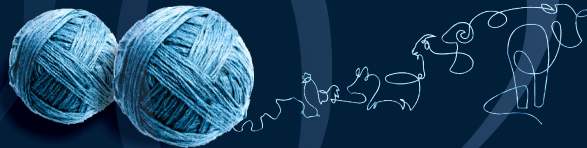


13th
INTERNATIONAL
SYMPOSIUM

MODERN
TRENDS
IN LIVESTOCK
PRODUCTION



P R O C E E D I N G S

6 - 8 October 2021, Belgrade, Serbia

Institute for Animal Husbandry
Belgrade - Zemun, SERBIA

**13th
INTERNATIONAL
SYMPOSIUM**

**MODERN
TRENDS
IN LIVESTOCK
PRODUCTION**



6-8 October 2021, Belgrade, Serbia

PATRON

Ministry of Education, Science and Technological
Development of the Republic of Serbia

ORGANIZER

Institute for Animal Husbandry
Autoput 16, P. Box. 23,
11080, Belgrade-Zemun, Serbia
Tel: +381 11 2691 611; +381 11 2670 121; +381 11 2670 541;
Fax: + 381 11 2670 164;

PUBLISHER

Institute for Animal Husbandry, Belgrade-Zemun, Serbia
Editor-in-Chief
Čedomir Radović, PhD, Senior Research associate
Director of the Institute for Animal Husbandry, Belgrade-Zemun

Editor

Zdenka Škrbić, PhD, Principal Research Fellow
Institute for Animal Husbandry, Belgrade-Zemun

The Proceedings is printed by the Institute for Animal Husbandry,
Belgrade, 2021

biotechnology.izs@gmail.com

www.istocar.bg.ac.rs

Circulation 100 copies.

ISBN 978-86-82431-77-0



INTERNATIONAL SCIENTIFIC COMMITTEE

CHAIRMAN

Prof. Dr. **Giacomo Biagi**,
Department of Veterinary Medical Sciences, University of Bologna, Italy

SECRETARY

Dr. **Čedomir Radović**,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

MEMBERS

Dr. **Zdenka Škrbić**,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Dr. **Veselin Petričević**,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Prof. Dr. **Marjeta Čandek-Potokar**,
Agricultural Institute of Slovenia, Slovenia

Dr. **Giuseppe Bee**,
Agroscope Posieux, Posieux, Switzerland

Prof. Dr. **Elena Kistanova**,
Institute of Biology and Immunology of Reproduction „Kiril Bratanov“,
Sofia, Bulgaria

Prof. Dr. **Stayka Laleva**,
Agricultural Institute, Stara Zagora, Bulgaria

Prof. Dr. **Galia Zamaratskaia**,
Department of Molecular Sciences, BioCenter, Swedish University of
Agricultural Sciences, Uppsala, Sweden

Dr. **Miloš Lukić**,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Dr. **Vlada Pantelić**,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Prof. Dr. **Maya Ignatova**,
Institute of Animal Science, Kostinbrod, Bulgaria

Dr. **Dragana Ružić-Muslić**,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Prof. Dr. **Marina I. Selionova**,
FSBSI-All-Russian Scientific Research Institute of Sheep and Goat Breeding,
Stavropol, Russia

Prof. Dr. **Radica Đedović**,
University of Belgrade, Faculty of Agriculture, Serbia



Prof. Dr. **Slavča Hristov**,
University of Belgrade Faculty of Agriculture, Serbia
Dr. **Duška Ostojić Andrić**,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia
Prof. Dr. **Lidija Perić**,
University of Novi Sad, Faculty of Agriculture Novi Sad, Serbia
Prof. Dr. **Wladyslaw Migdal**,
Department of Animal Product Technology,
University of Agriculture in Kraków, Poland
Prof. Dr. **Danijela Kirovski**,
University of Belgrade, Faculty of Veterinary Medicine, Serbia
Prof. Dr. **Yalçın Bozkurt**,
Isparta University of Applied Science,
Department of Animal Science, Isparta, Turkey
Dr. **Snežana Mladenović Drinić**,
Maize Research Institute „Zemun Polje“, Zemun Polje, Serbia
Prof. Dr. **Randelin Dmitry Alexandrovich**,
Faculty of Biotechnology and Veterinary Medicine,
Volgograd State Agricultural University, Russia
Assoc. Prof. **Itskovich Aleksandr Yuryevich**,
Faculty of Biotechnology and Veterinary Medicine,
Volgograd State Agricultural University, Russia
Prof. Dr. **Dragan Radojković**,
University of Belgrade Faculty of Agriculture, Serbia
Prof. Dr. **Milun Petrović**,
University of Kragujevac Faculty of Agronomy, Serbia
Prof. Dr. **Dragan Glamočić**,
University of Novi Sad, Faculty of Agriculture, Serbia
Prof. Dr. **Snežana Trivunović**,
University of Novi Sad, Faculty of Agriculture, Serbia
Prof. Dr. **Predrag Perišić**,
University of Belgrade, Faculty of Agriculture, Serbia
Prof. Dr. **Vladan Bogdanović**,
University of Belgrade, Faculty of Agriculture, Serbia
Dr. **Violeta Caro Petrović**,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia
Prof. Dr. **Zoran Ilić**,
University of Pristina, Faculty of Agricultural Sciences, Lešak, Serbia





Dr. Nevena Maksimović,

Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Dr. Ivan Pavlović,

Scientific Veterinary Institute of Serbia, Serbia

Dr. Aleksandar Stanojković,

Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Prof. Dr. Nenad Đorđević,

University of Belgrade, Faculty of Agriculture, Serbia

Dr. Zorica Bijelić,

Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Dr. Violeta Mandić,

Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Prof. Dr. Yusup A. Yuldashbaev,

Russian State Agrarian University,

Moscow Timiryazev Agricultural Academy,

Faculty of Animal Science and Biology, Russia

Prof. Dr. Pero Mijić,

Josip Juraj Strossmayer University of Osijek,

Faculty of Agrobiotechnical Sciences, Osijek, Croatia

Prof. Dr. Zoran Luković,

University of Zagreb Faculty of Agriculture,

Department of Animal Science and Technology, Croatia Asist.

Asist. Prof. Dubravko Škorput,

University of Zagreb Faculty of Agriculture,

Department of Animal Science and Technology, Croatia

Prof. Dr. Ivan Radović,

University of Novi Sad, Faculty of Agriculture, Serbia

Prof. Dr. Aleksandar Simić,

University of Belgrade, Faculty of Agriculture, Serbia

Prof. Dr. Nikola Pacinovski,

Ss Cyril and Methodius University in Skopje,

Institute of Animal Science, North Macedonia

Prof. Dr. Yessenbay Islamov,

Kazakh National Agrarian University, Kazakhstan

Prof. Dr. Ricmar P. Aquino,

University President, Isabela State University, Philippines

Prof. Dr. Rosa Nieto,

Departament of Physiology and Biochemistry of Animal Nutrition Estacion

Experimental del Zaidín, CSIC Armilla, Granada, Spain

Dr. Juan M. García Casco,

Departamento Mejora Genética Animal, INIA, Madrid, Spain

Dr. Slavica Stanković,

Maize Research Institute „Zemun Polje“, Zemun Polje, Serbia

Dr. Vesna S. Krnjaja,

Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Prof. Dr. Rui Miguel Carracha Charneca,

Universidade de Évora, Escola de Ciências e Tecnologia,

Instituto de Ciências Agrárias e Ambientais Mediterrânicas (ICAAM), Évora,

Portugal

Dr. Jean-Louis Peyraud,

INRA, UMR PEGASE, France



ORGANIZING COMMITTEE

CHAIRMAN

Dr. Čedomir Radović,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

SECRETARY

Dr. Dragan Nikšić,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

MEMBERS

Dr. Maja Petričević,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Dr. Marina Lazarević,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Dr. Nikola Delić,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Dr. Ljiljana Samolovac,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Dr. Marija Gogić,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia



