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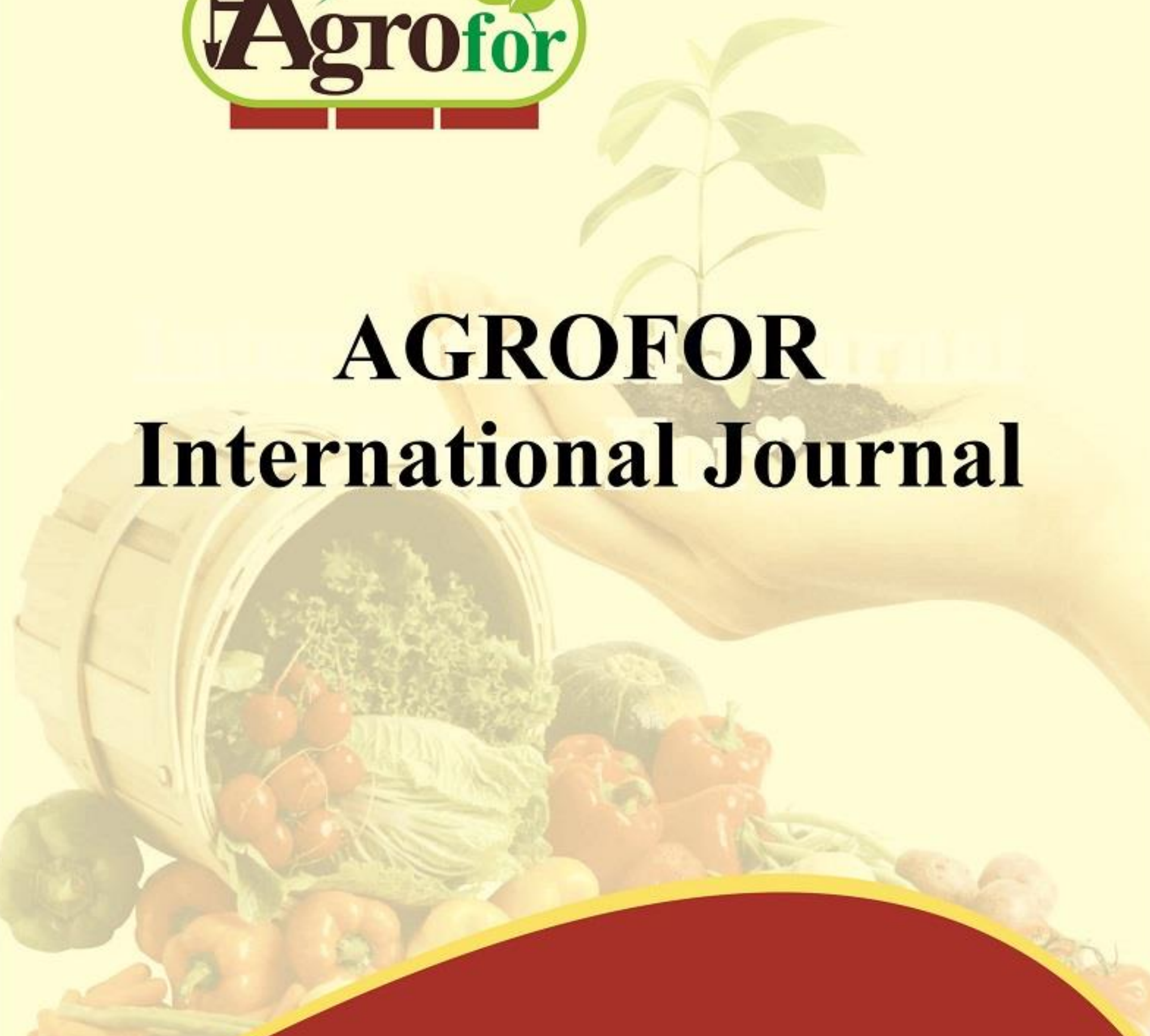

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SPECTROSCOPIC CHARACTERIZATION OF HUMIC SUBSTANCES OF ANTHROPOGENIC SOILS DERIVED FROM TERRA ROSSA

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ABSTRACT

The aim of the study was spectroscopic characterization of humic substances and evaluation of humus quality of anthropogenic soils derived from Terra Rossa. The study was conducted on 15 soil samples collected from top-soil horizon of olive groves in Middle Dalmatia (Croatia). Total organic carbon was determined according to Walkley-Black method (1934) and humic substances isolation following procedure given by Schnitzer (1982). Spectroscopic characterization of isolated humic substances was carried out by measuring absorbance in VIS spectral range 400-700 nm and optical indices ($Q_{4/6}$, $E_{4/6}$) were calculated. SOC content in top-soil samples varied from 1.45% to 4.21% with mean value of 2.98%. The absorption spectrum showed monotonous decrease of absorbance from 400 to 700 nm for all samples. The optical indices $E_{4/6}$ and $Q_{4/6}$ varied from 3.58 to 5.05 and from 3.91 to 5.04, respectively and indicated differences of humus quality. The optical index below 4, which implies a high quality of humus, was determined in six samples. The low humus quality (optical index above 4) was determined in other nine samples. The SOC content has significant positive correlation with optical indices $Q_{4/6}$ and $E_{4/6}$. Soils with higher organic carbon content have lower humus quality.

Key words: *VIS spectrum, $E_{4/6}$, humus quality, Dalmatia.*

INTRODUCTION

Humus defines key soil characteristics, its fertility and it is an indicator of the processes occurring in soil. Therefore, understanding of its content and quality is important for the sustainable land management, especially in Mediterranean karst region. Humic substances (HS) constitute a major fraction (60–70%) of soil organic matter and those are possibly the most abundant of naturally occurring organic macromolecules on the Earth (2–3 x 10^{10} t), (Jones and Bryan, 1998). Humic substances differ in molecular weight, elemental composition, acidity and cation exchange capacity and can be classified into three major groups according to their solubility; humic acid, fulvic acid and humins. The humic acids fraction

consists of hydroxyphenols, hydroxybenzoic acids and other aromatic structures with linked peptides, amino compounds and fatty acids. Fulvic acids are typically composed of a variety of phenolic and benzene carboxylic acids that are held together by hydrogen bonds to form stabile polymer structures. The low molecular weight of fulvic acid has higher oxygen but lower carbon content than humic acid. There are also more acidic functional groups particularly -COOH in fulvic acid molecule (Schnitzer and Khan, 1978).
Non-destructive spectroscopic methods ensure valuable informations on molecular structure, chemical and functional properties of humic substances (Chen et al, 1977). Therefore, new approaches of spectrometry that include a wide variety of techniques (UV–VIS, DRIFT, SFS, and ^{13}C-NMR) have been successfully applied to the study of HS chemical composition and structure (Pospišilova et al, 2008; Milori et al., 2002; Sierra et al., 2005). Humic substances generally show strong absorbance in the UV–VIS range (from 190 to 700 nm) because of the presence of aromatic chromophores and other organic compounds (Rupiasih and Vidyasagar, 2007). Stevenson (1982) has shown that absorption of humic substances on wave length of 465 nm is equal to absorption of light form components linked to initial phases of humification (young humic substances – fulvo acid) and absortion of light on wave lengt of 665 nm refers to well humified components - humic acid. Optical index $E_{4/6}$ calculated as ratio of optical absorbance at 465 nm versus 665 nm for humic substances in solution is often used for evaluation of humus quality. Generally, lower molecular weight and lower degree of condensation of aromatic structures in humic substances show higher values of $E_{4/6}$ than humic substances with a high degree of humification (Orlov, 1985).
The objective of the study was spectroscopic characterization of humic substances and evaluation of humus quality of anthropogenic soils derived from Terra Rossa.

MATERIAL AND METHODS

The study was conducted on 15 soil samples collected in three olive groves area in Middle Dalmatia (Croatia) including: the island of Brač (43°22'00" N, 16°38'27" E), Marina (43°31'40" N, 16°09'31" E) and Primošten (43°34'47" N, 15°56'38" E). Within each selected area five average soil samples from the depth 0-25cm were collected. Investigated soils are anthropogenic soils derived from Terra rossa, shallow, skeletic on limestones and dolomites (Škorić et al., 1975). According to IUSS Working Group (WRB, 2014) studied soils can be identified as Chromic Leptic Skeletic Cambisol (Clayic Colluvic). Soil samples were prepared for analysis of physical and chemical properties according to HRN ISO 11464:2009. Soil pH was determined according to HRN ISO 10390:2005, soil organic carbon was determined according to Walkley-Black method (1934), available phosphorus and potassium were determined according to Egner et al. (1960) and particle size distribution was made by HRN ISO 11277:2009.
The isolation of soil humic substances (HS) was made by Schnitzer method (1982). 5 g of air dried soil sample was sieved at the mesh size of 1 mm and extracted with solution of 0.1 M NaOH + 0.1 M $Na_4P_2O_7$. The mixture was shaken mechanically

for 24 h at room temperature. The supernatant solution was then separated from the residue by centrifugation at 4000 rpm for 20 min. The alkaline extract was acidified with concentrated H_2SO_4 to pH~1, allowed to stand for 24 h at room temperature to obtain the complete precipitation of humic acid (HA). The precipitated HA was separated from fulvic acid (FA) by repeating three times the following: centrifugation at 4000 rpm for 20 min, removal of the residue, washing the HA with 0.05 M H_2SO_4 solution. Finally, the centrifuged HA were dissolved in a minimal volume of 0.1 M NaOH and brought to dryness in a drying oven at 60°C. VIS spectra were measured by Shimadzu UV 1700 spectrometer in the range of 400-700 nm. Optical indices $E_{4/6}$ and $Q_{4/6}$ were determined as the absorbance ratio $A_{465}/_{665}$ and $A_{400}/_{600}$, respectively (Orlov, 1985; Szajdak et al., 2006).

RESULTS AND DISCUSSION

Descriptive statistics for basic soil properties given in Table 1. shows that investigated soils are weakly acid to neutral, non-calcareous to slightly calcareous and variably supplied with physiologically active nutrients. Soil supply with P_2O_5 varies from low to moderate, showing very high coefficient of variation (CV). Investigated soils are moderate to high supplied with K_2O and showing lower coefficient of variation. Soil organic carbon content varies from low to medium, in average medium (Table 1). These data are consistent with research of Miloš and Bensa (2012) which determined similar values of SOC content in anthropogenic soils derived from Terra Rossa (0.17-3.73%) in Dalmatia. Although, only less than a quarter (24.6%) of southern European top-soils contain medium to high (>2%) amounts of SOC (Zdruli et al, 2004). Higher level of SOC content in our research, compared to averages in European soils, can be related to land management and particularities of soils formed on the limestones and dolomites in Mediterranean region (high stoniness and rockiness and variable soil depth). Investigated soils are dominantly silty clay and silty clayey loam.

Table 1. Descriptive statistics for basic soil properties

Soil property	Mean	Median	Min.	Max.	Range	Std. dev.	#CV(%)
pH H_2O	7.62	7.65	6.53	8.02	1.49	0.40	5.25
pH KCl	6.67	6.87	5.36	7.18	1.82	0.51	7.63
$CaCO_3$ (%)	3.02	2.57	0.00	7.90	7.90	2.19	72.66
P_2O_5 mg/100 g	4.37	2.50	0,05	14.13	14.08	4.49	102.71
K_2O mg/100 g	35.89	34.20	18.00	69.38	51.38	12.01	33.46
SOC %	2.98	3.24	1.46	4.23	2.77	0.96	32.3
Coarse sand (%)	22.89	23.60	15.30	28.00	12.70	3.73	16.31
Fine sand (%)	6.64	7.00	0.30	15.10	14.80	4.48	67.42
Silt (%)	27.38	29.60	13.70	37.00	23.30	6.58	24.03
Clay (%)	43.09	43.00	31.00	61.80	30.80	9.04	20.99

#CV (%), coefficient of variation

The absorption spectrumes of humic substances (HS) extracted from the studied soils show monotonous decrease of absorbance in the range 400-700 nm, Figure 1. The steeper declines of curves imply domination of aromatic structures over apliphatics in humic substances (Pospišilova and Fasurova 2009; Fasurova and Pospišilova 2011; Milori et al. 2002). The steepest declines of curves were established in the VIS spectra of humic substances extracted from soils with the lowest SOC content. That means, soils with lower SOC content have more condensed aromatic structures than aliphatics in humic substances and higher humus quality.

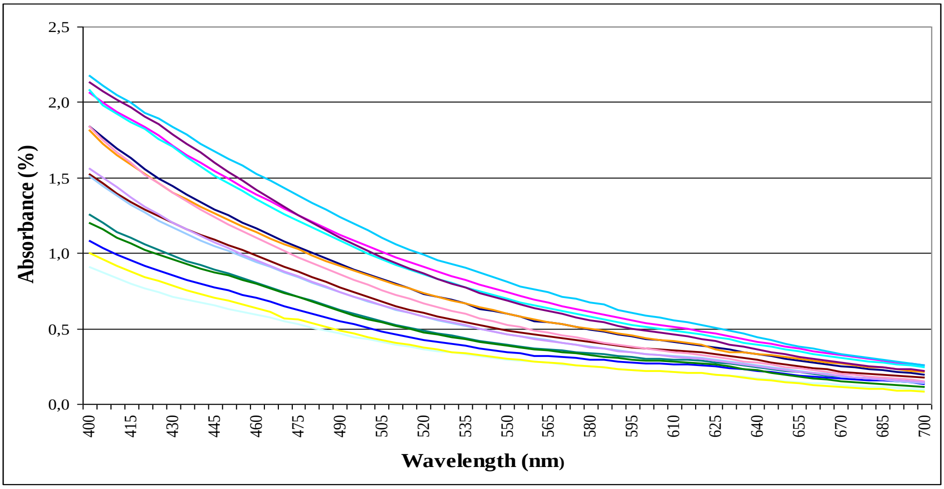

Figure 1. VIS spectra of extracted soil humic substances (HS) from top-soil horizon of investigated soils

Therefore the ratio between the absorbance at 465 nm and 665 nm ($E_{4/6}$) and 400 and 600 nm ($Q_{4/6}$) are frequently used to characterize composition of organic matter and evaluation of its humification degreee. The $E_{4/6}$ ratio decreases when the condensation and aromaticity of the humic substances rise and with increasing molecular weight (Stevenson, 1994; Fuentes et al., 2006), which is typical for more mature, more evolved organic materials, and is therefore useful as a humification indicator. The mean values of optical indices $E_{4/6}$ and $Q_{4/6}$ of humic substances isolated from investigated soils were 4.22 and 4.42 respectively, Table 2. The optical indices are characterized with short range and small coefficients of variation (CV %). These indices have lower coefficient of variation than SOC (Table 1), implying higher heterogenity of humus quantity than quality (Table 2).

Table 2. Descriptive statistics for optical indices

Optical index	Mean	Min.	Max.	Range	St. dev.	#CV(%)
$E_{4/6}$	4.22	3.58	5.05	1.47	0.50	11.74
$Q_{4/6}$	4.42	3.91	5.04	1.13	0.33	7.41

#CV (%), coefficient of variation

Generally, optical indices values above 4 indicate presence of more aliphatic and fewer aromatic compounds and lower humus quality. From a total of 15 samples, 6 have optical index below 4, which implies a high quality of humus. The other nine samples have optical index above 4 and low humus quality. The low humus quality were determined in soil samples with SOC content above 2%. These results shows that in anthropogenic soils developed from Terra Rossa under olive groves dominated low humus quality. This probably relates with specific soil management (addition organic matter), leading to increase of SOC content and higher proportion of aliphatic compounds in humic substances (higher E_4/E_6 ratio - lower humus quality).

These results are consistent with investigation (Čolak and Martinović, 1975.) which have found similar values of optical index of humic substances ($E_{4/6}$ 3.78-5.02) isolated from top-soil of Terra Rossa in Middle Dalmatia. Senesi et al (1999) also established high values of $E_{4/6}$ (4.6-4.9) in Terra rossa under olive groves in Mediterranean region.

Relations between SOC content and optical indices $Q_{4/6}$ and $E_{4/6}$ were fitted with linear type of equation: SOC % = -3.3522 – 0.5995*x + 2.1249*y, Figure 2.

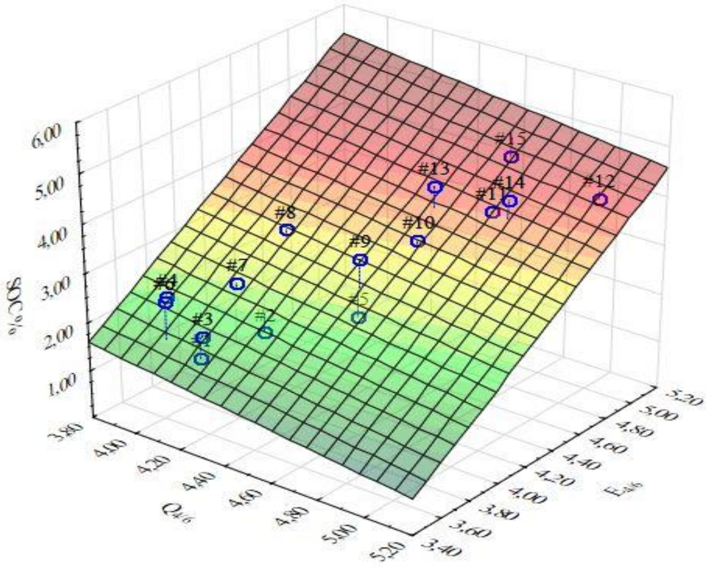

Figure 2. 3D surface plot of SOC against optical indices $Q_{4/6}$ and $E_{4/6}$

The 3D surface plot of SOC against optical indices $Q_{4/6}$ and $E_{4/6}$ (Figure 2) shows that increase of SOC content increases the value of the indices $Q_{4/6}$ and $E_{4/6.}$ The strength of these relations established with linear correlation shows that SOC content and the optical indices ($Q_{4/6}$ and $E_{4/6}$) are significantly positively correlated, Table 3. The optical index $E_{4/6}$ better correlates with SOC content than $Q_{4/6}$ due to possible inaccuaries in measurements when values of absorbance are up to 2 % (around 400 nm).

Table 3. Correlations of SOC content and optical indices $E_{4/6}$ and $Q_{4/6}$

	SOC %	$Q_{4/6}$	$E_{4/6}$
SOC %	1.00	0.76*	0.92*
$Q_{4/6}$		1.00	0.88*
$E_{4/6}$			1.00

* Marked correlations are significant at p <0,050

CONCLUSION

Our research showed domination of low humus quality in top-soil horizon of anthropogenic soils developed from Terra Rossa under olive groves in Middle Dalmatia, Croatia. The humus quality indicators (optical indices $Q_{4/6}$ and $E_{4/6}$) significantly correlate with SOC content. The soils with higher SOC content have lower humus quality.

REFERENCES

Chen Y., Senesi N., Schnitzer M. (1977). Information Provided on Humic Substances by E4/E6 Ratios. SSSAJ 41 (2): 352-358.

Čolak A., Martinović J. (1975). Basic Soil Map of Croatia at 1:50 000, map sheet Šibenik 1. Project Council for the Soil Map of the Republic of Croatia, Zagreb.

