertility restorer gene <i>RF1</i> in sunflower	
Renate Horn, Aleksandra Radanovic, Lena Fuhrmann, Yves Sprycha, Sonia Hamrit, Milan Jockovic, Dragana Miladinovic, Constantin Jansen.....	104

SHORT ORAL TALKS

Feature selection and performance assessment of machine learning algorithms for sunflower oil yield prediction	
Sandra Cvejić, Olivera Hrnjaković, Milan Jocković, Aleksandar Kupusinac, Ksenija Doroslovački, Ilija Radeka, Siniša Jocić, Dragana Miladinović, Vladimir Miklič	105
Development of magic populations for sunflower disease resistance breeding	
Matias Domínguez, Carla Filippi, Juan Montecchia, Mónica Fass, Facundo Quiroz, Daniel Álvarez, Ruth Heinz, Verónica Lia, Julio González, Norma Paniego	106
Comparison between the predicted performances of simulated sunflower breeding populations and the predicted breeding values of realized progenies.	
Alix Allard, Ignacio Navarro	107
Oil extraction from sunflower seeds assisted by pulsed electric field pre-treatment	
Ivan Shorstkii, Evgeny Koshevoi, Meysam S. Mirshekarloo	108
Time Domain-NMR with chemometric analysis : An alternative tool for determination protein content in sunflower seeds	
Loudiyi Mohammed, Le Dorze François, Fintz Christine, Lem Patricia.....	109
Extraction yield obtained by pressing sunflower seed	
Ranko Romanić, Tanja Lužaić, Nada Grahovac, Sandra Cvejić, Siniša Jocić, Snežana Kravić, Zorica Stojanović.....	110
Response of Seed Yield and Seed Size to Plant Density in Two Confectionary Sunflower Hybrids	
Monica López Pereira, Deborah Rondanini, Tomas Pueta, Fernando Turienzo, Ezequiel Barreto.....	111
Investigation and comparison of geometric characteristics of oily and non-oily sunflower hybrid seeds	
Tanja Lužaić, Ranko Romanić, Nada Grahovac, Nada Hladni, Zvonimir Sakač, Snežana Kravić, Zorica Stojanović	115
Morpho-chemical characterization of new confectionary sunflower (<i>Helianthus annuus</i> L.) genotypes from Argentina	
Rebeca Sandrinelli Tesán, Daniel Alvarez, Mercedes Silva, Roxana Aguilar, Adriana Pazos, Mónica Balzarini, María José Martínez.....	116

Secretory tissues of discs flowers in wild <i>Helianthus L.</i> species	
Jelena Jocković, Sreten Terzić, Lana Zorić, Dragana Miladinović, Jadranka Luković	117
Resistance of wild <i>Helianthus</i> species to the prevailing Chinese broomrape (<i>Orobanche cumana L.</i>) races	
Min Chang, Chao-Chien Jan	118
The French Sunflower Genebank	
Tapy Camille, Boniface Marie-Claude.....	122
Flow cytometrical characterization in sunflower genus	
Meryem Şahin, Gulsemin Savas Tuna, Metin Tuna, Yalcin Kaya.....	123
Preliminary study on the effect of different plant resistance inducers against sunflower downy mildew (<i>Plasmopara halstedii</i>)	
Ahmed Ibrahim Alrashid Yousif, Pratik Doshi, György Turóczi, Katalin Körösi, Nisha Nisha, Rita Bán.....	127
Innovative “Attract & kill” strategy for controlling wireworms in sunflower	
Sonja Gvozdenac, Željko Milovac, Stefan Vidal, Jelena Ovuka, Vladimir Miklič, Sandra Cvejić, Brankica Babec.....	128
Occurrence of <i>Plasmopara halstedii</i> (Sunflower downy mildew) pathotypes in Hungary	
Rita Bán, Attila Kovács, Nisha Nisha, Katalin Körösi, Zoltán Pálincás, Mihály Zalai, Ahmed Ibrahim Alrashid Yousif, Mihály Perczel, József Kiss.....	129
Evolution of sunflower downy mildew in France	
Penaud Annette, Perrot Sophie, Boniface Marie-Claude, Pauchet-Mattler Isabelle, Delos Marc, Bret-Mestries Emmanuelle.....	130
Sunflower oil yield responses to wide inter-row spacing	
Monica López Pereira, Andrés Paterniti, Edmundo Ploschuk.....	139
New approaches in phenotype prediction – Machine learning techniques	
Milan Jocković, Sandra Cvejić, Siniša Jocić, Ilija Radeka, Jelena Jocković, Aleksandra Radanović, Sreten Terzić, Boško Dedić.....	140
Assessment of the biofumigation potential of <i>Brassica</i> species against Sunflower <i>Verticillium Wilt</i> (<i>Verticillium dahliae</i>) – A field-experiment approach	
Ait Kaci Ahmed Neïla, Desplanques Jérémy, Galaup Benoit, Dechamp-Guillaume Grégory, Seassau Célia	141
The effects of climate change on sunflower yield in the Konya basin of Turkey	
Hüdaverdi Gürkan, Nilgün Bayraktar, Gerrit Hooogenboom	142
Sensitivity of different herbicide-tolerant sunflower hybrids to selected ALS-inhibiting herbicides	
Goran Malidža, Miloš Rajković, Siniša Jocić, Sandra Cvejić	143
The effect of climatic changes – hail and storm on sunflower hybrids – Constanta county, Dobrogea area, Romania	
Dumitru Manole, Ana Maria Giumba, Laurentiu Luca Ganea, Viorel Ion	144
Public and Private Partnership in evaluating and commercializing of sunflower hybrids in Uganda	
Walter O. Anyanga, Pius Elobu.....	154
Types of sunflower hybrids registered in Serbia	
Jasna Savić, Danijela Stojanović.....	155
The environmentally safe method of control of broomrape (<i>Orobanche cumana wallr.</i>) parasitising on sunflower	
Evgeniy Strelnikov, Tatiana Antonova, Lyudmila Gorlova, Victoria Trubina	156
Herbicide seed treatment in Clearfield® plus sunflower against early <i>Orobanche cumana</i> attack	
Matthias Pfenning, Juan Manuel Contreras, Rosa Gimenez	163

