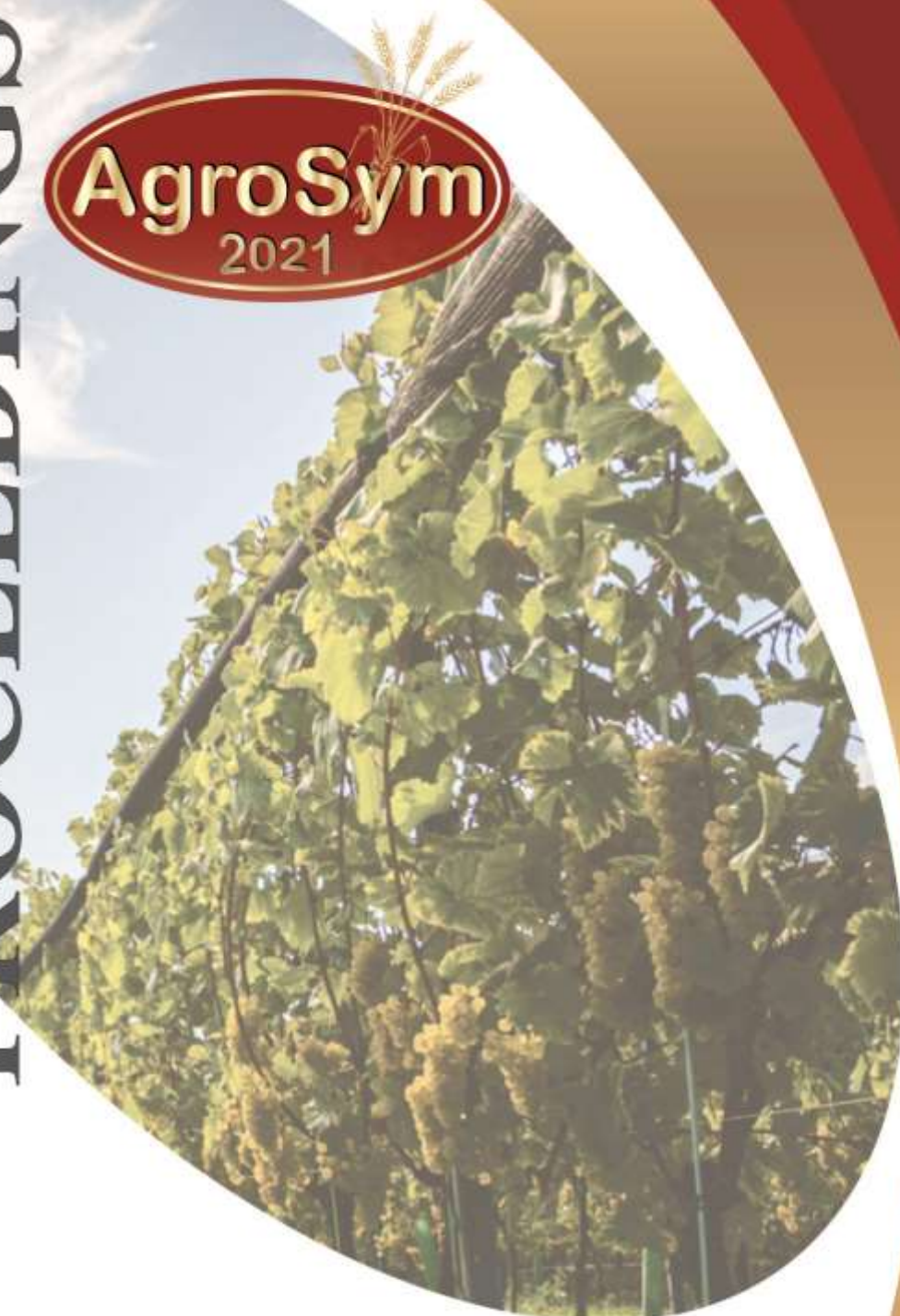


BOOK OF PROCEEDINGS



***XII International Scientific
Agriculture Symposium
"AGROSYM 2021"
October 7-10, 2021***

BOOK OF PROCEEDINGS

**XII International Scientific Agriculture Symposium
“AGROSYM 2021”**



Jahorina, October 07 - 10, 2021

Impressum

XII International Scientific Agriculture Symposium „AGROSYM 2021“

Book of Proceedings published by

University of East Sarajevo, Faculty of Agriculture, Republic of Srpska, Bosnia
University of Belgrade, Faculty of Agriculture, Serbia
Mediterranean Agronomic Institute of Bari (CIHEAM - IAMB) Italy
International Society of Environment and Rural Development, Japan
Balkan Environmental Association (B.EN.A), Greece
Centre for Development Research, University of Natural Resources and Life Sciences (BOKU),
Austria
Perm State Agro-Technological University, Russia
Voronezh State Agricultural University named after Peter The Great, Russia
Tokyo University of Agriculture
Faculty of Agriculture, University of Western Macedonia, Greece
Faculty of Bioeconomy Development, Vytautas Magnus University, Lithuania
Enterprise Europe Network (EEN)
Faculty of Agriculture, University of Akdeniz - Antalya, Turkey
Selçuk University, Turkey
University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania
Slovak University of Agriculture in Nitra, Slovakia
Ukrainian Institute for Plant Variety Examination, Kyiv, Ukraine
National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
Valahia University of Targoviste, Romania
National Scientific Center „Institute of Agriculture of NAAS“, Kyiv, Ukraine
Saint Petersburg State Forest Technical University, Russia
University of Valencia, Spain
Faculty of Agriculture, Cairo University, Egypt
Tarbiat Modares University, Iran
Chapingo Autonomous University, Mexico
Department of Agricultural, Food and Environmental Sciences, University of Perugia, Italy
Higher Institute of Agronomy, Chott Mariem-Sousse, Tunisia
Watershed Management Society of Iran
Institute of Animal Science- Kostinbrod, Bulgaria
Faculty of Economics Brcko, University of East Sarajevo, Bosnia and Herzegovina
Biotechnical Faculty, University of Montenegro, Montenegro
Institute of Field and Vegetable Crops, Serbia
Institute of Lowland Forestry and Environment, Serbia
Institute for Science Application in Agriculture, Serbia
Agricultural Institute of Republic of Srpska - Banja Luka, Bosnia and Herzegovina
Maize Research Institute “Zemun Polje”, Serbia
Faculty of Agriculture, University of Novi Sad, Serbia
Institute for Animal Science, Ss. Cyril and Methodius University in Skopje, Macedonia
Academy of Engineering Sciences of Serbia, Serbia
Balkan Scientific Association of Agricultural Economics, Serbia
Institute of Agricultural Economics, Serbia

Editor in Chief

Dusan Kovacevic

Technical editors

Sinisa Berjan
Milan Jugovic
Noureddin Driouech
Rosanna Quagliariello

Website:

<http://agrosym.ues.rs.ba>

CIP - Каталогизација у публикацији
Народна и универзитетска библиотека
Републике Српске, Бања Лука

631(082)(0.034.2)

INTERNATIONAL Scientific Agriculture Symposium "AGROSYM" (12 ;
Jahorina ; 2021)

Book of Proceedings [Електронски извор] / XII International
Scientific Agriculture Symposium "AGROSYM 2021", Jahorina, October 07
- 10, 2021 ; [editor in chief Dusan Kovacevic]. - Onlajn izd. - El. zbornik. -
East Sarajevo : Faculty of Agriculture, 2021. - Ilustr.

Sistemski zahtjevi: Nisu navedeni. - Način pristupa (URL):
http://agrosym.ues.rs.ba/article/showpdf/BOOK_OF_PROCEEDINGS_2021_FINAL.pdf. - El. publikacija u PDF formatu opsega 1465 str. - Nasl. sa naslovnog ekrana. - Opis izvora dana 15.11.2021. - Bibliografija uz svaki rad. - Registar.

ISBN 978-99976-787-9-9

COBISS.RS-ID 134751233

XII International Scientific Agricultural Symposium “AGROSYM 2021” Jahorina, October 07-10, 2021, Bosnia and Herzegovina

