AgroSym

BOOK OF PROCEEDINGS

AgroSym 2018

IX International Scientific Agriculture Symposium
"Agrosym 2018"
Jahorina, October 04-07, 2018

BOOK OF PROCEEDINGS

IX International Scientific Agriculture Symposium
"AGROSYM 2018"

Jahorina, October 04 - 07, 2018

Impressum

IX International Scientific Agriculture Symposium „AGROSYM 2018"

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
Aleksandras Stulginskis University, Kaunas, Lithuania
Selçuk University, Turkey
University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania
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

Tehnical 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)

INTERNATIONAL Scientific Agricultural Symposium "Agrosym 2018" (9 ; Jahorina)
Book of Proceedings [Elektronski izvor] / IX International Scientific Agriculture Symposium "Agrosym 2018", Jahorina, October 04 - 07, 2018 ; [editor in chief Dušan Kovačević]. - East Sarajevo =Istočno Sarajevo : Faculty of Agriculture =Poljoprivredni fakultet, 2018

Način pristupa (URL):
http://agrosym.ues.rs.ba/index.php/en/archive. - Bibliografija uz radove. - Registar.

ISBN 978-99976-718-8-2

COBISS.RS-ID 7815448

IMPROVED MAIZE CROPPING TECHNOLOGY TO REDUCE THE IMPACT OF CLIMATE CHANGES

Milena SIMIĆ*, Branka KRESOVIĆ, Vesna DRAGIČEVIĆ, Miodrag TOLIMIR, Milan BRANKOV

Maize Research Institute, Zemun Polje, Belgrade, Serbia
*Corresponding author: smilena@mrizp.rs

Abstract

Maize (*Zea mays* L.) is the highest ranking crop in terms of area and production in Serbia. During the whole growing period maize requires high temperatures and sufficient amounts of precipitation. High yields could be achieved on loose and porous soil with good capacity for water and those containing easily-accessible nutrients. The agro-ecological conditions for maize production differ over various regions of Serbia and meteorological parameters can seriously influence maize cultivation. Natural hazards, such as the occurrence of frosts, heavy rains in spring, floods, storms, hail, droughts, cause stress and to a significant degree can reduce or destroy maize yields. The application of appropriate cropping practices mitigates adverse effects of climate and soil and provides conditions for the maximum utilisation of the genetic yielding potential of maize hybrids. A system of measures that encompasses proper crop rotation, primary soil tillage, fertilisation, sowing date and density, irrigation, as well as some ecological measures such as intercropping or cover crops, are basic prerequisites for successful production of maize in Serbia. Many producers do not use these measures at the appropriate level even though results shows that fertilisation can improve maize yields from 7.87 t/ha to 10.00 t/ha under rainfed and from 9.42 t/ha to 12.32 t/ha under irrigated conditions. Irrigation can also increase maize yields by more than 30%. In the study, good agricultural practices as components of an improved technologies that could help to reduce the impacts of natural hazards and obtain high and stable yields, are identified and validated.

Key words: *Maize, Cropping practices, Yield, Natural disasters, Drought*

Introduction

Of a total of 5 million ha of agricultural land in Serbia, 3.3 million hectares are arable land. Maize is traditionally grown on 1.2 or even 1.3 million ha, but in 2018, maize was sown on about 0.9 million ha (http://www.zitasrbije.rs). Maize hybrids with the genetic potential of 10-15 t ha^{-1} have been grown for over 40 years in Serbia, but yielded 5.5 to 6.5 t/ha in average (Videnovic et al., 2013b). The main reasons for such a difference are drought; soils that are not suitable in the same degree for intensive production; the insufficient application of mineral fertilisers, outdated machinery and small and fragmented arable farms (Kovačević et al., 2012a; Videnović et al., 2013b). Drought often occurs, particularly in Eastern Serbia and only 1/3 of the total maize/soybean production is carried out on favourable soils; the irrigation is applied in only 2% of the maize production areas. Despite this, the Republic of Serbia is a significant producer of cereals within the European frames and the largest regional producer of maize with an average production of about 6 million tons (Statistical Office of the Republic of Serbia, http://webrzs.stat.gov.rs/WebSite/public/ReportView.aspx).

