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Imer RUSINOVCI, Sali ALIU
Shukri FETAHU, Petr SEDLAK, Dukagjin ZEKA [1]

THE MINERAL COMPOSITION IN SOME LOCAL POTATO (*Solanum tuberosum* L.) POPULATIONS GROWING IN KOSOVO

SUMMARY

The mineral composition of potato tubers are variable and depend on genotypes, soil fertility, agro-technology applied and climatic conditions. Aim of this paper was research of 22 local potato populations (LPP's) in terms of diversity of microelements (Zn, Cu, and Fe) and macro-elements (Ca, Na, K, and Mg) contents. The randomized block design experiment (RBDE) with three replications was carried out. The genetic relative variability between LPP for the mineral content were with significant differences at both levels of probability LSD=0.05 and LSD=0.01. The LPP's involved in this research generally showed high diversity in terms of mineral content.

Keywords: potato, populations, micro, and macro elements, variability

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of most important crop for human nutrition, food *industry*, and agriculture like for cultivation surface also for high production ability. In many countries potato is also used as animal feed. According to statistics, the global production of potatoes in 2010 was 325 million tons, with 52% of the production is used for the purpose of consumption, 33.5% for animal feed, 11% seed production, 2.8% for the manufacture of starch and 0.7% for the production of alcohol. Among the biggest producers are: China, Russia, Ukraine, India, Poland, Belarus (FAO, 2012). Kosovo has an area of 10.887 km^2 or 1.1 million ha, about 430.00 ha forested or 39.1% and 577.000 ha are agriculture land or 52% (Rusinovci et al., 2014)

In Kosovo potato is cultivated in about 10,000 ha with an average low production 10-12 $t.ha^{-1}$ and represents one of the main agricultural crops as agronomic importance, physiological and manufacturing, as well as nutrition to the population. To determinate the genotype structure the main factor are include genetically, agro ecological and agro technical factors (Jovovic et al., 2002). Plant genetic resources are considered to be priceless and the preservation of biological diversity a matter of the long term sustainability of human life (Aliu et

[1] Sali Aliu, (corresponding author: sali.aliu@uni-pr.edu), Imer Rusinovci, Shukri Fetahu, University of Prishtina, Faculty of Agriculture and Veterinary, Department of Crop Science, Bill "Bill Clinton" n.n. Prishtinë 10000, Kosovo; Petr Sedlák, Dukagjin Zeka: Czech University of Life Sciences Prague, Faculty of Agrobiology, Food and Natural Resources, Department of Genetics and Breeding, Kamýcká 129, Prague 6-Suchdol 165 21, Czech Republic.
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al., 2013). Plant genetic resources are a reservoir of genetic diversity and a valuable material for creating new cultivars (Jovovic et al., 2012). Chemical composition of potato tubers varies as far as each lengthwise and crosswise section of each individual tuber is concerned. The crude protein (N x 6.25) represents in tubers approximately 2% of a fresh weight that creates approximately 10% of dry matter. However, the crude protein content ranges significantly in dependence on genotype and growing conditions (Bartova et al., 2009).

Potato tubers are rich in chemicals, which don't have the same distribution. Most of them are found in large concentrations in the tubers skin (cortex), and less on their inside, Wszelaki et al., 2005). The concentration of dry matter, ash and other chemical components of tubers are highly influenced by the characteristics of the cultivars (Rusinovci et al., 2012). Mineral substances cannot be synthesized by plants, they acquired from dissolves in soil through the roots of plants. Although the tubers have associated rootlets with the possible exception of Ca, these rootlets in small quantities supply tubers with minerals (Karenlampi and White, 2009). Several studies point out the fact that the potato is an important route of transfer of minerals from the ground up to human consumption (Reid et al., 2003; Dugo et al., 2004). The concentration of mineral substances in potato tubers varies greatly among cultivars, soil type and land cultivation (Lewis et al., 2011). In general, the total amount of mineral substances ranges between 0.44-1.90 percent depending on the cultivar.