SYMPOSIUM SECRETARIAT

CHAIRMAN

Dr. Dragan Nikšić,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

MEMBERS

Slavko Maletić, grad. econ.
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Olga Devečerski, grad. prof.
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Nenad Mičić, MSc,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Bogdan Cekić, MSc,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Miloš Marinković, MSc,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Vladimir Živković, BSc,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Nenad Stojiljković, BSc,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Ivan Čosić, BSc,
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Tamara Stameniće, BSc,
Institute for Animal Husbandry, Belgrade-Zemun





Address:

Institute for Animal Husbandry,
Autoput 16, P. Box 23,
11080, Belgrade-Zemun, Serbia

Tel:

+381 11 2691 611

+381 11 2670 121

+381 11 2670 541

Fax:

+381 11 2670 164

E-mail: biotechnology.izs@gmail.com
www.istocar.bg.ac.rs

CONTENTS

INVITED PAPERS

<i>Marjeta Čandek-Potokar, Giuseppe Bee</i> NEW TRENDS IN PUBLISHING RESEARCH AND TRANSFERRING THE KNOWLEDGE ON ANIMAL PRODUCTION (Slovenia-Switzerland).....	1-10
<i>Vesna Gantner, Denis Kučević, Muhamed Brka</i> AGRICULTURE AND ANIMAL PRODUCTION – FROM A FOUNDER OF CIVILIZATION TO A FAILURE OR SUSTAINABILITY (Croatia-Serbia-Bosnia and Herzegovina).....	11-22
<i>Giuseppe Bee, Catherine Ollagnier</i> IMPACT OF NUTRIENT SELF-SUPPLY THROUGH CHOICE FEEDING ON GROWTH PERFORMANCE, FEEDING BEHAVIOUR AND PROTEIN EFFICIENCY IN GROWING FINISHING PIGS (Switzerland).....	23-45
<i>Pero Mijić, Zdenko Ivkić, Tina Bobić</i> RESEARCH OF PRODUCTION RESULTS IN THE TRANSITION FROM CONVENTIONAL TO ROBOTIC MILKING (Croatia).....	46-55
<i>Ljiljana Samolovac, Slavča Hristov, Dušica Ostojić Andrić, Vlada Pantelić, Dragan Nikšić, Dragan Stanojević, Tamara Stamenić</i> ASSESSMENT OF BIOSECURITY AND WELFARE OF CALVES REARED IN INTENSIVE HOUSING SYSTEM (Serbia).	56-72
<i>Marina Lazarević, Nevena Maksimović, Nenad Mičić, Miloš Marinković, Vlada Pantelić, Dragan Nikšić, Dragan Stanojević</i> THE ASSESSMENT OF BREEDING VALUE OF FIRST CALVING HOLSTEIN - FRISIAN HEIFERS BY APPLYING SELECTION INDEX METHODOLOGY (Serbia).....	73-86
<i>Violeta Caro Petrović, Milan P. Petrović, Dragana Ružić-Muslić, Nevena Maksimović, Marina I. Selionova, Bogdan Cekić, Ivan Ćosić</i> PARITY EFFECT ON LAMBING RATE AND LAMBS BIRTH WEIGHT (Serbia-Russia).....	87-95
<i>Nikola Metodiev, Penka Moneva, Ivan Yanchev, Kostadin Kanchev</i> HEMATOLOGICAL STATUS OF ILE DE FRANCE SHEEP DEPENDING ON THEIR BODY CONDITION SCORE (Bulgaria).	96-102

<i>Nevena Maksimović, Dragana Ružić-Muslić, Violeta Caro Petrović, Bogdan Cekić, Ivan Ćosić, Nikola Delić, Marina Lazarević</i> CURRENT STATE OF GOAT BREEDING IN CENTRAL SERBIA (Serbia).....	103-116
<i>Marina I. Selionova, Tatyana V. Mamontova, Ali-Magomet M. Aybazov, Violeta Caro Petrović, Milan P. Petrović</i> QUALITY OF ABORIGENOUS KARACHAY GOAT MEAT UNDER DIFFERENT CONDITIONS (Russia-Serbia).....	117-125
<i>Nataša Tolimir, Zdenka Skrbić, Marijana Maslovarić, Miloš Lukić, Dragan Milić</i> THE IMPORTANCE OF EGGS IN THE DIET, CONSUMER PREFERENCES, THE PRODUCTION AND MARKET OF TABLE EGGS IN SERBIA (Serbia).....	126-148
<i>Radomir Savić, Vesna Davidović, Ivana Božičković</i> ASSESSMENT OF FERTILITY OF BOARS – DIFFERENT APPROACHES (Serbia).....	149-162
<i>Zoran Luković, Danijel Karolyi, Sven Menčik, Dubravko Škorput</i> EFFECT OF BIRTH WEIGHT ON SURVIVAL AND GROWTH PERFORMANCE OF PIGLETS FROM LARGE LITTERS (Croatia).....	163-172
<i>Patricia Palma-Granados, Ignacio Fernández-Fígares, Isabel Seiquer, Manuel Lachica, Luis Lara, Ana Haro, Rosa Nieto</i> PERFORMANCE, METABOLIC AND MEAT QUALITY IMPLICATIONS OF IMMUNOCASTRATION IN IBERIAN PIGS (Spain).....	173-184
<i>Galia Zamaratskaia, Andriy Getya</i> RAISING MALE PIGS AS AN ALTERNATIVE TO SURGICAL CASTRATION (Sweden-Ukraine).....	185-194
<i>Władysław Migdał, Rafał Duś, Maria Walczycka, Łukasz Migdał</i> SILESIA PIGS' FATTENERS - THE IDEA FOR HEALTHY PIG AND HIGH QUALITY PORK MEAT (Poland).....	195-207
<i>Marija Gogić, Nenad Katanić, Vladimir Živković, Nenad Stojiljković, Violeta Mandić, Maja Petričević, Radomir Savić</i> LIFE DAILY GAIN OF INDIGENOUS PIG BREEDS IN SERBIA (Serbia).....	208-216

<p><i>Nikola Delić, Dragan Nikšić, Maja Petričević, Aleksandar Stanojković, Vladimir Živković, Marina Lazarević, Nevena Maksimović</i> THE EFFECT OF PHYTOGENIC ADDITIVES ON THE DEGREE OF BACTERIAL INFECTION <i>B. HYODYSENTERIAE</i> IN WEANED PIGLETS (Serbia).....</p>	217-226
<p><i>Costanza Delsante, Carlo Pinna, Federica Sportelli, Claudio Stefanelli, Carla G. Vecchiato, Giacomo Biagi</i> ASSESSMENT OF THE EFFECTS OF EDIBLE MICROALGAE IN A CANINE GUT MODEL (Italy).....</p>	227-242
<p><i>Yalcin Bozkurt, Serkan Ozkaya, Sukran Kuleasan</i> THE EFFECTS OF PRE-SLAUGHTER RESTING PERIODS ON CARCASS AND MEAT QUALITY DETERMINED BY DIGITAL IMAGE ANALYSIS (Turkey).....</p>	243-251
<p><i>Nikola Stanišić, Milo Mujović, Slaviša Stajić, Maja Petričević, Čedomir Radović, Marija Gogić, Aleksandar Stanojković</i> TECHNO-FUNCTIONAL PROPERTIES OF THREE DIETARY FIBERS USED IN THE MEAT PROCESSING INDUSTRY (Netherlands-Serbia).....</p>	252-262
<p><i>Slaviša Stajić, Ana Kalušević</i> TECHNOLOGICAL AND SENSORY PROPERTIES OF SERBIAN TRADITIONAL MINCED MEAT PRODUCT ČEVAPI WITH IMPROVED NUTRITIONAL PROPERTIES (Serbia).....</p>	263-274
<p><i>Maja Petričević, Tamara Stamenić, Dragan Nikšić, Ljiljana Samolovac, Veselin Petričević, Marija Gogić, Violeta Mandić</i> EXAMINATION OF CERTAIN OF BEEF MEAT QUALITY TRAITS UNDER THE INFLUENCE OF FLAXSEED DIET (Serbia).....</p>	275-286
<p><i>Vesna Dragičević, Milena Simić, Milan Brankov, Milena Šenk, Vesna Krnjaja, Violeta Mandić, Branka Kresović</i> BIOFORTIFICATION AS A WAY OF NUTRIENT DENSE FEED PRODUCTION (Serbia).....</p>	287-307
<p><i>Jordan Marković, Jasmina Milenković, Snežana Anđelković</i> ALFALFA AND RED CLOVER AS A PROTEIN SOURCE FOR RUMINANTS (Serbia).....</p>	308-321