The effects of climate change, which affect the Western Balkans include increased temperature, reduced total precipitation, increased number of summer days, extended period between the last spring and first autumn frost, increased sum of active air temperature above 10 °C, etc. (Čustović et al., 2012; Kovačević et al., 2013). Drought is a multidimensional stress affecting photosynthesis and maize growth. No other environmental factor limits global crop production more severely than water deficit and it is the most important abiotic stress that seriously decreases the final grain yield of maize (Videnović et al., 2013a). In addition, heavy rains, floods, storms, hails, as well as, extremely low and high temperatures, can cause stress and may, to a significant degree, reduce or destroy the yield of maize (Kovačević et al., 2012b). According to the 2015 World Risk Index, the exposure of the population in the Western Balkan countries to such hazards is the highest within the European region.

Maximum yield achievement is still the main strategy in agriculture and could be reached by innovative research orientated towards better understanding of soil-plant relations within the agro-ecosystem, maximum utilisation of the genetic potential of new genotypes and optimisation of cropping technology (inputs-outputs) in regard to climate changes (Byerlee et al., 2014). Crop growing practices can give advantages to the growing plant to maximise its genetic potential in years with regular and extreme conditions (Dragičević et al., 2015). It is very important that maize plant is well-supplied with moisture until the end of flowering, during the cob formation, and grain filling (Kovačević et al., 2013). In the fight against drought, regular and specific cultural practices could be used along with irrigation as the most direct practice by which water can be added in desired quantities independently of precipitation and with far-reaching effects (Kovačević et al., 2012a). The economic effect of climate changes on agriculture requires different practices for rain-fed (Schlenker et al. 2002) and for irrigated regions. In dry land farming areas, climate changes are equivalent to an exogenous shift in the fixed input associated with new supplies. In irrigated regions, the local climate is not directly connected to water supply. A risk reduction present in forecasting is a necessary part of any cropping practice (Iglesias et al., 2011).

Cropping technology determines the effectiveness of certain cultivation measures on morphological and productive traits of the crop, as well as effects of some components of the agro-environmental complex such as weeds and insects. Variations in cropping practices enable environmental factors to be overcome. A cropping practices that can help in overcoming the negative influence of climate changes on maize production and increase grain yield includes crop rotation, soil tillage, fertilisation, irrigation, sowing time and density, appropriate choice of hybrids, intercropping, cover crops, etc. (http://www.fao.org/3/I8848RS/i8848rs.pdf). In the three-crop rotation system with soybean as a legume crop, maize grain yield was higher by 11.4% than in the three-crop rotation system with winter wheat (Videnović et al., 2013a); conventional soil tillage that includes autumn ploughing at a depth of 25 cm or more resulted in the highest ten-year average maize yield of 10.61 t/ha (Videnović et al., 2011); fertilisation is one of the most important aspects in increasing yield and its stability (Berzsenyi et al., 2000; Varvel, 2000); sowing should be done earlier in case of drought and with a proper density for each hybrid (Kresović et al., 2011); irrigation needs to be conducted with adjusted norms in respect to the soil moisture and monthly water needs of maize (Kresović et al., 2013). Moreover, some ecological measures, such as intercropping or cover crops contribute to higher yield achievement (Dolijanović and Simić, 2016; Janosevic et al., 2017). Previous investigations also showed that soil moisture was slightly higher during anthesis under no-till in rain-fed cropping in relation to conventional and reduced tillage (Dragičević et al., 2012). All of the listed practices are basic prerequisites for successful production of maize in Serbia, but many producers do not apply these measures at the appropriate level even though results show that they are effective. Research results of good agricultural practices and improved technologies that could help producers to reduce the impacts of natural hazards and obtain high and stable yields are presented in the manuscript.