Macro-elements (Ca, Na, K, and Mg) are vital to human health. Calcium (Ca) plays a key role in hardening of the skeleton and is involved in neuromuscular function, blood coagulation and many metabolic processes (Frossard et al., 2000). Deficit of Ca can result in spasm and short pain of muscles and osteoporosis (Andre et al., 2007). Dietary reference intakes (DRIs), FAO/WHO, for Calcium are estimated to be 1000 mg day^{-1} for adults (Anonymous, 2002). Micro-elements (Zn, Cu, and Fe) although participate in minor amounts in the composition of plants and are important for their development and growth. Zinc (Zn) plays a role in the formation of growth hormones (auxins), the formation of the fruit, promotes ripening, helps the synthesis of proteins, etc. Copper (Cu) helps as activators of enzymes, plays great function in photosynthesis and reproduction phase, contributes to increased sugar content, etc. Whereas, Iron (Fe) supports the formation of chlorophyll, enzymes, contributes to the operating mechanism of the cell respiration system, and has a functional contribution in reactions involving cell division and development. Daily consumption in food of Cu and Zn was investigated by Blanusa and Jorhem (1990) (replace reference with a newer reference because, according to Thomson Reuters, this one is quite old) and it is estimated to be 8.1 µg/person/day for Zn and 0.6 µg/person/day for Cu.

The purpose of the paper is based on research of the impact of local populations in the content of mineral substances in the tubers of this culture.

MATERIAL AND METHODS

The research included 22 accessions of potato, collected from different localities (Table 1) during 2011 expeditions. These accessions were cultivated next two years in experimental farm of Faculty of Agriculture and Veterinary in Prishtina. Experimental farm is situated at latitude of 42º38′ N, longitude of 21º 08′ E and an altitude of 560 meters above sea level.

Table 1. Geographically Origin of Local potato populations

Order	Accession Code	Longitude	Latitude	Altitude	Location
1.	FAGB-01	21º06´25"	42º22'48"	611	Balaj - Ferizaj
2.	FAGB-02	21º18'64"	42º16'95"	547	Kaçanik i vjetër
3.	FAGB-03	21º18'007"	42º17'09"	564	Kaçanik i vjetër
4.	FAGB-04	21º10'56"	42º15"72"	511	Prushaj - Kaçanik
5.	FAGB-05	21º23'33"	42º16'24"	881	Dobëllde - Viti
6.	FAGB-06	21º20'96"	42º15'55"	1033	Dobëllde - Viti
7.	FAGB-07	21º23'99"	42º15'57"	1019	Dobeëlde - Viti
8.	FAGB-07A	21º23'99"	42º15'57"	1019	Dobëllde - Viti
9.	FAGB-08	21º32'82"	42º34'21"	625	Rubovc – Kamenicë
10.	FAGB-09	21º32'82"	42º34'21"	625	Rubovc – Kamenicë
11.	FAGB-10	21º30'40"	42º34'14"	867	Busavatë - Kamenicë
12.	FAGB-11	21º28'82"	42º22"76"	502	Zheger - Gjilan
13.	FAGB-12	20º30'53"	42º46"71"	494	Dushkajë - Burim
14.	FAGB-13	20º26'91"	42º46'66"	489	Cercë - Burim
15.	FAGB-14	20º27'05"	42º46'62"	482	Cercë - Burim
16.	FAGB-15	20º27'06"	42º46'58"	479	Cercë - Burim
17.	FAGB-16	20º28'58"	42º43'19"	441	Gurakoc - Burim
18.	FAGB-17	21º03'28"	42º49'90"	600	Samadraxhë - Vushtrri
19.	FAGB-18	21º08'56"	42º19'42	593	Greme - Ferizaj
20.	FAGB-19	21º09'38"	42º19'03"	559	Omuraj - Ferizaj
21.	FAGB-20	21º09'52"	42º19'54"	551	Omuraj - Ferizaj
22.	FAGB-21	21º13’12”	42024’48”	679	Prishtinë

The randomized block design experiment with three replications was carried out. For each replication plot by 20 plants (70 x 30 cm) were cultivated. Weeds elimination was done by mechanical and chemical way. Harvest was realized at the end of July. After harvesting, according to the standard methodology, from each accession in each experimental field samples of 5 kg tubers for chemical contents analysis were taken. Each sample was washed in de-ionized water to clean soil particles, briefly air-dried and then peeled. Tuber flesh was used for chemical analyses. Mineral composition, were determined after six hour sample combustion at 700ºC, then the samples were dissolved with HCl in the ratio 1:4. Determination of chemical elements contents in samples was done by atomic absorption spectroscopy (AAS). Data were analyzed using ANOVA procedure with the statistical software SAS 9.1 En, and Duncan's test for comparison of means was applied.