Sunflower broomrape – Update on virulence in Serbia	
Boško Dedić, Ilija Radeka, Siniša Jocić, Dragana Miladinović, Sandra Cvejić, Milan Jocković, Aleksandra Radanović, Vladimir Miklič.....	164
Planting date and environments affect sunflower development, yield and Sclerotinia head rot progression	
Mapfumo P, Wilkens M, Swanevelder D, Archer E, Creux NM.	165
Bee vectoring of biologicals in sunflowers as a crop protection tool	
John C. Sutton, Sherri Tedford, Gerardo Suazo, Christoph Lehnen, Sreten Terzić, Michael Wunsch, Venkataramana Chapara.....	166
The different invigoration techniques for sunflower seeds	
Dušica Jovičić, Jelena Ovuka, Zorica Nikolić, Gordana Petrović, Dragana Marinković, Milan Stojanović, Ana Marjanović-Jeromela.....	167
 POSTERS - Section 1: Breeding	
Correlations and path analyses of some sunflower breeding parameters	
Velimir Radić, Igor Balalić, Milan Jocković, Nada Hladni, Miloš Krstić, Siniša Jocić, Vladimir Miklič	169
Genome-wide association studies reveal new genetic loci associated with fatty acid composition in Sunflower	
Alina Chernova, Elena Martynova.....	170
Mapping of loci associated with tocopherol composition using genotyping by sequencing approach in sunflower	
Rim Gubaev, Stepan Boldyrev, Alina Chernova, Elena Martynova, Tatyana Kovalenko, Tatyana Peretyagina, Svetlana Goryunova, Denis Goryunov, Cecile Ben, Laurent Gentzittel, Philipp Khaitovich, Yakov Demurin	171
Adaptability potential of new sunflower hybrids under the conditions of Dobrudzha region	
Galim Georgiev	172
Correlation analysis for seed yield and its component traits in experimental sunflower IMI resistant hybrids	
D. Valkova.....	173
Components related to higher head diameter, heterosis and type of inheritance in oil seed sunflower (<i>Helianthus annuus</i> L.)	
Georgi Georgiev, Nina Nenova, Galim Georgiev, Daniela Valkova, Penka Peevska, Valentina Encheva	174
LSFH-171: A high yielding, downy mildew resistant sunflower hybrid suitable for the different agro-climatic zones of Indian conditions	
M. K. Ghodke, M.Y. Dudhe, A.M. Misal, M. Sujatha	175
New type of experimental sunflower hybrids Su-IMI plus	
Anton Florin Gabriel.....	176
New form cultivated sunflower (<i>Helianthus annuus</i> L.) with resistance to the herbicides pulsar and express	
Michail Christov, Miroslava Hristova-Cherbadzhi.....	177
Identification of a novel mutation in a stearyl-acyl carrier protein desaturase gene associated with enhanced stearic acid levels in sunflower seed	
Hirohisa Saga, Sayuri Kitagawa	181
Imidazolinone-induced male sterility in sunflower: a novel strategy for hybridization	
Marisa Della Maddalena, Germán Zuzul, Oscar Marques, José María Bruniard, Graciela Nestares, Ana Ochogavía	182
The first report on efficient CRISPR-based protocol for sunflower	
Kubilay Yildirim, İlkay Sevgen, Ankica Kondić-Špika, Sandra Cvejić, Siniša Jocić, Dragana Miladinović	186