Material and Methods

Effects of various cropping practices on maize production have been observed within a long-term research program of experiments that have been carried out in the fields of the Maize

Research Institute, Zemun Polje. Maize was cultivated in different crop rotations, soil tillage systems, under recommended and altered densities, with application of cover crops and within intercropping systems, as well as with and without irrigation. Standard grain quality hybrids were grown with modified sowing densities and the application of organic, mineral and microbiological fertilisers, and various forms of mineral nitrogen.

The soil type in the experimental field was slightly calcareous chernozem with 53% sand, 30% silt, 17% clay; with good fertility and 3.3% of organic matter content and moderate drainage. The pH was 6.9 and soil structure was a silty clay loam. The meteorological conditions varied during and between the seasons as evident through results.

Maize grain yield was the main parameter that was evaluated. This parameter was estimated in the two inner rows and then calculated to 14% moisture.

Results and discussion

The cropping systems were basically defined by **crop rotation** which means proper arrangement of crops in time and space to better utilise soil potentials and climate (Kovačević, 2010). The crop rotation improved soil physical and chemical properties, contributed to biodiversity by growing different crops and genotypes, and influenced the composition and structure of field weed communities (Dolijanović and Simić, 2016). Rotation sequences with row and dense crops, legumes and cereals, also included rotation of cropping technologies and herbicides with different modes of action (Simić and Dolijanović, 2016). Efficient crop rotation encompasses crops with deep and shallow root systems, crops that uptake large quantities of nutrients and crops that enrich the soil, crops that extract and consume large amounts of water from the soil vs. crops that accumulate and maintain the water in the soil.

Table 1. Efficacy of crop rotation in maize cultivation (grain yield), Zemun Polje, 1998-2015

Cropping systems	Fertiliser level				Average
	F1	F2	F3	F4	
Continuous maize	3.89	6.39	6.69	6.90	5.97
Maize - Soybean	6.95	7.99	7.80	7.66	7.60
Maize - Winter wheat	6.33	7.67	7.81	7.66	7.37
Maize - W. wheat - Soybean	8.01	8.78	8.77	8.65	8.55
Average (t ha^{-1})	6.29	7.71	7.77	7.72	7.37

F1 - 0 kg ha^{-1} NPK; F2 - 180 kg ha^{-1} NPK; F3 - 270 kg ha^{-1} NPK; F4 - 360 kg ha^{-1} NPK

In Serbia, maize is grown on approximately 70% of areas after small grains, usually winter wheat (Videnović et al., 2013a). These crops are good preceding crops, as they are dense and inhibit the development of weeds and there is also enough time after harvest for summer and autumn tillage. Continuous cropping or maize monoculture is applied on approximately 20% of arable areas in Serbia. It brings higher infestations with perennial, especially grass weeds potentially resistant to herbicides, and increased damage caused by western corn rootworm. For these reasons, this system is not spreading and in some regions its application even declines. Maize is grown on about 10% of areas in which soybean was a preceding crop which is a very important advancement in the improvement of maize growing practices in Serbia; it is well-known that soybean is one of the best preceding crops for maize, Table 1. Results from investigations showed that presence of plants from the family *Fabaceae* significantly contributes to the efficiency of crop rotation through the reduction of mineral nitrogen fertilisers by 50%, maize yields increase, accompanied by soil preservation and improvement (Videnović et al., 2013a; Jovanović et al., 2004). A cropping system such as double-crop rotation of maize and winter wheat and three-crop rotation of maize, soybean and winter wheat influences maize plant height and grain yield after only one rotation in comparison with maize continuous cropping (Spasojević, 2014; Simić et al. 2017). In years with unfavourable conditions for maize production, the beneficial effects of the crop rotation are even more pronounced.

Soil tillage supports efficient water use and prevents erosion, increases crop competitiveness, reduces the concentration of CO_2 and soil compaction and gives better texture etc. In most production regions in Serbia, a variety of measures such as proper tillage and fertilisation, autumn ploughing, summer ploughing etc., are employed to collect and store moisture in the soil. Maize plants can use the stored water during periods of drought. It is well known that accumulated water increases maize yield.

