

## Environmental and hereditary effects in plant nutrition: our collaboration with RISSAC Budapest

*Dedicated to the memory of Prof. Dr. Imre Kádár: 1943 -2018*

Vlado KOVAČEVIĆ<sup>1</sup> – Zdenko LONČARIĆ<sup>1</sup> – Domagoj ŠIMIĆ<sup>2</sup>

1: Faculty of Agriculture, Josip Juraj Strossmayer University in Osijek, Vladimira Preloga 1, 31000 Osijek, Croatia; E-mail: vlado.kovacevic@pfos.hr

2: Agricultural Institute Osijek, Juzno predgradje 17, 31000 Osijek, Croatia

**Abstract:** Imre Kádár (29<sup>th</sup> July 1943 - 1<sup>st</sup> March 2018), a world renowned retired scientist in the field of agrochemistry and plant nutrition from the Research Institute of Soil Science and Agricultural Chemistry (RISSAC) of the Hungarian Academy of Science (HAS) in Budapest, passed away suddenly in March 2018. Our collaboration has about a 30 year-long tradition. Intensive collaboration started in connection with the beginning of the Homeland war in Croatia (1991-1995). Imre's broad -minded soul was shown by his offer to make plant and soil analyses in RISSAC agrochemical laboratory for a price covering only the costs of chemicals and sample preparing. He made the offer after visiting Osijek and witnessing the total destruction of lecture rooms in the new building of Faculty and Institute, located on the southern outskirts of Osijek, and distanced only 0.5 km from the frontline. Until the end of 2012, we recorded about 6000 plant and soil samples for elemental analyses sent from the Faculty of Agriculture and Agricultural Institute Osijek to RISSAC Budapest. The outcome of this collaboration is numerous scientific and review articles. Until the end of 2016, Imre was included in 51 scientific, review articles and abstracts in total. Topics of our common articles can be divided into three parts: fertilization and liming effects on soil and plants, heavy metals and harmful elements in soil and plants, and hereditary impacts in maize nutrition. There is still unpublished data from the analyses made in RISSAC. We hope that, in the near future, some of the articles will be published including Imre in our team. Imre may have passed away, but his soul remains with us until our last breath. His rich legacy of development of environmental and genetic aspects of plant nutrition at the Faculty of Agriculture in Osijek and Agricultural Institute Osijek will be inspirational for many generations to come.

**Key words:** RISSAC, Kádár Imre, plant nutrition, Faculty of Agriculture in Osijek, Agricultural Institute Osijek

### Introduction

Imre Kádár (29<sup>th</sup> July 1943 - 1<sup>st</sup> March 2018), a world-renowned retired scientist in the field of agrochemistry and plant nutrition (Picture 1.), from the Research Institute of Soil Science and Agricultural Chemistry (RISSAC) of the Hungarian Academy of Science (HAS) in Budapest, died suddenly in March 2018. The aim of this study is to review our collaboration with RISSAC and to list our common published articles. Imre Kádár and Vlado Kovacevic met each other for the first time at the 7th Congress on Chemistry in Agriculture, which was held 22-24. 06. 1987 in Nitra (the former Czechoslovakia). They exchanged experiences regarding plant nutritional problems, particularly potassium (K) deficiency as a result of K fixation. A similar field of scientific interest became a basis for the future collaboration. At the beginning of the Homeland war in Croatia (1991-1995) and during very difficult conditions at our Faculty and Institute,

without a possibility for activities in destroyed laboratories, the great Imre expressed his highly sentimental human heart. He decided to help us by analysing about 6000 plant and soil samples using ICP AES technique by Jobin-Yvon Ultrace 238 ICP-OES spectrometer in the Agrochemical laboratory of the RISSAC with a payment at a low price covering only the costs of chemicals and the preparation of samples. The costs of the chemical analyses were covered by Agricultural Institute Osijek. Domagoj Šimić and Ivan Brkić from the Department of Maize Breeding and Genetics at Agricultural Institute Osijek were included in the collaboration after 1995. From 2007, Zdenko Lončarić from the Department of Agroecology, Faculty of Agriculture was included in the collaboration for the realization of two bilateral projects. Very successful collaboration resulted by 51 common scientific and review articles and abstracts in total, along with two PhD theses. Posthumously the article was accepted for publishing (Kovacevic et al, 2018). Also, two

Hungarian - Croatian bilateral projects (the national principal investigators Imre Kádár and Zdenko Lončarić) were realized as follows: “Soil chemical properties impact on heavy metals availability and concentrations in field crops” (01.08.2007 – 31.07.2009: Picture 2) and “Heavy metals from farm to fork (protection of food chain)” (01.09.2009 – 31.08.2011). Also, Imre Kádár was an exterior co-worker in our national project “Overcoming limits of maize growing on acid soils by fertilization and genotype” (the 2006-2013 period – code 079-0730463-0447, the principal investigator Vlado Kovačević).