POSTERS - Section 2: Oils and proteins

Influence of pulsed electrical discharge, hydrostatic pressure and temperature on rheological properties of sunflower cake during oil pressing
Ivan Shorstkii, Evgeny Koshevoi, Maxim Sosnin 187

A Novel Method of Determination of Individual Oil Content in Sunflower and Flaxseed Oil Blends
Marko Ilić, Kristian Pastor, Ana Marjanović Jeromela, Ranko Romanić, Vladimir Miklič, Dura Vujić, Marijana Ačanski..... 188

Dry fractionation process of sunflower meal for the production of protein and phenolic compounds enriched fractions
Oscar Laguna, Abdellatif Barakat, Hadil Alhamada, Erwann Durand, Bruno Baréa, Frédéric Fine, Pierre Villeneuve, Morgane Citeau, Sylvie Dauguet, Jérôme Lecomte..... 189

Fatty acid characterization of sunflower breeding materials at the IFVC
Nada Grahovac, Zvonimir Sakač, Siniša Jocić, Sandra Cvejić, Vladimir Miklič 190

Importance of tocopherol in modification the quality of sunflower oil
Dragan Škorić, Zvonimir Sakač, Yakov Demurin 191

Enzymatic release of caffeic acid from sunflower meal and improvement of its antioxidant activity in emulsion by lipophilisation
Oscar Laguna, Elise Odinot, Alexandra Bisotto, Bruno Baréa, Pierre Villeneuve, Jean-Claude Sigoillot, Eric Record, Craig B. Faulds, Frédéric Fine, Sylvie Dauguet, Alain Quinsac, Laurence Lesage-Meessen, Anne Lomascolo, Jérôme Lecomte 192

Amino acid profile in sunflower seeds
Le Dorze François, Seguineau Armelle, Loudiyi Mohammed, Fintz Christine, Lem Patricia... 193

POSTERS - Section 3: Confectionery sunflower

Assessment of stability of seed oil and protein content in confectionery hybrids using the apple AMMI analysis
Nada Hladni, Samet Salgam, Miroslav Zorić, Dragana Miladinović, Siniša Jocić, Ana Marjanović Jeromela, Sreten Terzić, Milan Jocković, Sandra Cvejić, Boško Dedić, Aleksandra Radanović, Zvonimir Sakač, Velimir Radić, Nenad Dušanić, Brankica Babec, Nemanja Ćuk, Jelena Ovuka, Nada Grahovac, Sonja Gvozdenac, Vladimir Miklič 194

Polyphenols and flavonoids contents in seed cake from Serbia confectionary sunflower (*Helianthus annuus* L.)
Zorica Stojanović, Nada Grahovac, Snežana Kravić, Ana Đurović, Ranko Romanić..... 195

POSTERS - Section 4: Genetic resources

Root xylem anatomy of the wild and cultivated sunflower
Jadranka Luković, Aleksandra Radanović, Anna Galinski, Dunja Karanović, Lana Zorić, Jelena Jocković, Kerstin A. Nagel, Dragana Miladinović 196

Fifty years of collecting wild *Helianthus* species for cultivated sunflower improvement
Gerald Seiler, Laura Fredrick Marek, Tom Gulya 197

Massive haplotypes underlie adaptive variation in wild sunflowers
Marco Todesco, Gregory L. Owens, Natalia Bercovich, Jean-Sébastien Légaré, Shaghayegh Soudi, Dylan O. Burge, Kaichi Huang, Katherine L. Ostevik, Emily B. M. Drummond, Ivana Imerovski, Kathryn Lande, Mariana A. Pascual, Winnie Cheung, S. Evan Staton, Stéphane Muñoz, Rasmus Nielsen, Lisa A. Donovan, John M. Burke, Sam Yeaman, Loren H. Rieseberg..... 201

