ISSN 1313 - 8820
Volume 8, Number 1
March 2016

AGRICULTURAL SCIENCE AND TECHNOLOGY

2016

An International Journal Published by Faculty of Agriculture,
Trakia University, Stara Zagora, Bulgaria

Scope and policy of the journal

Agricultural Science and Technology /AST/ – an International Scientific Journal of Agricultural and Technology Sciences is published in English in one volume of 4 issues per year, as a printed journal and in electronic form. The policy of the journal is to publish original papers, reviews and short communications covering the aspects of agriculture related with life sciences and modern technologies. It will offer opportunities to address the global needs relating to food and environment, health, exploit the technology to provide innovative products and sustainable development. Papers will be considered in aspects of both fundamental and applied science in the areas of Genetics and Breeding, Nutrition and Physiology, Production Systems, Agriculture and Environment and Product Quality and Safety. Other categories closely related to the above topics could be considered by the editors. The detailed information of the journal is available at the website. Proceedings of scientific meetings and conference reports will be considered for special issues.

Submission of Manuscripts

All manuscripts written in English should be submitted as MS-Word file attachments via e-mail to editoffice@agriscitech.eu. Manuscripts must be prepared strictly in accordance with the detailed instructions for authors at the website www.agriscitech.eu and the instructions on the last page of the journal. For each manuscript the signatures of all authors are needed confirming their consent to publish it and to nominate on author for correspondence.

They have to be presented by a submission letter signed by all authors. The form of the submission letter is available upon from request from the Technical Assistance or could be downloaded from the website of the journal. Manuscripts submitted to this journal are considered if they have submitted only to it, they have not been published already, nor are they under consideration for publication in press elsewhere. All manuscripts are subject to editorial review and the editors reserve the right to improve style and return the paper for rewriting to the authors, if necessary. The editorial board reserves rights to reject manuscripts based on priorities and space availability in the journal.

The journal is committed to respect high standards of ethics in the editing and reviewing process and malpractice statement. Commitments of authors related to authorship are also very important for a high standard of ethics and publishing. We follow closely the Committee on Publication Ethics (COPE), http://publicationethics.org/resources/guidelines

The articles appearing in this journal are indexed and abstracted in: DOI, EBSCO Publishing Inc. and AGRIS (FAO).

The journal is accepted to be indexed with the support of a project № BG051PO001-3.3.05-0001 "Science and business" financed by Operational Programme "Human Resources Development" of EU. The title has been suggested to be included in SCOPUS (Elsevier) and Electronic Journals Submission Form (Thomson Reuters).

Address of Editorial office:
Agricultural Science and Technology
Faculty of Agriculture, Trakia University
Student's campus, 6000 Stara Zagora
Bulgaria
Telephone.: +359 42 699330
+359 42 699446
www.agriscitech.eu

Technical Assistance:
Nely Tsvetanova
Telephone.: +359 42 699446
E-mail: editoffice@agriscitech.eu

ISSN 1313 - 8820

Volume 8, Number 1
March 2016

AGRICULTURAL SCIENCE AND TECHNOLOGY

2016

An International Journal Published by Faculty of Agriculture,
Trakia University, Stara Zagora, Bulgaria

AGRICULTURAL SCIENCE AND TECHNOLOGY, VOL. 8, No 1, pp 51 - 57, 2016
DOI: 10.15547/ast.2016.01.009

Determination of some macro and micro elements in grain of winter barley genotypes

N. Markova Ruzdik[1]*, Lj. Mihajlov[1], V. Ilieva[1], S. Ivanovska[2], D. Valcheva[3], B. Balabanova[1], M.Ilievski[1]

[1]Faculty of Agriculture, "Goce Delchev" University, 2000 Shtip, Republic of Macedonia
[2]Faculty of Agricultural Sciences and Food, "Ss. Cyril and Methodius" University, 1000 Skopje, Republic of Macedonia
[3]Institute of Agriculture, 8400 Karnobat, Republic of Bulgaria

(Manuscript received 27 January 2016; accepted for publication 1 March 2016)

Abstract. *The objective of this study was to determine the content of some macro and micro elements in grain of winter barley genotypes, as well as, to identify the relationships between those elements and grain yield. The experiment was carried out during the period of 2012/2013 and 2013/2014 on the research fields of the Faculty of Agriculture, "Goce Delchev" - University, in two locations in the Republic of Macedonia, Ovche Pole and Strumica. The total 21 genotypes were used as an experimental material, of which 5 were Macedonian, 2 were Croatian, 2 were Serbian and 12 genotypes originate from Bulgaria. The trial was arranged as randomized complete block design with three replications for each genotype and location. Microwave digestion method was used to destroy the organic matrix to determine the content of Na, Mg, P, Ca, Fe, Cu and Zn. The content of all elements was carried out by mass spectrometry with inductively coupled plasma (ICP-MS). During the period of study, the concentration of all examined elements was higher in genotypes grown in Strumica locality compare to Ovche Pole. In both locations, for all analyzed properties were found significant differences between examined barley genotypes. In Ovche Pole locality, the genotype Line 2 was the richer with macro and micro elements, while in Strumica locality the genotypes Izvor and NS 565 2R. Generally in both locations, barley genotypes were poor with macro and micro elements. In both locations, was not found significant correlation between content of macro and micro elements and grain yield. Using PCA analysis, two main components were extracted for the study conducted in Ovche Pole and three components in Strumica locality.*

Keywords: barley, elements, yield, mass-spectrometer, correlation

Introduction

In the recent years, the main focus in many researches is directed towards to providing sufficient and high quality of food supplies. Cereal crops are the basic source of energy, carbohydrates (McKevith, 2004), proteins (Charalampopulos et al., 2002; Ragaee et al., 2006; Comai et al., 2007; Shewry, 2007), dietary fibers and minerals especially magnesium and zinc (Kowieska et al., 2011). One of the main goals in selection of cereal grains is determination of mineral composition, especially phosphorus, potassium, magnesium, calcium, zinc and essential amino acids for production of functional food (Nardi et al., 2003; Sidhu et al., 2007). The contents of macro and micro elements in cereals depend by the chosen variety, soil and weather conditions during the growing period and use of fertilizers (Pietola and Salo, 2000; Bálint et al., 2001; Hattori and Chino, 2001).