Violeta Mandić, Snežana Đorđević, Zorica Bijelić, Vesna Krnjaja, Aleksandar Simić, Marija Gogić, Maja Petričević
INOCULATION OF MAIZE WITH PGPR (Serbia)..... 322-334

Maya M. Ignatova, Nadezhda M. Sertova
MYCOTOXIN CONTAMINATION OF CEREAL GRAINS IN BULGARIA (Bulgaria)..... 335-345

ORAL PRESENTATION

Slavča Hristov, Branislav Stanković, Dušica Ostojić Andrić, Ljiljana Samolovac, Nevena Maksimović, Marko Cincović, Dimitar Nakov
INFLUENCE OF CATTLE BREEDING CONDITIONS ON REPRODUCTION, GROWTH, MILK YIELD AND MEAT AND MILK QUALITY (Serbia-North Macedonia)..... 346-362

Ivan Pavlović, Violeta Caro Petrović, Dragana Ružić Muslić, Jovan Bojkovski, Nemanja Zdravković, Renata Relić, Vukašin Stefanović
GASTROINTESTINAL HELMINTHS OF SHEEP BREED IN POMORAVSKI AND RASINA DISTRICT (Serbia)..... 363-370

Jovan Bojkovski, Marina Spinu, Mihaela Niculae, Jasna Prodanov-Radulović, Aleksandar Stanojković, Ivan Pavlović, Nemanja Zdravković, Radiša Prodanović
PRODUCTION RELATED DISEASES (TECHNOPATHIES) IN SWINE COMMERCIAL FARM (Serbia-Romania)..... 371-390

Teodora Popova, Nadezhda Palova, Jivko Nakev, Maya Ignatova
CHEMICAL COMPOSITION AND FATTY ACID PROFILE OF TWO TRADITIONAL BULGARIAN DRY-CURED MEAT PRODUCTS MADE OF EAST BALKAN PIG (Bulgaria)..... 391-404

POSTER PRESENTATION

Branislav Stanković, Slavča Hristov, Dušica Ostojić Andrić, Milošević-Stanković Ivana, Dimitar Nakov, Rašović Bojanić Mirjana
PRECISION FARMING IN IMPROVEMENT OF DAIRY CATTLE WELFARE (Serbia-North Macedonia)..... 405-421

<i>Tina Bobić, Andrea Bejteš, Pero Mijić, Vesna Gantner, Maja Gregić</i> LAMENESS DETECTION IN CATTLE USING ICT TECHNOLOGY (Croatia).....	422-433
<i>Mirna Gavran, Danko Šinka, Vesna Gantner</i> THE EFFECT OF SEASON ON THE ESTIMATED AMMONIA EMISSION OF HOLSTEIN FIRST PARITY COWS (Croatia).....	434-441
<i>Franjo Poljak, Marija Špehar, Zvonimir Steiner, Mirna Gavran, Vesna Gantner</i> THE VARIABILITY IN THE ESTIMATED PREVALENCE RISK OF METABOLIC DISORDERS (KETOSIS/ACIDOSIS) IN SIMMENTAL FIRST PARITY COWS DUE TO RECORDING SEASON (Croatia).....	442-450
<i>Ivana Jožef, Dragan Solić, Zvonimir Steiner, Vesna Gantner</i> THE EFFECT OF RECORDING SEASON ON THE ESTIMATED PREVALENCE RISK OF MASTITIS IN SIMENTAL FIRST PARITY COWS (Croatia).....	451-457
<i>Marinela Enculescu</i> INVESTIGATIONS ON HAEMATO-BIOCHEMICAL INDICATORS IN ROMANIAN BLACK AND SPOTTED DAIRY COWS WITH RETAINED PLACENTA – PRELIMINARY RESULTS (Romania).....	458-467
<i>Zhivko I. Ducheve</i> ASSESSMENT OF THE RISK STATUS OF FOUR LOCAL BULGARIAN BREEDS BASED ON THEIR GEOGRAPHIC DISTRIBUTION (Bulgaria).....	468-476
<i>Tamara Papović, Denis Kučević, Miroslav Plavšić, Snežana Trivunović, Ksenija Čobanović</i> PREDICTION OF AMMONIUM EMISSION FROM DAIRY CATTLE BASED ON MILK UREA NITROGEN USING THE PRECISION FARMING METHODOLOGY (Serbia).....	477-486
<i>Dragana Ružić-Muslić, Bogdan Cekić, Ivan Ćosić, Ivan Pavlović, Nevena Maksimović, Violeta Caro Petrović, Zorica Bijelić</i> HEMATOLOGICAL AND BIOCHEMICAL BLOOD PARAMETERS OF PIROT PRAMENKA - ENDANGERED SHEEP POPULATION (Serbia).....	487-499

<i>Bogdan Cekić, Dragana Ružić Muslić, Nevena Maksimović, Violeta Caro Petrović, Ivan Ćosić, Tamara Stamenić, Madlena Andreeva</i> IMPORTANCE, PRODUCTIVITY AND POTENTIALS OF LOCAL SERBIAN SHEEP BREEDS (Serbia-Bulgaria).....	500-508
<i>Rossen Stefanov, Madlena Andreeva</i> STUDY OF THE SPERM PARAMETERS OF RAMS' EJACULATES OBTAINED IN THE BREEDING AND NON- BREEDING PERIOD (Bulgaria).....	509-515
<i>Vladimir Dosković, Snežana Bogosavljević-Bošković, Božidar Milošević, Zdenka Škrbić, Miloš Lukić, Simeon Rakonjac, Veselin Petričević</i> EFFECTS OF GENOTYPE AND PROTEASE ENZYME SUPPLEMENTATION ON THE PRIMAL CARCASS CUTS OF CHICKENS (Serbia).....	516-523
<i>Marija Pavlović, Ksenija Nešić, Aleksandra Tasić, Nikola Čobanović, Mihajlo Vićentijević, Ivan Pavlović</i> IMPACT OF INORGANIC PHOSPHORUS IN BROILERS DIET ON BONE MINERALIZATION (Serbia).....	524-531
<i>Aleksandar Pavličević, Ivan Pavlović, Nemanja Zdravković, Luis Francisco Angeli</i> Alves SUGGESTED APPROACH TO RED POULTRY MITE CONTROL IN EXTENSIVE POULTRY PRODUCTION (Serbia- Brazil).....	532-540
<i>Maja Gregić, Mirjana Baban, Pero Mijić, Vesna Gantner, Tina Bobić</i> THE CHALLENGES OF JUMPING HORSES THROUGH THE TRAINING (Croatia).....	541-551
<i>Nemanja Zdravković, Oliver Radanović, Milan Ninković, Radoslava Savić-Radovanović, Nataša Rajić Savić, Đordje Marjanović, Jovan Bojkovski</i> ACTIVITY OF SOME PLANT ESSENTIAL OILS AGAINST COMMON ISOLATES IN VETERINARY BACTERIOLOGY - A PILOT STUDY (Serbia).....	552-560
<i>Urška Tomažin, Klavdija Poklukar, Martin Škrlep, Nina Batorek Lukač, Marjeta Čandek-Potokar</i> THE EFFECT OF RYR1 GENE ON MEAT QUALITY IN AUTOCHTHONOUS BREED KRŠKOPOLJE PIG (Slovenia).....	561-571