### Material and methods

We reviewed our common articles with Imre Kádár published in the period from 1996 to 2016. The articles can be divided into three topics: fertilization and liming effects on soil and plant, heavy metals and harmful elements in soil and plants, and hereditary impacts in maize nutrition. The subject of some articles includes two topics. Also, some of the titles were first published as an abstract only, and then completed as an article with the same title. Also, two Hungarian - Croatian bilateral projects (principal investigators Imre Kádár and Zdenko Lončarić) supported by both State Ministries of Science (from 2007 to 2011) were shown.

### Results and discussion

The topic of majority of our articles with Imre Kádár is the impact of fertilization and liming on soil and plant properties (Andrić et al., 2016; Kádár et al., 1997, 1998, 2010; Iljkić et al., 2013; Kovačević and Kádár, 1998, 1999; Kovačević et al., 1996a, 1998, 1999, 2000, 2002a, 2009a, 2009b, 2010a, 2010b, 2010c, 2010d, 2011a, 2011b, 2013a, 2013b, 2014, 2015a, 2015b; Rastija et al., 2009; Lončarić et al., 2011b; Regalyi et al., 2010; Karalić et al., 2010, 2011; Rekasi et al., 2010). Thanks to these and many other articles that originated from our collaboration, a great step was made in the knowledge of soil and plant nutritional problems on some less fertile soils in Croatia: potassium (Kádár et al., 1998; Kovačević et al., 2010a), phosphorus (Kovačević et al., 2010c)

and zinc (Kovačević et al., 1998, 2015a, Šimić et al., 2012) deficiencies.

Heavy metals and other harmful elements in soil and plants were elaborated mainly with the aspect of environmental pollution and some articles were focused on the role of hereditary factors (Kádár et al., 2010, 2011; Kovačević et al., 2002a, 2002b, 2002c, 2002d, 2004, 2010d, 2011a, 2011b, 2012; Lončarić et al., 2010, 2011a, 2011b, 2012a, 2012b, 2012c; Rastija et al., 2016; Rekasi et al., 2010; Šimić et al., 2004, 2012). Concentrations of heavy metals in ecosystems are continuously increasing due to industry and traffic, power plants and agriculture. In general, arable soils in the eastern Croatia are clean unpolluted soils well below the limits for conventional and organic agriculture, especially considering total concentrations of toxic heavy metals Pb and Cd. Excessive concentrations of heavy metals were found mainly in the soils of urban areas of Croatia. Preserving the fertility of soils, liming, adequate fertilization, and plant protection, the choice of plant species and genotypes, of feed and animal products are the basis for a lower input of toxic heavy metals into the food chain (Lončarić et al., 2012a, 2012b; Rastija et al., 2016). Genotype aspects of maize mineral nutrition alone or in combination with soil and fertilization, are the topics of some common articles (Andrić et al., 2016; Brkić et al., 2003, 2004; Kovačević et al., 1996a, 1996b, 1997, 1998, 2002b, 2002c, 2002d, 2004, 2011a, 2011b, 2012; Šimić et al., 2002, 2004, 2005, 2012). Two PhD theses, focused on the genetic aspect of maize nutrition, were developed from the results made in RISSAC and defended at the Faculty of Agriculture in Osijek as follows: Environmental and heredity effects on yield and concentrations on phosphorus, potassium, manganese and zinc in maize (Rastija Mirta – July 11, 2006); Impacts of genotype and soil on phosphorus and potassium status in maize (Vragolović Antun - October 27, 2010). Our findings regarding considerable differences in contents of micronutrients in grain of maize hybrids could be used to alleviate micronutrient malnutrition, particularly by widely extended



*Picutre 1.* Imre Kadar (1st June 2007: Joint International Conference on Long-term Experiments): the Nyírlugos Field Trials



*Picutre 2.* visit to RISSAC (April 8, 2008): from left to right: Vlado Kovacevic, Blazenka Bertic, Imre Kádár and Zdenko Loncaric

iron and zinc (Šimić et al., 2005). Namely, we found significant differences among 121 maize genotypes in grain, iron and zinc ranging from 11.0 to 60.7 mg Fe/kg and from 11.9 to 33.2 mg Zn/kg on dry matter basis (Brkić et al., 2004). Based on some results, hereditary aspects of maize nutrition were used for improvement of yields on soils of limited fertility. For example, choice of maize hybrids characterized by specific K and Mg uptake under soil conditions of K-fixation and excessive amounts of available Mg contributed to yield increases without a considerable cost of potassium fertilization (Kovacevic et al., 1996a). Importance of boron in seed-production of maize hybrids and fertility of their parents was elaborated by Andrić et al. (2016).

### Conclusion

The collaboration between the RISSAC and the Faculty of Agriculture and Agricultural Institute

Osijek has over a 30 year-long tradition. As result of this collaboration, numerous scientific, review articles, and two doctor theses were published. Until the end of 2016, Imre was included in 51 scientific, review articles and abstracts in total.

These contributions cover fertilization effects on soil and plant nutritional status, environmental and hereditary effects on maize nutrition and heavy metals status in soil and plants as affected by environment and heredity.

On behalf of the Faculty of Agriculture in Osijek and Agricultural Institute Osijek, we would like to express our sincere gratitude to professor Kádár for his work and results, inspiration, his friendly personality, and at the same time we would like to say farewell.

Dear Imre, rest in peace!

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