Egner H., Riehm H., Domingo W.R. (1960): Studies concerning the chemical analysis of soils as background for soil nutrient assessment. II. Chemical extracting methods to determinate the phosphorous and potassium content of soil. Kungliga Lant-u brukshögskolans annaler, 26: 199–215.

Fasurova N., Pospišilova L. (2011). Spectroscopic Characteristics of Humates Isolated from Different Soils. Soil & Water Res. 6 (3): 147–152.

Fuentes, M., González-Gaitano, G., García-Mina, J.M. (2006) The usefulness of UV-visible and fluorescence spectroscopies to study the chemical nature of humic substances from soils and composts. Org. Geochem. 37, 1949-1959.

HRN ISO 11464:2009. Soil quality - Pre-treatment of samples for physical-chemical analysis. International standard. Zagreb Croatia: Croatian Standards Institute

HRN ISO 10390:2005. Soil quality - Determination of pH. International standard Zagreb Croatia: Croatian Standards Institute

HRN ISO 11277:2009. Soil quality – Determination of particle size distribution (mechanical composition) in mineral soil – Method by sieving and sedimentation. International standard. Zagreb Croatia: Croatian Standards Institute

IUSS Working Group WRB (2014). World reference base for soil resources 2014 - International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106, FAO, Rome

Jones M.N., Bryan N.D. (1998) Colloidal properties of humic substances. Adv. Colloid. Interface Sci. 78: 1-48.

Milori D.M.B.P., Martin-Neto L., Bayer C., Mielniczuk J., Bagnato V.S. (2002). Humification degree of soil humic acid determined by fluorescence spectroscopy. Soil Science, 167: 739–749.

Miloš B., Bensa A. (2012) Soil humus analysis by the refectance spectroscopy, Proceedings of 47. Croatian and 7. International Symposium of Agronomy, 13.-17. February 2012., Opatija,

Orlov D.S. (1985). Soils Chemistry. Moscow State University, Moscow

Pospišilova L., Fasurova N., Barančikova G., Liptaj T. (2008). Spectral characteristics of humic acids isolated from south Moravian lignite and soils. Petroleum & Coal 50/2: 30-36.

Pospišilova L., Fasurova N. (2009). Spectroscopic Characteristics of Humic Acids Originated in Soils and Lignite. Soil & Water Res. 4 (4): 168–175.

Rupiasih N.N., Vidyasagar P.B. (2007). Humic Substances: structure, function, effects and applications. International Journal of Environment and Pollution. 5(2):39-47.

Schnitzer M. (1982). Organic matter characterization. In: Methods of Soil Analysis Part 2 - Chemical and Microbiological Properties (Weaver R.W., Angle J.S., Bottomley P.S.), Madison, USA, No. 9. 2nd Edition

Schnitzer M., Khan S. U. (1978). Soil Organic Matter. Elsevier, New York

Senesi N, Brunetti G, Loffredo E, Miano T.M. (1999) Abiotic catalytic humification of organic matter in olive oil mill wastewater, Understanding Humic Substances – Advanced methods, Properties and Applications, Boston, USA

Sierra M.M.D., Giovanela M., Parlanti E., Soriano-Sierra E.J. (2005). Fluorescence fingerprint of fulvic and humic acids from varied origins as viewed by single-scan and excitation/emission matrix techniques. Chemosphere 58: 715-733.

Stevenson F.J. (1982). Humus Chemistry – Genesis, Composition, Reactions. J. Wiley Interscience Publication, New York

Stevenson, F.J. (1994). Humus chemistry: genesis, composition, reactions; Wiley, USA

Szajdak L., Maryganova M., Tychinskaja L. (2006). Particularities of the chemical structure of humic acids from soils under shelterbelts of different age and adjoining cultivated fields. In: Frimmel F.H., Abbt-Braun G. (Eds): Proc. 13th Meeting of the International Humic Substances Society. Karlsruhe, 513–516.

Škoric, A., Filipovski, G., Ćirić, M. (1985). Classification of Yugoslav soils (in Serbo-Croatian). Department of Sciences and Arts of Bosnia and Herzegovina, Sarajevo.

Zdruli P, Jones RJA, Montanarella L. (2004). Organic Matter in the Soils of Southern Europe. European Soil Bureau Technical Report, EUR 21083 EN, Luxembourg

Walkley A, Black I.A (1934). An examination of the method for determing soil organic matter and a proposed modification of the chromic acid method, Soil Science 37, 29– 38.

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INVESTIGATION ON TOMATO SPOTTED WILT VIRUS INFECTING PEPPER PLANTS IN HUNGARY

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ABSTRACT

In Hungary resurgence of *Tomato spotted wilt virus* (TSWV) frequently causes heavy crop losses in pepper production since the mid nineties. Management of TSWV control was first directed against the thrips (using different insecticides or plastic traps), and against weeds as host plants of the virus and the thrips. Later on *Tsw* resistance gene was introduced from *Capsicum chinense* PI 152225 and PI 159236 into different types of pepper. In 2010 and 2011 sporadically, but in 2012 more frequently a resistance breaking (RB) strain of TSWV on resistant pepper cultivars was observed in the Szentes region (South-East Hungary). The presence of a new resistance breaking strain was demonstrated by virological (test-plant, serological and RT-PCR) methods. Previously, the non-structural protein (NSs) encoded by small RNA (S RNA) of TSWV was verified as the avirulence factor for *Tsw* resistance, therefore we analyzed the S RNA of the Hungarian RB and wild type (WT) isolates and compared to previously analyzed TSWV strains with RB properties from different geographical origins. Phylogenetic analysis demonstrated that the different RB strains had the closest relationship with the local WT isolates and there was no conserved mutation present in all the NSs genes of RB isolates from different geographical origins. According to these results, it is concluded that the RB isolates evolved separately in geographic point of view and according to the RB mechanism. In order to find new genetic sources of resistance in *Capsicum* species 89 lines from *Capsicum annuum, C. chinense, C. frutescens, C. chacoense, C. baccatum var. baccatum, C. baccatum var. pendulum* and *C. praetermissum* were tested with the Hungarian TSWV-RB isolate.

Key words: *tomato spotted wilt virus, wild type and resistance breaking strains, NSs protein, resistance.*

INTRODUCTION

Tomato spotted wilt virus (TSWV) is the type member of the genus *Tospovirus* (family *Bunyaviridae*), causes an important disease of horticultural and agronomic crops. The virus distributed worldwide is having extremly broad host range and is now considered as one of the ten most economically destructive plant viruses (Tomlinson, 1987). TSWV is transmitted by thrips in a persistant manner. The virion varies in size from 80 to 120 nm and has spherical enveloped character. The genome of TSWV consists of three ssRNA segments: small (S) and medium (M) RNAs have ambisense coding strategies, whereas the large (L) RNA is of negative polarity (Hann et al., 1991; Prins and Goldbach, 1998). In Hungary TSWV was described in 1972 (Ligeti and Nagy 1972), but the virus was not considered as an important pathogen. In 1995 very severe damage of TSWV infection was observed in tomato and pepper production in the Szentes vegetable growing region (Gáborjányi et al., 1995). The introduction and spread of western flower thrips (*Frankliniella occidentalis*), an efficient TSWV vector, in that time certainly played an important role in TSWV emergence (Jenser, 1995).

Management of TSWV control was first directed against the thrips using different insecticides or plastic traps, and against weeds as host plants/reservoirs of the virus and the thrips. Later on *Tsw* resistance gene (Black et al.1996) was introduced into different types of pepper (conical white, long pale green hot and sweet, tomato shape, spice pepper and blocky types) (Csilléry unpublished). Pepper cultivars carrying *Tsw* resistance gene upon TSWV inoculation show necrotic local lesions on the leaves or other parts of the plant without systemic infection. In 2010 and 2011 sporadically, but in 2012 more frequently systemic virus symptoms were observed on resistant pepper cultivars in Szentes region (Bese et al., 2012; Csilléry et al., 2012; Salamon et al., 2010). The presence of new resistance breaking strain of TSWV was proved by virological (test-plant, serological and RT-PCR) methods. It was demonstrated that TSWV can adapt very rapidly to plant resistance, and the *Tsw* resistance gene was broken down only a few years after its deployment in pepper crops (Margaria et al., 2004; Roggero et al., 2002; Sharman and Persley, 2006). According to de Ronde et al. (2013, 2014), NSs is the suppressor protein of the host plant gene silencing mechanism and it is responsible for breakdown of the plant's resistance (avirulence factor, avr).

The aim of this research was to characterize the molecular differences between the WT and the recently emerged RB isolates in the S RNA to determine the potential origin of the RB strains and to identify the mutations in the avr factor responsible for breakdown of the Tsw resistance. Moreover our aim was to find genetic sources of resistance in *Capsicum* species against resistance breaking starin of TSWV (TSWV-RB).

MATERIALS AND METHODS

Virus isolates. TSWV isolates originated from pepper cultivars susceptible and resistant against TSWV from Szentes region (South-East Hungary). Fruit samples were collected from plants exhibiting typical symptoms of virus infection such as stunting, mosaic, chlorotic and/or necrotic spots, rings and distortion on the leaves and fruits. The isolates were used for ELISA serological tests, RT-PCR and maintained by mechanical inoculation on *Nicotiana tabacum* cv. Xanthi-nc test plants.

RNA extraction and RT-PCR. Total RNA was extracted from leaves of *N. tabacum* cv. Xanthi-nc plants systemically infected by TSWV or from infected pepper fruits using the Spectrum Plant Total RNA Kit (Sigma) following the manufacturer's instructions. RT-PCR reactions for synthesis of first-strand cDNA were performed with Revert Aid H Minus First Strand cDNA Synthesis Kit (Thermo Science) using NSs-Reverse primer. The PCR amplification of the 1,404 bp fragment of NSs region was carried out with the primers NSs-Forward (5'-GG CTGTAG CAG AGA GCA ATT GTG TCA TAA TTT T-3') and NSs-Reverse (5'-GGA CAT AGC AAG ATT ATT TTG ATC CTG-3'), PCR reaction was performed in 25µl – 50 µl final volume. PCR products were electrophoresed in 1% agarose gel and stained with ethidium bromide.

Phylogenetic and sequence analysis. The nucleotide homology of the Hungarian and other TSWV strains retrieved from the GenBank was analyzed/examined by the BLAST program of NCBI. The nucleotide and deduced amino acid sequences were aligned by the ClustalW algorithm of the MEGA 6.06 program. Phylogenetic trees were composed by the Neighbor-Joining method with 1,000 bootstrap replications (MEGA 6.06 program) with the entire viral proteins. *Groundnut ringspot virus* (GRSV) was incorporated into the phylogenetic trees as outgroup.

Agrobacterium infiltration. NSs genes of TSWV RB and WT strains were cloned into pBin19 vector and *Agrobacterium tumefaciens* cells were transformed with them. Final optical density of the *Agrobacterium* cultures containing NSs genes was adjusted at 600 nm (OD600) to 0.5. *Agrobacterium*-mediated transient expression on *Capsicum annuum* cv Brendon leaves was conducted by pressure infiltration into the abaxial air space of 4- to 6-week-old plants using a needleless 2-ml syringe. P14 suspension was used for negative control.

Resistance test. 89 *Capsicum* items [*Capsicum annuum* (8), *C. chinense* (50), *C. frutescens* (8), C. chacoense (2), C. baccatum var. baccatum (4), C. baccatum var. pendulum (11) és C. *praetermissum* (6)] were inoculated at cotyledon stage with TSWV-RB strain. Symptoms were observed in the next 4 weeks.

RESULTS AND DISCUSSION

TSWV isolates were tested on TSWV-susceptible pepper cultivars ('Carma', 'Century', 'Dimentio', 'Skytia'), and pepper cultivars carrying *Tsw* resistance gene ('Celtic', 'Censor', 'Karakter', 'Brendon', 'Bronson', 'Bravia'). TSWV isolates causing necrotic local lesions (HR) on resistant pepper cultivars belonged to wild type (TSWV-WT) strain, and isolates causing systemic symptoms (chlorotic mosaic and ringspot pattern on the leaves, stunting) on all pepper cultivars belonged to resistance breaking (TSWV-RB) strain. Three TSWV isolates were selected (HUP1-2012-RB, HUP2-2012-RB and HUP4-2012-WT) for further study. All the three virus isolates induced systemic symptoms (chlorotic or necrotic ringspot) on the inoculated leaves of *N. tabacum* cv. Xanthi-nc plants.

Sequence similarities of the NSs genes were compared among the sequences of WT and RB isolates, originated from pepper from distinct geographical locations. Nucleotide sequence identity among the Hungarian isolates was 99 %, while compared to other isolates this value varied between 95 and 99 %. Amino acid (aa) sequences of the NSs protein (467 aa) were compared among the WT and RB isolates

Several mutations/changes were present only in the three Hungarian isolates at positions 122 (A to D), 137 (T to K), 174 (M to T), 450 (G to R), and 459 (P to S). The Hungarian RB isolates (HUP1-2012-RB, HUP2-2012-RB) had two aa substitutions compared to the WT Hungarian isolate (HUP4-2012-WT) at positions 104 and 461 (A instead of T). Substitution at position 104 has occurred only in the case of the Hungarian RB isolates. Phylogenetic tree was constructed based on the deduced amino acid sequences of the NSs genes of the Hungarian and the selected isolates from the GenBank (Figure 1).

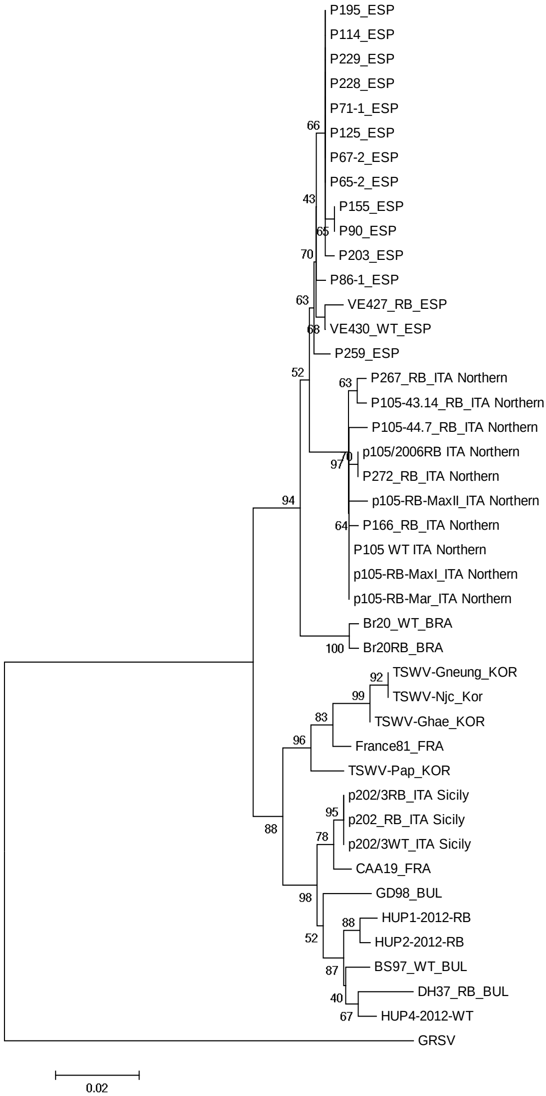

Figure 1. Phylogenetic tree based on the deduced amino acid sequences of the NSs protein of TSWV.

Abbreviations and accession numbers: HUP1-2012-RB : KJ649608; HUP2-2012-RB : KJ649609; HUP4-2012-WT: KJ649611; BS97: AJ418777; DH37: AJ418779; p202/3WT: HQ830187; p202/3RB: HQ830186; p202: DQ398945; GD98: AJ418780; CAA19: FR692822; VE430: DQ376184; VE427: DQ376185; p105: DQ376178; p105-RB-MaxI: HQ839730; p105/2006RB: DQ915946; p267: DQ376180; p105-RB-Mar: HQ839729; p105-44.7: DQ376183; p105-43.14: DQ376182; p105-RB-MaxII: HQ839731; Br20: DQ915948; Br20RB: DQ915947; p166: DQ376179; p272: DQ376181; France81: FR692829; TSWV-Pap: AB643674; TSWV-Ghae: AB643672; TSWV-Gneung: AB643671; TSWV-Njc: AB643673; p86-1: FR693020; p259: FR692932; p65-2: FR693005; p67-2: FR693007; p203: FR692900; p155: FR692871; p125: FR692857; p90: FR693023; p71-1: FR693811; p228: FR692917; p229: FR692918; p195: FR692895; p114: FR692852;

One of the two main clusters consists of Spanish, the Northern Italian, and the two Brasilian strains (further divided into different subgroups) regardless of the strain type, i.e., RB or WT. The other main branch contains the Korean, Hungarian, Bulgarian and Italian strains from Sicily. Amino acid differences in NSs protein of TSWV-WT and TSWV-RB strains from different geographical locations are different. The Brasilian WT and RB strains are different in aa position of 174 and 255, the Spanish at 84 and 407, North and South Italian strains at 424 and 427 respectively, while Hungarian WT and RB strains differ in 104 and 461 aa. The phylogenetic analysis supported the hypothesis that TSWV RB strains has been developed locally, and the worldwide trade and transport of plant propagating material seem not to contribute to the expansion of RB strains.

The NSs proteins were tested for their avirulence (Avr) activity by triggering of HR (necrosis) on *Capsicum annuum* cv Brendon (Tsw+) plants in *Agrobacterium* transient expression assay. The NSs protein of TSWV-WT strain caused HR on infiltrated leaves while NSs protein of TSWV-RB caused no necrosis. To determine which nucleotide or aa changes in NSs led to RB and how other functions altered, needs further mutational analysis.

CONCLUSION

Searching for resistance to TSWV-RB strain testing of 89 *Capsicum* items was carried out [*Capsicum annuum* (8), *C. chinense* (50), *C. frutescens* (8), *C. chacoense* (2), *C. baccatum var. baccatum* (4), *C. baccatum var. pendulum* (11) and *C. praetermissum* (6)]. 85 items were susceptible and 4 *C. baccatum* var. pendulum items showed HR-like symptoms. Further study is necessary to clear the genetic background and the possibility to use these items in resistance breeding.

REFERENCES

Bese, G., Krizbai, L., Horváth, J., Takács, A., (2012). Resistance breaking strain of *Tomato spotted wilt virus*, (TSWV) on resistant pepper cultivars in Hungary. Internat. Symp. on Current Trends in Plant Protection, Belgrade, Serbia 2012. pp. 239-241.

Black L.L., Hobbs H.A., Kammerlohr D.S. (1996). Resistance of *Capsicum chinense* lines to *Tomato spotted wilt virus* from Louisiana, USA, and inheritance of resistance. *Acta Horticulturae* 431,393-401.

Csilléry G., Almási A., Tóbiás I. (2012). Occurence of resistance breaking strain of *Tomato spotted wilt virus* on resistance papper cultivars in Hungary. The 21st Internatioanl Pepper Conference, Florida, November 4-6 2012, pp 27.

de Ronde, P. Butterbach, D. Lohuis, M. Hedil, J.W.M. van Lent, R. Kormelink (2013). *Tsw* gene-based resistance is triggered by a functional RNA silencing suppressor protein of the *Tomato spotted wilt virus*. Mol. Plant Pathol. 14, 405–415.