<i>Klavdija Poklukar, Marjeta Čandek-Potokar, Milka Vrecl Fazarinc, Nina Batorek Lukač, Gregor Fazarinc, Kevin Kress, Volker Stefanski, Martin Škrlep</i> EFFECTS OF ANDROGEN DEPRIVATION ON HISTOMORPHOLOGICAL PROPERTIES OF FAT TISSUE IN PIGS (Slovenia-Germany).....	572-580
<i>Aleksandra Petrović, Dragan Radojković, Čedomir Radović, Marija Gogić, Nenad Stojiljković, Nenad Parunović, Radomir Savić</i> IN VITRO BOAR FERTILITY DURING SUMMER AND AUTUMN SEASON (Serbia).....	581-589
<i>Nenad Stojiljković, Dragan Radojković, Čedomir Radović, Marija Gogić, Vladimir Živković, Zoran Luković, Dubravko Škorput</i> VARIABILITY OF THE NUMBER OF LIVE-BORN PIGLETS UNDER THE INFLUENCE OF FEMALE GENOTYPE, YEAR OF FARROWING AND PARITY (Serbia-Croatia).....	590-597
<i>Dragan Dokić, Maja Gregić, Mirna Gavran, Vesna Gantner</i> EFFECTS OF INVESTMENTS IN CAPITAL CROP PRODUCTION - A COMPARATIVE ANALYSIS OF THE REPUBLIC OF CROATIA AND THE EUROPEAN UNION (Croatia).....	598-605
<i>Sanja Živković, Tanja Vasić</i> MYCOPOPULATION OF ALFALFA AND RED CLOVER HAY IN SERBIA (Serbia).....	606-614
<i>Ksenija Nešić, Nikola Pavlović, Marija Pavlović, Jelena Vlajković, Aleksandra Tasić, Vladimir Radosavljević, Božidar Savić</i> AN INSIGHT INTO THE MYCOTOXICOLOGICAL SITUATION – RECENT EXPERIENCE AND CLOSE PREDICTION (Serbia)....	615-521
<i>Vesna Krnjaja, Violeta Mandić, Zorica Bijelić, Slavica Stanković, Milica Nikolić, Tanja Vasić, Nikola Delić</i> FUSARIUM SPP. AND DEOXYNIVALENOL CONTAMINATION OF RYEGRASS SEEDS (Serbia).....	622-631

INOCULATION OF MAIZE WITH PGPR

Violeta Mandić¹, Snežana Đorđević², Zorica Bijelić¹, Vesna Krnjaja¹,
Aleksandar Simić³, Marija Gogić¹, Maja Petričević¹

¹Institute for Animal Husbandry Belgrade-Zemun, Belgrade, Republic of Serbia

²Biounik D.O.O. Belgrade-Zemun, Belgrade, Republic of Serbia

³Faculty of Agriculture, University of Belgrade, Belgrade-Zemun, Republic of Serbia

Corresponding author: Violeta Mandić, violeta_randjelovic@yahoo.com

Invited paper

Abstract: Maize is a highly productive crop intended for human and animal nutrition, and industrial processing. The standard agrotechnical measures are used in its production. However, the utilization of bacterial inoculants is becoming more popular due to their effect on increased soil quality, plant performance, and yield while preserving and enhancing the agroecosystem. In addition, bacterial inoculants can be applied together with pesticides used in seed treatments. Our earlier results showed that the inoculation of maize seed with plant-growth-promoting rhizobacteria (PGPR) increased the number of diazotrophs bacteria in the rhizosphere, morphological and productive traits, and yield of maize. Accordingly, seed inoculation may represent an important strategy to improve commercial maize production and reduce the environmental impact of maize production processes.

Key words: N-fixing bacteria, nitrogen, maize, seed inoculation, yield

Introduction

Maize (*Zea mays* L.) is the most important crop in Serbia. In 2019, it was cultivated in a 962.000 ha area with a production of 7.3 million tons and with an average yield of 7.6 t ha⁻¹ (*Statistical Yearbook of the Republic of Serbia, 2020*). The average maize yield in Serbia is considered still very low (for 27.6%) compared to the USA average (10.5 t ha⁻¹), the largest maize producer in the world (*FAO, 2021*). The maize grain yield depends on the performance of the hybrid, characteristics of soil, applied agrotechnical measures, and climatic factors (*Mandić et al., 2013; Mandić et al., 2020*). Mostly the farmers in Serbia use available superior maize genotypes of domestic and foreign selection in combination with appropriate usual production technology. However, the use of microbial seed inoculation in maize production is not common practice, as is the

case with soybeans. In Serbia, seed inoculation of maize and other non-leguminous crops is not as popular as in developed countries. On the other hand, many countries, such as EU members, USA, China, India, and Japan are trying to increase the use of microbiological inoculants through legislation and incentives for agriculture. The use of biofertilisers can increase root microbiome, especially free-living nitrogen (N)-fixing bacteria in the rhizosphere, soil fertility, yield, and biomass of maize, and reduce the use of expensive artificial N fertilizers (Mandić, 2011). This is very important because artificial N fertilizers are known to adversely affect biological balance, soil quality, plant productivity, and ecological balance (Naher *et al.*, 2016; Vejan *et al.*, 2016). Thus, the inoculation of maize seed with *Azospirillum brasilense* reduces the amount of artificial N fertilizers by 25% (Fukami *et al.*, 2016). The mismanagement of artificial N fertilizers contributes to its loss from agroecosystems due to ammonia volatilization, nitrate leaching, and denitrification (Cui *et al.*, 2010). The increase in reactive nitrogen in the atmosphere, soils, and water is expected to come in the near future (Sutton *et al.*, 2011). In general, the chemical N fertilizers do have hidden dangers and represent health hazards to both humans and animals (Alori and Babalola, 2018). Accordingly, the use of biofertilizers is one of the basic and best strategies to reduce the use of synthetic N fertilizers and preserve the environment.

In the present study, we will consider only the effect of inoculation of seed with an individual strain and in a consortium of PGPR. The effect of PGPR mutants on maize growth will not be considered.

PGPR in maize and biological N fixation

The beneficial rhizobacteria are called plant growth-promoting bacteria (PGPR). In addition to symbiotic N-fixing bacteria which are associated with legumes, various PGPR are associated with non-leguminous plants, especially with cereal grasses. The bacteria responsible for N fixation are called diazotrophs. These bacteria reside at the surface or interior of the root of non-legume crops (de Bruijn, 2015).

PGPR such as *Bacillus*, *Azospirillum*, *Azotobacter*, *Pseudomonas*, *Streptomyces*, *Enterobacter*, *Rhizobium*, *Agrobacterium*, *Arthrobacter*, *Achromobacter*, *Micrococcus*, *Pantoea*, and *Serratia* are present in the rhizosphere of different crops (Olanrewaju and Babalola, 2019; Verma *et al.*, 2019). Their strains are good for the improvement of the growth and productivity of crops in a sustainable way.

The PGPR in biofertilizers improves plant growth primarily by synthesizing phytohormones (indole-3-acetic acid, gibberellic acid, cytokinins, and ethylene), fixing atmospheric N, and solubilising phosphates and other mineral

nutrients (Kudoyarova et al., 2015). PGPR has a role in the biocontrol of pathogenic microorganisms and the prevention of the development of plant diseases because of produced bacteriocins and antibiotics (Beneduzi et al., 2012). Example, *Bacillus* sp. strain B25 is a biocontrol agent of maize pathogen *Fusarium verticillioides* (Douriet-Gómez et al., 2018). The riboflavin, thiamin, auxin, and gibberellin of *Azotobacter* may accelerate seed germination and improve the control of maize plant diseases (Baral et al., 2013).

Also, PGPR produce extracellular enzymes which decompose organic and non-organic matter in the soil increasing its fertility (Alexander, 1977). Ahemad and Kibret (2014) and Olanrewaju et al. (2019) emphasize that the PGPR help maize production by nitrogen fixation, increasing the availability of phosphorus, and control pests with different mechanisms. The root system uptake properties improve when the PGPR colonize it allowing easier adsorption of ion nitrate, solubilization of phosphate, and chelation of iron (Islam et al., 2009). Furthermore, the inoculation of maize with a PGPR improves plant tolerance to water deficit (Pereira et al., 2020), high salt concentration (Chen et al., 2016), and high concentrations of heavy metals (Hassan et al., 2014).