RESULTS AND DISCUSSION

Besides productivity output, quality remains a key element in the use of agricultural crops in general.

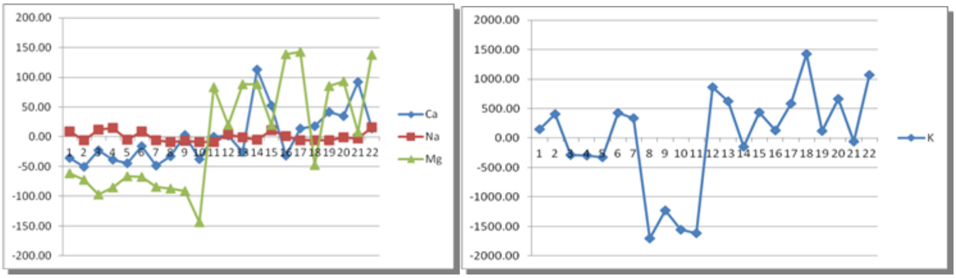
Table 2. Average mean of mineral elements (micro and macro-elements) $mg\ kg^{-1}$

Accession Code	Ca	Na	K	Mg	Zn	Cu	Fe
FAGB-01	64,76 ^{GHIJ}	27,05 ^{ABCD}	2884,80 ^{ABC}	218,76 ^{EF}	4,75 ^{ABCDE}	3,55 ^{BCDE}	9,85 ^{BC}
FAGB-02	49,78 ^{J}	11,40 ^{F}	3144,15 ^{AB}	207,94 ^{FG}	3,90 ^{CDEF}	2,65 ^{CDEF}	8,25 ^{BCDEF}
FAGB-03	77,39 ^{EFGHIJ}	29,30 ^{ABC}	2456,35 ^{BCDE}	183,29 ^{FG}	3,95 ^{BCDEF}	4,65 ^{AB}	18,04 ^{A}
FAGB-04	61,52 ^{HIJ}	32,55 ^{AB}	2438,90 ^{BCDE}	195,02 ^{FG}	3,15 ^{EF}	3,35 ^{BCDEF}	7,44 ^{BCDEFG}
FAGB-05	55,77 ^{HIJ}	12,70 ^{EF}	2417,55 ^{BCDE}	214,20 ^{EF}	5,75 ^{A}	2,70 ^{CDEF}	8,75 ^{BCDE}
FAGB-06	83,76 ^{EFGHIJ}	26,70 ^{ABCD}	3168,00 ^{AB}	213,45 ^{EF}	4,60 ^{ABCDE}	1,25 ^{F}	9,23 ^{BCD}
FAGB-07	51,13 ^{IJ}	12,30 ^{EF}	3078,45 ^{AB}	195,81 ^{FG}	3,18 ^{EF}	1,30 ^{F}	4,53 ^{FG}
FAGB-07A	67,28 ^{FGHIJ}	9,10 ^{F}	1040,10 ^{E}	193,78 ^{FG}	3,60 ^{DEF}	2,00 ^{EF}	5,36 ^{DEFG}
FAGB-08	103,15 ^{DEFGH}	10,75 ^{F}	1509,05 ^{CDE}	189,63 ^{FG}	4,40 ^{ABCDE}	1,90 ^{EF}	9,95 ^{B}
FAGB-09	62,54 ^{HIJ}	9,35 ^{F}	1186,10 ^{DE}	136,92 ^{G}	2,70 ^{F}	2,10 ^{EF}	6,14 ^{BCDEFG}
FAGB-10	99,82 ^{DEFGHI}	9,40 ^{F}	1123,35 ^{E}	363,50 ^{ABC}	4,55 ^{ABCDE}	3,55 ^{BCDE}	4,30 ^{FG}
FAGB-11	102,27 ^{DEFGH}	22,25 ^{BCDE}	3597,65 ^{AB}	300,35 ^{BCD}	5,50 ^{AB}	4,40 ^{ABCD}	3,37 ^{G}
FAGB-12	74,22 ^{EFGHIJ}	17,10 ^{DEF}	3363,10 ^{AB}	368,65 ^{AB}	4,85 ^{ABCD}	5,40 ^{AB}	6,00 ^{BCDEFG}
FAGB-13	212,94 ^{A}	13,35 ^{EF}	2594,00 ^{BCD}	368,95 ^{AB}	4,05 ^{BCDEF}	6,20 ^{A}	5,09 ^{DEFG}
FAGB-14	152,95 ^{BC}	28,85 ^{ABC}	3170,95 ^{AB}	299,95 ^{BCD}	4,05 ^{BCDEF}	1,40 ^{F}	3,55 ^{G}