De Ronde D., Pasquier A., Ying S., Butterbach P., Lohuis D., Kormelink R. (2014). Analysis of *Tomato spotted wilt virus* NSs protein indicates the importance of the N-terminal domain for avirulence and RNA silencing suppressor. Molecular Plant Pathology, 15 (2), 185-195.

Gáborjányi R., Csilléry G., Tóbiás I., Jenser G. (1995). *Tomato spotted wilt virus:* A new threat for pepper production in Hungary. IXth Eucapia Meeting, Budapest, 159-160.

de Haan P., Kormelink R., de Oliveira R.R., van Poelwijk F., Peters D., Goldbach R. (1991). Tomato spotted wilt virus L RNA encodes a putative RNA polymerase. J. Gen Virol 72: 2207-2216.

Jenser G. (1995). The role of the *Thysanoptera* species in the spread of *Tomato spotted wilt tospovirus*. Növényvédelem 31, 541–545.

Ligeti L., Nagy Gy. (1972). A Lycopersicum vírus 3 dohányültetvényeink új, veszedelmes kórokozója. Dohányipar: 41–43.

Margaria P., Ciuffo M., Turina M. (2004).Resistance breaking strain of *Tomato spotted wilt virus* (*Tospovirus, Bunyaviridae*) on resistant pepper cultivars in Almeria, Spain. Plant Pathol. 53. 795.

Prins M., Goldbach R. (1998). The emerging problem of tospovirus infection and nonconventional methods of control. Trends in Microbiology 6: 31-35.

Roggero P., Masenga V., Tavella L. (2002). Field isolates of Tomato spotted wilt virus overcoming resistance in pepper and their spread to other hosts in Italy Plant Disease. 86, 950-954.

Salamon P., Nemes K., Salánki K. (2010). A paradicsom foltos hervadás vírus (*Tomato spotted wilt virus*, TSWV) rezisztenciatörı törzsének első izolálása paprikáról (*Capsicum annuum* L) Magyarországon. Növényvédelmi Tudományos Napok pp 23.

Samuel, G., Bald, J.G., Pittman, H.A. (1930). Investigation on ’spotted wilt’ of tomatoes in Australia. Commonw. Coun. Sci. Ind. Res. Bull 44, 8-11.

Sharman M., Persley D.M. (2006). Field isolates of *Tomato spotted wilt virus* overcoming resistance in Capsicum in Australia Australasian Plant Pathology. 35, pp. 123-128.

Tomlinson J.A. (1987). Epidemiology and control of virus diseases of vegetables. Annals of Applied Biology 110: 661-681.

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POTATO MINITUBER PRODUCTION UNDER HYDROPONIC SAND CULTURE

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ABSTRACT

Isolation and use of sterile growing media are two important factors in hydroponic production of healthy potato mini-tubers. Sand can be disinfected by solarization, while organic growing media may harbor some pathogenic agents. Under hydroponic condition, number and size of potato tubers are usually controlled by nutritional factors such as nitrogen, phosphorus and pH. The main objective of present study was to find an appropriate combination of N, P and pH (with respect to tuber number) under hydroponic sand culture and to evaluate some physiological traits affected by nutrients and pH. A factorial experiment based on completely randomized design with 4 replications was conducted. The experimental factors included N, P and pH. Some morphological and physiological traits including tuber number, rate of net photosynthesis, concentration of hormones ABA and IAA were studied. Results showed that higher phosphorus concentration for 10 days increased tuber number per plant, but tuberization was not influenced by nitrogen interruption and intermittent reduction of pH. None of N, P and pH affected total nitrogen concentration of potato leaf, stem and tuber. Higher phosphorus concentration increased the level of endogenous ABA and IAA, induced tuberization and thereby increased net photosynthesis rate of potato plants.

Keywords: *potato, hydroponic, sand, nutrition, tuberization.*

INTRODUCTION

Adding substrate to hydroponic system is a tool to enhance chemical and physical inertia. As a consequence, labour and energy are saved (Rolot and Seutin, 1999).In developing countries, different organic growing media as peat-moss and coconut fiber have traditionally been used to produce potato mini-tubers. Organic growing media may harbor some pathogenic agents such as *Erwinia*spp, *Spongospora subterranean* or *Streptomyces scabies* (Rolot and Seutin, 1999). The other short-comings of such systems are relatively high cost of organic substrate as well as low rate of oxygen diffusion, which adversely affects plant growth (Cho et al., 2006). Nowadays, multiplication of potato mini-tubers is mainly done under NFT (Nutrient Film Technique) and aeroponic systems (Farran and Mingo-Castel, 2006). The advantages of multiplication via NFT and aeroponic over conventional methods include precise using of nutrients, high multiplication rate of tubers, better sanitary control of growing media and also relieved control of weeds. In spite of producing high number of tubers under these conditions, they are costly and laborious (Novella et al., 2008), so using such systems are not practical and commercial in developing countries.

Sand provides an inert nature media with more pore volume (more oxygen transport), stable structure, less water retention and large volume of accessible water to the plants (Dole and Wilkins, 1999).The nature of sand may cause a mechanical resistance and it may affect stolon development (Ewing and Struik, 1992). Insufficient resistance can result in vigorous stolon growth (Cary, 1986) or secondary stolons and many small tubers (Vreugdenhil and Struik, 1989). In this study nutritional management was applied to induce tuberization in potato plantlets. Chang et al. applied nitrogen interruption and increased tuber numbers by 18%. They suggested nutrient interruptions should be conducted after sufficient haulm development to minimize a reduction of tuber set (Chang et al., 2008). Kang et al. reported nitrogen deficiency induced potato tuberization without causing a significant retardation to the plant growth (Kang et al., 1996). Other nutritional element has been used to increase tuber set (Sanderson et al., 2003) and number (Rosen and Bierman, 2008) in potato plants is phosphorus. Rosen and Bierman (2008) reported that petiole P was positively correlated with number of potato tubers per plant. Intermittent reduction of solution pH could be a means to stimulate tuber production under hydroponic conditions. Wan et al. reported tuber initiation was induced in plants subjected to intermittent pH reductions compared to constant pH 5.5 (Wan et al., 1994).

The main objective of present study was 1. to develop a relatively low cost method for potato mini-tuber production and 2. to find the best combination of N, P and pH to produce maximum number of minitubers. Some morphological and physiological traits (including tuber number, rate of net photosynthesis, concentration of hormones ABA and IAA) were measured in order to understand why the best combination of N, P and pH gave higher numbers of minitubers.

MATERIALS AND METHODS

Experimental set up and treatments

The experimental set up was an opened sand and perlite (1:1 volume) hydroponic system. This inert, sustain and relatively inexpensive growing media was placed in 6-L pots and certified potato cv. Sante seed tubers (20 -25 mm mean diameter) were planted in these pots at a depth of 5 cm in the spring of 2011 at the research greenhouse of Seed and Plant Certification and Registration Research Institute (SPCRI) in Karaj, Iran. Pots were kept at 25±5 ˚C with an approximately 14-h natural photoperiod and 300-600 μmol m^{-2} s^{-1}Photosynthetic Photon Flux Density (PPFD) measured at the top of the canopy.

Plants were irrigated with basic nutrient solution (Table 1) through a network of tube, with a hole on the top of each pot. The pH and Electrical Conductivity (EC) of the nutrient solution were kept at 5.8-6 and 2 mS cm^{-1} respectively (Farran and Mingo-Castel, 2006).

Table1. Composition of basic nutrient solution (mgL^{-1})

N	P	K	Ca	Mg	S	Fe	Zn	Cu	Mo	Mn	B
160	42	239	152	38	40	1.7	0.6	0.2	0.1	1.2	0.8

A 2 × 2 ×2 factorial experiment based on completely randomized design with 4 replications was conducted. Experimental factors included N (N1: Constant consumption of 160 ppm N through the growth period, N2: Constant consumption of 160 ppm N until 65 DAE followed by 0 ppm N for 10 days), P (P1: Constant consumption of 42 ppm P through the growth period, P2: Constant consumption of 42 ppm P until 65 DAE followed by 84 ppm P for 10 days) and pH (pH1: Constant 6 through the growth period, pH2: Intermittent reduction of pH to 3.5: 3 times for 2 hours). Use of basic nutrient solution (Table 1) continued until 65 DAE. Between 65 DAE to 75 DAE, nutrition system was turned off and stimulating nutrient solution (the second level of N, P and pH) was applied to the related plots. Afterwards the composition of nutrient solution was returned back to the basic form as before. For intermittent pH treatment, the pH of well water was lowered to 3.5 by adding 1.0 M H2SO4 and then applied to related plots on 73 DAE for two hours. After two hours, the growing media in these pots was washed with normal well water (7.2 pH). After two hours pH treatment was repeated two times.

Measurements

Net photosynthesis rate: Net photosynthesis rate was measured at 75 DAE (at the end of nutritional and pH treatments) using a portable CI-340 Ultra-Light Photosynthesis System (CID, Inc., USA). Measurements were taken on terminal leaflet of the youngest fully expanded leaf of three plants from each plot. During the measurements, the PPFD at the top of plant canopy was between 300 and 500 $\mu mol\ m^{-2}\ s^{-1}$.

Total N concentration: One plant from each plot was harvested and separated into leaves, stems, roots and tubers at 75 DAE. Separated plant parts were thoroughly washed by 2 dippings, of 5 minutes each, in distilled water, then were dried at 105˚C and total nitrogen concentration was determined using macro-Kjeldahl method (AOAC,1984).

ABA and IAA concentration: In order to analyze ABA and IAA concentration, 75 DAE leaf samples of second plant from each plot were harvested and frozen in liquid nitrogen and stored at -80˚C until analysis. ABA and IAA concentration was measured in the leaves of treatments with highest (N1P2pH1) and lowest (N1P1pH1) tuber number.

Tuber characteristics: Third plant from each plot was harvested 90 DAE and number of tubers was counted. For dry weight determination, surface of randomized selected tubers cracked, these tubers oven-dried at 70˚C until constant weight was reached.

Statistical Analysis: SAS software (version 9.0) was used for statistical analysis and means were compared by Duncans Multiple Range Test at a p of 5%. In addition, concentration of ABA and IAA in specific treatments compared by Least Significant Different (LSD).

RESULTS AND DISCUSSION

Leaf gas exchange

Net photosynthesis rate of potato plants was not affected by either of nitrogen interruption and pH intermittent reduction. However increased phosphorus concentration resulted in net photosynthesis increment(Figure 1). There were likely two reasons for increased net photosynthesis rate by phosphorous. First, this nutrient plays an important role in photosynthesis and intermediary metabolism. Phosphorous in the form of nucleotides such as ATP and ADP as well as inorganic phosphate (Pi) and phosphorylated sugars also plays an integral role in the energy metabolism of cell. Second, it is postulated that the promoted early potato crop growth and increased tuber set by phosphorus (Figure 4) increased the development of new sinks. Creation of strong sinks, the newly formed tubers, could result in increased demand for assimilate. According to the second hypothesis, increased demand for assimilates in the sinks probably caused the rate of net photosynthesis to be increased.

Net photosynthesis rate of potato plants was not significantly influenced by other studied factors (nitrogen interruption or intermittent reduction of pH). In favor of this finding, Vos and van der Putten (1998) reported that the dominant effect of nitrogen supply was on leaf size and not on the rate of photosynthesis. Also Marshall and Vos (1991) suggested that an increasing proportion of leaf nitrogen was not associated with the performance of the photosynthetic system. Our findings are in contrast with previous observations of Chang et al., (2008) reported that photosynthetic rates of potato plants decreased by 10 days nitrogen interruption.

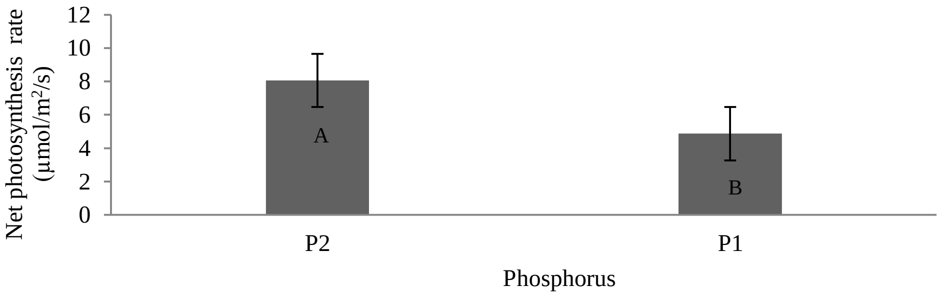

Figure1. Effect of phosphorusconcentration on net photosynthesis rate of potato plants

Total N concentration

According to the variance analyses, none of the nutritional and pH factors affected total nitrogen concentration of potato leaf, stem and tuber. This is in conformity with the findings of Sattelmacher and Marschner (1979) who observed that after 9 days of nitrogen withdrawal, the concentration of nitrogen in the plants with discontinues nitrogen was particularly the same as in the plants with continues nitrogen. However, both nutritional factors (nitrogen interruption and increased phosphorus concentration) increased total nitrogen concentration of roots (Figure 2).

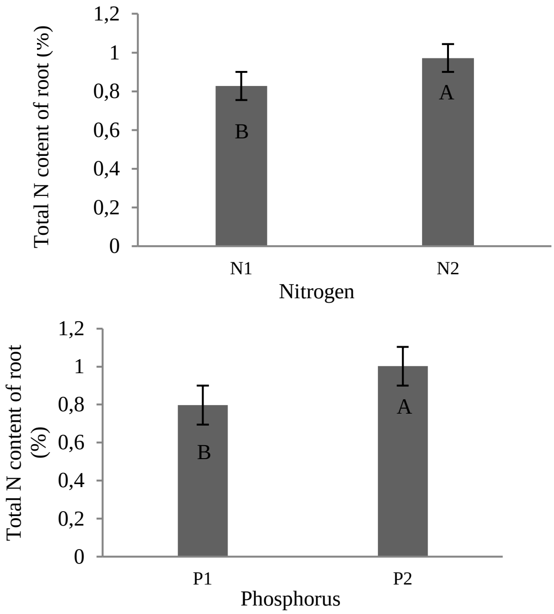

Figure 2. Total N content of potato root under nitrogen (A) and phosphorus (B) nutrition

ABA and IAA concentration

Concentration of ABA and IAA was only influenced by phosphorus. In selected plots (N1P1pH1 and N1P2pH1) higher phosphorus concentration in nutrient solution increased both hormones (ABA and IAA) in potato plant leaves (Figure 3). In favor of our finding, Chang et al. reported ABA levels increased in cv. Superior as a result of nutrient interruption (Chang et al., 2008). The promoting effect of exogenous ABA on tuberization was demonstrated by the increasing numbers of tubers (Abdullah and Ahmad, 1980). Chang et al. (2008) reported ABA levels increased in cv. Superior as a result of nutrient interruption. It is postulated that higher phosphorus concentration increased the level of endogenous ABA and IAA, induced tuberization and thereby increased net photosynthesis rate.

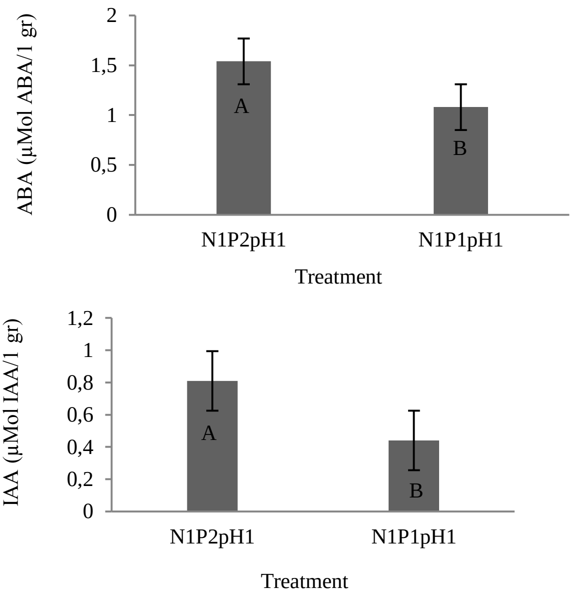

Figure 3. Comparison of ABA (A) and IAA (B) content in the leaves of treatments with highest ($N_1P_2pH_1$) and lowest ($N_1P_1pH_1$) tuber number

<u>Tuber characteristics</u>

Tuber number per plant was significantly increased with an increase in phosphorus concentration (Figure 4). Rolot and Seutin (1999) reported that more phosphorus had a positive effect on multiplication rate and increased tuber numbers from 6.4 (in peat culture) to 6.96 per plant. Rosen and Bierman (2008) reported that phosphorus fertilizer application increased total number of tubers per plant. Sucrose synthase (SuSy) and ADP-glucose pyrophosphorylase(AGPase) are two key enzymes involved in sucrose to starch conversion. Expression of AGPase is decreased by phosphate. AGPase is exquisitely sensitive to allosteric regulation being activated by 3PGA and inhibited by Pi (Preiss,1988). Sowokinosand Preiss (1982) reported that AGPase from potato tubers resembles the leaf enzyme. Therefore during tuber development, expression and activity of AGPase may be inhibited by increased Pi concentration in amyloplasts. Under activity inhibition of AGPase by Pi in developing tuber, produced assimilates can be directed to the new initiated tubers. However the effect of nitrogen and pH on this trait was not significant. Chang et al. (2008) reported nitrogen interruption increased tuber numbers in cv. Superior (medium-early season) and did not influence on tuber numbers of cvs. Atlantic (mid-late) and Jasim (late). On the contrary, in water culture of potato plants nitrogen withdrawal increased tuber numbers (Sattelmacher and Marschner, 1979). Tuber dry weight was not affected by any of studied factors (nutritional and pH factors).

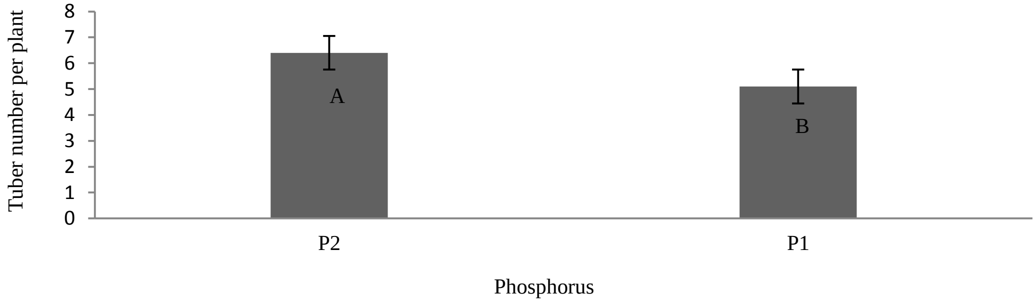

Figure4. Effect of phosphorus on tuber number of potato plants

CONCLUSION

Among studied nutritional factors (N, P and pH), increased phosphorus concentration significantly enhanced tuber numbers of potato plants in hydroponic sand culture. This nutrient increased net photosynthesis rate, ABA and IAA concentration of potato plant leaves and did not affect nitrogen absorption by potato. Therefore the best combination of N, P and pH (with respect to tuber number) in nutrient solution under hydroponic sand culture was N1P2pH1.