Recently, systems of reduced tillage, particularly direct sowing, have entered into widespread use (Fulton, 2010). In dry years and on chernozem as a rich and quality soil, no-till could be an effective measure for soil moisture preservation in relation to conventional and reduced tillage (Dragičević et al., 2012). The effectiveness of reduced tillage systems should be tested for other types of soils and agro-ecological conditions in Serbia. However, these systems require the implementation of measures for intensive weed control (herbicides).

Table 2. Effects of soil tillage on maize grain yield (t ha^{-1}), Zemun Polje, 2000-2013

Tillage system	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average
No till	3.0	6.0	8.5	6.0	11.5	8.9	8.0	6.4	3.9	11.6	8.1	6.7	2.8	5.5	6.9
Reduced tillage	5.2	8.0	8.8	7.5	12.8	12.4	10.8	7.6	6.3	11.1	8.9	8.0	3.5	7.6	8.5
Conv. tillage	8.8	9.0	10.3	8.8	14.3	13.9	12.1	8.3	9.6	12.5	10.3	10.4	3.3	8.7	10.0
Average	5.7	7.7	9.2	7.4	12.9	11.7	10.3	7.4	6.6	11.7	9.1	8.4	3.2	7.3	8.5

Under the agro-ecological conditions of Serbia, the highest maize yields and the most efficient weed suppression, especially perennial, are achieved by using a conventional soil tillage which is also most suitable in regard to changeable climatic conditions. In average for fourteen years, conventional tillage contributed to higher yield of maize for 1,5 t/ha and 3,1 t/ha in comparison to reduced and no-till under agro-ecological conditions of Zemun Polje, Table 2. The conventional tillage includes ploughing in autumn (20-25 cm) - soil remains in the form of open furrows to freeze during winter; a single pass land preparation is applied in spring - shallow tillage 10-12 cm. In such a way a good soil structure is provided, moisture is maintained, the soil is not trampled, and weed seedlings are destroyed, which is all of particular importance for efficient herbicide actions.

Fertilisation provides the necessary elements for growth and development of maize. Fertilisation with manure improves soil properties, particularly water - air capacity, which is especially evident when plants are exposed to stress in conditions of natural disasters (Simić et al., 2016a). The application of mineral fertilisers to maize can be managed by time, place and amount of fertilisers (Liu and Wiatrak (2011). Fertilisation changes the relationship in crop competition to weeds, not only for nutrients, but also for other resources, so it is essential that the optimal quantity of fertilisers is provided to the plant at the right time and at the place from which it will best be used (Simić et al., 2016b). The most intensive and the highest rate of nitrogen intake occurs at the beginning of the growing season, and in the period of flowering, respectively. After the start of the milk grain stage, the absorption of nitrogen slows down. Phosphorus is taken by plants in significantly smaller amounts than potassium and nitrogen, in the period of tillering until the beginning of flowering. Potassium is most quickly absorbed from the soil during germination and the formation of tillers. On heavy and substantially sandy soils, maize responds very well to manure fertilisation. Application of mineral fertilisers in maize cultivation can contribute to obtaining higher yields, under rain-fed and especially irrigated soils, Table 3. In Central Serbia, soils are porous with a good water availability, but recently the climate has altered towards an increased frequency of drought years. The use of N fertilisers with inhibitors may reduce the risk of environmental N loss associated with application of conventional N fertiliser sources under variable-climatic conditions (Simić et al., 2016c). The highest yield of a late-maturing hybrid in the experimental plot with long-term continuous cropping (over 35 years) was achieved when manure was applied, harvest residues ploughed down completely and N fertiliser applied in spring at the beginning of the growing season (Simić et al., 2013).