FAGB-15	68,02 ^{FGHIJ}	18,75 ^{CDEF}	2864,30 ^{ABC}	418,80 ^{A}	4,35 ^{ABCDEF}	3,55 ^{BCDE}	5,70 ^{CDEFG}
FAGB-16	114,15 ^{CDEFG}	11,95 ^{EF}	3326,35 ^{AB}	422,95 ^{A}	3,80 ^{CDEF}	2,45 ^{DEF}	5,30 ^{DEFG}
FAGB-17	117,80 ^{CDE}	12,30 ^{EF}	4161,60 ^{A}	233,10 ^{DEF}	4,75 ^{ABCDE}	1,75 ^{F}	6,00 ^{BCDEFG}
FAGB-18	141,89 ^{CD}	11,40 ^{F}	2860,80 ^{ABC}	365,90 ^{AB}	5,20 ^{ABCD}	3,00 ^{CDEF}	5,34 ^{DEFG}
FAGB-19	134,45 ^{CD}	16,65 ^{DEF}	3401,40 ^{AB}	373,60 ^{AB}	5,25 ^{ABCD}	6,45 ^{A}	7,10 ^{BCDEFG}
FAGB-20	191,84 ^{AB}	15,05 ^{EF}	2678,55 ^{BC}	287,95 ^{CDE}	5,40 ^{ABC}	5,35 ^{AB}	4,80 ^{EFG}
FAGB-21	114,33 ^{CDEF}	34,00 ^{A}	3811,30 ^{AB}	417,95 ^{A}	4,65 ^{ABCDE}	4,40 ^{ABCD}	7,80 ^{BCDEF}
Mean	100,08	17,83	2739,85	280,47	4,38	3,33	6,90
LSD $_{0.05}$	36,45	7,95	1045,7	55,95	1,23	1,58	3,09
$_{0.01}$	49,54	10,80	1421,4	76,04	1,67	2,14	4,20

* Mean values of the same category followed by different letters are significant at $p \leq 0.01$ level.

Average amount of Ca in tubers in our experimental research was 100.08 *mg kg*$^{-1}$ (Table 2). The extreme values of the accessions were found in accession FABG-13 with average value +112.86 *mg kg*$^{-1}$ or expressed in relative value 112.77%, while lowest value, compared to the experimental average, was found in accession FABG-02 (-50.30 *mg kg*$^{-1}$) or -50.26 % of relative genetic value.

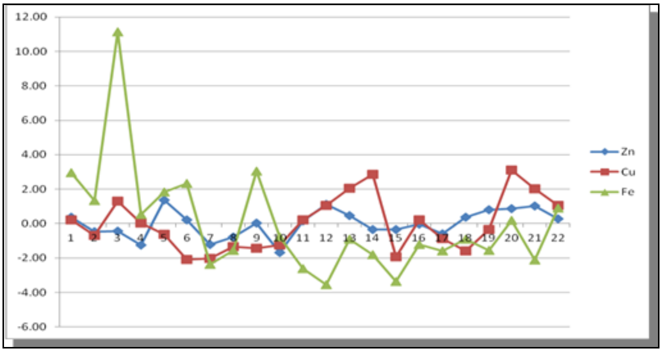
Genetic relative variability between accessions for the amount of Ca in the tuber was 163.04 % and the results are significant at both levels of probability (LSD $_{p\leq0.05}$ and LSD $_{p\leq0.01}$) (the details are presented in Table 2 and Graph 1 respectively). Rusinovci et al. (2012) found lower value of Ca in some commercial variety cultivated in Kosovo.