The previous studies for determinations of macro and micro elements have been based on soil, water quality and air pollution (Klavins and Vircavs, 2001; Nicodemus et al., 2004; Tabors et al., 2004; Gilucis, 2007; Cekstere and Osvalde, 2013). Stapkevica et al. (2013) examined the metal uptake from contaminated soils by some plant species (lettuce and dill). Vincevica-Gaile et al. (2011) reported the distribution of trace and macro elements in honey. Only a few researches have been related to food composition, for example potatoes (Murniece et al., 2011), cranberries (Osvalde and Karlsons, 2010), honey (Dimiņš, 2006) and cereal crops or cereal mixtures (Sager and Hoesch, 2005; Cioùek et al., 2012; Vinceva-Gaile, 2014; Jākobsone et al., 2015; Kan, 2015).

Barley (*Hordeum vulgare* L.) is one of the earlier cultivated cereal crops. This crop is still considered one of the four most important cereals in the world (Kanbar, 2011; Zaefizadeh et al., 2011; Biel and Jacyno, 2013). In Republic of Macedonia, barley production takes the second place, after wheat (*Triticum aestivum* L.). Barley is used for animal feed, producing malt, for seed, human food and as a cover crop to improve soil quality (Gallegos-Infante et al., 2010; Babaeian et al., 2012; Shar et al., 2013).

On the other side, mineral nutrition contributed significantly to increase crop yields. Borlaug and Dowswell (1994) presented that around 50% of the increase in crop yields worldwide in the last period was due to application of chemical fertilizers. Crops need micronutrient elements in small quantities, for normal growth and production. Deficiencies of essential elements cause disturbance in the physiological and metabolic processes in plants (Bacha et al., 1997). Plants growth can be limited cause little amount of followed elements: nitrogen, phosphorus, potassium, calcium, magnesium, iron and molybdenum (Rao et al., 1993; Samac and Tesfaye, 2003). The content of calcium is low in maize and barley, but barley is the first crop according to content of phosphorus, compared to other cereals (Shar et al., 2013). According to Welch et al. (1991), the elements manganese, iron, copper, zinc, boron and molybdenum are essential for higher plants, while Parker et al. (1992) reported that zinc is of the eight essential elements, necessary for normal growth and plants development.

This research was carried out to determine the contents of

* e-mail: natalija.markova@ugd.edu.mk

some macro and micro elements in barley genotypes and to analyze the correlation between those elements and grain yield.

Material and methods

Experimental design

The experiment was conducted during the period of 2012/13 and 2013/14, on the research fields of the Faculty of Agriculture, "Goce Delchev" University, Shtip, Republic of Macedonia, in two locations – Ovche Pole and Strumica. Ovche Pole locality is characterized with an altitude between 200–400 m above sea level, latitude 41°49'21.9" and longitude 21°59'03.9". Other locality, Strumica lies at latitude 41°26'32.0" and longitude 22°39'54.5". According to Filipovski et al. (1996), Republic of Macedonia is divided on eight climatic vegetation areas. Based on this classification, both experimental locations belong to the continental sub-Mediterranean area.

Before the sowing, from the experimental plots were taken soil samples for agrochemical analysis. The soil properties of experimental plots are given in Table 1. The experimental trial was in accordance to the randomized block system, in three replications for each of the genotype and location. Each replication plot was 1 m^2, consisted of 10 rows and the amount of cultivated seed was evaluated at 500 seeds per m^2. The sowing was done by hand, 3 to 5 cm depth, on the same date in both locations (18 October in the first experimental year and 14 October in the second testing year). Standard growing measurements were applied on both locations. Pre-sowing soil preparation was conducted in suitable timing, in both testing years and in accordance with weather and soil conditions for both locations. For the analysis, ten plants were randomly chosen from the middle part of each replication plot from both locations. The barley genotypes were harvested in June. After harvest, the grain yield of each genotype was calculated. Determination of some macro and micro elements was performed in Laboratory for plant and environment protection, Faculty of Agriculture, "Goce Delchev" University.

Table 1. Agrochemical analysis of the soil samples taken from the experimental plots in Ovche Pole and Strumica locations

Properties	Ovche Pole locality	Strumica locality
Available P_2O_5 (mg/100 g soil)	24.19	10.6
Available K_2O (mg/100 g soil)	74.1	15.2
Humus (%)	1.94	1.75
Conductivity (mS/cm)	0.25	0.16
Total N (mg/g)	0.98	0.89
pH	7.65	7.49
Mn (mg/kg)	1 260	953
Zn (mg/kg)	139	123
Fe (mg/kg)	4.86	4.66
Ca (mg/kg)	5.40	2.07
P (mg/kg)	827	538
K (mg/kg)	2.18	2.78
Na (mg/kg)	1.19	2.54

Plant material

Twenty one winter barley genotypes were used as experimental material. Five of them have Macedonian origin (*Hit, Izvor, Egej, Line 1* and *Line 2),* two genotypes are Croatian *(Zlatko* and *Rex),* two genotypes have Serbian origin *(NS 525* and *NS 565)* and the rest one have Bulgarian origin (*Obzor, Perun, Emon, Lardeya, Orfej, Imeon, Zagorec, Asparuh, Kuber, Sajra, Devinija* and *Odisej*).

Samples preparation and elements determination

For digestion of barley grain samples, the microwave digestion system (model Mars, CEM) was applied. From each genotype, precisely was measured 0.5 g of grind barley grain and placed in Teflon digestion vessels. 5 ml concentrated nitric acid, HNO_3 (69%, 108 m/V) and 2 ml hydrogen peroxide, H_2O_2 (30%, m/V) were added. The Teflon vessels were carefully closed and placed in microwave for digestion. Barley samples were digested in two steps for total dissolving at 180°C. After the digestion method was finished, digested samples were quantitatively transferred into 25 ml volumetric flaks.