Study of the reaction of *Helianthus debilis* accessions to *Phomopsis/ Diaporthe helianthi* Munt.-Cvet.
Maria Petrova, Daniela Valkova, Valentina Encheva..... 202

Evaluation of sunflower inbred lines resistance to <i>Macrophomina phaseolina</i> using different inoculation methods	
Nemanja Ćuk, Sandra Cvejić, Velimir Mladenov, Brankica Babec, Boško Dedić, Vladimir Miklič, Siniša Jocić	203
Click beetles monitoring using pheromone traps in Serbia	
Željko Milovac, Sonja Gvozdenc, Filip Franeta, Petar Čanak.....	204
Fungicide tolerance of <i>Plasmopara halstedii</i> (sunflower downy mildew) to Mefenoxam in Hungary	
Nisha Nisha, Attila Kovács, Katalin Körösi, Rita Bán, Ahmed Ibrahim Alrashid Yousif, Arbnora Berisha, Mihály Perczel.....	205
Colonization of sunflower seed with <i>Alternaria alternata</i>	
Dragana Milošević, Maja Ignjatov, Vladimir Miklič, Maja Karaman, Zorica Nikolić, Gordana Tamindžić, Boško Dedić	206
New races of the sunflower downy mildew pathogen (<i>Plasmopara halstedii</i>) in Bulgaria	
Valentina Encheva, Maria Petrova, Neno Nenov, Galin Georgiev, Nina Nenova, Daniela Valkova, Penka Peevska, Georgi Georgiev.....	207
<i>Cadophora helianthi</i>, a new fungus affecting sunflowers in Eastern Europe	
David Gramaje, Alberto Martín-Sanz, Carmen Berlanas, Leire Molinero-Ruiz	208
<i>Botrytis cinerea</i> as causal agent of sunflower seed grey mould	
Maja Ignjatov, Dragana Milošević, Vladimir Miklič, Boško Dedić, Gordana Tamindžić, Dragana Bjelić, Žarko Ivanović.....	209
<i>Plasmopara halstedii</i> race 735 in Serbia	
Boško Dedić, Stevan Maširević, Siniša Jocić, Sandra Cvejić, Milan Jocković, Dragana Miladinović, Aleksandra Radanović, Vladimir Miklič.....	210
Dissection of the downy mildew genes cluster on chromosome 8	
Paris Clémence, Rousseau Jean-Christophe	211
Tolerance of NS-sunflower genotypes to charcoal rot	
Sonja Tančić Živanov, Boško Dedić, Sandra Cvejić, Vladimir Miklič, Miroslav Zorić.....	212
New races of <i>Puccinia helianthi</i> schwein on sunflower in the Russian federation	
Nina Araslanova, Tatiana Antonova, Ekaterina Lepeshko, Tatiana Usatenko, Yulya Pitinova, Maria Iwebor, Svetlana Saukova.....	213
The identification of sunflower resistance genes to downy mildew	
Svetlana Ramazanova, Evgeny Badyanov, Saida Guchetl.....	214
Changes in the antioxidant enzyme activity levels of sunflower (<i>Helianthus annuus</i> L.) inoculated by <i>Plasmopara halstedii</i> (sunflower downy mildew) and treated with Azadirachtin (Neemazal t/s)	
Kevein Ruas Oliveira, Katalin Körösi, Pratik Doshi, Nisha Nisha, Ahmed Ibrahim Alrashid Yousif, György Turóczy, Priscila Lupino Gratão, Rita Bán	215
<i>Alternaria</i> on sunflower in regions of the Russian federation: species and their pathogenicity	
Maria Iwebor, Tatiana Antonova, Nina Araslanova, Svetlana Saukova	216
Races and oomyceticide tolerances of <i>Plasmopara halstedii</i> in Argentina	
Ana Laura Martínez, María Eugenia Bazzalo, Norma I. Huguet, Amelia Bertero, Ignacio Erreguerena, Ariel Jesús Faberi, Macarena Petrucelli, Jonathan Bannister, Franco Di Giano, Marisa Della Maddalena, Silvana Piubello, Alicia Carrera, Facundo Quiroz	217
Climate risk of the Argentine pampas region regarding the release of <i>Diaporthe helianthi</i> ascospores	
Corró Molas A., Edwards Molina J., Therisod G., Colombo D., Martínez M.I., Bilbao A., Bertero A., Moschini R.C	218