HONORARY COMMITTEE

Prof. dr Boris Pasalic, Minister of Agriculture, Water Management and Forestry of Republic of Srpska, Bosnia and Herzegovina
Mr Srdjan Rajcevic, Minister of Scientific-Technological Development, Higher Education and Information Society of Republic of Srpska, Bosnia and Herzegovina
Prof. dr Mario T. Tabucanon, President of the International Society of Environment and Rural Development, Japan
Prof. dr Milan Kulic, Rector of the University of East Sarajevo, Bosnia and Herzegovina
Prof. dr Dusan Zivkovic, Dean of the Faculty of Agriculture, University of Belgrade, Serbia
Dr. Maurizio Raeli, Director of the Mediterranean Agronomic Institute of Bari, Italy
Prof. dr Metin Aksoy, Rector of the Selcuk University, Turkey
Prof. dr Aleksey Andreev, Rector of the Perm State Agro-Technological University, Russia
Prof. dr Antanas Maziliauskas, Rector of the Vytautas Magnus University Agriculture Academy, Lithuania
Prof. dr Alexey Yu. Popov, Rector of the Voronezh State Agricultural University named after Peter The Great, Russia
Prof. dr Barbara Hinterstoisser, Vice-Rector of the University of Natural Resources and Life Sciences (BOKU), Austria
Prof. dr Sorin Mihai Cimpeanu, Rector of the University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania
Doc. Ing. Klaudia Halászová, Rector of the Slovak University of Agriculture in Nitra, Slovakia
Prof. dr Calin D. Oros, Rector of the Valahia University of Targoviste, Romania
Prof. Dr Katerina Melfou, Dean of the Faculty of Agriculture, University of Western Macedonia, Greece
Prof. dr Amr Ahmed Mostafa, Dean of the Faculty of Agriculture, Cairo University, Egypt
Prof. dr José Sergio Barrales Domínguez, Rector of the Chapingo Autonomous University, Mexico
Prof. dr Davut Karayel, Dean of Faculty of Agriculture, University of Akdeniz - Antalya, Turkey
Prof. Dr EGUCHI Fumio, Rector of the Tokyo University of Agriculture, Japan
Prof. Dr Zeki Bayramoğlu, Dean of Faculty of Agriculture, University of Selçuk- Konya, Turkey
Dr Chokri Thabet, the General Director of the High Agronomic Institute of Chott Mariem, Sousse, Tunisia
Prof. dr Ivan Yanchev, Director of the Institute of Animal Science- Kostinbrod, Bulgaria
Prof. dr Seyed Hamidreza Sadeghi, Professor at Tarbiat Modares University and the President of the Watershed Management Society of Iran, Iran
Prof. dr Francesco Tei, Director of the Department of Agricultural, Food and Environmental Sciences, University of Perugia, Italy
Prof. dr Viktor Kaminskyi, Director of National Scientific Center „Institute of Agriculture of NAAS“, Kyiv, Ukraine
Prof. dr Mirza Dautbasic, Dean of the Faculty of Forestry, University of Sarajevo, Bosnia and Herzegovina
Prof. dr Bozidarka Markovic, Dean of the Biotechnical Faculty, University of Podgorica, Montenegro
Prof. dr Rade Jovanovic, Director of the Institute for Science Application in Agriculture, Serbia
Prof. dr Lazar Radovanovic, Dean of the Faculty of Economics Brcko, University of East Sarajevo, Bosnia and Herzegovina
Prof. dr Vojislav Trkulja, Director of Agricultural Institute of Republic of Srpska - Banja Luka, Bosnia and Herzegovina
Dr. Branka Kresovic, Director of the Maize Research Institute “Zemun Polje”, Serbia
Dr Svetlana Balesevic-Tubic, Director of the Institute of Field and Vegetable Crops, Serbia
Prof. dr Nedeljko Tica, Dean of the Faculty of Agriculture, University of Novi Sad, Serbia
Prof. dr Rodne Nastova, Director of the Institute for Animal Science, Skoplje, Macedonia
Prof. dr Sasa Orlovic, Director of the Institute of Lowland Forestry and Environment, Serbia
Prof. dr Jonel Subic, Director of the Institute of Agricultural Economics, Serbia
Prof. dr Branko Kovacevic, President of the Academy of Engineering Sciences of Serbia, Serbia
Prof. dr Radovan Pejanovic, President of Balkan Scientific Association of Agricultural Economics, Serbia