REFERENCES

Abdullah, Z. N., and Ahmad, R. (1980).Effect of ABA and GA3 on tuberization and some chemical constituents of potato.Plant Cell Physiology. 21:1343-1346.

AOAC.(1984). Official methods of analysis.Association on official analytical chemists, 14th ed., Washington DC, USA.

Cary, J. W. (1986). Effects of relative humidity, oxygen, and carbon dioxide on initiation and early development of stolons and tubers.American Potato Journal. 63: 619-628.

Chang, D. C., Park.C. S., Kim.S. Y.,. Kim.S. J, and Lee, Y. B. (2008). Physiological growth responses by nutrient interruption in aeroponically grown potatoes.American Journal of Potato Research. 85:315-323.

Cho, M. S., Park.Y. Y., Jun.H. J., and Chung, J. B. (2006). Growth of Gerbera in mixtures of coir dust and perlite.Horticulture, Environment and Biotechnology.47:211-216.

Dole, J. M, and Wilkins, H. F. (1999).Floriculture principles and species. Prentice-Hall, Inc. USA. pp.79-89.

Ewing, E. E., and Struik, P. C. (1992). Tuber formation in potato: Induction, initiation and growth. Horticultural Reviews. 14:89-198.

Farran, I., and Mingo-Castel, A. M. (2006). Potato minituber production using aeroponics: effect of plant density and harvesting intervals. American Journal of Potato Research. 83:47-53.

Kang, J. G., Yang,S. Y., and Kim, S. Y. (1996). Effects of nitrogen levels on the plant growth, tuberization and quality of potatoes grown in aeroponics.Journal of the Korean Society for Horticultural Science. 37:761-766.

Krauss, A., and Marschner, H. (1982). Influence of nitrogen nutrition, day length and temperature on contents of gibberellic and abscisic acid and on tuberization in potato plants. Potato Research. 25:13-21.

Marshall, B., and Vos, J. (1991). The relationship between the nitrogen concentration and photosynthetic capacity of potato (*Solanum tuberosum* L.) leaves. Annals of Botany. 68:33-39.

Novella, J., Andriolo, L., Bisognin, D. A., Cogo, C. M., and Bandinelli, M. G. (2008). Concentration of nutrient solution in the hydroponic production of potato minitubers.Ciência Rural. 38:1529-1533.

Preiss, J. (1988). Biosynthesis of starch and its regulation. In: Preiss, J. ed. The biochemistry of plants.Vol. 14. San Diego, California: Academic Press. 181-254.

Rolot, J. L., and Seutin, H. (1999).Soilless production of potato minitubers using a hydroponic technique.Potato Research. 42:457-469.

Rosen, C. J., and Bierman, P. M. (2008).Potato Yield and Tuber Set as Affected by Phosphorus Fertilization.American Journal of Potato Research. 85:110-120.

Sattelmacher, B., and Marschner, H. (1979).Tuberization in potato plants as affected by applications of nitrogen to the roots and leaves. Potato Research. 22: 49-57.

Sowokinos, J.R., and Preiss, J. (1982).Phosphorylases in *Solanum tuberosum* .III.Purification, physical and catalytical properties of ADP-glucose pyrophosphorylase in potatoes.Plant Physiology. 69:1459-1466.

Vos, J., and van der Putten, P. E. L. (1998). Effect of nitrogen supply on leaf growth, leaf nitrogen economy and photosynthetic capacity in potato.Field Crops Research. 59:63-72.

Wan, W. Y., Cao,W., and Tibbitts, T. W. (1994). Tuber initiation in hydroponically grown potatoes by alteration of solution pH.Horticultural Science. 29:621-623.

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POPULATION DYNAMICS OF DAGGER NEMATODE ATTACKING ALEPPO PINE TREE IN JORDAN

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ABSTRACT

The temporal distribution of an isolate of the dagger nematode attacking Aleppo pine, *Pinus halepensis* grown in AL-Jubiha area in Jordan was investigated. A total of eighteen samples were collected from rhizosphere about 30 cm deep in soil and 50 cm away from the trunk of a Pine tree showing decline and brown needles as one sample per month starting in November 2014 until April 2016. Cobb sieving and gravity methods were used for the nematode isolation from rhizosoil. The soil type is clay with 51 % porosity. The monthly air temperature, precipitation, and relative humidity were monitored and tabulated. The results showed that the number of recovered nematodes ranged from 2 individuals /100 cm^3 to 88 individuals /100cm^3 of rhizosoil. The lowest number was recovered on October whereas the highest numbers were recovered in December. The reason of decline in numbers may be due to a raise in temperature. The highest number may be due to favorable temperature and soil moisture. The difference of nematode in same month in two different years may be due to the temperature and precipitations.

Keywords: *Aleppo pine, dagger nematode, population, temperature, moisture*.

INTRODUCTION

Forest trees are basic components of an ecosystem in Jordan which occupies now less than 1% of Jordan total area dominated by Aleppo pine, *Pinus halepensis*. It is severely affected by several factors and thus it is critically endangered (Al-Eisawi, 2012). Each year, large areas of Aleppo pines forests are destroyed by outbreaks of pathogenic fungi, viruses, insects, nematodes, and recently phytoplasma (Seliskar, 1966; Lieutier and Ghaioule, 2006; Karadžić and Vujanović, 2009; Botella *et. al.*, 2010). Only one species belonging to the spiral nematode, *Helicotylenchus digonicus* and two species belonging to the dagger nematodes, *Xiphinema pachtaicum* and *X. vuittenezi*, were recorded to be associated with roots of *P. halepensis*, in Jordan (Hashim, 1979; EPPO quarantine pest, 2006). Dagger nematodes, belong to the genus *Xiphinema*, are migratory ectoparasites and several species belong to this genus were recorded to be associated with pine trees worldwide (Griffiths *et. al*., 1982). Riffle (1972) recorded indirect effect of some *X. americanum* on pine trees since it directly attacked ectomycorrhizae associated with seedlings of *P. edulis* leading to decline in pine growth.

Recently, it has been noticed that several trees of Aleppo pine grown in the campus at the University of Jordan at Jubeiha are weak and several needles are brown in color (Luma Al Banna observations). The dagger nematode was found in the rhizosoil of the roots of those weak trees. This study aimed to identify the species of this nematode and furthermore to investigate the temporal distribution of this dagger nematode attacking Aleppo pine.

MATERIALS AND METHODS

Sampling and Extraction of Dagger Nematode Isolate: Soil samples from rhizosphere of a 25m tall Aleppo pine ***tree*** grown in Jordan university campus were collected monthly. The tree appeared weak with many dead branches, the remain green branches also have several brown colored leaves while the surrounding trees look healthier than the sampled tree. Sampling started in November 2014 until April 2016, with a total of 18 samples. The samples were collected from the rhizosoil about 50 cm away from the trunk base of the tree. The upper 30 cm soil were excluded and rhizosoil sample were collected with a shovel from the next 30-40 cm deep of soil. The rhizosoil cores were stored in small plastic bags, and properly labeled. Air temperature, precipitation, and relative humidity were monitored monthly and the data were tabulated. Rhizosoil samples were stored in cold temperature at 4-8℃ until used. Cobb sieving and gravity method was followed as described by Hooper (1986) to extract the dagger nematode from the 18 samples.

Soil Analysis: Physical and chemical properties of rhizosoil samples which was collected in December 2015 from tested Aleppo pine tree were determined. Such properties include: soil moisture content, soil particle density, soil bulk density, porosity, organic matter percentage, soil pH, electrical conductivity, soil texture and soil fraction.

Effect of Cold Storage of Rhizosoil Samples on the Number of Dagger Nematodes: To investigate the effect of cold storage on dagger nematode population, a monthly specimen was taken from a rhizosoil sample which was collected in 9 March 2015, and stored at 4 - 8℃. The extraction repeated once monthly for six months of cold storage. Nematode extraction was performed as mentioned earlier.

Identification of Collected Nematode Sample: Recovered nematodes were examined and counted using a dissecting microscope. Mounts of the recovered nematodes were prepared for the purpose of identification. Temporary and permanent mounts of the recovered nematodes were prepared following in order Seinhorst slow method (Seinhorst, 1959). Mounts were examined using a light compound microscope. Both qualitative and quantitative morphological characters were documented. These morphological characters were used to identify the species of the dagger nematode following original descriptions and diagnostic keys (Luc *et. al.*, 1964; Groza *et. al.*, 2013).

Temporal Distribution of the Recovered Dagger Nematode: Monthly total numbers of recovered nematodes from 100cm^3 of rhizosoil (from November 2014 until April 2016) were tabulated and a histogram was established.

RESULTS AND DISCUSSION

The analyses of the collected rhizosoil samples revealed that the soil type is a clay soil with 17.5% sand, 30 % silt and 52.5% clay. Clay soil is compact soil that is not preferred to harbor dagger nematodes due to low porosity and reduction level of oxygen, however, the presence of organic matter (7.2 %) which surrounds the soil particles with small particle density 2.05 g/cm3 resulted in high pore space (51%) and lower bulk density (1 g/cm^3). Similarly, Harris (1979) reported that under conditions of limited moisture, nematode reproduction increases in fine-textured soil with a greater moisture holding capacity. The pH of the sampled rhizosoil was 7.84 which is considered suitable for the survival of dagger nematode. The recovered dagger nematode was identified as *Xiphinema vuittinezi*. All specimens were longer than the previously recorded populations that associated with pome fruits, grapevine and stone fruits in different area in Europe, USA, Australia, Czech Republic and Iran (Groza *et. al.*, 2013). This variation can be due to differences in host plant, geographical location, and other environmental conditions.

Temporal Distribution of the Recovered Dagger Nematode: Seasonal variation of *X. vuittinezi* around roots of Aleppo pine at Jubiha from 17 November 2014 till 28 April 2016 as total number of individuals /100 cm^{3}of rhizosoil are shown in Figure (1). Monthly air temperatures and precipitations are also shown in Figure (1).

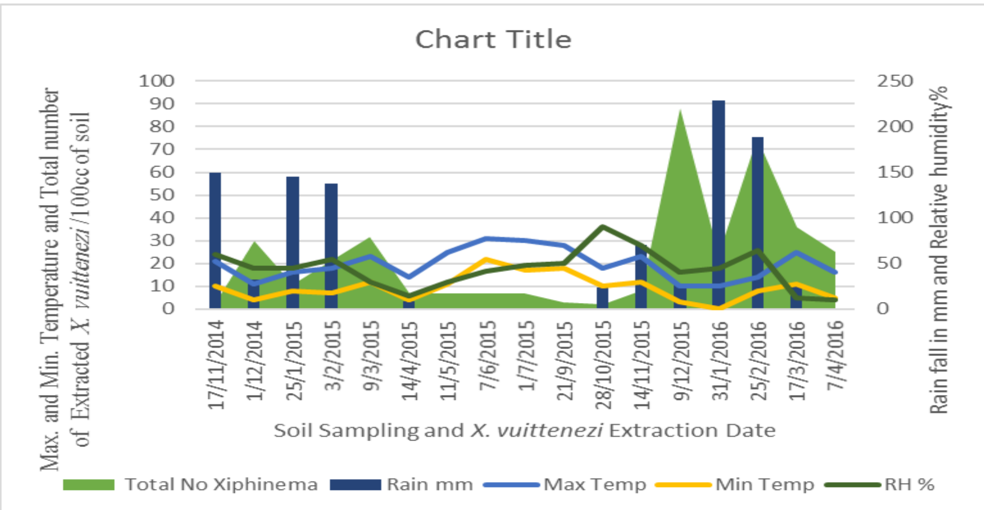

Figure 1. Seasonal population fluctuations of *Xiphinema vuittenezi* around roots of Aleppo pine at Jubiha, Amman= Jordan from November 2014 till Abril 2016.

The results showed that the number of recovered nematodes ranged from 2 individuals /100 cm^3 to 88 individuals /100cm^3 of rhizosoil. The lowest number was recovered in October 2015 whereas the highest numbers were recovered in December 2015. The economic threshold (ETH) for dagger nematode was determined to be 50–100 individuals /100cm^3 of soil for horticultural crops (Ravichandra, 2014). This can explain the observed damage of sampled tree since the highest recovered population during 2015 reached 88 individuals /100 cm^3 of soil while it was only 30 individuals/100cm^3 of rhizosoil in previous year. This can explain the slow effect of this nematode on pine trees which increase year after year. There was low number of *X. vuittenezi* during November 2014 but after rain fall started, the population increase in next December, Similarly, when the rain falls started again during October 2015 a remarkable population increase was recorded in November 2015. The low number of recovered nematodes from April to October 2015, might be due to low soil moisture since no precipitation events were recorded during this period. This result is similar to Feil, *et. al*., (1997) who recorded that period of soil dryness may increase reproduction rate of *X. index* and increase population level during next winter season. Low temperature averaged to 16℃ from November 2014 till March 2015 with presence of high soil moisture elevated the recovered numbers of *X. vuittenezi*. However, during January 2015 the population declined sharply from 30 individuals /100 cm^3 in December 2014 to 12 individuals /100 cm^3 and similar trend was also recorded next year where the population declined from 88 individuals /100 cm^3 in December 2015 to 24 individuals /100 cm^3 in January 2016 which may be attributed to the very low temperature as a result of snowing event during this month. Sharp decline in population was recorded from May (7 individuals /100cm^3 of rhizosoil) to the end of October (2 individuals /100cm^3 of rhizosoil) as a result of reduced soil moisture due to elevated air temperature above 20℃. this is in similar to Griffin *et. al.*, (1996) who reported that the optimum temperature for *X. americanum* was 21℃, and the nematode cannot survive high soil temperatures but it can survive winter months at low temperatures. Both soil moisture and temperature have an effect on population of *X. vuittenezi* and this is in similar to Ferris and Mckenry (1974) who found that soil moisture is a critical factor for egg hatching of *X. americanum* at time of suitable temperature. The combination of suitable host roots, favorable temperature and sufficient soil moisture resulted in population build up as recorded during the months February, March and April 2016.

Effect of Cold Storage on *X. vuittenezi* Population

Soil sample during March 2015 was kept at 4-8℃ for further extraction. The monthly recovered *X. vuittenez*i individuals are graphed in figure (2).

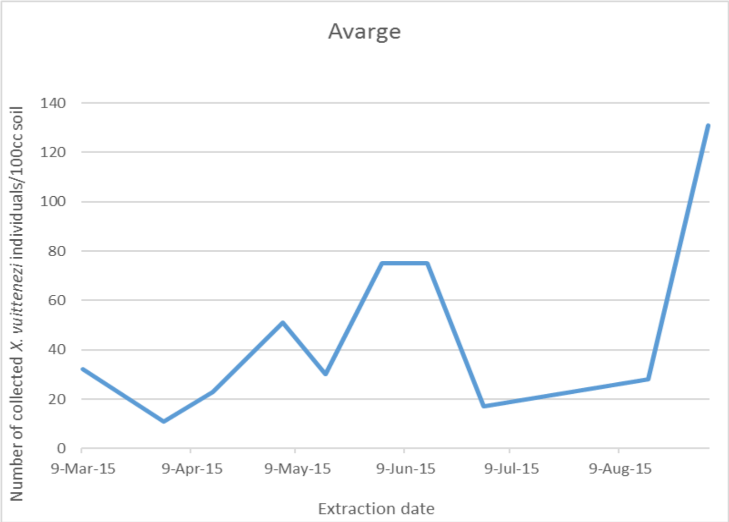

Figure 2: *Xiphinema vuittenezi* population at different extraction time from collected sample in 9 March 2015 around roots of Aleppo pine at Jubiha, Amman, Jordan

The recovered individuals declined after one month of storage. With extending the period of storage, the population fluctuated with a sharp three peaks after second, third, and sixth months of storage. Most of the recovered individuals were immature stages. The increase of the nematode number might be because of egg hatching or the end of a quiescent stage.

CONCLUSION

This study illustrates the presence of high population of *X. vuittenezi* within the soil of studded Aleppo pine tree. The population dynamic of this nematode show fluctuation during the sampling period as a reflect of several biotic and abiotic factors. Cold storage of a soil sample also resulted in fluctuation of collected *X. vuittenezi* individuals. More biological and ecological studies are needed to understand the critical damage of this nematode on forest Aleppo pine trees in Jordan.

REFERENCES

Al-Eisawi, D. (2012). Conservation of natural ecosystem in Jordan, Pakistan Journal of Botany, 44, (95-99).

Botella, L. Santamaria, J. and Diez, J. (2010). Fungi associated with the decline of *Pinushalepensis* in Spain. Fungal Diversity, 40, (1-11).

EPPO/CABI (2006). *Xiphinemaamericanumsensulato*. data sheets on quarantine pests 2nd edition (6) (Ed. by Smith, I.M.; McNamara, D.G.; Scott, P.R.; Holderness, M.) CAB International, Wallingford, UK.

Feil, H. Westerdahl, B. Smith, R. and Verdegaal, P. (1997). Effects of Seasonal and Site Factors on *Xiphinema index* Populations in Two California Vineyards, Journal of Nematology, 29(4): (491-500).

Ferris, H., and McKenry, M. V. (1974). Seasonal fluctuations in the spatial distribution of nematode populations in a California vineyard. Journal of nematology, *6*(4), 203.

Griffin, G. Asay, K. and Horton, W. (1996). Factors Affecting Population Trends of Plant-Parasitic Nematodes on Rangeland Grasses. Journal of Nematology, 28(1): (107-114).

Griffiths, S. Robertson, M. and Trudgill, L. (1982). Nuclear changes induced by the nematodes *Xiphinemadiversicaudatum*and *Longidoruselongatus*in root-tips of perennial ryegrass, *Loliumperenne*. Histochemical Journal, 14, (719–730)

Groza, M. Lazarova, S.Costache, C. De Luca, F. Rosca,I. Fanelli, E. Peneva, V. (2013). Morphological characterisation and diagnostics of *Xiphinema* non-*americanum* group species (Nematoda: Longidoridae) from Romania using mutiplex PCR. Helminthologia,Volume 50, Issue: 3, pp (215-231)

Harris, R. (1979). Seasonal populations of *Xiphinema index* in vineyard soils of northeastern Victoria, Australia, Nematologica, 25:(336-347).

Hashim, Z. (1979). A Preliminary report on the plant-parasitic nematodes in Jordan, Nematologia Mediterranea, 7, (177-186)

Hooper, D. (1986). Extraction of free-living stages from soil. In Laboratory Methods for Work with Plant and Soil Nematodes (ed. Southey JF), Her Majesty's Stationary Office, London, pp (5–30).

Karadžić, D. and Vujanović, V. (2009). Aleppo pine defense against *Sphaeropsissa pinea*, *Cronartium flaccidum* and other fungal pathogens in the Mediterranean part of Montenegro, Bulletin of the Faculty of Forestry, 99 (59-74).

Lieutier, F. and Ghaioule, D. (2006). Entomological research in Mediterranean forest ecosystems. Institute National de la Recherche Agronomique. Paris.