Alternaria leaf spot of sunflower in regions of the Russian federation: fungal species and their pathogenicity

Maria Iwebor, Tatiana Antonova, Nina Araslanova, Svetlana Saukova 219

POSTERS - Section 6: Crop production and modeling

Agronomic attribute and stability of new exotic sunflower hybrids in Iran

Mehdi Ghaffari, Bahram Alizadeh, Hossein Sadeghi, Siamak Kolbadi, Abbasali Andarkhor, Malihe Homayonifar, Ahmad Kalantar Ahmadi 223

Sunflower seed oil content depending on the seedling type

Jelena Ovuka, Sonja Gvozdenac, Dušica Jovičić, Miloš Krstić, Daliborka Butaš, Vladimir Miklič 224

Determination of yield performances of IMI type sunflower (*Helianthus annuus* L.) hybrids resistant to broomrape and downy mildew

Ibrahim Mehmet Yilmaz, Veli Pekcan, Samet Sağlam, Kadirhan Tekcan, Guray Dinler, Goksel Evci 225

The influence of sowing date on yield and quality of NS sunflower hybrids

Jovan Crnobarac, Igor Balalić, Dragana Latković, Goran Jaćimović 226

The effect of legumes and sunflower intercropping on soil compaction

Brankica Babec, Nada Hladni, Jovan Crnobarac, Bojan Vojnov, Milorad Živanov, Srđan Šeremešić 227

Importance of Halauxifen-methyl for integrated weed management in sunflower, with special emphasis on the control of resistant common ragweed to ALS inhibitors

Goran Malidža, Maria Salas, Miloš Rajković, Notter Jean-Sébastien 228

SREG model evaluation of sunflower hybrids in South-East Europe

Milan Jocković, Sandra Cvejić, Siniša Jocić, Dragana Miladinović, Velimir Radić, Vladimir Miklič, Jelena Ovuka, Ana Marjanović-Jeromela 229

Study on important indices in the seeds of some sunflower hybrids and their correlation

Nina Nenova, Daniela Valkova 230

Feasibility of double cropping system with Camelina and sunflower in Serbia

Ana Marjanović Jeromela, Sandra Cvejić, Siniša Jocić, Jovan Crnobarac, Zlatica Miladinov, Goran Malidža, Miloš Rajković, Željko Milovac, Dušan Dunderski, Igor Balalić, Petar Čanak, Andrea Monti, Federica Zanetti 231

The improvement of sunflower crop technology in Dobrogea under climate changes

Vasile Jinga, Dumitru Manole, Ioan Radu, Ana Maria Giumba, Lorena-Roxana Gurau 232

How to combine environmental indicators for characterizing and clustering variety testing trials? Application to sunflower in France

Amélia Landré, Pierre Casadebaig, Arnaud Gauffreteau, Nicolas Augis, Christine Fintz, Emmanuelle Bret-Mestries, Philippe Debaeke 237

Mapping sunflower areas using high resolution sentinel-2 images

Predrag Lugonja, Miloš Pandžić, Sanja Brdar, Oskar Marko, Vladan Minić, Nataša Ljubičić, Vladimir Crnojević 241

Sunflower and climate changes: adaptation and mitigation potential from case study in RN Macedonia

Zoran Dimov, Ordan Cukaliev, Dusko Mukaetov, Vjekoslav Tanaskovic 245

Planting date and environments affect sunflower development, yield and *Sclerotinia* head rot progression

Mapfumo P, Wilkens M, Swanevelder D, Archer E, Creux NM 249

POSTERS - Section 7: Abiotic stress resistance

Mining root traits for sunflower drought tolerance improvement by use of an automated phenotyping platform

Aleksandra Radanović, Anna Galinski, Milan Jocković, Sandra Cvejić, Sreten Terzić, Siniša Jocić, Dragana Miladinović, Fabio Fiorani, Kerstin A. Nagel..... 250

Climate crops Centre of excellence – bringing innovation in sunflower breeding for climate resilience