SCIENTIFIC COMMITTEE

Chairman: Academician Prof. dr Dusan Kovacevic, Faculty of Agriculture, University of Belgrade, Serbia
Prof. dr Machito Mihara, Tokyo University of Agriculture, Japan
Prof. dr John Brayden, Norwegian Agricultural Economics Research Institute (NILF), Norway
Prof. dr Steve Quarie, Visiting Professor, School of Biology, Newcastle University, United Kingdom
Prof. dr Andreas Melcher, CDR, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria
Prof. dr Dieter Trautz, University of Applied Science, Germany
Prof. dr Sergei Eliseev, Vice-Rector for Research and Innovations, Perm State Agro-Technological University, Russia
Prof. dr Dani Shtienberg, full professor, Department of Plant pathology and Weed Research, ARO, the Volcani Center, Bet Dagan, Israel

Prof. dr William Meyers, Howard Cowden Professor of Agricultural and Applied Economics, University of Missouri, USA

Prof. dr Markus Schermer, Department of Sociology, University of Innsbruck, Austria

Academician Prof. dr Novo Przulj, Faculty of Agriculture, University of Banjaluka, Bosnia and Herzegovina

Prof. dr Thomas G. Johnson, University of Missouri – Columbia, USA

Prof. dr Fokion Papatthasiou, School of Agricultural Sciences, University of Western Macedonia, Greece

Prof. dr Sabahudin Bajramovic, Faculty of Agriculture and Food Sciences, University of Sarajevo, Bosnia and Herzegovina

Prof. dr Hiromu Okazawa, Faculty of Regional Environment Science, Tokyo University of Agriculture, Japan

Prof. dr Tatiana Sivkova, Faculty for Veterinarian Medicine and Zootechny, Perm State Agro-Technological University, Russia

Prof. dr Aleksej Lukin, Voronezh State Agricultural University named after Peter The Great, Russia

Prof. dr Matteo Vittuari, Faculty of Agriculture, University of Bologna, Italy

Prof. dr Seyed Mohsen Hosseini, Faculty of Natural Resources, Tarbiat Modares University, Iran

Prof. dr Ardian Maci, Faculty of Agriculture and Environment, Agricultural University of Tirana, Albania

Prof. dr Regucivilla A. Pobar, Bohol Island State University, Philippines

Prof. dr Sudheer Kundukulangara Pulissery, Kerala Agricultural University, India

Prof. dr EPN Udayakumara, Faculty of Applied Sciences, Sabaragamuwa University, Sri Lanka

Prof. dr Vladimír Smutný, full professor, Mendel University, Faculty of agronomy, Czech Republic

Prof. dr Franc Bavec, full professor, Faculty of Agriculture and Life Sciences, Maribor, Slovenia

Prof. dr Jan Moudrý, full professor, Faculty of Agriculture, South Bohemia University, Czech Republic

Prof. dr Stefan Tyr, full professor, Faculty of Agro-biology and Food Resources, Slovakia

Prof. dr Natalija Bogdanov, Faculty of Agriculture, University of Belgrade, Serbia

Prof. dr Richard Barichello, Faculty of Land and Food Systems, University of British Columbia, Canada

Prof. dr Francesco Porcelli, University of Bari Aldo Moro, Italy

Prof. dr Vasilije Isajev, Faculty of Forestry, University of Belgrade, Serbia

Prof. dr Elazar Fallik, Agricultural Research Organization (ARO), Volcani, Israel