Luc. M., Lima, M.B., Weischer B., and Flegg.J.M. (1964). Xiphinemavuittenezi n. sp. (Nematoda: Dorylaimidae). Nematologica, 10: (151–163).

Ravichandra, N. (2014). Nematode population threshold level in Horticultural Nematology, Springer, India (101-126).

Riffle, W. (1972). Effect of certain nematodes on the growth of *Pinusedulis* and *Juniperusmonosperma* seedlings, Nematology, 4, 9 (1-94)

Seinhorst, J. (1959). A Rapid method for transfer of nematodes from fixative to anhydrous glycerin, Nematologica, 4, (67-69).

Seliskar, E. (1966). Virus and virus- like disorders of forest trees, Food and Agriculture Organization. 1, (36- 44).

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GROUND COVER VEGETATION DEVELOPMENT IN *HYLOCOMIOSA* FOREST SITE TYPE AFTER THE CLEARCUT

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ABSTRACT

Most of the ground cover vegetation descriptions given for characteristic of certain forest site types are made for mature forest stands. However the site type estimation for the practical forest inventory needs knowledge about the vegetation in every age class of forest. The clearcut as an artificial forest disturbance causes dramatically changes in plant community. Especially fast changes proceed during the first years after the clearcut. Due to increase of temperature and nutrient availability there proceeds several processes causing significant changes in ground cover vegetation. In 2015 a research was started to clarify the changes in ground cover vegetation in *Hylocomiosa* forest site type. This forest site type is most abundant in Latvian forests taking around 22%. The dominant tree species in *Hylocomiosa* is Scots pine (*Pinus sylvestris* L.) although the silver birch (*Betula pendula* Roth), Norway spruce (Picea abies (L.) Karsten) and aspen (*Populus tremula* L.) can form a tree stand there. The chronosequence method was used by providing the inventory at 5 tree stands dominated by pine. Six sample plots at each forest stand with size of 10 m^2 were established. The point-square method by using of 1mm thick and 1m high metallic needle was used for registration of plants at each square of sample plot. The inventory showed significant changes of species composition and projective cover of moss species and caulescent plants. The results of calculation of the Ellenberg's ecological values and Tschekanovsky coefficient suggest of appearance of plants with another attitude to the ecological factors.

Keywords: *forest typology, ground cover vegetation, hylocomiosa forest site type, clearcut.*

INTRODUCTION

Forest site type merges similar growth conditions and describes how to recognize them. Latvian forest site type descriptions are obtained for age of pre-mature and mature forest stand (Buss, 1981). However, till up to now, there is little knowledge about the ground cover vegetation succession during all the forest rotation cycle.

The forest typology in Latvia started in the beginning of 20^{th} century when I. Gutorovics for the first time defined forest site types in Latvian according to the specific growth conditions and the tree stand parameters (Sarma, 1954). In 1920 K. Melderis established grounds of Latvian forest typology and during the time several forest scientists (Kirsteins, 1926; Sarma, 1954; Buss, 1976) upgraded descriptions of forest site types which included biological and silvicultural information for various forestry actions in forest. K. Buss (1981) summarized forest typology information available in Latvia that forestry field is using even in nowadays. In Latvia is used complexed or ecosystematic forest site type classification where description is consistently coordinated demands of forest biology, ecology and silviculture (Liepa *et al*, 2014).

The present research aim is to estimate the succession of ground cover vegetation in *Hylocomiosa* forest site type with Scots pine (*Pinus sylvestris* L.) as a dominant tree species which is one of advisable tree species growing in this forest site type (Liepa *et al*, 2014). This forest type is called *Pinetum hylocomiosum* (Sarma, 1954) which is forest site type on dry mineral soil with well-aerated medium fertile sandy loam, loamy and clay soil. The texture class depends of soil parent material, geographical location and hydrological regime (Buss, 1981).

MATERIALS AND METHODS

To clarify this scientific question was the *chronosequence method* used which assumes that different sites are similar except in age (Johnson and Miyanishi, 2007), when the forest stands of the same forest site type and dominant tree species at different ages in different places are taken. For the beginning we took forest stands of the first 5 years after the clearcut. Six sample plots with size of 10 m^2 per each forest stand (see Fig. 1) – clearcut were established in indicative – hillock, plain and decline places.

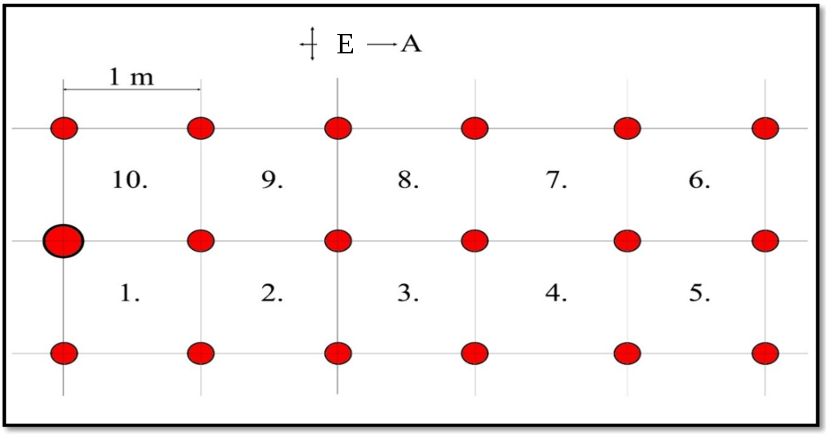

Figure 1. Structure scheme of sample plot.

Both, the Brown-Blanquet (Wikum and Shanholtzer, 1978) and the point-square methods by accounting of ground cover plants were used. Species with coverage of 2 % or smaller are counted together in section "Other". Twenty sticks of 1 mm thick metallic needle were made in each square to estimate the taxonomic structure and abundance of plant species.

The ecological values of Ellenberg (Ellenberg, 2009) were used to describe the environmental status of each site. The coefficient of Tschekanovsky was used to estimate the difference between plant communities in forest young growths of different age. The forest site type investigated was the *Hylocomiosa* site type with Scots pine (*Pinus sylvestris* L.) as a dominant tree species. This forest site type is dominant in forests of Latvia, taking 20% of total forest area (State Forest Service, 2015).

RESULTS AND DISCUSSION

The results suggest considerable changes in taxonomic structure and abundance of ground cover plants in first years after the clearcut (see Figure 2. – 4.). Visual differences are visible in Fig. 2.

Figure 2. *Pinetum hylocomiosum* mature stand (a), first year after the clearcut (b) and pine young growth 5 years after the clearcut.

During the first two years after the cutting the average height of ground cover plants reduces by 3.25 cm. Later the height of ground cover vertical structure increases. In five years old clearing it is 8.25 cm bigger than in stand before cutting. There are registered changes in vascular plants, mosses, lichens and trees projective covering's proportion.

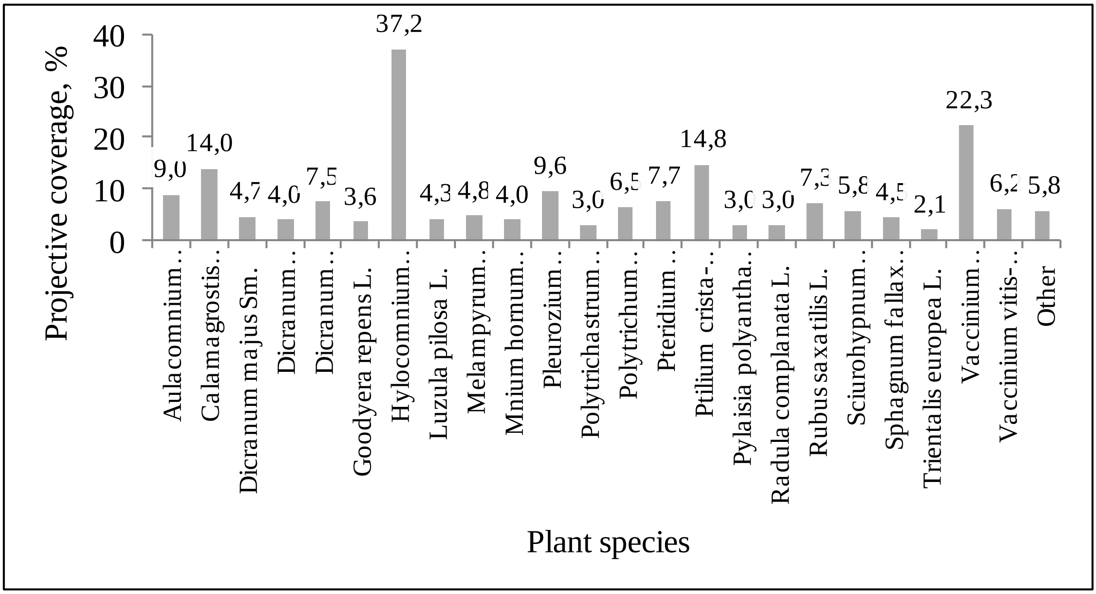

Figure 3. Projective cover of plants in mature *Pinetum hylocomiosum* forest stand before the cutting.

Moses in mature pine stand are most often encountering species (see Fig. 3). From all ground cover and regrowth species average projective coverage of one moss species reaches 19.86 %. One tree and vascular plant species projective coverage is equal – 10.35 % and 10.58 % but comparatively small was lichen projective coverage of one species.

During forest felling used heavy machinery decrease coverage of understory trees, shrubs and larger vascular plants but instead increases sun-demanding plants, also moss and lichen coverage. The splendid feather moss (*Hylocomium splendens* Hedw.) one year after clear cut stays with largest projective covering (see Fig.4). Other *Hylocomiosa* forest site type ground cover plant species are observed but in different proportion comparing to mature pine stand. Projective coverage proportion after both registering methods increased for red-stemmed feathermoss (*Pleurozium schreberi* Brind.Mitt.), wood cow-wheat (*Melampyrum nemorosum* L.) and reed grass (*Calamagrostis arundinacea* L.) but using point-square method also notable projective coverage gained Pellucid four-tooth moss (*Tetraphis pellucida* Hedw.), bilberry (*Vaccinium myrtillus* L.), common wood sorrel (*Oxalis acetosella* L.), rare spring-sedge (*Carex ericetorum* Pollich.), European goldenrod (*Solidago virgaurea* L.), sweet vernal-grass (*Anthoxanthum odoratum* L.), toothed plagiomnium moss (*Plagiomnium cuspidatum* Hedw.) and cypress-leaved plait-moss (*Hypnum cupressiforme* Hedw.). Count of species with projective coverage under 2% decreased one year after clear cut was made.

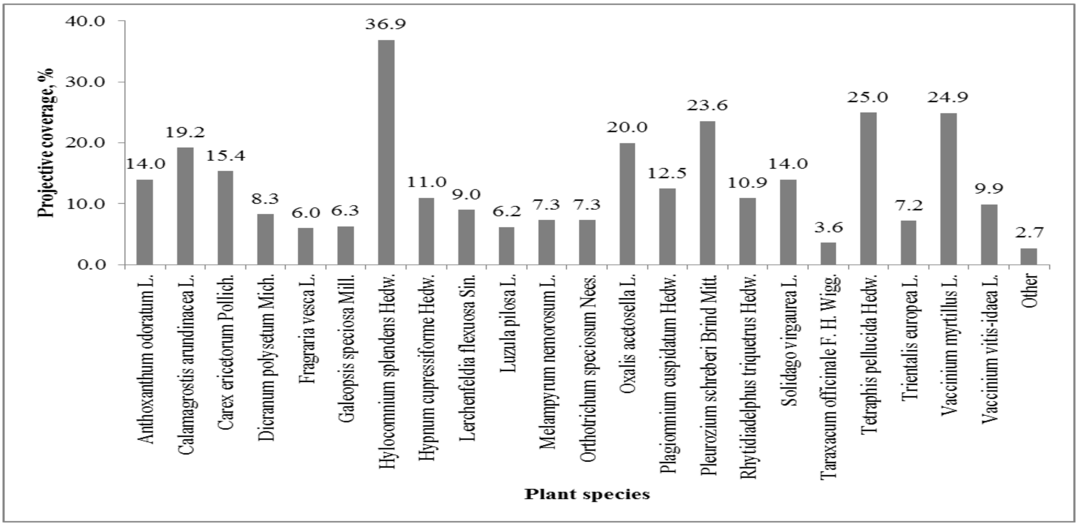

Figure 4. Projective cover of plants in *Pinetum hylocomiosum* in first year after the clearcut.

Five years after clearcut species count has raised and raspberry (*Rubus idaeus* L.) has the largest projective coverage but more than 10 % projective coverage has sheep's sorrel (*Rumex acetosella* L.), large-flowered hemp-nettle (*Galeopsis speciosa* Mill.), oval sedge (*Carex leporina* L.) and also common cow-wheat (*Melampyrum pratense* L.), small tufted-sedge (*Carex cespitosa* L.), un hairy wood-rush (*Luzula pilosa* L.). As ground cover plants get taller and form larger groups (see Fig. 1c) and needle touching point also raises, then increases average vertical height of registered vegetation.

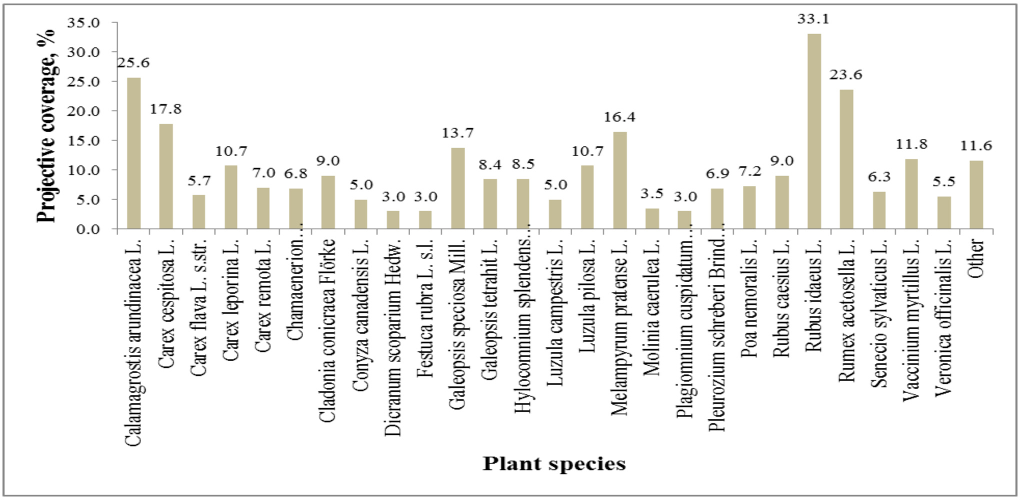

Figure 5. Projective cover of plants in a 5 years old *Pinetum hylocomiosum* young growth area.

Pykälä (2004) in South–West Finland established that the total and mean numbers of vascular plant species were almost double in clear-cut areas compared to mature forests. The biological diversity of species in this research compared to mature stand also is increasing: four species using point-square method and 17 species using Braun – Blanquet method appear as growth conditions improved and growth space increased. Shannon – Wiener index's values show that ground vegetation biological diversity has increased after the clear cut: H(s) in mature stand = 2.912, but in five years old clearing H(s) = 3.202. Ellenberg's ecological indicator values (Ellenberg, 1991) as light and nitrogen are also increasing: nitrogen value has increased the most - by 2.62 units (Fig. 6).

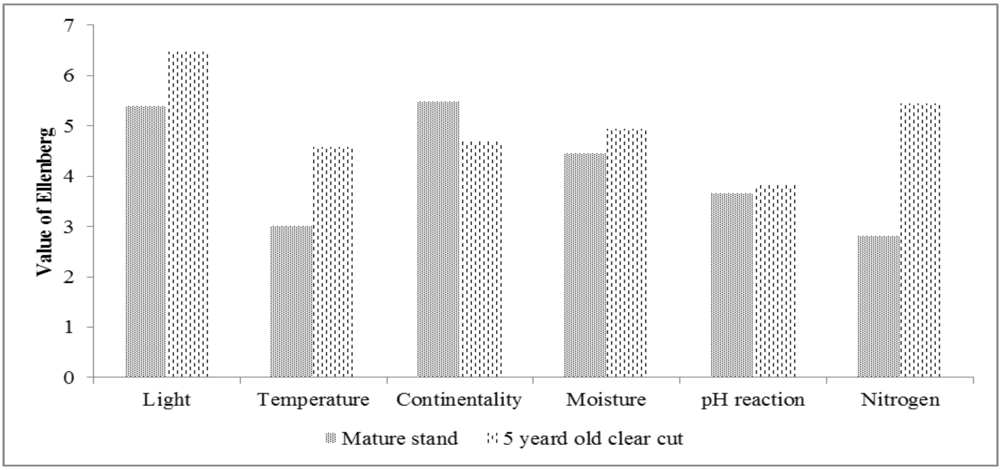

Figure 6. Ecological values of Ellenberg in a mature *Pinetum hylocomiosum* forest stand before and 5 years after the cutting

The most significant changes in individual species occurrence are between the second and third year's and Tschekanovsky coefficient value (0.19) is confirming that. Five years after clear cut ground vegetation has changed seriously: the Tschekanovsky's coefficient between the mature stand and five years old clearing is 0.18.

CONCLUSIONS

After performing the clearcut there are significant changes in abundance of species of ground cover plants and in vertical structure of plant community. Till the second year after the cutting the total coverage of plants reduces. The most abundant are mosses. During the third year after clear cut there proceeds a rapid increase of weeds and decrease of mosses. The total species richness increases.

In the 4th and 5th year after the clearcut there increase the projective cover of *Monocotyledonae* plants (families *Graminaea* and *Cyperaceae*) forming higher vertical structure and overtaking the dominance from another groups. The dominance of this group reduces by development of young tree stand.

The results obtained and further research will be valuable supplement for practical forest inventory describing the characteristic ground cover vegetation in *Hylocomiosa* forest site type not only in mature forest age but during all forest rotation cycle.

REFERENCES

Buss K. (1976). Latvijas PSR meza tipologijas pamati (Forest typology base of Latvian SSR). Riga: LRZTIPI. (in Latvian)

Buss K. (1981). Meza ekologija un tipologija (Forest ecology and typology). Riga, Zinātne. (in Latvian)

Ellenberg H. H. (2009). Vegetation Ecology of Central Europe. 4th Edition. Cambridge: Cambridge University Press.

Ellenberg H. H., Weber E., Düll R., Wirth V., Werner W., Paulißen. (1991). Indicator values of plants in Central Europe. Göttingen: Erich Goltze KG.

Johnson E. A., Miyanishi K. (2007). Plant disturbance ecology: the process and the response. Elsevier/AP.