Table 3. The influence of fertiliser level on maize grain yield (t ha^{-1}) in different soil tillage systems, Zemun Polje, 2000-2017

	No till	Reduced tillage	Convent. tillage	Average
		Rainfed		
F1 - 0 kg NPK	5.84	7.39	10.39	7.87
F2 - 150 N, 105 P, 75 K	7.76	9.43	11.50	9.56
F3 - 330 , 211 P, 150 K	8.85	9.93	11.22	10.00
Average	7.48	8.92	11.04	9.14
		Irrigation		
F1 - 0 kg NPK	7.24	9.15	11.88	9.42
F2 - 150 N, 105 P, 75 K	10.15	11.27	13.40	11.61
F3 - 330 , 211 P, 150 K	11.02	12.19	13.74	12.32
Average	9.47	10.87	13.00	11.12

Irrigation helps to reduce the impact of soil and air drought on maize. This concerns the application of water in controlled quantities and certain intervals to the soil or plants to support the optimal growth and development of crops. The achievement of high yields under conditions in Serbia is limited by two factors: - the uneven distribution and deficit in precipitation. In Serbia, six of ten years are dry (extreme to moderate and weak drought), two years have moderate conditions and two are optimum for maize production. In the case of maize, the critical period begins 15–20 days prior to tasselling and lasts until the beginning of the milk stage. When the years are average in terms of weather conditions, maize production under irrigation conditions will result in higher yields by 15-30% or even by 50% in seed maize production (Simic et al., 2016d). Irrigation provides the optimum water supply, activates soil microorganisms and nutrient reserves, and contributes to a better utilisation of incorporated fertilisers.

Sowing and crop density - Maize sowing involves several operations (selection of hybrids, preparation of seed for sowing, sowing time, sowing depth, number of plants per ha, i.e. sowing density, and plant arrangement). High yields of today's maize hybrids can be obtained only if the necessary number of plants is sown per area unit: 70-80,000, 60-70,000 and 60,000 plants ha^{-1} for hybrids of FAO 300-400, FAO 500-600 and FAO 700, respectively.

The sowing time and density are important because they affect crop biomass, lodging, efficiency of nutrient use, harvest time, etc. The optimum sowing time of maize should be harmonized with weather forecasts for a given year, with particular reference to the possible occurrence of drought, floods, etc. Late sowing does not give satisfactory yields, especially in

no-irrigation conditions, and in the case of FAO 600-700 hybrids. In such conditions, it often happens that later FAO groups do not complete their vegetation.
Producers in the regions with frequent occurrence of drought such as Banat, East Serbia and South Serbia, usually grow hybrids with shorter vegetation, FAO 300-400 or FAO 500, with 115-125 days of vegetation period. In dry years, it is more efficient to conduct early sowing at the beginning of April with maximum density of 55-65,000 plants/ha and adapt cropping technology to dry conditions.

A B

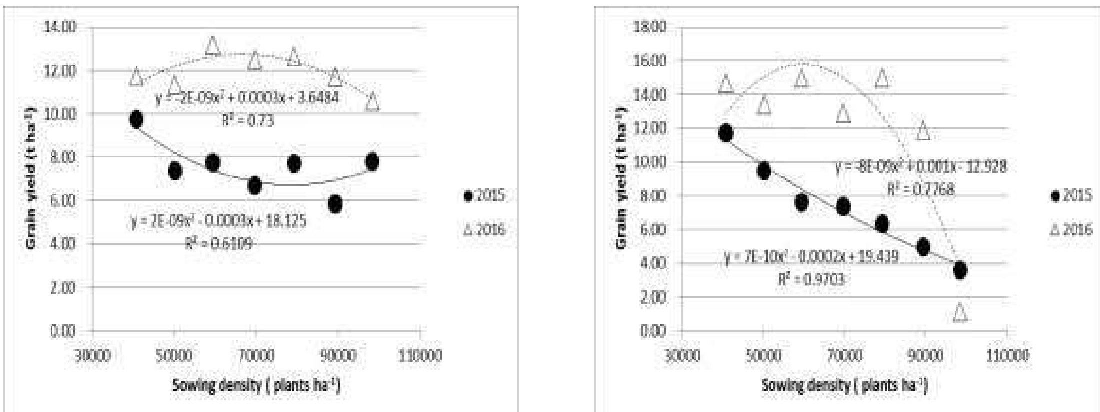

Figure 1. Average yields (t/ha) of maize hybrids of different FAO groups – ZP 366 (A) and ZP 606 (B) in different sowing densities under irrigation conditions (2015-2016 in Zemun Polje)