Prof. dr Junaid Alam Memon, Pakistan Institute of Development Economics, Pakistan

Prof. dr. Jorge Batlle-Sales, Department of Biology, University of Valencia, Spain

Prof. dr Pandi Zdruli, Land and Water Resources Department; IAMB, Italy

Prof. dr Mladen Todorovic, Land and Water Resources Department; IAMB, Italy

Dr. Hamid El Bilali, Mediterranean Agronomic Institute of Bari, Italy

Prof. dr Maksym Melnychuk, National Academy of Agricultural Science of Ukraine, Ukraine

Prof. dr Borys Sorochnykyi, Ukrainian Institute for Plant Variety Examination, Kyiv, Ukraine

Dr. Lorenz Probst, CDR, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria

Prof. dr Mohsen Boubaker, High Institute of Agronomy of Chott Meriem, Sousse, Tunisia

Dr. Nouredin Driouech, Coordinator of MAIB Alumni Network (FTN), Mediterranean Agronomic Institute of Bari, Italy

Prof. dr Ion Viorel, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania

Prof. dr. Chuleemas Boonthai Iwai, Faculty of Agriculture, Khon Kaen University, Thailand

Prof. dr Wathuge T.P.S.K. Senarath, Department of Botany, University of Sri Jayewardenepura, Colombo, Sri Lanka

Dr. Hamada Abdelrahman, Soil Science Dept., Faculty of Agriculture, Cairo University, Egypt

Prof. dr Maya Ignatova, Agricultural Academy – Sofia, Bulgaria

Prof. dr Ioannis N. Xynias, School of Agricultural Technology & Food Technology and Nutrition, Western Macedonia University of Applied Sciences, Greece

PhD ing. Artur Rutkiewicz, Department of Forest Protection, Forest Research Institute - IBL, Poland

Prof. dr Mohammad Sadegh Allahyari, Islamic Azad University, Rasht Branch, Iran

Dr. Lalita Siri wattananon, Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi (RMUTT), Thailand

Prof. dr Konstantin Korlyakov, Perm Agricultural Research Institute, Russia

Dr. Mohammad Farooque Hassan, Shaheed Benazir Bhutto University of Veterinary & Animal Sciences Sakrand, Sindh, Pakistan

Dr. Larysa Prysiashniuk, Ukrainian Institute for Plant Variety Examination, Kyiv, Ukraine

Prof. dr Oksana Kliachenko, National University of Life and Environmental Science of Ukraine, Ukraine

Prof. dr Ivan Simunic, Department of amelioration, Faculty of agriculture, University of Zagreb, Croatia

Dr. Abid Hussain, International Centre for Integrated Mountain Development (ICIMOD), Nepal

Dr. Amrita Ghatak, Gujarat Institute of Development Research (GIDR), India

Prof. dr Naser Sabaghnia, University of Maragheh, Iran

Dr. Karol Wajszczuk, Poznan University of Life Sciences, Poland

Prof. dr Penka Moneva, Institute of Animal Science - Kostinbrod, Bulgaria

Prof. dr Mostafa K. Nassar, Animal husbandry Dept., Faculty of Agriculture, Cairo University, Egypt

Prof. dr Márta Birkás, full professor, St. Istvan University, Godollo - Hungary

Prof. dr Andrzej Kowalski, Director of the Institute for Agricultural and Food Economy, Warszawa-Poland

Prof. dr Yalcin Kaya, The Director of the Plant Breeding Research Center, University of Trakya, Turkey