Nitrogen input from the air (N_2) through the process of biological N_2 -fixation in agricultural soils is about 50-70 million tonnes of N per year (Matiru and Dakora, 2004; Herridge et al., 2008). N_2 -fixing bacteria synthesize enzyme nitrogenase which converts inert N_2 into biologically useful NH_3 . These bacteria isolated from root, stem, and leaf tissues of maize belong to different genera *Pantoea*, *Pseudomonas*, *Rhanelia*, *Herbaspirillum*, *Azospirillum*, *Rhizobium* (*Agrobacterium*), and *Brevundimonas*, and may contribute to biological nitrogen fixation which ranges from 12 to 33% (Montañez et al., 2009). The bacteria can fix from 30 to 90 kg N ha⁻¹, and even up to 150 kg N ha⁻¹ (Milošević et al., 1994). Van Deynze et al. (2018) point that the atmospheric N fixation contributes to 29–82% of the N nutrition of maize. Kuan et al. (2016) report that the N_2 -fixing bacteria are able to fix N from the air up to 304 mg N plant⁻¹. Baral et al. (2013) concluded that the *Azotobacter* fixes about 20 kg N ha⁻¹ year⁻¹.

Zahir et al. (2004) report that the fresh biomass and weight of the ear of maize are significantly higher in treatment with inoculation of seed with *Azotobacter* sp. compared to the control. Adjanohoun et al. (2011) show that the *Azospirillum lipoferum*, *Pseudomonas fluorescens*, and *Pseudomonas putida* isolated from the rhizosphere of maize significantly increase grain yield compared to *Pseudomonas aeruginosa*, *Bacillus coagulans*, *Bacillus thurengensis*, *Bacillus pumilus*, *Bacillus poly*, *Bacillus fimosus*. Therefore they can be used to produce biofertilizers for maize. Similarly, Kang et al. (2010) demonstrate that the *Bacillus* spp., *Pseudomonas* spp., and *Azospirillum lipoferum* improve plant growth and maize yield. Nezarat and Gholami (2009) show that the inoculation of maize seed

with strains of *P. putida* (R-168 and DSM291) and *P. fluorescens* (R-93 and DSM 50090) significantly increases germination and growth of maize compared to an uninoculated seed. Also, *Biari et al. (2008)* find that the *Azospirillum lipoferum* DSM 1691, *Azospirillum brasilense* DSM 1690, *Azotobacter chroococcum* DSM 2286 increase yield and growth parameters of maize. According to *Olanrewaju and Babalola (2019)*, the six indigenous isolates (A1 - *Bacillus subtilis*, A18 and A29 - *Pseudomonas* sp., NWU4 - *Streptomyces globisporus*, NWU14 - *Streptomyces griseoflavus*, and NWU198 - *Streptomyces heliomycini*) and their consortium of two or three organisms, enhance maize growth, but the effect of the consortia was greater. *Azospirillum brasiliense* increases the grain yield of maize (*Lana et al, 2012; Oliveira, 2018*). *Arruda et al. (2013)* have isolated 292 bacterial isolates from five maize crop areas and concluded that the dominant genera were *Klebsiella* and *Burkholderia*, but strains, identified as *Achromobacter*, *Burkholderia*, and *Arthrobacter*, were effective as PGPR in two investigated maize cultivars. *Akhtar et al. (2018)* report that the inoculation of maize seed with a consortium of beneficial bacteria significantly increases root length and biomass and improves root architecture. Therefore, the root absorbs N, P, and K better due to the solubilization of nutrients (*Ranjan et al., 2013*). The inoculation with strains of *Azotobacter* and *Azospirillum* significantly increased the dry matter accumulation and grain yield of maize (*Naserirad et al., 2011; Sharifi et al., 2011*). The inoculation treatment of seeds with consortia of six PGPR strains (*Pseudomonas putida* strain R-168, *P. fluorescens* strain R-93, *P. fluorescens* DSM 50090, *P. putida* DSM291, *Azospirillum lipoferum* DSM 1691, and *A. brasilense* DSM 1690) increases nitrogen content in the rhizosphere, germination, plant height, 100-grain weight, number of seed per ear, leaf area, grain yield and quality (*Gholami et al., 2009*). *Hungria et al. (2010)* have found increases of up to 30 % in the grain yields of maize, inoculated with *A. brasilense* due to improved N nutrition and increased nutrient absorption. Inoculation of maize with strains *A. brasilense* Az39 increases yield from 13 to 33% (*Cassán and Diaz-Zorita, 2016*).

It must be pointed out that the species and strains of PGPR colonize differently the roots of maize hybrids and influence soil biogeny (*Galazka et al., 2017; Walters et al., 2018*). That primarily depends on root exudates of which are under host-genetic control (*Bulgarelli et al., 2013*). For that reason, it is necessary to select strains of PGPR according to the plant genotype.

The inoculation of maize with PGPR in Serbia

Previous researches on chernozem in the Srem District (Vojvodina province, northern Serbia) shows the significant effect of the inoculation of rhizobacteria on maize growth and yield. *Mandić et al. (2016)* report that the maize

seed inoculated with consortia of *Azotobacter chroococum*, *Azotobacter vinelandii*, *Bacillus megaterium*, and *Bacillus licheniformis* has significantly increased nitrogen content, the total number of microorganisms, number of azotobacter and aminoheterotrophs in the soil and grain yield of Serbian maize hybrid ZP 684 during 2006-2008. Also, maize seed inoculation with *Azotobacter chroococum*, *Azotobacter vinelandii*, *Bacillus megaterium*, and *Bacillus licheniformis* has increased the stem diameter, grain yield, and rain-use efficiency, and decreased the stem lodging and percentage of barren plants in maize hybrid Dijamant 6 belong to FAO 600 maturity group (Mandić et al., 2018a). Accordingly, the seed bacterial inoculation reduces the risk of stem lodging due to the accumulation of soluble solids in the stem (Fancelli and Dourado Neto, 2000). It is known that the lodging of plants ranges from 5% to 20% annually worldwide (Flint-Garcia et al., 2003) with losses of grain yield from 40% (Ransom, 2005) to 75% (Van Dyk, 2001). Thus, bacterial inoculation of maize seed can reduce the risk of lodging, especially at high plant densities, and contribute to high grain yields. Mandić et al. (2018b) find that the higher nitrogen amount, total number of microorganisms, number of azotobacters, number of aminoheterotrophs, number of oligotrophic and grain yield of two maize hybrids NS 6010 and Dijamant 6 are obtained in the treatment with inoculation of seed with *Azotobacter chroococum*, *Azotobacter vinelandii*, *Bacillus megaterium*, and *Bacillus licheniformis* than in untreated treatment. Also, the individual strains of *Azotobacter chroococum* and *Bacillus megaterium* and their combination increased nitrogen content in the rhizosphere of two maize hybrids PKB-509 and Srećko-5 (Hajnal et al., 2001). The consortia of *Azotobacter vinelandii*, *Azospirillum lipoferum*, *Bacillus megaterium* and *Bacillus subtilis* (Govedarica et al., 2002), *Azotobacter chroococum*, *Azotobacter vinelandii*, *Azospirillum lipoferum*, *Bacillus megatherium*, and *Bacillus subtilis* (Cvijanović et al., 2007) and *Azotobacter chroococum* and *Bacillus megaterium* (Hajnal and Govedarica, 2004) significantly increase microbial activity in the soil and maize production in Vojvodina Province. Similarly, Jarak et al. (2011) find that the *Azotobacter chroococum* significantly increases microbiological activity, early plant growth, and grain yield of maize. In essence, the higher number and biomass of soil microorganisms increase microbial activity, mineralization of organic matter, and concentration of mineral nutrients available for maize plants (Mandić, 2011; Mrkovački et al., 2012). In addition, according to Govedarica et al. (1999) and Bjelić et al. (2010) the total number of microorganisms and the number of azotobacters increases in the course of the growing season. Bjelić et al. (2010) concluded that the *Azotobacter chroococum*, *Bacillus subtilis*, and *Pseudomonas fluorescens* applied individually and in mixture increased the number of microorganisms in the rhizosphere and height and weight of maize plants. Jarak et al. (2012) found that the individual strains *Pseudomonas sp.* Q4b, *Bacillus sp.* Q5a

and *Azotobacter chroococcum* strain 8 and their combinations increased the number of azotobacters, pseudomonads, and aerobic spore-forming bacteria, plant height, dry weight, and yield of maize compared to control. These authors got the highest yield in the treatment with a mixture of three strains. *Govedarica et al. (1992)* find that the mixture of two strains of *Beijerinckia dextr* increases the yield of maize hybrid NSSC-606, while one strain of *Azotobacter chroococcum* increases the yield of maize hybrid PKB-624.