Kirsteins K. (1926). Tipologiskas mezaudzu klasifikacijas izveidosanas un pielietosanas prakse (Formation and practical usage of typological forest stand classification). Mezsaimniecibas rakstu krajums, 4. sej. pp. 3-16. (in Latvian)

Liepa I., Miezite O., Luguza S., Sulcs V., Straupe I., Indriksons A., Dreimanis A., Saveljevs A., Dubrovskis D. (2014). Meza tipologija (Forest typology). Jelgava: Studentu biedriba “Salkone”. pp. 5 – 65. (in Latvian)

Pykälä J. (2004). Immediate Increase in Plant Species Richness after Clear-Cutting of Boreal Herb-Rich Forests. Applied Vegetation Science, 7(1), 29-34. Retrieved from http://www.jstor.org/stable/1478964

Sarma P. (1954). Latvijas PSR meza tipi (Forest types of Latvian PSR). Riga: Latvijas Valsts izdevnieciba. (in Latvian)

State Forest Service. (2015). Meza statistika (Forest statistics). Retrieved August 21, 2016, from http://www.vmd.gov.lv/valsts-meza-dienests/statiskas-lapas/publikacijas-un-statistika/meza-statistikas-cd?nid=1809#jump. (in Latvian)

Wikum D. A., Shanholtzer G. F. (1978). Application of the Braun-Blanquet cover-abundance scale for vegetation analysis in land development studies. Environmental Management, 2(4), 323–329.

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VALUE NETWORK OF THE PERSIAN LIME IN MEXICO

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ABSTRACT

Mexico produces the three most important types of lime: Mexican, Persian, and Italian. Persian lime (*Citrus latifolia*) is the second most important in planted area. Forty-six percent of the production is intended for export. The objective of this research was to analyze the Persian lime value network of the packing and exporting companies. It was conducted at the main Persian lime producing area, located in the central coastal region of the Gulf of Mexico. As an average, the sampled companies were using 55% of their packing capacity. Most of them (83%) work all year long. They have been from 6 to 15 years in operation. They employed a mean of 41 people, thus they are medium-size enterprises. Fourteen actors were complementing their business in production and marketing. The relationship between packers and the small lime producing farmers was very inequitable. Low prices were common for Persian lime producers.The fruits they were packing came mainly from local producers (90%).Their main export destinations were: United States, Europe, Canada, and Japan. Other regions are increasing Persian lime production, threatening the marketing of the farmers of the central coast of the Gulf of Mexico.

Keywords: *Citrus latifolia, citrus, packing companies.*

INTRODUCTION

Mexico has the soils and climate to produce the three most important types of lime: Mexican, Persian, and Italian. Mexican lime(*Citrus aurantifolia*) is the most important in area and production (SIAP, 2014). It is used in fresh, and to extract pectin and essential oils for foreign markets.

Persian lime (*Citrus latifolia*) is the second most important in planted area.It was introduced in 1975, but it grew as an important crop in the 1980s years. Over one million tons are produced every year (SIAP, 2014). The coastal plains of the Gulf of Mexico are the largest producing area.Sixty percent of the Persian lime is harvested at their central part.

Mexico is the main producer and exporter of Persian lime (FAOSTAT, 2014). Forty six percent of the production is intended for export. United States is the main destination. Netherlands and Great Britain are other markets. Over 242.5 million U.S. dollars are earned for these sales (SIAVI, 2014).

It is important to study the links between the different stakeholders of a value network. They should promote the increase in productivity, an efficient administration, the rational use of available resources, and the reduction of middle men through the marketing process, among others (García, 2000). The success of a great number of companies around the world has been a strategy of having a relationship with business or organizations that complement their resources and capabilities to deliver to the market an offer of products or services with higher value than their competitors (Rodriguez and Hernandez, 2003).

The objective of this research was to analyze the Persian lime value network of the packing and exporting companies at the central coastal plains of the Gulf of Mexico to identify its key stakeholders.

MATERIALS AND METHODS

The research was conducted at the Martinez de la Torre municipality, in the State of Veracruz,which is located at the coastal plains in the center of the Gulf of Mexico. Six lemon packing facilities were surveyed in the second semester of 2015. The samplewas 15% of the registered companies. They were selected due to their close relationship with the Persian Lime Producing and Exporting Council (Copelp). They were classified according to the size criteria of INEGI (2009), based on the number of permanent workers.

The survey included six parts: a) The general data about the person interviewed, b).The characteristics of the company, c).The suppliers, d).The customers, e). The complementors, and f).The competitors.The owners or general managers of the packing facilities were interviewed.They provided the information requested. It was used to study the relationships and roles of the stakeholders. The Brandenburger and Nalebuff (1997), adapted by Muñoz-Rodríguez(2010) value network approach was used. The stakeholders were identified and diagramed. The governance structure was classified according to Gereffi*et al* (2005).

RESULTS AND DISCUSSION

The lemon packing facilities studied were classified as medium businesses (INEGI, 2009), with 25 to 100 employees. They have been functioning from 6 to 15 years, with 10 years as an average. Some have been working longer, but with different denomination. They use 55% of their capacity.The largest agribusiness belonged to a farmer´s association. It exports its production, mainly to Texas (Table 1).

Table 1. Lemon packing facilities studied

N/P	Name	Years in operation	Partners	Employees	
				Fix	Eventual
1	Cítricos M y Cis	6	-	-	25
2	Prolime, S.A de C.V.	8	30	26	-
3	CítricosCadillo, S.A de C.V.	15	5	100	-
4	Exportadora de cítricos y otros productos del estado de Veracruz, S.A de C.V.	14	-	30	-
5	Citrícola Tropical, S. A.	8	2	30	-
6	CorporativoCitrijal, S.A de C.V.	10	6	35	-

**Source: Interviews with owners or general managers, 2015.*

Most of the Persian lime packed (90%) came from local production. It is available all year round. The rest is from another lime producing areas in Central and Southwest Mexico, it is only needed during limited periods. In a nearby municipality (Cuitlahuac), other packing facilities, for Persian lime exports are established. They are a direct competition to the ones studied.

The relationship between packers and the small lime producing farmers was very inequitable. Low prices were common for Persian lime producers.There were not formal contracts between farmers and packers. The price volatility has limited the interactions.A large proportion of them are small holders who sell their harvest to middle men with the best offer.The middle men acted as purchasing agents for the packers, reducing their transaction costs. They also limit the transfer of informationbetween producers and packers.Thus, their articulation is very low.

Although there has been a differentiation in Persian lime prices by quality, the scarce transfer of information about the requirements of the fruit from packers tofarmers has limited the implementation of crop management practices to improve the quality of the fruit to be packed. It is, the producers have a “basic routine capability." An effort is needed to promote them to “basic innovative capabilities” in order to provide them with the ability to make incremental changes in their processes to improve quality. The support of the packers is needed in this process(Zhenming and Guanghui, 2009). This increment in capabilities is beneficial for both.

In the network governance hierarchy, the agribusinesses acted as lead player, and they were at the core of the network (Figures 1 and 2). The governance structure was a “market” type, because the cost to switching to new partners is low for both parties (Gereffi*et al*.,2005)The other stakeholders identified were the customers (intermediate and final), the suppliers, the complementors, and the competitors according to Brandenburger and Nalebuff (1997) and Muñoz-Rodríguez (2010).

Based on the destination of the production, the Persian Lime Packing facilities were classified in two groups. The first one includes the business selling domestically, and exporting mainly to the United States. In the second one, the limes were only exported to Canada, United States, Europe, Japan, and Korea.

In the first group, two companies were placed, Prolime S.A. de C.V. (Number 2 at the Table 1) and Citricola Tropical S.A. (Number 5 at the Table 1). Their suppliers were mainly producers from the region.They were complemented by farmers from nearby regions of the same state, and only in occasionaltimes; they packed fruit from other states. They exported limes to Texas, United States. Other fruits were sold at the local auction (only for Prolime), and to companies producing juice.

For Prolime, the lime packing facilities of the region acted as complementors, but they were competitors for Citricola Tropical. Other complementor for Prolime was the Ministry of Agriculture (Sagarpa). The governmental organism related with food quality, and safety (Senasica) acted as a complementor for both enterprises. It promoted,verified, and certified the systems to reduce the risks of contamination in the production and packing, such as Good Agricultural Practices (GAP), and Good Manufacturing Practices (GMP; FAO, 2003). They are essential for food safety, and a requirement for exporting. The Persian Lime Producing and Exporting Council (Copelp) acted as complementor only for Citricola Tropical. The lime production from other states acted as competitorfor Prolime (Figure 1).

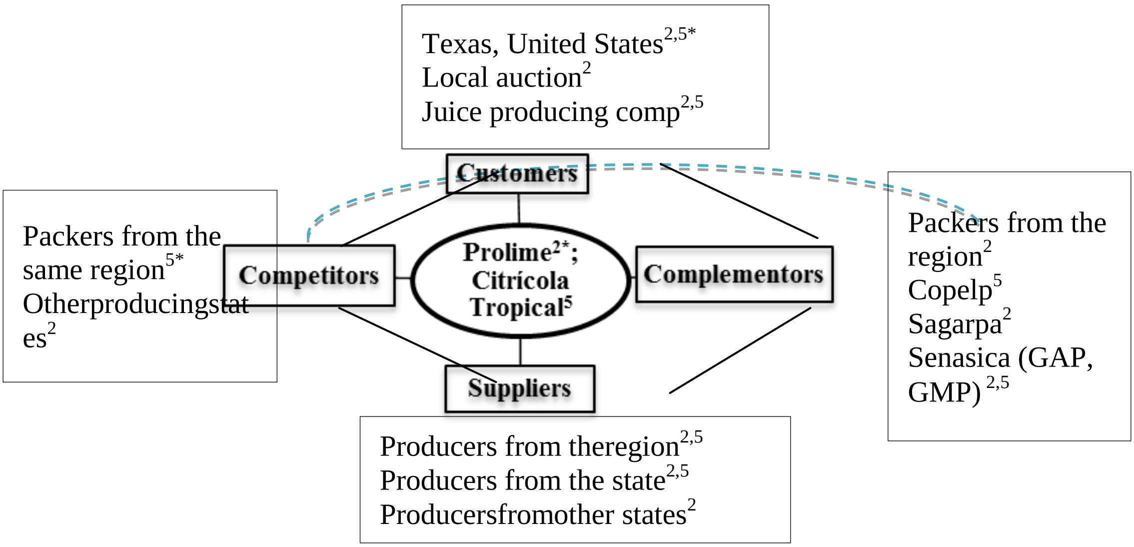

Figure 1. Value network of the Persian lime packing business with domestic and exporting markets.* It refers to the packing facilities listed in Table 1.
**Source: Interviews with owners or general managers and field research, 2015.*

The second group included the other four lime packing facilities: Citricos M y C (M y C, number 1 at the Table 1); CitricosCadillo S.A. de C.V (Cadillo, Number 3 at the Table 1), Exportadora de cítricos y otrosproductos del estado de Veracruz, S.A de C.V.(Exportadora, number 4 at the Table 1), and CorporativoCitrijal, S.A de C.V. (Citrijal, number 6 at the Table 1). Theyonly have as customer, markets from other countries. They exported mainly to Texas (for 1, 3, and 4) and California (for 4, and 6) in the United States. Canada, Europe, and Korea were other important destinations for the fruit forCadillo. Cadillo andExportadorasold fruit to Japan.

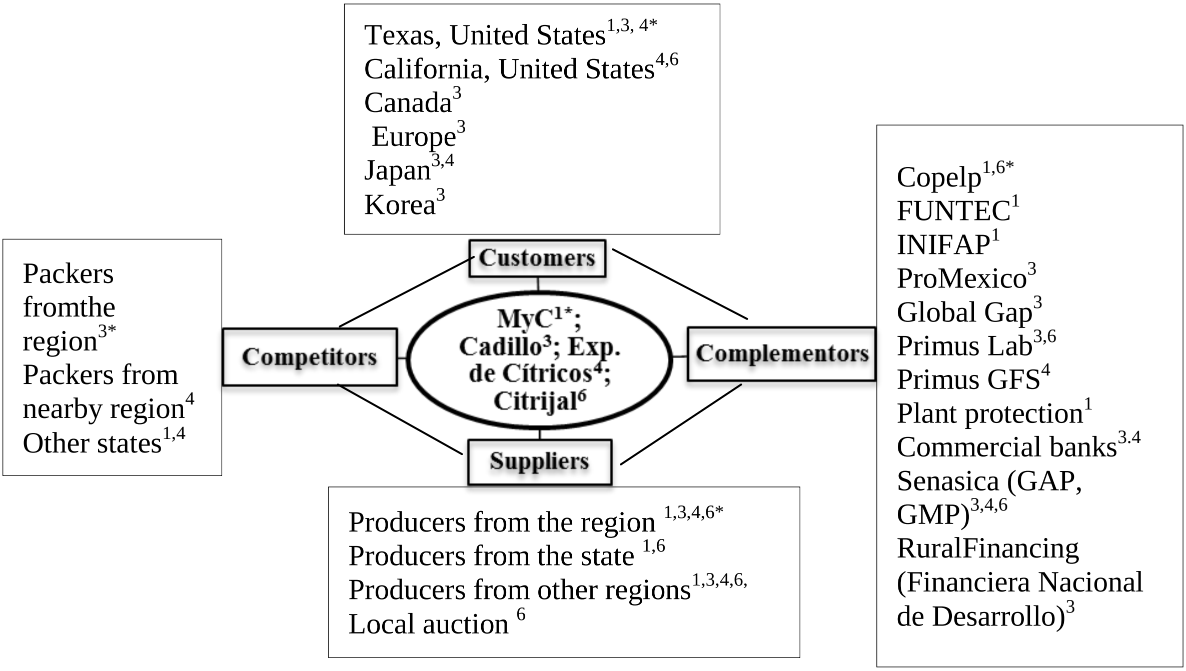

Figure 2. Value network of the Persian lime packing business with only exporting markets* It refers to the Packing facilities listed in Table 1.
**Source: Interviews with owners or general managers and field research, 2015.*

All the companies in the second group had, as suppliers, the producers within the region, and those from other states. M y C, and Citrijal used the farmers from other regions within the state as suppliers too. Citrijal also got fruit from the local auction. Cadillo had the packers from the same region as competitors. The packers from the nearby region acted as competitors for Exportadora. The packers from other states were competitors for M y C, and Exportadora.
Cadillo had the greater number of destinations for exports. Therefore, they need several types of certifications. It used ProMexico, Global Gap, Primus Lab, and Senasica for such purpose. The last one was used by Exportadora and Citrijal too. Primus GFS was the certification agent forExportadora. M y C had FUNTEC, the National Institute for Forestry, Agricultural, and Livestock Research (INIFAP), and the state committee related with Plant Protection (SanidadVegetal) as complementors. The Persian Lime Producing and Exporting Council (Copelp) was complementor for M y C and Citrijal.

Financing is important for several needs ofcompanies. Cadillo used the governmental organization for rural financing (Financiera Nacional de Desarrollo). It and Exportadora used commercial banks for credit.The lack of formal financing of the other packers can limit their business.

The value networks need to increase their articulation through better communication channelsbetween parties. The main emphasis should be the relationship packers-suppliers.Tooffer better conditions to Persian lime producers, a collaborationof the packers is needed to increase the capabilities of their suppliers tobasic innovative ones. This upgrade process is very important in order to compete successfully with companies from other regions, and have a sustainable growth and development.

CONCLUSIONS

Most of the Persian lime packed (90%) at the coastal plains in the center of the Gulf of Mexicocame from local production. The agribusinesses acted as leadplayer of the value network. But the relationship between packers and the small lime producing farmers was very inequitable. It limited the articulation between farmers and packers, and the implementation of crop management practices to improve the quality of the fruit to be packed.

Two types of value networks were identified. One included the business selling domestically, and exporting mainly to the United States. In the other, the limes were only exported to Canada, United States, Europe, Japan, and Korea. It included a greater number of complementors to satisfy the requirements of different markets.

REFERENCES

Brandenburger, A. M. and B. J. Nalebuff (1997).Co-opetition. A Currency Paperback. Doubleday. Kindle Edition. New York.

FAO (2003). Development of a Framework for Good Agricultural Practices. Committee on Agriculture. Seventeenth Session.Food and Agriculture Organization. Rome.

FAOSTAT (2014). http://www.faostat.fao.org (Consulted: October, 2015).

García, L. (2000). The organization of agricultural producers in the framework of the globalization process*(in Spanish)*.RevistaVenezolana de Sociología y Antropología, 10(29), (477–490).

Gereffi, G., J. Humphrey, and T. Sturgeon (2005). The governance of global value chains. Review of International Political Economy 12(1): 78-104.

INEGI (2009). Econimic Census. Micro, small, medium CensosEconómicos. Micro, pequeña, mediana y gran empresa: estratificación de losestablecimientos: CensosEconómicos 2009 / InstitutoNacional de Estadística y Geografía. México: INEGI. 47, 172 p.

Muñoz-Rodríguez, M (2010). Identification of problems and opportunities at the agri-bussinesvalue networks. *In* Aguilar-Ávila, J., J. R. Altamirano-Cárdenas, and R. Rendón-Medel (Coord.), Santoyo-Cortés, V. H. (Ed.) From agricultural extension service to rural innovation networks (*in Spanish)*. CIESTAAM. U.A.Ch. Mexico

Rodríguez, A. andHérnandez, M. (2003). Value creation and competitive advantage of the bussines relationship network *(in spanish)*. Universidad EAFIT, 39(132), (8–22).

SIAP (2014). Agricultural Production Yearbook of Mexico (*in Spanish)*. http://www.siap.gob.mx/aagricola_siap/ientidad/index.jsp (Consulted: November, 2015).

SIAVI (2014). Mexican System of Tariffs Information Website.http://www.economia-snci.gob.mx (Consulted: November, 2015).

Zhenming, S., and Z. Guanghui (2009). Beyond Typologies of Global Value Chain Governance: the Accumulation of Technological Capabilities. International Journal of Business and Management 4 (1): 32-36.

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PERFORMANCE OF SOYBEAN (*Glycine max L.*) INFLUENCED BY DIFFERENT RATES AND SOURCES OF PHOSPHORUS FERTILIZER IN SOUTH-WEST NIGERIA

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ABSTRACT

Low yields of soybean in Nigeria are attributed to many factors such as declining soil fertility and use of low yielding soybean varieties. Phosphorus is a soybean plant growth-limiting nutrient.Therefore, application of phosphorus fertilizer at optimum level is essential. Two experiments were carried out at Ibadan, Nigeria to estimate the optimum P-fertilizer rate for soybean and to investigate the response of soybean to different sources of P fertilizer applied at the optimum rate. The treatments in the first experiment were two soybean varieties (TGX1987-10F and TGX1987-62F) and single superphosphate (SSP) fertilizer applied at five rates: 0kgPha^{-1}, 20kgPha^{-1}, 40kgPha^{-1}, 60kgPha^{-1} and 80kgPha^{-1}. The treatments in the second experiment were: SSP, *Tithonia* compost (TC), poultry manure (PM), TC+PM, SSP+TC, SSP+PM applied at optimum P (40kgPha^{-1})rate obtained from Experiment 1and control. Data collected on morphological parameters, grain yield (GY) and nutrient uptake were subjected to analysis of variance, the means were separated using least significant difference ($p \leq 0.05$). Results showed that TGX1987-62F (1.96Mgha^{-1}) produced significantly higher GY than TGX1987-10F (1.26Mgha^{-1}). Application of SSP at 40kgPha^{-1} produced tallest plants (131.8cm), highest number of leaves/plant (19.0), number of pods/plant (19.4), and GY (2.28Mg/ha) across the two varieties. Highest K-uptake (6.1mgplant^{-1}) and P-uptake (2.6mgplant^{-1}) were obtained in plants treated with TC+SSP and SSP, respectively. The combination of TC and SSP at 40kgPha^{-1} produced highest number of flowers/plant (35.6), pods/plant (38.7) and GY (3.9Mgha^{-1}). A combination of *Tithonia* compost and SSP applied at 40kgPha^{-1} will increase grain yield of soybean in South-West Nigeria.