Graph 1. Variability of mean values of macro-elements (Ca, Na, Mg & K) compare to the general average value.

The accession FAGB-21 obtained the highest amount of sodium (Na) and magnesium (Mg) with average value +16.17 and +142.14 *mg kg*$^{-1}$, or expressed in genetic relative value 90.69% and 50.80% respectively, over experimental average of respective parameters. However, lowest concentration of Na reviled in accession FAGB-07A with value -87.3 *mg kg*$^{-1}$ or -48.98% according to the relative genetic variability, whereas accession FABG-09 obtained lowest concentration of Mg (-143.56 *mg kg*$^{-1}$) or -51.18 % of genetic relative variability. General genetic variability, compare between extreme values of experiment, to the Na was 139.66 % respectively 101.98 % to the Mg, furthermore results were statistically highly significant (LSD $_{p\leq0.05}$ and LSD $_{p\leq0.01}$) and presented in Table 2 and Graph 1. Researched accessions had lower concentration of Na and higher concentration of Mg compare to modern varieties (Rusinovci et al., 2012). Potassium (K) is vital in plant processes, even it is not part of any of their chemical structure, plays many regulating roles in development. Potassium plays a vital role in stoma activity, photosynthesis, sugar transport, transport of nutrient and water, protein and starch synthesis, activation of enzymes and production quality. The results of our research on local accessions for amount of K in the potato tubers were different (Table 2, Graph 1). The highest concentration was found in accession FAGB-17, which compared with the experimental average value was higher +857.80 *mg kg*$^{-1}$ or 31.31% of relative genetic variability, whereas the lowest concentration was found in accession FAGB-07A (-1699.75 *mg kg*$^{-1}$) or -62.04% of genetic relative variability. The relative genetic variability between extreme values of the potassium was 93.35%. Results of the concentration of K in this study were higher compared with previous data (Rusinovci et al., 2012).

The amount of micro-minerals in our research was different, depending on the accession. Experimental average value of the amount of Zn was 438 $mg\ kg^{-1}$ (Table 2). Accession FAGB-05 realized higher value +1.37 $mg\ kg^{-1}$, while the lowest value performed accession FAGB-09 (-1.68 $mg\ kg^{-1}$), compared with the experiment average value (Graph 2). Relative genetic variability of extreme values of Zn, compared with experimental average was 38.37% and -31.25% respectively, while the relative variability between them was 69.62% in total.



Graph 2. Variability of mean values of micro-elements (Zn, Cu & Fe) compare to the general average value.

The amount of Cu, compared with the experimental average differs from +3.12 $mg\ kg^{-1}$ in accession FAGB-19 to -2.08 $mg\ kg^{-1}$ that was obtained in accession FAGB-06 (Graph 2). Moreover, extreme values of relative genetic variability for Cu companied to experimental average are 93.46% and 62.51%, while the value of the general relative genetic variability is 155.69%. The higher value of Fe concentration is determined to accession FAGB-03 18.4 $mg\ kg^{-1}$ or +11.14 $mg\ kg^{-1}$ compared with the experimental average (Graph 2) or expressed in terms of relative genetic variability was 161.34%, whereas accession FAGB-11 realized lowest value -3.53 $mg\ kg^{-1}$ compared to the experimental average or according to the relative value of genetic variability was -51.18%, whereas the overall variability of genetic relative of tested accession was 212.52%. Rusinovci et al. (2012) found much lower values of Fe concentration in commercial varieties. This research found significant results in micro-elements at both levels of probability LSD $_{p\leq0.05}$ and LSD $_{p\leq0.01}$ (Table 2).

CONCLUSIONS

Based on the results obtained from the research it can be concluded that the potato genetic resources involved in this research generally showed high diversity in terms of content of minerals. Higher amounts of most minerals compared to commercial cultivars indicate the quality of indigenous genetic resources which have to conserve in national gene bank of plant genetic resources and can be a good basis for breeding programs also. An integrated research of these resources needed.

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