Prof. dr Sanja Radonjic, Biotechnical Faculty, University of Montenegro, Montenegro
Prof. dr Ionela Dobrin, Department for Plant Protection, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania
Prof. dr Inocencio Buot Jr., Institute of Biological Sciences, College of Arts and Sciences, University of the Philippines Los Banos, Philippines
Prof. dr Monica Paula Marin, Department for Animal Husbandry, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania
Prof. dr Nedeljka Nikolova, Institute for Animal Science, Ss. Cyril and Methodius University in Skopje, Republic of Macedonia
Prof. dr Mohammad Al-Mamun, Department of Animal Nutrition, Bangladesh Agricultural University, Bangladesh
Prof. dr Anucha Wittayakorn-Puripunpinyoo, School of Agriculture and Co-operatives, Sukhothai Thammathirat Open University, Nonthaburi, Thailand
Dr. Redouane Choukr-Allah, International Center for Biosaline Agriculture (ICBA), United Arab Emirates
Prof. dr Ignacio J. Díaz-Maroto, High School Polytechnic, University of Santiago de Compostela, Spain
Prof. dr Nidal Shaban, University of Forestry Sofia, Bulgaria
Prof. dr Mehdi Shafaghati, Faculty of Geography, Tarbiat Moalem (kharazmi) University, Iran
Prof. dr Youssif Sassine, Lebanese University Beirut, Lebanon
Prof. dr Cafer Topaloglu, Faculty of Tourism, Mugla Sitki Kocman University, Turkey
Prof. dr Seyed Hamidreza Sadeghi, Faculty of Natural Resources, Tarbiat Modares University, Iran
Prof. dr Mohsen Mohseni Saravi, University of Teheran and Member of WMSI Management Board, Iran
Prof. dr Branislav Draskovic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Prof. dr Mahmood Arabkhedri, Soil Conservation and Watershed Management Research Institute and Member of WMSI Management Board, Iran
Prof. dr Ataollah Kavian, Sari Agricultural Science and Natural Resources University and Member of WMSI Management Board, Iran
Prof. dr Tugay Ayasan, Department of Organic Farming Business Management, Osmaniye, Applied Science School of Kadirli, Osmaniye Korkut Ata University, Turkey
Prof. dr Sakine Özpınar, Department of Farm Machinery and Technologies Engineering, Faculty of Agriculture, Çanakkale Onsekiz Mart University, Çanakkale, Turkey
Prof. dr Sherein Saeide Abdelgayed, Faculty of Veterinary Medicine, Cairo University, Cairo, Egypt
Prof. dr Zohreh Mashak, Islamic Azad University, Karaj Branch, Iran
Dr. Khalid Azim, National Institute of Agriculture Research, Morocco
Dr. Mario Licata, Department of Agricultural, Food and Forest Sciences, University of Palermo, Italy
Prof. dr Srdjan Lalic, University of East Sarajevo, Bosnia and Herzegovina
Prof. dr Zeljko Vasko, Faculty of Agriculture, University of Banja Luka, Bosnia and Herzegovina
Dr. Edouard Musabanganji, School of Economics/CBE, University of Rwanda, Rwanda
Prof. dr Kubilay Baştaş, Department of Plant Protection, Faculty of Agriculture, Selçuk University, Turkey
Dr. Branka Kresovic, Director of the Maize Research Institute “Zemun Polje”, Serbia
Dr. Nenad Delic, Maize Research Institute “Zemun Polje”, Serbia
Dr. Milan Stevanovic, Maize Research Institute “Zemun Polje”, Serbia
Dr. Svetlana Balesevic-Tubic, Institute of Field and Vegetable Crops Novi Sad, Serbia
Dr. Ana Marjanovic Jeromela, Institute of Field and Vegetable Crops Novi Sad, Serbia
Prof. dr Tatjana Krajisnik, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Prof. dr Aleksandra Govedarica-Lucic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Prof. dr Desimir Knezevic, University of Pristina, Faculty of Agriculture, Kosovska Mitrovica - Lesak, Kosovo i Metohija, Serbia
Dr. Snezana Mladenovic-Drinic, Maize Research Institute “Zemun Polje”, Serbia
Prof. dr Nebojsa Momirovic, Faculty of Agriculture, University of Belgrade, Serbia
Prof. dr Osman Mujezinovic, Faculty of Forestry, University of Sarajevo, Bosnia and Herzegovina
Prof. dr Dalibor Ballian, Faculty of Forestry, University of Sarajevo, Bosnia and Herzegovina
Prof. dr Velibor Spalevic, Faculty of Philosophy, Geography, University of Montenegro
Prof. dr Zoran Jovovic, Biotechnical Faculty, University of Montenegro, Montenegro
Prof. dr Danijel Jug, Faculty of Agriculture, University of Osijek, Croatia
Prof. dr Milan Markovic, Biotechnical Faculty, University of Montenegro, Montenegro
Prof. dr Zeljko Dolijanovic, Faculty of Agriculture, University of Belgrade, Serbia
Dr Dejan Stojanovic, Institute of Lowland Forestry and Environment, Serbia
Dr Dobrivoj Poštić, Institute for plant protection and environment, Belgrade, Serbia
Dr Srdjan Stojnic, Institute of Lowland Forestry and Environment, Serbia
Dunja Demirović Bajrami, Research Associate, Geographical Institute “Jovan Cvijić,” Serbian Academy of Sciences and Arts, Belgrade, Serbia