Increasing the number of plants per hectare up to a certain extent increased the grain yield of maize, but once this limit was achieved the yield decreased. This is, for both hybrids, particularly observable in 2016, a very favourable year for maize production. In this year, yield slowly decreased only when maize was sown in very high densities (more than 70,000 plants per ha), Figure 1. On the other hand, in the dry 2015 year, increased plant density lead to the reduction of grain yield of maize hybrids. The intraspecific competition occurs when the number of maize plants per ha increases and the full yield potentials are manifested only in good years, such as 2016. The impact of meteorological conditions in some years could be very important and similar results were presented for other years, which were not optimal regarding precipitation (Kresovic et al., 2011).
Maize hybrids with a rapid initial growth rate are more competitive than the other hybrids and, a careful selection of competitive hybrids can dramatically reduce grain yield losses and weed biomass, as well as seed production (Simić et al., 2009; Travlos et al., 2011).
Cover crops and intercropping - The cultivation of cover crops is a special way of overlaying/covering the soil. Thus cover crops contribute to the sustainable management of soil structure and soil functioning for water infiltration and storage in crop production (Bodner et al., 2014). Cover crops reduce the runoff/leaching of nutrients from the soil and increase the content of organic matter and they should be cultivated to preserve the fertility of the soil. In a study recently conducted in Zemun Polje, sweet maize yield was highest after a fodder kale and field pea cultivation, but smallest after winter oat and common vetch as cover crops. Different autmn-winter cover crops and microbiological fertiliser showed more efficiency in the dry year on nitrogen utilisation in the soil and sweet maize yield (Janosevic et al., 2017).
Inter-cropping provides greater stability and diversity of production and better use of nutrients, light, heat, air, and vegetation space. Maize can successfully be intercropped with legumes (soybeans, beans and lupines). The choice of genotype in intercropping depends on

the aim of the cultivation. For stock production, usually specific maize hybrids are grown that would be most productive in intercropping with soybean. However, in addition to numerous advantages, this cropping system encounters numerous limitations (e.g. mechanical sowing and harvesting, weed control), which prevent its greater application in practice. Despite this, many results suggest that intercropping is a potential strategy to increase agro-ecosystem preservation by enhancing crop production, improving soil quality and mitigating greenhouse gas emissions (Dolijanović and Simić, 2015).

Conclusion

Based on the analysis of many results it could be concluded that maize production in Serbia significantly depends on meteorological conditions. Genetic potential of maize hybrids was not used enough. Good agricultural practices within maize cropping technology proved in the experimental work must be implemented in order to increase maize yield. In regard to present climate changes, precipitation deficiency is the main limiting factor in maize production in Serbia, so the irrigation is one of the most important measures which could contribute to significant maize production improving. All recommended practices contribute to the crop withstanding negative effects of climate changes and maintaining yield and grain quality with the least possible adverse consequences. Recommendations for their application are particularly emphasised when certain natural hazards are expected or it is known that they will occur.

Acknowledgements

This study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia through the project TR31037.

References

Berzsenyi, Z., Gyorffy D., Lap D. (2000): Effect of crop rotation and fertilisation on maize and wheat yields stability in long-term. European Journal of Agronomy, 13: 225-244.

Bodner, G., Scholl P., Loiskandl W., Kaul H.P. (2014): Cover crop root systems to improve soil hydraulic properties. Proceeding of the 13th ESA Congress, 25-29 August 2014, Debrecen, Hungary, 109-110.

Byerlee, D., Stevenson, J., Villoria, N. (2014): Does intensification slow crop land expansion or encourage deforestation? Global Food Security, 3: 92–8.

Čustović H., Đikic, M., Ljuša, M., Žurovec O. (2012): Effect of climate changes on agriculture of the western Balkan countries and adaptation policies. Agriculture & Forestry, 58: 127-14.