The content of Na, Mg, P, Ca, Fe, Cu and Zn in digest samples was determined by mass spectrometry with inductively coupled plasma (ICP-MS).

Statistical data processing

The obtained values for the contents of the investigated elements were statistically processed using basic descriptive statistics (Stat Soft, 8.0). The data were analyzed using JMP, 5.0.1a (2002) software, mean comparison was done using LSD at 5% probability level.

The correlation between macro and micro elements and grain yield was determined by using linear correlation (Singh and Chaudhary, 1985) with SSPS statistical package (2010).

Also, to determine the variability of analyzed properties and to understand the connection between metal contents and grain yield, principal component analysis (PCA) was applied (Mohammadi and Prasanna 2003).

Results and discussion

Barley has wide distribution, because its polymorphism, it can grow on various soil types. This crop has poorly developed root system that requires soils with good structure and soils with favorable water-air regime. Winter barley varieties require heavier soils. The highest yields of barley are achieved on humus and alluvial types of soils. In Table 1 are given the values obtained from the agrochemical analysis of soil samples taken from the experimental plots in Ovche Pole and Strumica. The soil sample taken from Ovche Pole locality shows a good supply with readily available phosphorus, total nitrogen, abundant supply of easily accessible potassium, low organic matter content and low salinity. On the other hand, the soil from Strumica locality delivering good assistance to total nitrogen, average supply of readily available phosphorus, low humus content and low salinity with pH neutral reaction. In Table 1, are also given the concentrations for the most important elements in experimental soils from our study. If we compare the results from both locations (Ovche Pole and Strumica), will perceive that significant differences between them do not exist. The soil sample taken from Ovche Pole locality has higher content of Mn, Zn, Fe, Ca and P compare to soil from Strumica. The presence of metals in soil and their concentration depend largely on the

Table 2. Mean values for macro and micro elements content (mg/kg) and grain yield (kg/ha) in barley genotypes grown in Ovche Pole locality

Genotypes	Na	Mg	P	Ca	Fe	Cu	Zn	Grain yield
Hit	31.59ij*	427.20c	851.0d	117.4c	18.2a	1.712def	5.120h	4 107a_d
Izvor	48.27a	394.20h	787.5l	115.3d	17.0b	1.510h	4.320s	3 915a_d
Egej	32.68h	387.25j	834.5g	139.0a	13.7hi	1.628fgh	5.115i	3 825a_d
Line 1	31.85i	411.40f	768.5n	104.1f	13.6hi	1.789cde	4.717o	3 953a_d
Line 2	24.36mn	437.25a	912.5a	103.6f	15.2ef	1.959ab	5.770b	3 534bcd
Zlatko	35.44f	384.85k	872.0b	121.2b	14.7de	1.683d_g	3.789u	4 031a_d
Rex	34.42g	378.30l	734.0r	115.2d	13.7hi	1.684d_g	4.707p	4 324a_d
NS 525 2R	36.62e	420.95d	836.5g	120.9b	14.7fg	2.063a	5.570c	5 258a
NS 565 2R	23.35o	395.80g	756.0p	99.1h	14.1gh	1.668efg	4.673q	4 974ab
Obzor	35.61f	389.15i	778.5m	111.0e	15.9cde	1.702def	5.295e	3 299dc
Perun	27.43l	375.05m	761.0o	120.6b	14.1gh	1.764cde	5.080l	4 763ab
Emon	21.57p	417.00e	840.0f	113.8d	14.1gh	1.813fgh	5.020m	4 121a_d
Lardeya	24.70m	355.85p	744.0q	94.7i	13.0ij	1.781cde	4.582r	4 516a_d
Orfej	32.98h	394.10h	801.5j	117.9c	14.8fg	2.004ab	5.085k	4 135a_d
Imeon	41.03c	389.55i	792.5k	97.7h	14.7fg	1.569gh	5.280f	3 106d
Zagorec	39.76d	377.20n	825.5i	101.5g	16.4bcd	1.659efg	5.110j	3 846a_d
Asparuh	12.75q	357.45o	693.0s	68.5k	14.3gh	1.603fgh	4.780n	4 596abc
Kuber	41.76b	417.80e	829.5h	101.4g	15.5ef	1.881bc	5.560d	4 991a
Sajra	31.07jk	412.05f	844.0e	85.6j	16.0cde	1.806cd	5.210g	4 879ab
Devinija	23.70no	342.90q	641.5t	84.7j	12.3j	1.361i	4.090t	4 343a_d
Odisej	30.67k	430.05b	862.0c	111.5d	16.6bc	2.024a	6.050a	4 856ab
Mean	31.51	395.02	798.4	106.9	14.9	1.746	4.996	4 256
$LSD_{0.05}$	0.66	1.53	2.48	1.58	0.87	0.13	0.01	1 414.83
Min	12.75	342.90	641.5	68.5	12.3	1.361	3.789	3 106
Max	48.27	437.25	912.5	139.0	18.2	2.063	6.050	5 258

*Mean in each column followed by the same letter are not significantly different (P>0.05)

geological composition (Spoito, 2008).

Barley grain is consist of about 65 – 68% starch, 10 – 17% protein, 4 – 9% β-glucans, 2 – 3% free lipids and 1.5 – 2.5% minerals (Izydorczyk et al., 2000; Quinde et al., 2004). Mineral elements are distributed throughout the seed, but the greatest concentrations are found in the embryo, pericarp and aleurone layer (Duffus and Cochrane, 1993; Marconi et al., 2000). Plant ability for provides macro and micro elements depends of their concentrations in the soil, grain and also of their distribution in grain (White and Broadley, 2009).