Key words: *Phosphorus fertilizer, Tithonia compost, SSP, soybean varieties, Nigeria.*

INTRODUCTION

Soybean yields in Nigeria have been found to be low (Makinde*et al*., 2001, Adeyemo*et al*., 2002). This low yield was attributed to many factors which include

declining soil fertility, the use of blanket rate of Phosphorus fertilizer application, low population density and the use of low yielding soybean varieties (IITA, 2000).
Phosphorus (P) is a soybean plant growth-limiting nutrient despite being abundant in soils in both inorganic and organic forms. Phosphorus deficiency can limit nodulation by legumes. However, many soils are phosphorus deficient because the free phosphorus concentration (the form available to plants) even in fertile soils is generally not sufficient (Gyaneshwar et al., 2002; Darryl *et al.,* 2004) Therefore application of phosphorus fertilizer at optimum level is essential. The use of chemical fertilizer is limited mainly by its high cost, long adverse effect when used on soil and environment. Organic inputs generally do not provide sufficient P for optimum crop growth due to their low P concentration (Aulakh*et al*., 2003). However, addition of organic materials as soil amendments has been identified as an alternative approach to application of chemical fertilizers for improved soil fertility and crop productivity in the tropics where most soils are relatively low in fertility. An organic-based fertilizer technology which allows integration of minimum dosage of chemical fertilizer may alleviate the drudgery involved in manure preparation and equally encourage more rapid release of nutrients.
The study was therefore carried out to estimate the optimum P requirement for Soybean production and investigate the response of soybean to different sources of P-fertilizer.

MATERIALS AND METHODS

Two experiments were carried out in the Screen house of the Department of Agronomy, University of Ibadan, Ibadan, Nigeria ($7^0$20’N and $3^0$50’E).

Soil collection

Soil used for the experiment were collected at the depth of 0-15cm from the Teaching and Research Farm at Parry Road, University of Ibadan, Nigeria. The soil used is classified as alfisols according to USDA soil taxonomy classification. Soil collected were air-dried and sieved (2mm and 0.5mm), some portion of the sampled soil was processed in the laboratory to determine the chemical and particle size distribution using the methods described by Udo and Ogunwale (1981).
<u>Experiment 1 - Determination of optimum P application rate for growth and yield of soybean in Ibadan:</u> Treatments in this experiment were: two improved soybean varieties (TGX 1987-10F and TGX 1987-62F) obtained from International Institute of Tropical Agriculture (IITA), Ibadan and single super phosphate (SSP) fertilizer applied at five different rates: 0kgP/ha, 20kgP/ha, 40kgP/ha, 60kgP/ha and 80kgP/ha. The experiment was a 2 x 5 factorial with the two soybean varieties and five application rates laid out in a Completely Randomized Design (CRD) and replicated five times. The experiment was carried out in pots. 10kg soil collected from Teaching and Research Farm, University of Ibadan was weighed to fill each planting pots. The soil was watered to 60% field capacity before planting; three (3) seeds were sown per pot and thinned to one (1).

Experiment 2 - Examining the response of soybean (TGX 1987-62F) to different fertilizer sources at optimum P-rate: The experiment was laid out in a Completely Randomized Design (CRD) with four replicates. The treatments used (at optimum rate of 40kgPha^{-1} obtained from experiment 1) were: SSP, *Tithonia*compost, Poultry manure, *Tithonia* compost plus Poultry manure, SSP plus *Tithonia*compost, SSP plus Poultry manure and Control (no fertilizer). Each treatment was applied to seven (7) pots to give a total of 49 experimental units per replicate and 196 pots in all. Each pots were filled with 10kg sieved soil and watered to 60% field capacity followed by the application of corresponding treatments which was allowed to mineralized for two weeks before the seeds were sowed at three (3) per pot and later thinned to one (1) plant per pot at two weeks after planting.

Data collection

Data were taken on plant height (cm), yield components which include: Number of pods/plant, pod length/plant (cm), pod weight/plant (g), number of seeds/pod, weight of 100 seeds (g) and on grain yield in both experiments.

Data Analysis

Data collected were subjected to statistical analysis using GENSTAT and the treatments means were separated using Least Significant Difference (LSD) at 5% significance of probability.

RESULTS AND DISCUSSION

Influence of Phosphorus (P) rates on morphological and yield parameters of two soybean varieties grown in Ibadan in shown in Table 1. TGX 1987-62F had taller plants (114.6cm), greater number of leaves per plant (18.6cm), more pods per plant (14.08) and grain yield (1.96Mg/ha) than TGX 1987-10F at $p<0.05$. Among P-rates, highest plant height was obtained at 40kgPha^{-1}(131.8cm) significantly higher than values obtained at other rates ($p<0.05$). A similar trend was also observed for number of leaves per plant and number of pods per plant. Highest grain yield was obtained at 40kgPha^{-1}(2.28Mgha-1), significantly higher ($p<0.05$) than grain yield obtained for all other P-rates. Significant variety by P-rates interaction with respect to plant height, leaves per plant and pods per plant indicating that the varieties differed in their response pattern to P. 40kgPha^{-1} was revealed in Experiment 1 to be the optimum rate for soybean production.This results contrast with previous reports by Aulakh et al., 2003: the authors reported that increase in grain yield due to direct application of P to soybean was consistent with increasing rates up to 80kgP_2O_5ha^{-1}. However, Kamara et al., 2008recommended 40kgPha^{-1}for soybean production. TGX1987-62F performed better than TG 1987-10F with regards to all parameters measured and treatments applied. This could be attributed to genetic variability between the two varieties which necessitated its use for Experiment 2.
Table 2 shows the effects of various sources of P at40kgha^{-1} on grain yield and yield parameters of soybean. TC+SSP produced highest number flowers per plant (35.6) significantly higher ($p<0.05$) than number of flowers per plants obtained

from control (16.1), TC+PM (26.3) and PM+SSP (27.5). Highest number of pods per plant (38.7) and highest value for 100 seed weight (10.6g) were also observed in plots that received 40kgPha^{-1} from a combination of TC+SSP. Highest grain yield and dry matter yield were also produced by TC+SSP combination (3.9Mgha-1; 12.5g/pot) though comparable to values obtained at other treatments except the control (1.30Mgha-1; 9.2g/pot)*Tithonia* compost has been reported to produce a nutrient–rich biomass which improves the yield of annual crops. Adediran*et al*., 2003 had earlier reported results that indicate that addition of organic materials as soil amendments as an alternative approach to application of chemical fertilizers for improved soil fertility and crop productivity in the tropics where most soils are relatively low in fertility. In developing countries such as Nigeria, the use of chemical fertilizer is limited by its high cost and long term degradation of the soil and environment. Organic fertilizer although cheaper, may not provide sufficient nutrient in quantityrequired for optimum yield of crops. A combination of both organic and inorganic fertilizers ensures that the physical, chemical and biological requirements of the soil are supplied for the optimum growth and yield of soybean. The results obtained in this study is attributed probably to other nutrient content of*Tithonia*compostand high release of P_2O_5 attribute of SSP (Olabode et al., 2004).
Table 3 shows the various sources of P-fertilizer on soybean nutrient uptake at vegetative stage. N-uptake was similar for all fertilizer sources ($p<0.05$). Highest P-uptake was observed in plots treated with SSP (2.6mgplant^{-1}) though not significantly different from P-uptake in plots treated with TC+SSP and PM+SSP. K-uptake was highest in plots treated with TC+SSP(6.10mgplant$^{-1)}$ significantly higher than K-uptake obtained at other P-fertilizer treatments ($p<0.05$).

Table 1. Influence of Phosphorus (P) rates on morphological and yield parameters of two soybean varieties grown in Ibadan, Nigeria

	Morphological and yield parameter				
	Max. Plant height (cm)	Max. No Leaves per plant	Pods per plant	100 seed Weight(g)	Grain yield (Mg/ha)
Variety (V)					
TGX 1987-10F	105.0	13.6	10.24	7.5	1.26
TGX 1987-62F	114.6	18.6	14.08	8.7	1.96
LSD (0.05)	6.01	1.79	1.38	1.7	0.31
P-rates KgPha^{-1}(P)					
0	98.3	15.4	8.8	6.4	0.72
20	99.3	16.9	9.9	7.9	1.51
40	131.8	19.0	19.4	10.7	2.28
60	109.8	12.7	11.1	7.8	1.68
80	104.9	16.8	11.6	7.7	1.55
LSD (0.05)	9.6	2.78	2.35	ns	0.49
V x P	*	*	*	ns	ns

V x P-rate: Varieties by P-rates interactions*: significant at ($p \leq 0.05$), ns: not significant. LSD: least significant difference. Max: maximum.

Table 2. Effects of various sources of P at optimum rate (40kgPha^{-1}) on grain yield and yield components of Soybean grown in Ibadan, Nigeria

P-Sources (40kgha^{-1})	Flowers per plant	Pods per plant	100 seed weight (g)	Dry matter yield (g/plant)	Grain yield (Mg/ha)
Control	16.1	23.7	6.6	9.2	1.30
Single superphosphate	31.1	30.7	10.3	10.4	3.20
*Tithonia*compost	30.0	27.7	8.8	10.7	3.06
Poultry manure	30.5	28.0	7.8	12.2	2.79
Tithonia compost + Poultry manure	26.3	36.0	7.9	12.1	2.37
*Tithonia*compost + SingleSuperphosphate	35.6	38.7	10.6	12.5	3.90
Poultry manure +Single superphosphate	27.5	35.0	8.3	11.7	2.48
LSD (0.05)	6.45	7.6	1.14	1.0	1.02

LSD: least significant difference.

Table 3. Influence of various sources of optimum P on nutrient uptake of Soybean

	Nutrient Uptake (mg/plant) at vegetative stage		
P-sources at 40kgPha^{-1}	N	P	K
Control	2.30	1.10	2.90
Single superphosphate	2.50	2.60	4.40
Tithonia compost	2.50	1.90	3.50
Poultry manure	2.70	1.80	4.20
Tithonia compost + Poultry manure	2.50	1.60	4.00
Tithonia compost + SingleSuperphosphate	2.60	2.50	6.10
Poultry manure +Single superphosphate	2.70	2.20	4.50
LSD (0.05)	ns	0.62	1.30

ns: not significant; LSD: least significant difference

CONCLUSION

Results of the present investigation with soybean influenced by different rates and sources of P- fertilizer in south-western Nigeria have shown that monoculture of soybean require 40kgPha^{-1}, higher P-fertilizer rates produced no significant increase in grain yield and related parameters of soybean. This study provides evidence that a combination of organic and inorganic fertilizers produced significantly higher dry matter and grain yield in soybean.*Tithonia*compost combined with SSP applied at 40kgPha^{-1} will increase the yield of soybean (*Glycine max*) in South west Nigeria.

REFERENCES

Adediran J.A, Taiwo L.B, Solubo R.A (2003). Organic wastes and their effect on tomato (*Lycorpersicumesculentus*) yield. Afr. Soil 33: 99-116.

Adeyemo M.O, Bello L.L. (2002). The effects of plant density on the growth, reproductive efficiency and seed yield of a determinate tropical soybean. Trop Oilseeds Journal 7: 42-52.

Aulakh, MS, Pasricha NS, Bahl GS (2003). Phosphorus fertilizer response in an irrigated soybean-wheat production system on a subtropical, semiarid soil.Field Crops Res., 80: 99–1 09.

Darryl, W., Dahl, J., Jacobs, L. and Laboski, C. (2004).Nutrient Recommendation for Field Crops.Extention Bulletin E2904. Michigan State Univ. 32pp.

Gyaneshwar P, Kumar GN, Parekh LJ, Poole PS (2002). Role of soil microorganisms in improving P nutrition of plants. Plant Soil 245: 83–93.

International Institute of Tropical Agriculture (2000). *Annual Report*, IITA, Ibadan, Nigeria.Pp.6.

Kamara, A.Y., Kwari J.D., Ekeleme, F., Omoigui, L.O., Abaidoo, R. (2008). Effect of Phosphorus application and soybean cultivar on grain and dry matter yield of subsequent maize in the tropical savannah of North-eastern Nigeria. African Journal of Biotechnology 7:2593-2599

Makinde E.A, Agboola A.A. (2001). Effects of fertilizer type and soybean residue Incorporation on the performance and yield of cassava – soybean intercrop. Tropical Oil seeds Journal,32-40.

Olabode, O.S., Sola, O., Akanbi, W.B. ,Adesina, G.O. and Babajide, P.A. (2007). Evaluation of *Tithoniadiversifolia*(Hemsl).A Gray for Soil Improvement. World Journal of Agriculture Sciences 3 (4): 503-507.

Udo E. J., Ogunwale, J. A. (1981). *Laboratory manual for the analysis of soil, plant and water samples*. Ibadan, Nigeria: Department of Agronomy, University of Ibadan, Nigeria.

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MILK PRICES IN THE EUROPEAN UNION BY 2025 AND PROJECTION OF THE PROFITABILITY OF MILK PRODUCTION IN POLAND IN 2020

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ABSTRACT

In Europe, more than 70% of milk production falls on the European Union countries. Among the largest milk producers in the EU, Poland ranks fourth. The abolition of quotas for milk production and increase in supply to the market contributed to the decline in milk prices. The aim of the study is to determine the impact of the rate of change in prices of agricultural inputs and changes in milk yield of cows and milk prices on the profitability of milk production in Poland projected for 2020. The sample consisted of 169 farms which in 2014-2015 kept an average of 27 cows. In 2015, the index of the profitability of milk production amounted to 130.7%, and in comparison to 2014 it decreased by 18.4 percentage point. The results projection for 2020 show an improvement in milk yield of cows (by 12.4%) and milk prices (by 15.4%). Stronger growth in the revenues (by 29.1%) than the cost of keeping cows (by 15.5%) will stimulate the improvement of economic results. The index of the profitability of milk production will increase by 15.4 percentage points, and income per cow by 73.3%. This means that it will be at a level similar to 2014. Research shows that fluctuations in selling prices of milk are possible (+/-8.7%). Despite this, the milk production will continue to be profitable. Results of this study are consistent with the projection of the European Commission, which provides for an increase in milk prices and milk production in the EU.

Keywords: *milk production, prices of milk, profitability of milk in 2020, Poland.*

INTRODUCTION

In Poland, the largest share in the commodity structure of agricultural production is held by cow's milk, in 2014 it amounted to 18.8%, while the share of milk in livestock commodity production amounted to 31.7% (Central Statistical Office, 2015). For many agriculturalholdings, it is the most important source of income. Regular income from milk sales is of great importance in order to maintain financial liquidity of the holding. In Poland, for many years, we have been observing the processes of concentration and intensification of milk production. The number of cow rearing holdings and of cowsthemselves is decreasing and increase in milk production is related to an increase in the milk productivity of cows. However, if dairy holdingsare to continue to develop, actions must be conducted taking into account the specificity of milk production, i.e. high capital- and labour-intensity of production. Resources (e.g. long-term low interest loans) should be allocated for the construction or modernisation of livestock buildings, helping increase the scale of production and make work less difficult. The method of calculating direct payments per hectare of agricultural land, almost regardless of the type of production conducted, maylead to a situation where farmers abandontime-consuming milk production (Parzonko, 2010). According to Ziętara (2002), the profitability of milk production is one of the more complex issues in the economics of agricultural holdings. The reason is the close links between dairy cattle breeding and plant production. To conduct it, the specific size of the holding is required, so are appropriate equipment, extensive knowledge and commitment of the farmer. The functioning of the milk market until 30 March 2015 was subject to regulation of the EU common agricultural policy instruments. Milk quotas were a factor shaping the supply,demand and prices of milk. The abolition of the milk production limits and, consequently, an increase in its supply, contributed to a decline in prices of milk. In the European Union (EU), in December 2015, the average price of milk was EUR 30.47/100 kg and when compared to December 2014 it was lower by 7.9%, and to December 2013 – by 24.2%. On the other hand,the price of milk in Poland in December 2015 was EUR 27.39/100 kg, and when compared to December 2014 it decreased by 8.6%, and to December 2013 – by 26.3% (European Commission, 2016a).

The objective of the studies is to determine how the profitability of milk production in Poland is affected by the rate of change in prices of means of agricultural production, as forecast in the perspective of 2020, and changes in milk yield of cows and prices of milk. The results were presented against a background of changes forecast by 2025 by the European Commission.

MATERIALS AND METHODS

The studies made use of the actual data characterising the activity of livestock production – dairy cows. Those data have been collected and processed according to the rules of the AGROKOSZTY system;the Polish FADN (Farm Accountancy Data Network)database has also been used. The study sample was made of 169 holdings which in 2014 kept dairy cows. Those holdings have been selected by means of purposive sampling from the Polish FADN sample. The empirical data from 2014 were revalued to 2015 in accordance with the change in milk yield and the change in prices of the individual components of the production value and direct and indirect costs. The change indicators applied in revaluations have been calculated using the public statistics data. The results of milk production in 2015 have been adopted as a starting point for drawing up a projection of the profitability of milk production in 2020. The year 2015 has been selected due to a significant decline in the prices of milk (mainly due to the abolition of milk quotas). The structure of the projection is based on extrapolating the selected time series into the future (Skarżyńska, 2014).To each variable describing revenues and costs of milk production the corresponding times series, along with the public statistics data, have been assigned. Those data covered the period from 1995 to 2015. In order to model the created series and to project their value, the classic trend models have been applied. The trendhas been extracted using the analytical method, i.e. by finding a trend function f(t) (t means time), which best describes the change in the phenomenon over time (Wasilewska, 2011). This approach assumes that the level of the analysed phenomenon is a function of time, and the effect of various factors affecting its coursehas been included in the changes observed over time. The selection of the analytical form of the trend function has been made using a heuristic method. It consists in finding several forms of this function and then selecting one of them according to the criterion applied (Stańko, 1999). Seven functions have been analysed: linear, second degree polynomial (quadratic), exponential, power, logarithmic, hyperbolic and linear-hyperbolic. The trend models created had the following form:

$Y_t = \beta_0 + \beta_1 t + \varepsilon_t$ – linear trend model,

$Y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \varepsilon_t$ – quadratic (second degree polynomial) trend model,

$Y_t = \beta_0 e^{\beta_1 t} \cdot \varepsilon_t$ – exponential trend model,

$Y_t = \beta_0 (t+2)^{\beta_1} \cdot \varepsilon_t$ – power trend model,

$Y_t = \beta_0 + \beta_1 \ln(t+2) + \varepsilon_t$ – logarithmic trend model,

$Y_t = \beta_0 + \beta_1 \frac{1}{t+2} + \varepsilon_t$ – hyperbolic trend model,

$Y_t = \beta_0 + \beta_1 t + \beta_2 \frac{1}{t+2} + \varepsilon_t$ – linear-hyperbolic trend model,

where:

Y_t – value of the endogenous variable in time*t*,

t – exogenous variable (time), takes integer values from *1*to *n*,

β_0 – absolute term,

β_1, β_2 – slope coefficients of the function,

ε_t – random component.