ORGANIZING COMMITTEE

Chairperson: Prof. dr Vesna Milic, Dean of the Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Dr Marko Gutalj, Vice rector of the University of East Sarajevo, Bosnia and Herzegovina
Dr Jelena Kronic, Vice rector of the University of East Sarajevo, Bosnia and Herzegovina
Dr. Maroun El Moujabber, Mediterranean Agronomic Institute of Bari, Italy
Mrs. Rosanna Quagliariello, Mediterranean Agronomic Institute of Bari, Italy
Prof. dr Aleksandra Despotovic, Biotechnical Faculty Podgorica, University of Montenegro, Montenegro
Dr. Nouredin Driouech, Coordinator of MAIB Alumni Network (FTN), Mediterranean Agronomic Institute of Bari, Italy
Dr Milic Curovic, The journal "Agriculture and Forestry", Biotechnical Faculty Podgorica, University of Montenegro, Montenegro
Dr. Tatiana Lysak, International Relations Office, Voronezh State Agricultural University named after Peter The Great, Russia
Dr. Oksana Fotina, International Relations Center, Perm State Agro-Technological University, Russia
Prof. dr Fokion Papathanasiou, School of Agricultural Sciences, University of Western Macedonia, Greece
Dr Ana Marjanović Jeromela, Institute of Field and Vegetable Crops, Serbia
Dr. Anastasija Novikova, Faculty of Bioeconomy Development, Vytautas Magnus University, Lithuania
Prof. dr Engr. Teodora Popova, Institute of Animal Science - Kostinbrod, Bulgaria
Prof. dr Mehmet Musa Ozcan, Faculty of Agriculture, Selçuk University, Turkey
Dr. Abdulvahed Khaledi Darvishan, Faculty of Natural Resources, Tarbiat Modares University, Iran
Prof. dr Nikola Pacinovski, Institute for Animal Science, Ss. Cyril and Methodius University in Skopje, N. Macedonia
MSc. Erasmo Velázquez Cigarroa, Department of Rural Sociology, Chapingo Autonomous University, Mexico
Dr. Ecaterina Stefan, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania
Dr. Jeeranuch Sakkhamduang, The International Society of Environmental and Rural Development, Japan
Dr. Raoudha Khanfir Ben Jenana, High Institute of Agronomy of Chott Meriem, Sousse, Tunisia
Dr. Hamada Abdelrahman, Soil Science Dept., Faculty of Agriculture, Cairo University, Egypt
Dr. Dragana Sunjka, Faculty of Agriculture, University of Novi Sad, Serbia
MSc. Vedran Tomic, Institute for Science Application in Agriculture, Serbia
Dr. Milan Stevanovic, Maize Research Institute "Zemun Polje", Serbia
Dr. Andrej Pilipovic, Institute of Lowland Forestry and Environment, Serbia
Dr. Sc. Morteza Behzadfar, Tarbiat Modares University, Tehran, Iran
Dr. Larysa Prysiazniuk, Ukrainian Institute for Plant Variety Examination, Kyiv, Ukraine
Dr. Diana Bilić-Šobot, Faculty of Agriculture, University of Niš, Serbia
Doc. dr Sead Ivojevic, Faculty of Forestry, University of Sarajevo, Bosnia and Herzegovina
Dr. Nenad Markovic, Enterprise E. N. (EEN) Coordinator, University of East Sarajevo, Bosnia and Herzegovina
Mrs Branislavka Boroja, Agricultural Institute of Republic of Srpska - Banja Luka, Bosnia and Herzegovina
MSc. Milan Jugovic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Prof. dr Sinisa Berjan, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
MSc. Milena Stankovic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Dr. Stefan Stjepanovic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Doc. dr Dejana Stanic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
MSc. Stefan Bojic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
MSc. Tanja Jakisic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
MSc. Tijana Banjanin, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
MSc. Boban Miletic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
MSc. Todor Djorem, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
Dr. Igor Djurdjic, Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina, General Secretary

CHARACTERIZATION OF COLORED MAIZE SEED FRACTIONS USING FLUORESCENCE SPECTROSCOPY AND MULTIVARIATE ANALYSIS

Dragana BARTOLIĆ*, Miloš PROKOPIJEVIĆ, Mira STANKOVIĆ, Ksenija RADOTIĆ

Institute for Multidisciplinary Research, University of Belgrade (IMSI), Belgrade, Serbia

*Corresponding author: dragana.bartolic@imsi.rs

Abstract

Application of fluorescence spectroscopy combined with chemometrics algorithms provides rapid and non-destructive screening method in seed quality estimation, widely used in the agricultural industry and crop breeding. Fluorescence spectroscopy is a technique capable of detecting differs fluorophores among various colored maize seed cultivars and through different seed fractions. In the present study, we used the Multivariate Curve Resolution-Alternating Least Squares (MCR-ALS) algorithm to analyse the excitation-emission matrices (EEMs) of various cultivars of colored maize (*Zea mays* L.) seeds and its fractions. The EEMs were recorded as a set, with the excitation ranging from 280 nm to 330 nm and the emission spectra ranging from 300 nm to 550 nm. The MCR-ALS analysis yielded two major fluorescence components for all of the analysed samples. Both position and shape of component 1 (C1) varied among the samples. On the other hand, the position and shape were similar for component 2 (C2). C1 could be used as a marker for the discrimination of colored seeds and their fractions. The observed variations in C1 between the analysed seeds may be due to the presence of their individual fluorophores, assigned to anthocyanins, proteins, and phenolics. In conclusion, the MCR-ALS analysis of the seed emission spectra has a great potential for the rapid and non-expensive characterization of various cultivars of colored seeds.

Keywords: *maize seed, fluorescence, Multivariate Curve Resolution-Alternating Least Squares.*

Introduction

Maize (*Zea mays* L.) is considered one of the major food sources worldwide. Health benefits correlated to consumption of the whole grain are related not only to nutrients like carbohydrates, proteins, dietary fiber, vitamins, and minerals but also to the presence of various phytochemicals (Siyuan, Tong, and Liu 2018). Properties of these phytochemicals contribute to the high antioxidant activities of the maize seeds (Del Pozo-Insfran et al. 2006). It is well known that phenolic compounds, mainly phenolic acids, flavonoids, and tannins are major phytochemicals abundant in seeds, with different composition and distribution within the seed fractions (Ndolo and Beta 2014). Polyphenolics like ferulic and p-coumaric acid found in white maize as well as their derivatives, have antioxidant and anticarcinogenic effects according to reported studies. Red colored maize seeds on the other hand have higher anthocyanins content which also expresses antioxidant activity (Del Pozo-Insfran et al. 2006).