The content of macro and micro elements in analyzed barley genotypes grown in Ovche Pole locality is presented in Table 2. Among all barley genotypes analyzed in Ovche Pole locality, the highest value of Na was found in genotype *Izvor* and the lowest in Bulgarin genotype *Asparuh*. Genotype *Asparuh* also has the lowest content of Ca and *Egej* was genotype with highest content of this element. In Ovche Pole locality, genotype *Line 2* was the riches with Mg and P content, while the genotype *Devinija* has the lowest concentration from these two elements. Also, in *Devinija* was determined the minimum concentration of Fe and Cu. Maximum value for Fe content has genotype *Hit*, while the content of Cu was the highest in genotype *NS 525 2R*. In our study, zinc concentration was found in range of 3.789 mg/kg (genotype *Zlatko*) to 6.050 mg/kg (genotype *Odisej*). Shar et al. (2013) have reported higher range for this element (from 30.24 mg/kg to 53.05 mg/kg), but also higher concentration for Cu.

The mean value for barley yield, during the period for the experiment, for all analyzed genotypes was 4 256 kg/ha and was lower compare to the grain yield obtained from the genotypes grown in Strumica locality. Genotype *NS 525 2R* has the highest mean value for yield and genotype *Imeon* the lowest.

Using LSD test with level of significance 0.05, it was found that all genotypes were significantly differ for all analyzed elements, also including the yield. Base on LSD test, the genotypes were divided into groups and statistically differ between them self. Dividing the barley genotypes into different groups allows in future being selected genotypes which have a higher concentration of mineral elements. Those genotypes can be used as parents in barley breeding process in order to improve mineral composition.

In Table 3 are given the values for content of macro and micro elements obtained from the genotypes examined in Strumica locality. Also in this locality, the genotype *Izvor* has the highest content of Na and the smallest was found in genotype *Emon*. *Emon* has the highest concentration of P. The mean value for Na concentration, during the period of study, in all barley genotypes was 60.93 mg/kg. Macedonian genotype *Hit* has the lowest concentration of Mg and P. As in Ovche Pole locality, in Strumica the genotype *Asparuh* also showed the lowest concentration for Ca and the highest was found in genotype *Izvor*. In this study, the concentration of iron was found in the range of 17.1 mg/kg (in genotype *Rex*) to 28.0 mg/kg (in genotype *Obzor*). Higher minimum and maximum values for this element were reported by Shar et al. (2013). The highest content of Cu and Zn was determined in genotype *NS 565 2R*, while genotype *Imeon* has the lowest concentration from those elements. Genotype *Imeon* has also the smallest value for grain yield. The mean value for grain yield in Strumica locality, during the period of study, for all tested genotypes was 4 834 kg/ha and the genotype *NS 525 2R* has the highest value for yield. All genotypes grown in Strumica locality, also, significant differ for all analyzed properties. Kowieska et al. (2011) reported higher average values for content of Mg, P, Zn, Fe and Cu, compared with the concentrations of those elements obtained in our research.

Table 3. Mean values for macro and micro elements content (mg/kg) and grain yield (kg/ha) in barley genotypes grown in Strumica locality

Genotypes	Na	Mg	P	Ca	Fe	Cu	Zn	Grain yield
Hit	57.40j	378.75k	796.0t	133.7m	17.6i	1.839o	5.375o	4770a_f
Izvor	95.80a	492.00cd	1059.0j	195.9a	22.5g	2.616b	6.070h	4163b_f
Egej	83.85b	453.25i	973.0p	160.3h	23.9e	2.219h	6.705b	5486ab
Line 1	50.00q	550.45a	1155.5d	179.3d	23.0f	2.190i	5.680l	4947a_e
Line 2	53.80m	554.50a	1208.5c	169.3g	24.5d	2.183i	6.950a	4032c_f
Zlatko	51.50p	503.00bc	998.5n	192.8b	23.9e	2.067k	5.825k	4786a_f
Rex	49.21r	416.90j	889.5s	156.7i	17.1j	1.781p	5.150p	4758a_f
NS 525 2R	58.25h	456.20hi	942.0r	172.4f	21.9h	2.286f	5.895j	5794a
NS 565 2R	80.05e	504.00b	1043.5k	184.2c	23.7e	6.090a	6.950a	5448abc
Obzor	83.60c	544.50a	1219.0b	175.8e	28.0a	2.452c	6.645d	3532ef
Perun	40.11s	509.00b	1138.5f	131.7o	23.9e	2.280f	6.010i	5362a_d
Emon	29.71t	554.00a	1268.0a	153.2j	24.7d	2.362d	6.300e	4012def
Lardeya	53.35n	509.00b	1140.0e	139.0l	25.4c	2.188i	5.635m	5033a_d
Orfej	56.90k	476.65f	1039.5l	133.5m	25.1c	2.235g	6.075g	4941a_e
Imeon	58.00i	410.00j	941.5r	118.8r	22.3g	1.698q	4.342r	3405f
Zagorec	73.30f	480.50ef	1127.5g	132.4n	26.2b	2.345e	6.155f	4426a_f
Asparuh	65.65g	471.15i	1031.0m	114.8t	23.6e	2.039l	5.115q	5334a_d
Kuber	54.80l	488.20de	1105.0h	131.2p	26.3b	2.115j	6.700c	5764a
Sajra	80.75d	511.50b	1096.5i	117.0s	24.5d	2.186i	5.680l	5203a_d
Devinija	51.70o	465.30gh	982.5o	130.3q	23.9e	1.914n	5.540n	5449abc
Odisej	51.85o	471.25fg	972.0q	147.9k	23.0f	1.957m	5.680l	4869a_e
Mean	60.93	485.72	1053.6	151.0	23.6	2.335	5.927	4834
$LSD_{0.05}$	0.18	1.20	0.82	0.34	0.34	0.01	0.01	1431.75
Min	29.71	378.75	796.0	114.8	17.1	1.698	4.342	3405
Max	95.80	554.50	1268.0	195.9	28.0	6.090	6.950	5794

*Mean in each column followed by the same letter are not significantly different (P>0.05)

Generally, the mean values obtained for analyzed elements, from the period of study, for all barley genotypes, showed that the content of Na, Mg, P, Ca, Fe, Cu and Zn was higher for barely genotypes grown in Strumica, compare to genotypes tested in Ovche Pole locality. It is observed that the concentrations of micro and macro elements are generally higher on the surface of soil and decreased with the soil depth. One of the reasons can be the movement of macro and micro elements into grain involve the phloem. Also, increasing the pH content in soil decreased the movement of elements. In our study pH value for the soil taken from Ovche Pole locality was higher and the concentrations of investigated elements in barley genotypes were smaller compare to the same genotypes analyzed in Strumica locality.