In general, these results demonstrate that the PGPR can improve maize production, microbial abundance in the rhizosphere, and soil fertility because they increase the content of available nitrogen in the soil. However, it is necessary to constantly expand knowledge about the mutual interactions of plants and diazotrophic bacteria.

Commercialization of bacterial inoculants

The cited researches report that the use of PGPR bacteria in the cultivation of maize can be beneficial to improve yield. All this has led to the development of biofertilizers or bio-inoculants. Biofertilizers are eco-friendly organic agro-input intended to improve the growth and yield of crops and soil health and thus are considered as the best alternative to synthetic fertilizers. The form of the inoculant depends on the carrier and can be solid or liquid. There is a wide range of commercial preparations (monovalent, bivalent, and polyvalent) for the inoculation of maize seeds. In Europe and South America, the most represented is the monovalent inoculum containing *Azospirillum* sp. (*Dobbelaere et al., 2001*). The genus *Azospirillum* is able to improve the grain yield of maize, wheat, and rice (*Steenhoudt and Vanderleyden, 2000*). *Santos et al. (2019)* state that about 70 million doses of *A. brasilense* inoculants, for maize and wheat, are sold annually in Brazil. Nowadays, global interest has increased for the development of new microbiological inoculants, the identification of new strains, and new inoculation methods. Scientists are constantly making great innovative efforts to find new microbiological inoculants and this is an inexhaustible area for investing knowledge, techniques, and skills to improve crop yields. China has registered 800 patents related to inoculation, while India has about 100 (*Santos et al., 2019*). There is a tendency to discover new inoculants with a wide range of applications consisting of a consortium of bacteria.

Conclusions

In the near future, the development of agriculture must be based on the application of crop cultivation technology and plant breeding that contribute to better establishment of ecological balance and stability of natural resources in the agroecosystem. In doing so, the method of growing crops must be based on an economically effective basis. Biofertilization fits into this concept. The components of microbiological fertilizers are various bacteria, mostly from the group of N-fixing bacteria that deliver nitrogen to plants (*Azotobacter*, *Azospirillum*, *Bacillus*, *Pseudomonas*, and others), but also translate inaccessible phosphorus, potassium, iron, and sulfur into an accessible form for plants. In addition, these bacteria synthesize plant hormones (auxin and gibberellins) affecting plant growth and induce plant resistance and increase the free-living root microbiome. Accordingly, the application of microbiological fertilizers containing mixed populations of microorganisms can improve the growth and development of plants through the supply of plants with essential nutrients while increasing yields and preserving the environment, and producing safe food.

Inokulacija kukuruza sa PGPR

Violeta Mandić, Snežana Đorđević, Zorica Bijelić, Vesna Krnjaja, Aleksandar Simić, Marija Gogić, Maja Petričević

Rezime

Kukuruz je visokoproduktivni usev namenjen za ishranu ljudi i životinja i industrijsku preradu. U njegovoj proizvodnji koriste se standardne agrotehničke mere. Međutim, upotreba bakterijskih inokulanata postaje sve popularnija zbog povećanja kvaliteta zemljišta, performansi biljaka i prinosa. Pored toga, bakterijski inokulanti se mogu primeniti zajedno sa pesticidima koji se koriste u tretiranju semena. Naši raniji rezultati pokazali su da inokulacija semena kukuruza sa rizobakterijama koje podstiču rast biljaka (PGPR) povećava brojnost diazotrofa u rizosferi, morfološke i produktivne osobine i prinos kukuruza uz očuvanje i unapređenje agroekosistema. Shodno tome, inokulacija semena može predstavljati važnu strategiju za poboljšanje komercijalne proizvodnje kukuruza i smanjuje uticaj procesa proizvodnje kukuruza na životnu sredinu.

Ključne reči: N-fiksirajuće bakterije, azot, kukuruz, inokulacija semena, prinos

Acknowledgements

The results of the research presented in this paper were financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia, on the basis of the Agreement on the realization and financing of scientific research work of SRO in 2021 no. 451-03-9/2021-14/200022.

References

- ADJANOHOUN A., ALLAGBE M., NOUMAVO P., GOTOECHAN-HODONOU H., SIKIROU R., DOSSA K., GLELEKAKAĀ R., KOTCHONI S., BABA-MOUSSA L. (2011): Effects of plant growth promoting rhizobacteria on field grown maize. *Journal of Animal and Plant Sciences*, 11, 1457–1465.
- AHEMAD M., KIBRET M. (2014): Mechanisms and applications of plant growth promoting rhizobacteria: Current perspective. *Journal of King Saud University–Science*; 26, 1–20.
- AKHTAR N., NAVEED M., KHALID M., AHMAD N., RIZWAN M., SIDDIQUE S. (2018): Effect of bacterial consortia on growth and yield of maize grown in *Fusarium* infested soil. *Soil and Environment*, 37, 35–44.
- ALEXANDER M. (1977): Introduction to soil microbiology. John Willey Inc., New York, London.
- ALORI E.T., BABALOLA O.O. (2018): Microbial inoculant for improving crop quality and human health. *Frontiers in Microbiology*, 9, 2213.
- ARRUDA L., BENEDUZI A., MARTINS A., LISBOA B., LOPES C., BERTOLO F., PASSAGLIA L.M.P., VARGAS L.K. (2013): Screening of rhizobacteria isolated from maize (*Zea mays* L.) in Rio Grande do Sul State (South Brazil) and analysis of their potential to improve plant growth. *Applied Soil Ecology*, 63, 15–22.
- BARAL B.R., ADHIKARI P., PARBATI A. (2013): Effect of Azotobacter on growth and yield of maize. *SAARC Journal of Agriculture*, 11, 141–147.
- BENEDUZI A., AMBROSINI A., PASSAGLIA L.M. (2012): Plant growth-promoting rhizobacteria (PGPR): Their potential as antagonists and biocontrol agents. *Genetics and Molecular Biology*, 35, 4, 1044–1051.
- BIARI A., GHOLAMI A., RAHMANI H.A. (2008): growth promotion and enhanced nutrient uptake of maize (*Zea mays* L.) by application of plant growth promoting rhizobacteria in arid region of Iran. *Journal of Biological Sciences*, 8, 1015–1020.