Fluorescence spectroscopy is a sensitive, non-destructive and rapid technique, which doesn't require complex sample pretreatment and preparation. It has been used in analysis of various kinds of food, such as cereals food, dairy products, wine, honey and other samples (Sádecká and Tóthová 2007). Fluorescence spectra of cereals are dependent on the species and the cultivar (Zandomeneghi 1999). Cereal food contains a large number of fluorescent molecules

(fluorophores) such as proteins, phenolics and others. The fluorescence spectrum of a food sample is complex, composed of the signals of the contributing fluorophores. In combination with suitable statistical analysis, fluorescence spectra are useful tools for various applications (Sádecká and Tóthová 2007). Applications of the fluorescence spectroscopy combined with Multivariate Curve Resolution-Alternating Least Squares (MCR-ALS) for food analyses have been reported previously in many studies (Bartolić et al. 2018; Stanković et al. 2019, 2021).

We developed methods for the measurement and analysis of emission spectra with MCR-ALS of macromolecules composed of different kinds of monomers such as proteins and polyphenols for characterization of different cultivars of pigmented maize seeds (white and red).

Material and Methods

The pigmented (white and red) maize seeds were purchased from the local market in Belgrade, Serbia. The two fractions, inner and outer, were separated using the corresponding laboratory sieves after homogenisation in a mill and subsequently with liquid nitrogen in a mortar with a pestle. Obtained powder samples were used without any further processing before the fluorescence measurements.

The front-face fluorescence measurements of the red and white maize fractions were recorded by an F13-221 P spectrofluorimeter (JobinYvob, Horiba, France), equipped with a 450 W Xe lamp and a photomultiplier tube. The ranges of the excitation spectra were 280 - 330 nm, while the range for the recorded fluorescence emission spectra was 300 - 550 nm. A spectral bandwidth of 2 nm was used for excitation and emission slits.

The Multivariate Curve Resolution-Alternating Least Squares (MCR-ALS) algorithm was applied to analyse the excitation-emission matrices (EEMs) of studied samples. The MCR-ALS has been used to decompose the overlapping mixture of spectral signals into individual components (Stanković et al. 2019).

Results and Discussion

The representative excitation-emission matrices (EEMs) for the inner and outer seed fractions of the various cultivars of pigmented *Zea mays* L. seeds, are presented in Figure 1 (A-D). The differences were observed in their EEMs, which could be explained by the presence of their individual fluorophores, assigned to anthocyanins, proteins, and phenolics (Sádecká and Tóthová 2007). The EEMs of white seeds (Figure 1 A and B), showed considerably weaker emission signal in the range 330 - 360 nm for the excitation 280 - 295 nm, compared to red seeds.

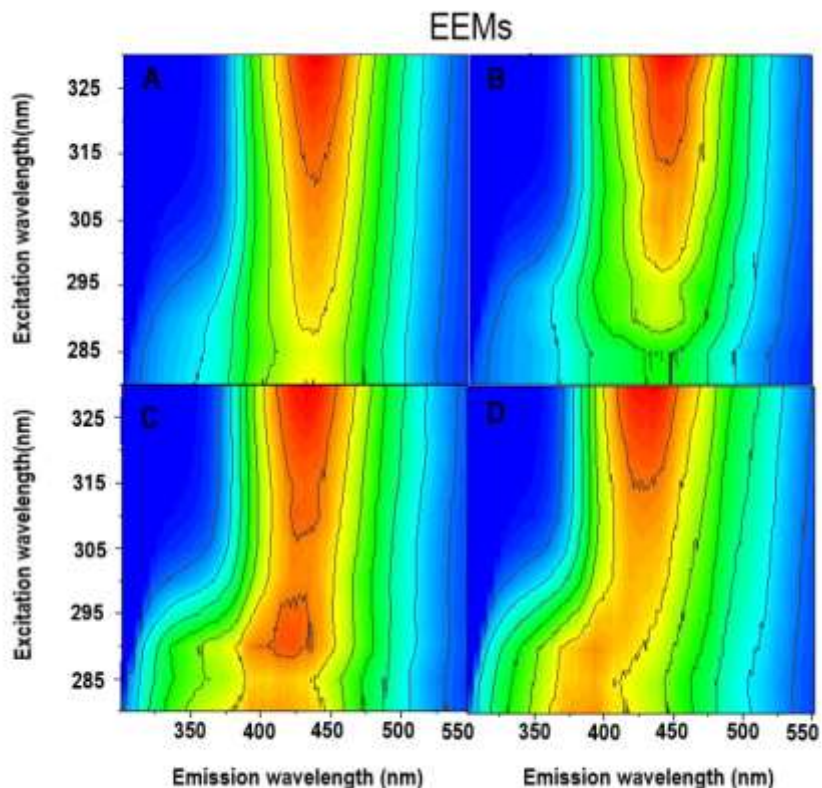


Figure 1. EEMs of the *Zea mays* L. seeds' fractions: inner (A-White and C-red) and outer (B-white and D-red).

Results of MCR-ALS analysis yielded two major fluorescence components. The position and shape of components C1 and C2 varied among the analysed samples.

As shown in Figure 2, the peak position of component 1 (C1) and component 2 (C2) were found around 360 nm and 450 nm, respectively. According to literature data, the fluorescence of the first component (C1) with the emission maximum at 360 nm originates from the aromatic amino acids present in cereal proteins (Zandomenighi, 1999). Among the analysed samples, the C1 component of the red seeds fraction exhibited the highest relative intensity. Position of the emission maximum of C2 component, assigned to phenolic compounds, varied among the samples.