The concentration of copper, iron, manganese and zinc present in barley grain may vary to a large extent due to growing conditions (Novus, 1996). According to Jākobsone et al. (2015), the concentration of Cu in barley grains range from 1.71 to 5.9 mg/kg. Similar values for Cu concentrations were obtained in our study realized in Strumica locality, but the results for this element in study done in Ovche Pole locality were lower. On the other hand, higher values for Zn concentration were reported in Jākobsone et al. (2015) study (from 16 to 53 mg/kg), compared with results received in our research. According to Jākobsone et al. (2015) barley had the widest range of Fe concentration (from 25 to 66 mg/kg) with mean value 37.8 mg/kg and the lowest in rye (from 25 to 45 mg/kg). Those minimal and maximal values for iron concentrations in barley were higher compare with results obtained in our experiment (from 12.3 to 18.2 mg/kg in Ovche Pole locality and from 17.1 to 28.0 mg/kg in Strumica locality, respectively). Jākobsone et al. (2015) had reported also higher concentrations for Na, Mg and Ca in barley grains compare with the mean values obtained in our research. Sager and Hoesch (2015) determined Ca, Fe, Cu, S and P concentrations in wheat, rye, barley and maize in Austria. Fe concentration in barley was in range from 31.1 to 54.1 mg/kg which are significantly differing to the range of those elements obtained in Macedonia. In Poland, Cioùek et al. (2012) determined the concentration of K, Ca, Mg, Cu, Mn, Fe and Zn in wheat, oats and barley. The results from their study for all examined elements significantly differ from ours, because they had reported higher values for macro and micro elements in barley grains. These differences might be due to variety, growing area, type of soil, climate, used fertilizer and agricultural practice. According to Kashain and Fathivand (2015), most important elements for barley are Fe, Ca, Cu and Zn.

Linear correlation showed that there was no significant correlation between content of macro and micro elements and grain yield, in both locations (Table 4 and 5). In Ovche Pole locality, were found more positive and significant correlations between content of macro and micro elements, compare to the same relationships in Strumica locality. The highest positive and significant correlation was determined between content of P and Mg ($r = 0.807$). Also, manganese concentration was in positive correlation with content of Fe ($r = 0.566$), Cu ($r = 0.680$) and Zn ($r = 0.655$), at level of significance 0.01. Positive and significant relation was found between content of Na and Ca ($r = 0.444$) and Na and content of Fe ($r = 0.465$), at level of significance 0.05. The concentration of P showed positive and significant relation with content of Ca ($r = 0.488$), Fe ($r = 0.574$), Zn ($r = 0.517$) and content of Cu ($r = 0.605$). Jaskulski et al. (2011) reported not significant relationship between content of Ca and P. Significant and positive correlation was obtained between content of Cu and Zn ($r = 0.684$), at level of significance 0.01.

In Strumica locality, the concentration of P was in positive and

Table 4. Linear correlation between macro and micro elements content and grain yield in genotypes grown in Ovche Pole locality

Properties	Mg	P	Ca	Fe	Cu	Zn	Grain yield
Na	0.225	0.323	0.444*	0.465*	-0.005	0.073	-0.255
Mg	1	0.807**	0.339	0.566**	0.680**	0.655**	0.061
P		1	0.488*	0.574**	0.605**	0.517*	-0.123
Ca			1	0.163	0.275	0.116	-0.157
Fe				1	0.208	0.398	-0.105
Cu					1	0.684**	0.356
Zn						1	0.091

*,** Level of significance p<0.05, p<0.01

Table 5. Linear correlation between macro and micro elements content and grain yield in genotypes grown in Strumica locality

Properties	Mg	P	Ca	Fe	Cu	Zn	Grain yield
Na	0.138	-0.070	0.233	0.182	0.357	0.255	-0.058
Mg	1	0.208	-0.100	0.366	0.152	0.354	-0.105
P		1	0.137	0.765**	0.147	0.529*	-0.279
Ca			1	-0.030	0.398	0.466*	-0.151
Fe				1	0.154	0.530*	-0.079
Cu					1	0.507*	0.178
Zn						1	0.130

*,** Level of significance p<0.05, p<0.01

Table 6. Principal component analysis of the analyzed properties

Component number	Ovche Pole locality			Strumica locality		
	Eigenvalue	Percent of variance	Cumulative percentage	Eigenvalue	Percent of variance	Cumulative percentage
PC1	3.60	45.06	45.06	2.77	34.65	34.65
PC2	1.70	21.22	66.28	1.59	19.92	54.58
PC3				1.15	14.41	68.98

Table 7. Weights of analyzed properties to main components of barley genotypes grown in Ovche Pole and Strumica locations

Properties	Ovche Pole locality		Strumica locality		
	PC1	PC2	PC1	PC2	PC3
Na	0.22	0.53	0.23	0.36	-0.06
Mg	0.48	-0.10	0.29	-0.22	0.30
P	0.47	0.08	0.44	-0.41	-0.15
Ca	0.27	0.32	0.26	0.44	-0.51
Fe	0.35	0.22	0.46	-0.37	0.15
Cu	0.39	-0.40	0.35	0.46	0.13
Zn	0.39	-0.27	0.52	0.13	0.12
Grain yield	0.01	-0.56	-0.06	0.30	0.76

significant correlation with content of Fe (r = 0.765) and content of Zn (r = 0.529). On the other hand, the content of Zn was in positive and significant correlation with content of Ca (r = 0.466), Fe (r = 0.530) and content of Cu (r = 0.507) at level of significance 0.05. Those correlations are typical because those elements activate some enzymes that control plant growth.