- BJELIĆ D., MRKOVAČKI N., JARAK M., JOŠIĆ D., ĐALOVIĆ I. (2010): Effect of PGPR on the early growth of maize and microbial abundance in rhizosphere. *Contemporary Agriculture*, 59, 3–4, 339–345.
- BULGARELLI D., SCHLAEPPI K., SPAEPEN S., VER LOREN VAN THEMAAT E., SCHULZE-LEFERT P. (2013): Structure and functions of the bacterial microbiota of plants. *Annual Review of Plant Biology*, 64, 807–838.
- CASSÁN F., DIAZ-ZORITA M. (2016): *Azospirillum* sp. in current agriculture: from the laboratory to the field. *Soil Biology and Biochemistry*, 103, 117–130.
- CHEN L., LIU Y., WU G., VERONICAN NJERI K., SHEN Q., ZHANG N., ZHANG R. (2016): Induced maize salt tolerance by rhizosphere inoculation of *Bacillus amyloliquefaciens* SQR9. *Plant Physiology*, 158, 1, 34–44.
- CVIJANOVIĆ G., MILOŠEVIĆ N., JARAK M. (2007): The importance of diazotrophs as biofertilizers in the maize and soybean production. *Genetika*, 39, 395–404.
- CUI Z., CHEN X., ZHANG F. (2010): Current nitrogen management status and measures to improve the intensive wheat-maize system in China. *Ambio*, 39, 5–6, 376–384.
- de BRUIJN F.J. (2015): Biological nitrogen fixation. John Wiley and Sons, Inc, Hoboken, New Jersey, USA.
- DOBBELAERE S., CROONENBORGH S., THYS A. (2001): Response of agronomically important crops to inoculation with *Azospirillum*. *Australian Journal of Plant Physiology*, 28, 1–9.
- DOURIET-GÁMEZ N.R., MALDONADO-MENDOZA I.E., IBARRA-LACLETTE E., BLOM J., CALDERÓN-VÁZQUEZ C.L. (2018): Genomic analysis of *Bacillus* sp. Strain B25, a biocontrol agent of maize pathogen *Fusarium verticillioides*. *Current Microbiology*, 75, 247–255.
- FANCELLI A.L., DOURADO NETO D. (2000): Produção de milho. Guaíba: Agropecuária. p. 360.
- FAO. Food and Agriculture Organisation of the United Nations, 2021. Available online: <http://www.fao.org/faostat/en/#data> (accessed on 28 April 2021).
- FLINT-GARCIA S.A., JAMPATONG C., DARRAH L.L., MCMULLEN M.D. (2003): Quantitative trait locus analysis of stalk strength in four maize populations. *Crop Science*, 43, 13–22.
- FUKAMI, J., NOGUEIRA, M.A., ARAUJO, R.S. HUNGRIA, M. (2016): Accessing inoculation methods of maize and wheat with *Azospirillum brasilense*. *AMB Express*, 6, 3.
- GAŁAŻKA A., GAWRYJOLEK K., GRZĄDZIEL J., FRĄC M., KSIĘŻAK J. (2017): Microbial community diversity and the interaction of soil under maize growth in different cultivation techniques. *Plant, Soil and Environment*, 63, 264–270.

- GHOLAMI A., SHAHSAVANI S., NEZARAT S. (2009): The effect of plant growth promoting rhizobacteria (PGPR) on germination, seedling growth, and yield of maize. *International Journal of Agricultural and Biosystems Engineering*, 1, 1, 35–40.
- GOVEDARICA M., JARAK M., MILOŠEVIĆ N., MANOJLOVIĆ S. (1992): The role of microorganisms in modern plant production. *A Periodical of Scientific Research on Field and Vegetable Crops*, 20, 95–103.
- GOVEDARICA M., JELIČIĆ Z., JARAK M., MILOŠEVIĆ N., STOJNIĆ N., RAŠKOVIĆ D., PAVLOVIĆ M. (1999): Effect of diazotrophs and P–mobilisers on microbial activity under maize. *Proceeding of Research Papers PKB-INI Agroekonomik*, 5, 1, 115–121.
- GOVEDARICA M., MILOSEVIĆ N., JARAK M., ĐURIC S., JELIČIĆ Z., KUZEVSKI J., ĐORĐEVIĆ S. (2002): Use of biofertilizers, biostimulators and biopesticides in agriculture production. *Ratarstvo i povrtarstvo/Field and Vegetable Crops Research*, 37, 85–95.
- HAJNAL T., GOVEDARICA M. (2004): Possibilities of biofertilizers application in maize production, *Zemljište i biljka*, 53, 3, 211–216.
- HAJNAL T., GOVEDARICA M., JELIČIĆ Z. (2001): Effect of bacterization on the number of microorganisms and the nitrogen content in soil under maize. *Acta Agriculturae Serbica*, 6, 11, 77–90.
- HASSAN W., BANO R., BASHIR F., DAVID, J. (2014): Comparative effectiveness of ACC-deaminase and/or nitrogen-fixing rhizobacteria in promotion of maize (*Zea mays* L.) growth under lead pollution. *Environmental Science and Pollution Research*, 21, 10983–10996.
- HERRIDGE D.F., PEOPLES M.B., BODDEY R.M. (2008): Global inputs of biological nitrogen fixation in agricultural systems. *Plant Soil*, 311, 1–18.
- HUNGRIA M., CAMPO R.J., SOUZA E.M., PEDROSA F.O. (2010): Inoculation with selected strains of *Azospirillum brasilense* and *A. lipoferum* improves yields of maize and wheat in Brazil. *Plant Soil*, 331, 413–25.
- ISLAM M.R., MADHAIYAN M., DEKA BORUAH H.P., YIM W., LEE G., SARAVANAN V.S., FU Q., HU H., SA T. (2009): Characterization of plant growth-promoting traits of free-living diazotrophic bacteria and their inoculation effects on growth and nitrogen uptake of crop plants. *Journal of Microbiology and Biotechnology*, 19, 1213–22.
- JARAK M., JELIČIĆ Z., KUZEVSKI J., MRKOVAČKI N., ĐURIC S. (2011): The use of azotobacter in maize production: the effect on microbiological activity of soil, early plant growth and grain yield. *Contemporary Agriculture*, 60, 1–2, 80–85.
- JARAK M., MRKOVAČKI N., BJELIĆ D., JOŠIĆ D., HAJNAL–JAFARI T., STAMENOV D. (2012): Effects of plant growth promoting rhizobacteria on maize

in greenhouse and field trial. *African Journal of Microbiology Research*, 6, 27, 5683–5690.

KANG Y., CHENG J., MEI L., YIN S. (2010): Screening and identification of plant growth-promoting rhizobacteria. *Wei Sheng Wu Xue Bao*, 50, 853–861.

KUAN K.B., OTHMAN R., ABDUL RAHIM K., SHAMSUDDIN Z.H. (2016): Plant Growth-Promoting Rhizobacteria inoculation to enhance vegetative growth, nitrogen fixation and nitrogen remobilisation of maize under greenhouse conditions. *Plos One*, 11, 3, e0152478.

KUDOYAROVA G.R., DODD I.C., VESELOV D.S., ROTHWELL S.A., VESELOV S.Y. (2015): Common and specific responses to availability of mineral nutrients and water. *Journal of Experimental Botany*, 66, 2133–2144.

LANA M.C., DARTORA J., MARINI D., HANN J.E. (2012): Inoculation with *Azospirillum*, associated with nitrogen fertilization in maize. *Revista Ceres*, 59, 3, 399–405.

MANDIĆ V. (2011): Genotype response of stay green maize hybrids on increased crop density. Ph.D. Thesis, University of Belgrade, Faculty of Agriculture, Belgrade, Serbia, 2011.

MANDIĆ V., BIJELIĆ Z., KRNJAJA V., SIMIĆ A., SIMIĆ M., BRANKOV M., ĐORĐEVIĆ S. (2020): Sowing and fertilization strategies to improve maize productivity. *Maydica*, 65, 2, 1–9.

MANDIĆ V., ĐORĐEVIĆ S., STANOJEVIĆ D., BIJELIĆ Z., KRNJAJA V., TOMIĆ Z., DRAGICEVIĆ V. (2016): Effect of bacterial seed inoculation on nitrogen dynamics, number of bacteria in soil under maize, and maize yield. *Journal of Environmental Protection and Ecology*, 17, 3, 1003–1010.

MANDIĆ V., ĐORĐEVIĆ S., BIJELIĆ Z., KRNJAJA V., RUŽIĆ MUSLIĆ D., PETRIČEVIĆ M., SIMIĆ A. (2018a): Effect of intra-row spacing and seed inoculation on stem lodging, yield and rain-use efficiency of maize under different climatic conditions. *Philippine Agricultural Scientist*, 101, 3, 243–250.

MANDIĆ V., KRNJAJA V., DJORDJEVIĆ S., DJORDJEVIĆ N., BIJELIĆ Z., SIMIĆ A., DRAGIČEVIĆ V. (2018b): Effects of bacterial seed inoculation on microbiological soil status and maize grain yield. *Maydica*, 63, 3, 1–7.