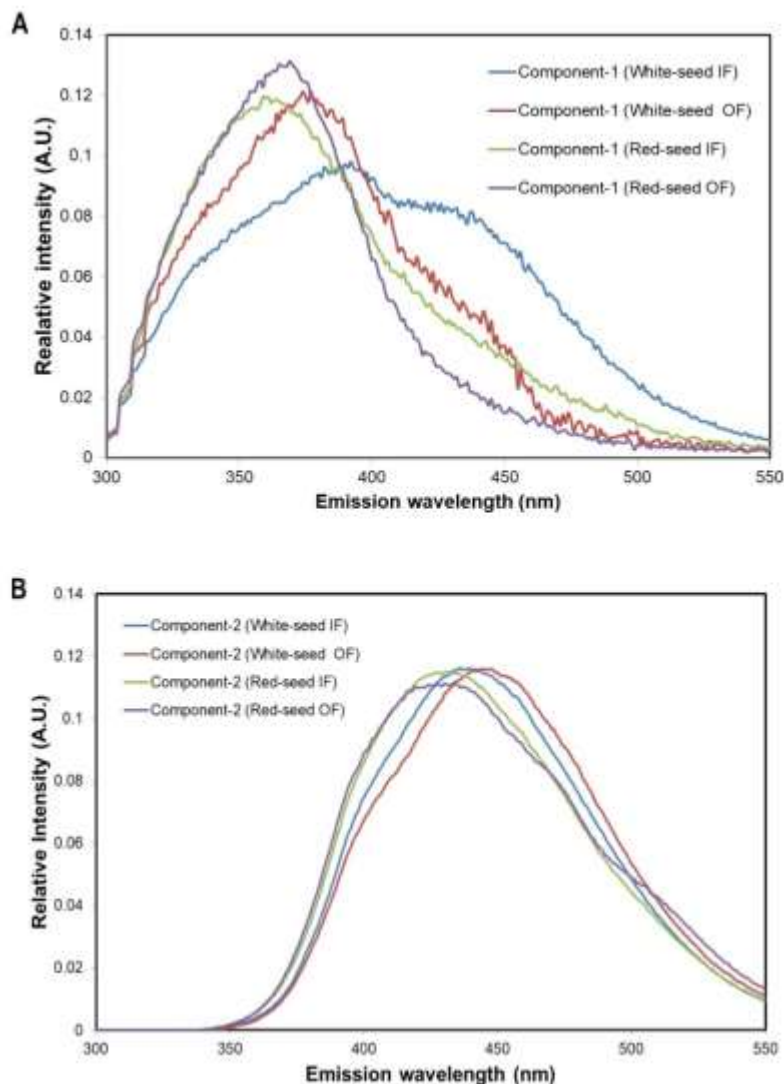


Figure 2. Emission profiles of the spectral components A) component 1 (C1) and B) component 2 (C2) obtained using the MCR-ALS method.

Conclusions

Our results imply that fluorescence spectroscopy combined with the MCR-ALS method could be applied to the rapid, simple, non-expensive characterization of various cultivars of colored seeds and their fractions. As the seed quality depends on different conditions, such as processing, storage, and others, MCR-ALS-derived components may be useful indicators for the screening of cereal seeds' health effects.

Acknowledgement

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, by the grant number 451-03-9/2021-14/200053.

References

- Bartolić D, Stanković M, Mutavdžić D, Stanković S, Jovanović D, Radotić K (2018). Multivariate Curve Resolution - Alternate Least Square Analysis of Excitation-Emission Matrices for Maize Flour Contaminated with Aflatoxin B1, *Journal of Fluorescence*, 28 (3), 729–733.
- Ndolo VU, Beta T (2014). Comparative Studies on Composition and Distribution of Phenolic Acids in Cereal Grain Botanical Fractions, *Cereal Chemistry*, 91 (5), 522–530.
- Del Pozo-Insfran D, Brenes CH, Serna Saldivar SO, Talcott ST (2006). Polyphenolic and Antioxidant Content of White and Blue Corn (*Zea Mays* L.) Products, *Food Research International*, 39 (6), 696–703.
- Sádecká J, Tóthová J (2007). Fluorescence Spectroscopy and Chemometrics in the Food Classification - A Review, *Czech Journal of Food Sciences*, 25 (4), 159–173.
- Siyuan S, Tong L, Rui Hai L (2018). Corn Phytochemicals and Their Health Benefits, *Food Science and Human Wellness*, 7 (3), 185–195.
- Stanković M, Bartolić D, Šikoparija B, Spasojević D, Mutavdžić D, Natić M, Radotić K (2019). Variability Estimation of the Protein and Phenol Total Content in Honey Using Front Face Fluorescence Spectroscopy Coupled with MCR–ALS Analysis, *Journal of Applied Spectroscopy*, 86 (2), 256–263.
- Stanković M, Bartolić D, Mutavdžić D, Marković S, Grubić S, Jovanović NM, Radotić K (2021). Estimation of Honey Bee Colony Infection with *Nosema Ceranae* and *Varroa Destructor* Using Fluorescence Spectroscopy in Combination with Differential Scanning Calorimetry of Honey Samples, *Journal of Apicultural Research* 0 (0), 1–7. DOI: 10.1080/00218839.2021.1889803.
- Zandomenighi, M (1999). Fluorescence of Cereal Flours, *Journal of Agricultural and Food Chemistry*, 47 (3), 878–882.