Dragana Miladinović, Ankica Kondić-Špika, Ana Mrajanović Jeromela, Goran Bekavac, Sonja Tančić Živanov, Miroslav Zorić, Sandra Cvejić, Sanja Mikić, Bojan Mitrović, Aleksandra Radanović, Boško Dedić, Sonja Gvozdenac, Milan Mirosavljević, Jelena Ovuka, Milan Jocković, Dragana Rajković, Verica Takač, Nemanja Čuk, Miloš Krstić, Nada Hladni, Sreten Terzić, Vladimir Miklič, Siniša Jocić, Jegor Miladinović 251

Creating climate smart sunflower for future challenges – The SMARTSUN multidisciplinary project

Aleksandra Radanović, Sandra Cvejić, Jadranka Luković, Milan Jocković, Siniša Jocić, Boško Dedić, Sonja Gvozdenac, Nemanja Čuk, Nada Hladni, Jelena Jocković, Olivera Hrnjaković, Dragana Miladinović..... 252

POSTERS - Section 9: Broomrape

Chemotropism of *Orobanche cumana*

Anna Krupp, Barbara Bertsch, Otmar Spring 253

Pathogen development in compatible and incompatible combinations of *Orobanche cumana* and sunflower

Anna Krupp, Annerose Heller, Otmar Spring 254

Sunflower resistance to broomrape

Dejana Panković, Igor Vukelić, Gordana Racić, Mirjana Topić, Dragan Škorić..... 255

Evaluation of different methods to test the sunflower resistance to broomrape

Sergey Gontcharov, Julia Scibina, Alexandra Baziz 256

Aggressiveness of broomrape populations infesting sunflower in different countries

Maria Duca, Steliana Clapco, Ion Gisca, Aliona Cucereavii, Rodica Martea, Chao Wang 257

Degree of intra- and interpopulation diversity of some Moldovan

***O. cumana* populations**

Angela Port, Ana Mutu, Olese Tabara, Ina Bivol..... 258

Aggressiveness of sunflower broomrape from different countries

Maria Duca, Steliana Clapco, Ion Gisca, Rodica Martea, Chao Wang..... 259

Genetic variability of *O. cumana* populations infesting sunflower in different countries

Maria Duca, Angela Port, Steliana Clapco 260

ORTOBOX – A toolbox to evaluate sunflower varieties for their resistance to broomrape

Stéphane Muñoz, Sylvie Ducournau, Nicolas Augis Muriel Archipiano, Marie-Claire Tardin, Pierre Castellanet, Camille Henry, Antoine Mezzarobba, Sophie Pardo, Isabelle Pauchet, Christophe Jestin 261

Investigation on the resistance of new Bulgarian sunflower hybrids

to economically important diseases and the parasite *Orobanche*

Penka Peevska, Miglena Drumeva, Galin Georgiev, Valentina Encheva, Georgi Georgiev..... 262

Broomrape (*Orobanche cumana* Wallr.) control, by developing genetic resistant genotypes in sunflower

Joita Păcureanu Maria, Rîșnoveanu Luxița, Dan Mihaela, Anton Gabriel,
Sava Elisabeta, Bran Alexandru 263

The dynamics of the pathogens which attack sunflower crop in Romania

Joita Păcureanu Maria, Rîșnoveanu Luxița, Dan Mihaela, Stanciu Danil,
Sava Elisabeta, Bran Alexandru 264

BSA-seq identify the resistance Genes for broomrape in Sunflower

Liu Sheng-Li, Wang Peng, Liu YanTao, Wang Pei-Zheng..... 265

Anthropogenic evolution of broomrape *Orobanche cumana* wallr., parasitizing on sunflower in the Russian federation

Tatiana Antonova 266

POSTERS - Section 10: Bees and seeds

Sadik's new CMS conversion method for maintainer inbred lines in sunflower

El Sayed Sadik 267

Heliopollen: deciphering the molecular bases of sunflower nectar production in response to drought stress.