In some cases, when the data set contains a large number of variables, it may prove useful to reduce the data set into smaller segments to provide clearer results. Principal component analysis (PCA) is an ideal statistical tool for such tasks. Table 6 contains the results from performed PCA analysis for macro and micro elements content and grain yield. For genotypes grown in Ovche Pole locality, two main components with eigenvalue higher that 1 were obtained. The first principal component covers as much of the variation in the data as possible (45.06%). The second principal component is orthogonal to the first and covers as much of the remaining variation as possible (21.22%). The cumulative percentage for both components in total variation was 66.28%. In Strumica locality, using multivariate data processing for micro and macro elements, three main principal components (PC1, PC2 and PC3) were assumed with a total variation of 68.98%.

In study conducted in Ovche Pole locality two groups were shown using PCA analysis. Responsible for these groups, by PC1 were concentrations of Mg and P, followed by content of Cu, Zn and Na concentration respectively for the second main component (Table 7). In research realized in Strumica locality, the first main component showed highly and positive connections with content of Zn, Fe and P. Second PC component was extracted by concentration of Cu, Ca and Na. Only third PC component showed positive and significant correlation with grain yield (Table 7).

Conclusion

The experimental soil samples taken from Ovche Pole locality were richer with Mn, Zn, Fe, Ca and P, compare with the soil samples from Strumica locality. During the period of study, for all barley genotypes, the mean values for concentration of all examined elements were higher in Strumica locality, compare to Ovche Pole, which means that concentrations of macro and micro elements in barley genotypes depends from type of soil (location) and climate conditions. In both locations, for all examined properties were found significant difference between analyzed genotypes. In Ovche Pole locality, the genotype *Line 2* was the richer with macro and micro elements, while in Strumica locality the genotypes *Izvor* and *NS 565 2R*. In both locations, was not found significant correlation between content of macro and micro elements and grain yield. Using PCA analysis, two main components were obtained for the study conducted in Ovche Pole and three PC components in Strumica locality. In study realized in Ovche Pole locality, the first main component had a major influence of Mg element, followed to a lesser extent by the elements P, Cu and Zn. In Strumica locality, the major contributors for PC1 had concentrations of Zn, Fe and P, for PC2 were Cu, Ca and Na, while the major contributor for PC3 had grain yield. The results from this study indicate that the investigated barley genotypes in both locations are poor with macro and micro elements.

References

Babaeian M, Tavassli A, Essmaeilian Y and Javaheri M, 2012. Effects of Fe, Zn, Mg and manure on seed germination character of barley (*Hordeum vulgare* L.). African Journal of Microbiology Research, 6, 7302-7305.

Bacha MA, Sabbah AM and Hamady MA, 1997. Effect of foliar application of iron, zinc and manganese on yield, berry quality and leaf mineral composition of Thompson seedless and roomy red grape cultivars. Journal of King Saud University, Agriculture Science, 9, 127-140.

Bálint AF, Kovacs G and Erdei LJ, 2001. Comparison of the Cu, Zn, Fe, Ca and Mg contents of the grains of wild, ancient and cultivated wheat species. Cereal Researches Communications, 29, 375-382.

Biel W and Jacyno E, 2013. Chemical composition and nutritive value of spring hulled barley varieties. Bulgarian Journal of Agriculture Science, 19, 721-727.

Borlaug NE and Dowswell CR, 1994. Feeding a human population that increasingly crowds a fragile planet. Paper presented at the 5th World Congress of Soil Science, 10-16 July 1994, Acapulco, Mexico.

Cekstere G and Osvalde A, 2013. A study of chemical characteristics of soil in relation to street trees status in Riga (Latvia). Urban Forestry Urban Greening, 12, 69-78.

Charalampopulos D, Wang R, Pandiella SS and Webb C, 2002. Application of cereals and cereal components in functional foods: a review. International Journal for Food Microbiology, 79, 131-141.

Cioùek A, Makarska E, Wesoùowski M and Cierpiaùa R, 2012. Content of selected nutrients in wheat, barley and oat grains from organic and conventional farming. Journal of Elementology, 2, 181-189.

Comai S, Bertazzo A, Bailoni L, Zancato M, Costa CVL and Allegri G, 2007. Non-protein (free and protein-bound) tryptophan content in cereal and legume seed flours. International Congress Series, 1304, 227-232.

Dimiņš F, 2006. Assessment parameters of honey quality. Thesis for DSc, Latvia.

Duffus CM and Cochrane MP, 1993. "Formation of the barley grain - Morphology, physiology and biochemistry", in A.W. MacGregor and R.S. Bhatty (eds.), Barley: Chemistry and technology, AACC, St. Paul, Minnesota, USA, 31-72.

Filipovski G, Rizovski R and Ristevski P, 1996. Characteristics of climate-soil vegetation zones (regions) in the Republic of Macedonia. Macedonian Academy of Sciences and Arts, Skopje, 177 (in Macedonian).

Gallegos-Infante JA, Rocha-Guzman HE, Gonzalez-Laredo RF and Pulido-Alonso J, 2010. Effect of processing on the antioxidant properties of extracts from Mexican barley (*Hordeum vulgare* L.) cultivar. Food Chemistry, 119, 903-906.

Gilucis A, 2007. Relevancies of content and distribution of trace and major elements in the Latvian topsoils. Thesis for DSc, Latvia.

Hattori H and Chino M, 2001. Growth, cadmium, and zinc contents of wheat grown on various soils enriched with cadmium and zinc. Developments in Plant and Soil Science, 92, 462-463.

Izydorczyk MS, Storsley J, Labossiere D, MacGregor AW and Rossnagel BG, 2000. Variation in total and soluble β-glucan content in hulless barley: effects of thermal, physical and enzymic treatments. Journal of Agricultural and Food Chemistry, 48, 982-989.