MANDIĆ V., SIMIĆ A., TOMIĆ Z., KRNJAJA V., BIJELIĆ Z., MARINKOV G., STOJANOVIĆ LJ. (2013): Effect of drought and foliar fertilization on maize production. *Proceedings of the 10th International Symposium Modern Trends in Livestock Production*, Belgrade, Republic of Serbia, 2–4 October 2013, 416–429.

MATIRU V.N., DAKORA F.D. (2004): The potential use of rhizobial bacteria as promoters of plant growth for increased yield in landraces of African cereal crops. *African Journal of Biotechnology*, 3, 1–7.

- MILOŠEVIĆ N., GOVEDARICA M., JARAK M., HADŽIĆ V. (1994): Inoculation technology and potential application of symbiotic and non-symbiotic diazotrophs in vegetable crop production. *Contemporary Agriculture*, 42, 295.
- MONTAÑEZ A., ABREU C., GILL P.R. HARDARSON G., SICARDI M. (2009): Biological nitrogen fixation in maize (*Zea mays* L.) by ¹⁵N isotope-dilution and identification of associated culturable diazotrophs. *Biology and Fertility of Soils*, 45, 253–263.
- MRKOVAČKI N., JARAK M., ĐALOVIĆ I., JOCKOVIĆ Đ. (2012): Importance of PGPR application and its effect on microbial activity in the maize rhizosphere. *Ratarstvo i povrtarstvo/Field and Vegetable Crops Research*, 49, 335–344.
- NAHER U.A., PANHWAR Q.A., OTHMAN R., ISMAIL M.R., BERAHIM Z. (2016): Biofertilizer as a supplement of chemical fertilizer for yield maximization of rice. *Journal of Agriculture Food and Development*, 2, 16–22.
- NASERIRAD H., SOLEYMANIFARD A., NASERI R. (2011): Effect of integrated application of bio-fertilizer on grain yield, yield components, and associated traits of maize cultivars. *American-Eurasian Journal of Agricultural and Environmental*, 10, 271–277.
- NEZARAT S., GHOLAMI A. (2009): Screening plant growth promoting rhizobacteria for improving seed germination, seedling growth and yield of maize. *Pakistan Journal of Biological Sciences*, 12, 26–32.
- OLANREWAJU O.S., BABALOLA O.O. (2019): Bacterial consortium for improved maize (*Zea mays* L.) production. *Microorganisms*, 7, 11, 519.
- OLANREWAJU O.S., AYANGBENRO A.S., GLICK B.R., BABALOLA O.O. (2019): Plant health: Feedback effect of root exudates-rhizobiome interactions. *Applied Microbiology and Biotechnology*, 103, 1155–1166.
- OLIVEIRA, I.J., FONTES, J.R.A., PEREIRA, B.F.F., Muniz A.W. (2018): Inoculation with *Azospirillum brasiliense* increases maize yield. *Chemical and Biological Technologies in Agriculture*, 5, 6.
- PEREIRA S.I.A., ABREU D., MOREIRA H., VEGA A., CASTRO P.M.L. (2020): Plant growth-promoting rhizobacteria (PGPR) improve the growth and nutrient use efficiency in maize (*Zea mays* L.) under water deficit conditions. *Heliyon*, 6, e05106.
- RANJAN A., RAJAN M., MAHALAKSHMI, SRIDEVI M. (2013): Isolation and characterization of phosphate-solubilizing bacterial species from different crop fields of Salem, Tamil Nadu, India. *International Journal of Nutrition, Pharmacology, Neurological Diseases* 3, 1, 29–33.
- RANSOM J. (2005): Lodging in cereals: Crop and Pest report. *Plant Science*, 9, 1–4.

- SANTOS M.S., NOGUEIRA M.A., HUNGRIA M. (2019): Microbial inoculants: reviewing the past, discussing the present and previewing an outstanding future for the use of beneficial bacteria in agriculture. *AMB Express*, 9, 205.
- SHARIFI R.S., KHAVAZI K., GHOLIPOURI A. (2011): Effect of seed priming with plant growth promoting rhizobacteria (PGPR) on dry matter accumulation and yield of maize (*Zea mays* L.) hybrids. *Journal of Food, Agriculture and Environment*, 9, 393–397.
- STATISTICAL YEARBOOK OF THE REPUBLIC OF SERBIA, 2020
- STEENHOUDT O., VANDERLEYDEN J. (2000): *Azospirillum*, a free-living nitrogen-fixing bacterium closely associated with grasses: genetic, biochemical and ecological aspects. *FEMS Microbiology Reviews*, 24, 487–506.
- SUTTON M.A., HOWARD C.A., ERISMAN J.W., BILLEN G., BLEEKER A., GRENNFELT P., VAN GRINSVEN P., GRIZZETTI B. (2011): *The European Nitrogen Assessment: Sources, Effects and Policy Perspectives* (Eds.). Cambridge University Press.
- VAN DEYNZE A., ZAMORA P., DELAUX P.-M., HEITMANN C., JAYARAMAN D., RAJASEKAR S., GRAHAM, D., MAEDA J., GIBSON D., SCHWARTZ K.D., et al. (2018): Nitrogen fixation in a landrace of maize is supported by a mucilage-associated diazotrophic microbiota. *Plos Biology*, 16, e2006352.
- VAN DYK J. (2001): Corn lodging sets. In: *integrated crop management: plant diseases*. Department of Entomology, Iowa State University Press, Ames, Iowa.
- VEJAN P., ABDULLAH R., KHADIRAN T., ISMAIL S., BOYCE A.N. (2016): Role of plant growth promoting rhizobacteria in agricultural sustainability—A review. *Molecules*, 21, 573.
- VERMA M., MISHRA J., ARORA N.K. (2019): Plant growth-promoting rhizobacteria: diversity and applications. In: Sobti R., Arora N., Kothari R. (eds) *Environmental biotechnology: for sustainable future*. Springer, Singapore.
- WALTERS W.A., JIN Z., YOUNGBLUT N., WALLACE J.G., SUTTER J., ZHANG W., GONZÁLEZ-PEÑA A., PEIFFER J., KOREN O., SHI Q., KNIGH R., GLAVINA DEL RIO T., TRINGE S.G., BUCKLER E.S., DANGL J.L., LEY R.E. (2018): A large-scale replicated field study of maize rhizosphere identifies heritable microbes. *Proceedings of the National Academy of Sciences*, 115, 7368–7373.
- ZAHIR A.Z., ARSHAD M., FRANKENBERGER W.T. (2004): Plant-growth-promoting rhizobacteria: Applications and perspectives in agriculture. *Advance in Agronomy*, 81, 97–168.

=====
CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

636/638(082)(0.034.2)
631/635(082)(0.034.2)

**INTERNATIONAL Symposium Modern Trends in Livestock
Production (13 ; 2021 ; Beograd)**

Proceedings [Elektronski izvor] / 13th International Symposium Modern
Trends in Livestock Production, 6 -8 October 2021, Belgrade, Serbia ;
[organizer] Institute for Animal Husbandry, Belgrade - Zemun ; [editor
Zdenka Škrbić]. - Belgrade : Institute for Animal Husbandry, 2021 (Belgrade
: Institute for Animal Husbandry). - 1 USB fleš memorija ; 1 x 3 x 6 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. -
Tiraž 100. - Bibliografija uz svaki rad.

ISBN 978-86-82431-77-0

а) Сточарство -- Зборници б) Пољопривреда -- Зборници

COBISS.SR-ID 46411785

=====



13th INTERNATIONAL SYMPOSIUM
MODERN TRENDS IN LIVESTOCK PRODUCTION

6 - 8 October 2021 - Belgrade, Serbia

P R O C E E D I N G S

INSTITUTE FOR ANIMAL HUSBANDRY

Autoput 16, P. Box 23, 11080, Belgrade - Zemun, Serbia

www.istocar.bg.ac.rs

ISBN 978-86-82431-77-0