Dolijanović, Ž., Simić, M. (2015): Intercropping Systems: Principles, Production Practices and Agronomic Benefits. In: Agricultural Research Updates (ed. P. Gorawala and S. Mandhatri), Volume 12, 1-41. Editors: Prathamesh Gorawala and Srushti Mandhatri. Publisher: Nova Science Publishers.

Dolijanović, Ž., Simić, M. (2016): The Role of the Crop Rotation in Maize Agroecosystem Sustainability. *In*: *Zea mays* L.: Molecular Genetics, Potential Environmental Effects and Impact on Agricultural Practices (ed.) Loretta Barnes, Nova Science Publishers, New York, SAD, 93-124.

Dragičević V., Simić M., Videnović Ž., Kresović B., Spasojević I., Brankov M. (2012): The influence of different tillage prctices on the soil moisture and nitrogen status. Journal of Central European Agriculture, 13(4): 729-738.

Dragičević, V., Kresović, B., Videnović, Ž., Spasojević, I., Simić, M. (2015): Fitting cropping technology in a changing climate. Agriculture and Forestry, 61(3): 171-180.

Fulton, M. (2010): Foreword. In: Lindwall C, Sonntag B (eds.) Landscapes transformed: the history of conservation tillage and direct seeding. Knowledge impact in society. Saskatoon, Saskatchewan, 9–14.

Iglesias, A., Schlickenrieder, J., Pereira, D., Diz, A. (2011): From the farmer to global food production: use of crop models for climate change, drought and agricultural production, In: Handbook on Climate Change and Agriculture, Robert Mendelsohn, Ariel Dinar, Edward Elgar Publishing Inc., Northampton, Massachusetts, USA, 49-72

Janosevic, B., Dolijanovic, Z., Dragicevic, V., Simic, M., Dodevska, M., Djordjevic S., Moravcevic, Đ., Miodragovic, R. (2017): Cover crop effects on the fate of N in sweet maize (*Zea mays* L. *saccharata* Sturt.) production in a semiarid region. International Journal of Plant Production, 11 (2): 285-294.

Jovanović, Ž., Vesković M., Jovin, P., Kovačević, D. (2004): Effect of different growing systems on maize yield according to the concept of sustainable agriculture. Proceedings of the VIIIth ESA Congres, Copenhagen, Denmark, 611-612.

Kresović, B., Dragičević, V., Simić, M., Tapanarova, A. (2011): The responses of maize genotypes to growth conditions. Genetika (Belgrade), 43(3): 655-666.

Kresovic B., Dragicevic V., Gajic B., Tapanarova A., Pejic B. (2013): The dependence of maize (*zea mays*) hybrids yielding potential on the water amounts reaching the soil surface. Genetika (Belgrade, Serbia), 45(1): 261-272.

Kovačević, D. (2010): Crop science. Second Edition. University of Belgrade, Faculty of Agriculture, Belgrade, Serbia, 1-771.

Kovacevic, D., Oljaca S., Dolijanovic, Z., Milic V. (2012a): Climate changes: Ecological and agronomic options for mitigating the consequences of drought in Serbia. Proceedings of the 3rd International Symposium „Agrosym 2012" Jahorina, Republic of Srpska, Bosnia and Herzegovina, Keynote paper, November 15 - 17, 17-36.

Kovacevic, D., Dolijanovic, Z., Jovanović, Z., Simic M., Milic V. (2012b): Climate change in Serbia: Dependence of maize yield on temperatures and precipitation. Proceedings of the 3rd International Symposium „Agrosym 2012" Jahorina, Republic of Srpska, Bosnia and Herzegovina, Keynote paper, November 15 - 17, 263-269.

Kovačević, V. Kovačević, D., Pepo P., Marković, M.(2013): Climate changes in Croatia, Serbia, Hungary and Bosnia and Herzegovina: The coparison of two vegetation seasons of maize production, 2010 and 2012. Agriculture (Osijek, Croatia), 19(2): 16-23.

Liu, K., Wiatrak, P. (2011): Corn production and plant characteristics response to N fertilization management in dry-land conventional tillage system. International Journal of Plant Production, 5: 405-416.