Jākobsone I, Kantâne I, Zute S, Jansone I and Bartkeviès V, 2015. Macro-elements and trace elements in cereal grains cultived in Latvia. Proceeding of the Latvian Academy of Science, Section B, 69, 152-157.

Jaskulski D, Jaskulska I, Woźniak M and Osiński G, 2011. Assessment of variability of cereal grain quality as a component of fodder mixtures. Acta Scientiarum Polonorum Agricultura, 10, 87-95.

JMP 5.0.1a, 2002. Version 5.0 1a, A Business Unit of SAS 1989 - 2002 SAS Institute Inc.

Kan A, 2015. Characterizaton of the fatty acid and mineral composition of selected cereal cultivars from Turkey. Records of Natural Products Journal, 9, 124-134.

Kanbar A, 2011. Discriminating between barley (*H. vulgare* L.) genotypes using morphological and ISSR Markers. American Eurasian Journal of Sustainable Agriculture, 5, 318-324.

Kashian S and Fathivand AA, 2015. Estimated daily intake of Fe, Cu, Ca and Zn through common cereals in Tehran. Iran Food and Chemistry, 176,193-196.

Klavins M and Vircavs M, 2001. Metals in sediments of inland waters of Latvia. Boreal Environment Research, 6, 297-306.

Kowieska A, Lubowicki P and Jaskowska I, 2011. Chemical composition and nutritional characteristics of several cereal grain. Acta Scientiarum Polonorum Zootechnica, 10, 37-50.

Marconi E, Graziano M and Cubadda R, 2000. Composition and utilization of barley pearling by-products for making functional pastas rich in dietary fibre and β-glucans. Cereal Chemistry, 77, 133-139.

McKevith B, 2004. Nutritional aspects of cereals. Nutrition. Bulletin, 29, 111-142.

Mohammadi SA and Prasanna BM, 2003. Analysis of genetic diversity in crop plants-salient statistical tools and considerations. Crop Science, 43, 1235-1248.

Murniece I, Karklina D, Galoburda R, Santare D, Skrabule I and Costa HS, 2011. Nutritional composition of freshly harvested and stored Latvian potato (*Solanum tuberosum* L.) varieties depending on traditional cooking methods. Journal of Food Composition and Analysis, 24, 699-710.

Nardi S, Calcagno C, Zunin P, D'Egidio MG, Cecchini C, Boggia R and Evangelisti F, 2003. Nutritional benefits of developing cereals for functional foods. Cereal Research Communications, 31, 445-452.

Nikodemus O, Brumelis G, Tabors G, Lapina L and Pope S, 2004. Monitoring of air pollution in Latvia between 1990 and using moss. Journal of Atmospheric Chemistry, 49, 521-531.

Novus Inetrnational, 1996. Raw Material Compendium (2nd Edition). Novus Europe.

Osvalde A and Karlsons A, 2010. Evaluation of the nutrient status of American cranberry in Latvia during 2001–2007. Acta Horticulture, 868, 213-218.

Parker DR, Aguileram JJ and Thomason DN, 1992. Zinc-phosphorus interactions in two cultivars of tomato (*Lycipersicon esculentum* L.) grown in chelator-buffered nutrient solutions. Plant Soil, 143, 163-177.

Pietola L and Salo T, 2000. Response of P, K, Mg and NO3-N contents of carrots to irrigation, soil compaction, and nitrogen fertilization. Agricultural and Food Science, Finland, 9, 319-331.

Quinde Z, Ullrich SE and Baik BK, 2004. Genotypic variation in color and discolouration potential of barley-based food products. Cereal Chemistry, 81, 752-758.

Ragaee S, Abdel-Aal El-Sayed M and Noaman M, 2006. Antioxidant activity and nutrient composition of selected cereals for food use. Food Chemistry, 98, 32-38.

Rao MI, Zeigler RS, Vera R and Sarkarung S, 1993. Selection and breeding for acid soil tolerance in crop. Biological Science, 43, 454-465.

Sager M and Hoesch J, 2005. Macro - and micro element levels in cereals grown in lower Austria. Journal of Central European Agriculture, 6, 461-472.

Samac A and Tesfaye M, 2003. Plant improvement for tolerance to aluminum in acid soils – a review. Plant Cell Tissue and Organ Culture, 75, 189-207.

Shar GQ, Kazi TG, Jatoi WB, Makhija PM, Sahito SB, Shar AH, Fateh M and Soomro FM, 2013. Determination of heavy metals in eight barley cultivars collected from wheat research station Tandojam, Sindh, Pakistan. Pakistan Journal of Analytical and Environmental Chemistry, 14, 47-53.

Shewry PR, 2007. Improving the protein content and composition of cereal grain. Journal of Cereal Science, 46, 239-250.

Sidhu JS, Kabir Y and Hoffman FG, 2007. Functional foods from cereal grain. International Journal for Food Properties, 10, 231-244.

Singh RK and Chaudhary BD, 1985. Biometrical Methods in Quantitative Genetics Analysis. Kalyani Publishers, New Delhi, 318.

Sposito G, 2008. The chemistry of soils. (2nded), Oxford University press, New York, USA.

SPSS Statistics 19, 2010. SPSS Inc., an IBM Company.

Stapkevica M, Vincevica-Gaile Z and Klavins M, 2013. Metal uptake from contaminated soils by some plant species—radish, lettuce, dill. Research for Rural Development, 1, 43-49.

Tabors G, Brumelis G, Lapina L, Pospelova G and Nikodemus O, 2004. Changes in element concentrations in moss segments after cross-transplanting between a polluted and non-polluted site. Journal of Atmospheric Chemistry, 49, 191-197.

Vincevica-Gaile Z, 2014. Impact of environmental conditions on micro and macro element content in selected food from Latvia. Doctoral thesis, Latvia, 179.

Vincevica-Gaile Z, Klavins M, Rudovica V and Viksna A, 2011. Geographical dissemination of trace and major elements in honey. In: Brebbia, C. A. (ed.). *Sustainability Today.* WIT Press, Southampton, pp. 211-220.