Catrice Olivier, Tapy Camille, Blanchet Nicolas, Hernandes Melissa,
Langlade Nicolas..... 268

Unraveling the Mechanism behind Delay Sowing Date to Reduce Occurrence of Sunflower Verticillium Wilt

JianFeng Yang, Jian Zhang, Yuanyuan Zhang, Hongyou Zhou, Jun Zhao 269

Towards new solutions for the chemical desiccation of sunflower

Vladimir Miklič, Jelena Ovuka, Goran Malidža, Branislav Ostojić,
Velimir Radić, Nenad Dušanić, Siniša Jocić 270

Growth promoting activity of *Trichoderma* spp. on sunflower seedlings

Sonja Tančić Živanov, Siniša Jocić, Vladimir Miklič 271

Seed size and substrate effect on seed germination of inbred sunflower lines

Miloš Krstić, Jelena Ovuka, Velimir Radić, Sonja Gvozdenac,
Vladimir Miklič, Velimir Mladenov, Borislav Banjac, Teodora Kukrić 272

ASSOCIATION STUDIES AND MARKER DEVELOPMENT FOR THE FERTILITY RESTORER GENE *Rf1* IN SUNFLOWER

Renate Horn^{1*}, Aleksandra Radanovic², Lena Fuhrmann¹, Yves Sprycha¹, Sonia Hamrit³, Milan Jockovic², Dragana Miladinovic² and Constantin Jansen³

¹ Department of Plant Genetics, Institute of Biological Sciences, University of Rostock, Albert-Einstein-Str. 3, D-18059 Rostock, Germany

² Sunflower Department, Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21000 Novi Sad, Serbia

³ Strube Research GmbH & Co. KG, D-38387 Söllingen, Hauptstr. 1, Germany

Corresponding author: *renate.horn@uni-rostock.de

Abstract

Fertility restoration is an essential part of hybrid breeding based on cytoplasmic male sterility. In sunflower, the CMS PET1 originating from an interspecific hybridization between *Helianthus petiolaris* and *H. annuus* is world-wide used in hybrid breeding. The restorer gene *Rf1* is responsible for restoring fertility in the hybrids by specifically reducing the co-transcript of *atp1* and the CMS-specific *orfH522* in the anthers. From the mode of action (differences in RNA stability) *Rf1* could be a pentatricopeptide repeat gene. Blasting BAC-end sequences and sequences of markers linked to the restorer gene *Rf1* two physical locations (encompassing 30 Mb and 3.9 Mb, respectively) on linkage group 13 could be identified in the sunflower genome sequence of HanXRQ. These two regions contained nine possible candidate genes for *Rf1*: seven pentatricopeptide repeat genes, one aldehyde dehydrogenase and one poly(A) polymerase 3 gene. Using a next generation sequencing approach, the nine candidate genes were sequenced with 120 x coverage in an association panel of 59 lines (27 maintainer and 32 restorer lines) and 210 single nucleotide polymorphisms (SNPs) as well as 67 insertions/deletions (InDels) could be identified. Ten SNPs located in three of the candidate genes (PPR841, PPR861 and PPR621) showed significant associations with the fertility restoration. All three genes were located within the 3.9 Mb region. Haplotypes characteristic for the maintainer and restorer lines could be assigned and SNP-based markers e.g. Kompetitive Allele Specific Polymorphism (KASP) markers were successfully developed and tested for the capacity to identify restorer and maintainer lines as well as hybrids. In addition, a new co-dominant marker 67N04_P and two dominant sequence-tagged-site markers PPR621.5R and PPR621.5M were developed. A larger association panel of 557 accessions was screened with these markers to verify the versatility of their use.

Association studies narrowed the restorer gene *Rf1* down to three potential candidates, all three of them pentatricopeptide restorer genes. Further investigations of the identified three candidate genes for *Rf1* will reveal their relevance for fertility restoration. Several new markers for hybrid breeding in sunflower have been developed and will improve and ease marker-assisted selection in breeding for restorer and maintainer lines.

Keywords: Fertility restoration, association studies, pentatricopeptide repeat gene, KASP marker, marker-assisted selection, restorer gene

CIP - Каталогизација у публикацији
Библиотеке Матице српске, Нови Сад

633.854.78(082)

INTERNATIONAL Sunflower Conference (20 ; 2022 ; Novi Sad)
Proceedings of the 20th International Sunflower Conference, Novi Sad,
June 20-23, 2022 / [editors Sreten Terzić, Dragana Miladinović]. - Novi Sad :
The Institute of Field and Vegetable Crops ; Paris : The International Sunflower
Association, 2022 (Novi Sad : Atelje «Mudri»). - 306 str. : ilustr. ; 25 cm

Tiraž 400. - Bibliografija uz svaki rad.

ISBN 978-86-80417-89-9

a) Сунцокрет - Узгајање - Зборници

COBISS.SR-ID 68512521

Front page design: Aleksandar Vojisavljević
Photography: Goran Mulić – Petrovaradin fortress