Schlenker, W., Hanemann, W. M., Fisher, A. C. (2002): The impact of global warming on U.S. agriculture: An econometric analysis, Department of Agricultural and Resources Economics and Policy Working Paper 936, University of California, Berkeley

Simić, M., Dolijanović, Ž., Maletić, R., Filipović, M., Grčić, N. (2009): The genotype role in maize competitive ability. Genetika-Belgrade, 41: 59-67.

Simić, M., Dragičević, V., Spasojević, I., Brankov, M., Jovanović, Ž. (2013): Effects of fertilising systems on maize production in long-term monoculture. Proceedings of the IV International Symposium "Agrosym 2013", Jahorina, Republic of Srpska, Bosnia and Herzegovina, 153–160.

Simić, M., Dolijanović, Ž. (2016): Maize protection: The integrated weed management system benefits. *In*: *Zea mays* L.: Molecular Genetics, Potential Environmental Effects and Impact on Agricultural Practices (ed.) Loretta Barnes, Nova Science Publishers, New York, SAD, 51-84.

Simić, M., Dragičević, V., Momirović, N., Brankov, M., Spasojević, I. (2016a): The effect of organic and mineral fertilization in different cropping systems of maize. Proceeding of the 7th International Scientific Agricultural Symposium "Agrosym 2016", October **6-9**, Jahorina, Republic of Srpska, Bosnia and Herzegovina, 366-372.

Simić, M., Dragičević, V., Dolijanović, Ž., Oljača, S., Brankov, M. (2016b): Effects of fertilization in sustainable farming systems in the presence of weeds. Book of Abstracts of the 10th Serbian Weed Science Congress, 21-23 September, Vrdnik Spa, Serbia, 38.

Simić, M., Dragičević, V., Brankov, M. (2016c): Chemical control effects on maize – weed interference under different nitrogen sources. Proceedings of the 7th International Weed Science Congress, Prague, Czech Republic, 391.

Simić, M., Dragičević, V., Kresović, B., Videnović, Ž., Dumanović, Z. (2016d): Advanced cropping technology of maize (*Zea mays* L.) in Serbia. Agriculture & Forestry, 62(1): 227-240.

Simić, M., Spasojević, I., Dragičević, V., Kovačević, D., Dolijanović, Ž., Brankov, M. (2017): Plant height and grain yield of maize in different cropping systems. Proceedings of the VIII International Agricultural Symposium "Agrosym 2017", October 05-08, Jahorina, Republic of Srpska, Bosnia and Herzegovina, 583-589.

Spasojević, I. (2014): The importance of the crop rotation for the increase of maize crop productivity and preservation of the agroecosystem. PhD thesis, University of Belgrade, Faculty of Agriculture, 1-137.

Travlos, I., Economou, G., Kanatas, J.P. (2011): Corn and Barnyardgrass Competition as Influenced by Relative Time of Weed Emergence and Corn Hybrid. Agronomy Journal, 103: 1-6.

Varvel, E.G. (2000): Crop rotation and nitrogen effects on normalized grain yields in a long-term study. Agronomy Journal, 92: 938-941.

Videnović Ž., Simić M., Srdić J., Dumanović Z. (2011): Long term effects of different soil tillage systems on maize (*Zea mays* L.) yields. Plant, Soil and Environment, 57 (4): 186-192.

Videnović, Ž., Jovanović, Ž., Dumanović, Z., Simić, M., Srdić, J., Dragičević, V., Spasojević, I. (2013a): Effect of long term crop rotation and fertilizer application on maize productivity. Turkish Journal of Field Crops, 18 (2): 233-237.

Videnović, Ž., Dumanović, Z., Simić, M., Srdić, J., Babić, M., Dragičević, V. (2013b): Genetic potential and maize production in Serbia. Genetika, 45(3): 667-678.

http://www.zitasrbije.rs

http://webrzs.stat.gov.rs/WebSite/public/ReportView.aspx

http://www.fao.org/3/I8848RS/i8848rs.pdf