Welch RM, Allaway WH, House WA and Kubota J, 1991. Geographic distribution of trace element problems. In: Mortvedt JJ, ed. Micronutrients in Agriculture, 2, 31-57.

White PJ and Broadley MR, 2009. Biofortification of crops with seven mineral elements often lacking in human diets – iron, zinc, copper, calcium, magnesium, selenium and iodine. New Phytologist, 182, 49-84.

Zaefizadeh M, Ghasemi M, Azimi J, Khayatnezhad M and Ahadzadeh B, 2011. Correlation analysis and path analysis for yield and its components in hulless barley. Advances in Environmental Biology, 5, 123-126.

CONTENTS

CONTENTS

Instruction for authors

Preparation of papers

Papers shall be submitted at the editorial office typed on standard typing pages (A4, 30 lines per page, 62 characters per line). The editors recommend up to 15 pages for full research paper (including abstract references, tables, figures and other appendices)

The manuscript should be structured as follows: Title, Names of authors and affiliation address, Abstract, List of keywords, Introduction, Material and methods,Results, Discussion, Conclusion, Acknowledgements (if any), References, Tables, Figures.

The title needs to be as concise and informative about the nature of research. It should be written with small letter /bold, 14/ without any abbreviations.

Names and affiliation of authors The names of the authors should be presented from the initials of first names followed by the family names. The complete address and name of the institution should be stated next. The affiliation of authors are designated by different signs. For the author who is going to be corresponding by the editorial board and readers, an E-mail address and telephone number should be presented as footnote on the first page. Corresponding author is indicated with *.

Abstract should be not more than 350 words. It should be clearly stated what new findings have been made in the course of research. Abbreviations and references to authors are inadmissible in the summary. It should be understandable without having read the paper and should be in one paragraph.

Keywords: Up to maximum of 5 keywords should be selected not repeating the title but giving the essence of study.

The introduction must answer the following questions: What is known and what is new on the studied issue? What necessitated the research problem, described in the paper? What is your hypothesis and goal ?

Material and methods: The objects of research, organization of experiments, chemical analyses, statistical and other methods and conditions applied for the experiments should be described in detail. A criterion of sufficient information is to be possible for others to repeat the experiment in order to verify results.

Results are presented in understandable tables and figures, accompanied by the statistical parameters needed for the evaluation. Data from tables and figures should not be repeated in the text.

Tables should be as simple and as few as possible. Each table should have its own explanatory title and to be typed on a separate page. They should be outside the main body of the text and an indication should be given where it should be inserted.

Figures should be sharp with good contrast and rendition. Graphic materials should be preferred. Photographs to be appropriate for printing. Illustrations are supplied in colour as an exception after special agreement with the editorial board and possible payment of extra costs. The figures are to be each in a single file and their location should be given within the text.

Discussion: The objective of this section is to indicate the scientific significance of the study. By comparing the results and conclusions of other scientists the contribution of the study for expanding or modifying existing knowledge is pointed out clearly and convincingly to the reader.

Conclusion: The most important consequences for the science and practice resulting from the conducted research should be summarized in a few sentences. The conclusions shouldn't be numbered and no new paragraphs be used. Contributions are the core of conclusions.

References:

In the text, references should be cited as follows: single author: Sandberg (2002); two authors: Andersson and Georges (2004); more than two authors: Andersson et al.(2003). When several references are cited simultaneously, they should be ranked by chronological order e.g.: (Sandberg, 2002; Andersson et al., 2003; Andersson and Georges, 2004).

References are arranged alphabetically by the name of the first author. If an author is cited more than once, first his individual publications are given ranked by year, then come publications with one co-author, two co-authors, etc. The names of authors, article and journal titles in the Cyrillic or alphabet different from Latin, should be transliterated into Latin and article titles should be translated into English. The original language of articles and books translated into English is indicated in parenthesis after the bibliographic reference (Bulgarian = Bg, Russian = Ru, Serbian = Sr, if in the Cyrillic, Mongolian = Mo, Greek = Gr, Georgian = Geor., Japanese = Ja, Chinese = Ch, Arabic = Ar, etc.)

The following order in the reference list is recommended:

Journal articles: Author(s) surname and initials, year. Title. Full title of the journal, volume, pages. Example:

Simm G, Lewis RM, Grundy B and Dingwall WS, 2002. Responses to selection for lean growth in sheep. Animal Science, 74, 39-50

Books: Author(s) surname and initials, year. Title. Edition, name of publisher, place of publication. Example:

Oldenbroek JK, 1999. Genebanks and the conservation of farm animal genetic resources, Second edition. DLO Institute for Animal Science and Health, Netherlands.

Book chapter or conference proceedings: Author(s) surname and initials, year. Title. In: Title of the book or of the proceedings followed by the editor(s), volume, pages. Name of publisher, place of publication. Example:

Mauff G, Pulverer G, Operkuch W, Hummel K and Hidden C, 1995. C3-variants and diverse phenotypes of unconverted and converted C3. In: Provides of the Biological Fluids (ed. H. Peters), vol. 22, 143-165, Pergamon Press. Oxford, UK.

Todorov N and Mitev J, 1995. Effect of level of feeding during dry period, and body condition score on reproductive performance in dairy cows,IXth International Conference on Production Diseases in Farm Animals, September 11–14, Berlin, Germany.

Thesis:

Hristova D, 2013. Investigation on genetic diversity in local sheep breeds using DNA markers. Thesis for PhD, Trakia University, Stara Zagora, Bulgaria, (Bg).

The Editorial Board of the Journal is not responsible for incorrect quotes of reference sources and the relevant violations of copyrights.

Animal welfare

Studies performed on experimental animals should be carried out according to internationally recognized guidelines for animal welfare. That should be clearly described in the respective section “Material and methods”.

AGRICULTURAL
SCIENCE AND TECHNOLOGY

Volume 8, Number 1
March 2016

Journal web site:
www.agriscitech.eu

Publisher:
www.alfamarket.biz