The parameters of all models have been estimated using the classic method of least squares. For each analysed time series, one trend function has been selected. The selection was made based on the amount of the R^2coefficient of determination and knowledge about the development of the analysed phenomenon over time. The models, in which the parameters were statistically insignificant, have been rejected[1]. On the basis of the selected models, the individual variables have been extrapolated to 2020. In this way, the projection of the economic results of milk production under the average production and price conditions, i.e. arising from the trend, has been obtained. Among the factors determining the profitability of milk production, the milk yield of cows and milk production costs are subject to relatively small changes. The much greater variability is characteristic of the selling price of milk. The variability of the price of milk has beendetermined on the basis of the

[1] The significance of the parameters has been tested using the t-student test, at the significance level of 0.05.

Central Statistical Officedata from the years 1998-2015 using the created trend models. The calculations have been made using the following formula:

$$V = \frac{\sqrt{n^{-1}\sum(Y-\hat{Y})^2}}{\bar{Y}}$$

where:

V – variability of the studied variable,

Y – empirical values of the variable,

$\hat{Y}$ – theoretical values of the variable, resulting from the model,

$\bar{Y}$ – arithmetic mean of the value of the variable,

n – number of observations.

Given the variability of the price of milk, two variants of the projection of the economic results for milk production in 2020 have been drawn up, i.e. with favourableprice conditions of milk (variant A) and with unfavourable conditions (variant B).

RESULTS AND DISCUSSION

Production and prices of cow's milk in the EU – projection by 2025

In Europe, more than 70% of milk production are attributable to the countries of the EU, which when treated as the single market becomes a world leader in milk production (Olszewska, 2015). In 2014, cow's milk production in the EU amounted to 159.6 million tonnes, of which milk produced in the EU-15 countries[2] accounted for 82% of, and in the EU-N13 countries[3]–18%. The largest producers of milk in the EU include Germany, France, Great Britain, Poland, the Netherlands and Italy. Poland is ranked fourth in the EU production of cow's milk, with the share of more than 8% (for comparison, Germany's share is around 20%). The volume of milk production in the EU is very diversified, there are many countries in which it does not exceed 1 million tonnes and others such as e.g. France or Germany, where annual production is about 31 and 25 million tonnes, respectively. In the EU, therefore, only a few countries with a high production potential have a decisive impact on the market situation(European Commission, 2016).

From the data contained in Table 1 it results that by 2025 the EU analysts foresee a systematic increase in milk production, when compared to 2015, on average in the EU by 7.8% (in the EU-15 by 9.0%, while in the EU-N13 by 3.1%). Milk production is a function of two variables – the number of cows and milk yield of cows. The European Commission data indicate that the number of cows in the EU has been decreasing for several years and in 2025 – when compared to 2015 – it will be lower by about 8%, i.e. by 1.8 million head (European Commission, 2016b).Thus, an increase in milk production will take place only due to the milk yield of cows higher

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[2] EU 15 – the countries forming the EU before the accession of the new members in 2004, they are: Austria, Belgium, Denmark, Finland, France, Greece, Spain, the Netherlands, Ireland, Luxembourg, Germany, Portugal, Sweden, Great Britain, Italy.

[3] EU-N13 – the countries which joined the EU after 2004, they are: Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Lithuania, Latvia, Malta, Poland, Romania, Slovakia, Slovenia, Hungary.

by 17.6% (in the EU-15 by 14.5%, while in the EU-N13 by 28.5%). On average in the EU, in 2015, when compared to 2014, the price of milk decreased by 18.3% (table 1). It is anticipated, however, that in the next few years, the price of milk will slowly rise. In 2025, it may only insignificantly exceed the level from 2014 (by 0.5%), but when compared to 2015 it may be higher by about 23%. The prices of milk vary among the EU countries. In 2014, the highest monthly prices of milk wererecorded in Cyprus, Malta, Finland, Greece, Sweden, Great Britain, Austria, the Netherlands, Denmark, Ireland, Italy and Germany. On the other hand, the relatively low prices were in Lithuania, Latvia, Romania, Estonia and Poland (European Commission, 2016a).

Table 1. Supply and prices of cows' milk in the EU in 2014-2015 and projection to 2025

Specification	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Total cows' milk production, million t	**159.6**	**161.3**	**162.7**	**163.9**	**165.1**	**166.3**	**167.5**	**168.8**	**170.0**	**171.3**	**172.6**	**173.9**
of which EU-15	130.8	132.2	133.5	134.7	135.8	136.9	138.1	139.3	140.5	141.6	142.8	144.1
of which EU-N13	28.8	29.0	29.2	29.2	29.3	29.3	29.4	29.5	29.6	29.7	29.8	29.9
Milk yield, kg/cow	**6732**	**6806**	**6919**	**7033**	**7149**	**7265**	**7383**	**7504**	**7626**	**7749**	**7874**	**8001**
of which EU-15	7278	7330	7441	7542	7644	7747	7851	7957	8065	8174	8284	8396
of which EU-N13	4914	5028	5130	5263	5401	5541	5685	5832	5984	6140	6299	6463
EU milk producer price, EUR/t	**372**	**304**	**313**	**329**	**323**	**324**	**327**	**336**	**346**	**358**	**367**	**374**

**Source: Own elaboration based onEuropean Commission (2016).*

Profitability of cow's milk production in Poland – projection for 2020

The study sample was 169 farms, which, on average, in the years 2014-2015 kept 27 dairy cows. Their milk yield in 2015 was 6,191 litres and when compared to 2014 it increased by 2.9%. On the other hand, a decrease was recorded in case of: price of milk – 17.0%, income per 1 cow – by38.5%, and per 1 litre of milk by 39.8%. The milk production profitability index (the relationof the production value to direct and indirect costs in total) in 2014 was 149.1% and in 2015 130.7%. The results of milk production in those holdings in 2015 were a starting point for carrying out the projection of changes for 2020.

The projection method used – by extrapolation of the trend observed in the past – allowed determining the expected direction of change both in revenues and in production costs. It is estimated that at the rate of change inthe milk yield foreseen in the perspective of 2020(2.4%) and in the price of milk (2.8-3.2%), we may expect revenues higher by 29.1% (at an annual rate of their increase by 5.1-5.4%). The expected annual increases in revenues in total are estimated at 2.8-3.1%, as a result, in the year 2020, when compared to 2015 – the costs may be higher by 15.5%[4]. This means that the growth of the production value will be stronger by 13.6 percentage pointsthan the cost increase. In this situation, incomefrom activity per 1 cow will increase by 73.3%, and per 1 litre of milk by 54.2%. It is envisaged that in 2020 the cost of generating the unit of income per 1 cow will decrease by 33.3% (will account for 66.7% of the level from 2015). In contrast, the total costs (direct and indirect in total) of producing 1 litre of milk will increase by 2.8% (Table2).

Among the forecast categories, an important place is occupied by the price. The processes of integration and globalisation are a reason for which the evolution of the prices of agricultural products results not only from the demand and supply relations at home but also from the situation in the global markets and linking with global prices, the impact of the Common Agricultural Policy instruments and even from other conditions. These circumstances suggest that there may be deviations from the level of the price foreseen for 2020 and resulting from the trend. The variant aspect of the projection results in the perspective of 2020 shows the impact of the change in the price of milk resulting from variability over time on the level of income (+/-8.7%). The scope of the presented changes is also affected by the data, which were a starting point for the studies conducted. This means that the presented changes in income and profitability expressed as a relation refer exclusively to the study sample of holdings. Nevertheless, the results obtained give a picture of the situation and its consequences. The objective of the authors was to draw attention to the economic risk whose basis is the price variability.

Table 2. Indicators of changes in the results of milk production in 2015 in relation to 2014 (2014 = 100) and according to the projection in 2020 in relation to 2015 (2015 = 100)

Specification		2015 / 2014	Projection for 2020 of the trend	Variants of the projection for 2020	
				A –favorable	B –unfavorable
Milk yield of cows	l/cow	102.9	112.4	112.4	112.4
Selling price of milk	PLN/liter	83.0	115.4	125.6	106.0
Production value	PLN/cow	86.3	129.1	139.2	119.0
Total cost (direct + indirect)	PLN/cow	98.5	115.5	115.5	115.5
	PLN/liter	95.2	102.8	102.8	102.8
Income from activity	PLN/cow	61.5	173.3	216.4	130.2
	PLN/liter	60.2	154.2	192.5	115.9
Cost production of 1 unit income	PLN/cow	159.7	66.7	53.4	88.7

PLN: Polish Zloty.

**Source: Elaborated based on own studies.*

[4] In the projection model, the invariability of the structure and amount of inputs incurred for keeping dairy cows. This means that the predicted increase in costs results only from the expected change in prices of means of production – based on extrapolation of the trend observed in the past into the future.

The calculations made on the basis of the CSO data showed that over 18 years (1998-2015), the variability of the price of milk in Poland amounted to 8.7%. Taking into account this level of the price variability, deviations from the level of the value of production and income, as foreseen for 2020, have been determined. From the studies it results that the value of production per 1 cow may be subject to fluctuations of +/-10.1%. This means that the increase in relation to 2015 may be 39.2% (favourable variant) or 19.0% (unfavourable variant). On the other hand, income per 1 cow and projected for 2020 may be subject to fluctuations (with the unchanged level of other factors) of +/-43.1%. In the favourable variant, it will be higher than in 2015 by 116.4%, while in the unfavourable variant by only 30.2%(Table2). Fluctuations will also affect the profitability of milk production as a relation of the value of production to the costs incurred for its production. In the analysed holdings, due to an increase or a decrease in the price of milk (by 8.7%), the profitability index in relation to its size resulting from the trend (146.1%) shall decrease or increase by 11.4 percentage points. It will amount to 157.5% or 134.7%. Taking into account the unfavourable variant, it will be lower than in 2014 by 14.4 percentage points, but higher by 4 percentage points when compared to 2015 (Figure 1).

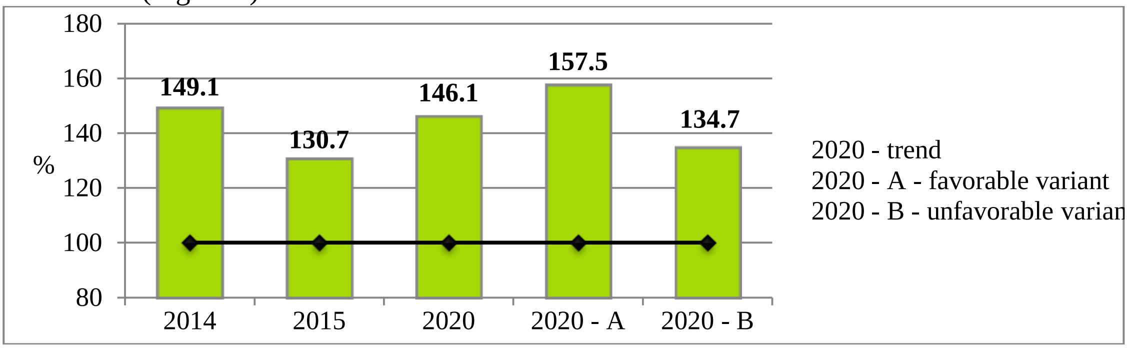

Figure1. Milk production profitability index in the years 2014-2015 and projection for 2020

**Source: Elaborated based on own studies.*

CONCLUSION

By forecasting future events, we are seeking to minimise the risk accompanying the decisions being made. The results of the projection prepared for 2020 in average conditions, i.e. those resulting from the long-term trend indicate an improvement in the milk yield of cows (by 12.4%) and prices of milk (by 15.4%). The stronger growth of revenues (by 29.1%) rather than ofcow maintenance costs (by 15.5%) will stimulate an improvement in economic performance.As a result, the economic efficiency of production will increase by 15.4 percentage points, and income per 1 cow by 73.3%. This means that they will be at a level close to that of 2014. The results of the studies show that within the years there may be fluctuations in the selling price of milk (+/-8.7%), whose consequence will be fluctuations in income and profitability understood as the relation of the value of production to the costs. Despite these fluctuations, it is estimated that milk production will be profitable, however, in the unfavourable variant the results will be worse than in 2014. The projection of results for 2020 and its variants show the benefits but also potential risks. However, being aware of them is very useful, reduces uncertainty and may contribute to an increase in the accuracy of decisions to be made, and thus to elimination of losses, which could take place in different conditions. The projection of results for milk production in the sample of holdings in Poland is, to some extent, convergent with the EC forecast, which provides for an increase in the price and production of milk in the EU. As a consequence, we should expect also ahigher profitability of milk production.

REFERENCES

Central Statistical Office (2015). *RocznikStatystycznyRolnictwa 2015* (Statistical Yearbook of Agriculture 2015), Warsaw, pp.153-155.

European Commission (2016). *Milk and milk products.* http://ec.europa.eu/agriculture/ milk/index_en.htm [Access: 26.02.2016].

European Commission (2016a). *European Milk Market Observatory. EU historical prices.* http://ec.europa.eu/agriculture/milk-market-observatory/index_en.htm [Access: 26.02.2016].

European Commission (2016b). *European Milk Market Observatory. Short-term outlook details.* http://ec.europa.eu/ agriculture/milk-market-observatory/index_en.htm [Access: 26.02.2016].

Olszewska M. (2015). *Produkcjamleka w PolscenatleświataikrajówUniiEuropejskiej* (Milk production in Poland against a background of the world and the European Union countries), WiadomościZootechniczne, Vol. LIII, No. 3, pp. 150-157.

Parzonko A. (2010). *Rozwój czy zaniechanie produkcji mleka w przeciętnych polskich gospodarstwach mlecznych? Rozważania modelowe* (Development or discontinuation of milk production in average Polish dairy holdings? Model considerations), Roczniki Nauk Rolniczych, Seria G, Vol. 97, No. 4, pp. 57-171.

Skarżyńska A. (ed.) (2014). *Nadwyżka bezpośrednia z wybranych produktów rolniczych w 2013 roku oraz projekcja dochodów na 2020 rok* (Gross margin from selectedagricultural products in 2013 and projection of income for 2020), IERIGŻ-PIB, Warsaw, pp. 119-129.

Stańko S. (1999). *Prognozowanie w rolnictwie, wyd. 2* (Forecasting in agriculture, ed. 2),SGGW, Warsaw.

Wasilewska E. (2011). *Statystyka opisowa od podstaw* (Descriptivestatistics from scratch), SGGW, Warsaw.

Ziętara W. (2002). *Kierunki i możliwości rozwoju przedsiębiorstw nastawionych na produkcję mleka* (Directions and opportunities of the development of enterprises orientedtowardsmilkproduction), Roczniki Naukowe SERiA, Vol. IV, No. 4, pp. 38.

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THE COMPETITIVE POSITIONS OF POLAND AND OF THE COUNTRIES OF THE WESTERN BALKANS IN AGRI-FOOD TRADE WITH THE EUROPEAN UNION

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ABSTRACT

The aim of the paper is to compare the competitive positions of Poland and of six countries of the Western Balkans (Albania, Bosnia and Herzegovina, Croatia, Macedonia, Montenegro and Serbia) in their trade in agri-food products with the European Union (EU) in 2010–2015. To this end, the synthetic trade competitiveness index (CI) was created, being the arithmetic average of two normalised indices of the competitive position, i.e. the trade coverage index (TC) and the Balassa revealed comparative advantages index (RCA). The study is based on the trade data from the WITS – *World Integrated Trade Solution* database (Comtrade, HS – Harmonised System 2002), expressed in USD. Agri-food products are understood as products classified in chapters 01–24 of the Harmonised Commodity Description and Coding System (HS). The research results show that only in trade of 5 product groups no country from the Western Balkans competed with Poland in the EU market. In other product groups which were competitive in Polish exports Poland competed in the EU market with some of the Western Balkan countries.

Keywords: *Poland, Western Balkans, competitive position, agri-food products.*

INTRODUCTION

The term competitiveness has been widely used and discussed in the literature. In the literature there are a lot of definitions of the competitiveness (e.g. Krugman 1981; Aiginger et al. 2013; Peneder 2001; Farole et al. 2010). It results from the fact that individual authors pay attention to the different aspects of competitiveness and analyse it at different levels. According to the definition of the Organization for Economic Co-operation and Development (OECD 2016), 'competitiveness is a measure of a country's advantage or disadvantage in selling its products in international markets'. Similar definition was adopted by the Institute of Agricultural and Food Economics - National Research Institute (IAFE-NRI) for the purpose of the studies on international competitiveness of the Polish food sector. According IAFE-NRI, 'food manufacturers' competitiveness is the ability of domestic producers to place their products in foreign markets – both in the EU and in third country markets – and the ability to developed effective exports' (Szczepaniak 2014). Sometimes the term competitiveness is understood broader as a 'competitiveness system' (Szczepaniak 2014, p.17). It consists of four elements: competitive potential, competitive strategy, competitive instruments and the competitive position. Generally, it can be stated that the competitive potential held by a given company determines adopting a specific competitive strategy. This strategy creates a base for selecting specific instruments of competition, which in turn helps to achieve a specific competitive position (Szczepaniak 2014, p. 16). Thus, the competitive position can be considered as an indicator of competitiveness. According to Misala (2005, p. 300), the competitive position means condition and changes in shares of the given country in the widely understood international turnover, i.e. in international trade in goods and services, and in international movements of production factors as well as the evolution of the structure of these movements. To evaluate the competitive position, many indicators are used, which allow to evaluate the results of foreign trade in the past. Two of them, i.e. the trade coverage index (TC) and the Balassa revealed comparative advantages index (RCA) are used in this research study. Thus, the purpose of the paper is to compare the competitive position of Poland and those of the six studied countries of the WB in their trade in agri-food products with the EU (EU countries except for Poland and Croatia) in the period of 2010–2015.

MATERIALS AND METHODS

For the purpose of the paper, the synthetic trade competitiveness index (CI) of the competitive position of the New EU Member States in exports of agri-food products was created. It was step-by-step process.

1. In order to create the synthetic trade competitiveness index, two indicators of the competitive position in trade were employed, namely trade coverage index (TC) and Balassa's revealed comparative advantages index (RCA). TC index was calculated according to the formula:

$$TC_{ij} = \frac{X_{ij}}{Y_{ij}},$$

where:

TC_{jj} – trade coverage index in trade in the i^{th} product group of the j^{th} country with the EU,

X_{ij} – exports of the i^{th} product group (here: agri-food products in total and by HS chapters) of the j^{th} country to the EU,

M_{ij} – imports of the i^{th} product group (here: agri-food products in total and by HS chapters) of the j^{th} country from the EU.

TC index determines the extent to which expenses on imported goods are covered by the revenue from their exports. The TC index is used to study the relationship between the exports and the imports at the level of entire trade, sector or product. The TC index greater than 1 means that the export value exceeds the import value, thus the given country has the relative competitive advantage over partners.

Revealed comparative advantages indices were calculated according to the formula:

$$RCA_{ij} = \frac{X_{ij}}{\sum_{i=1}^{N} X_{ij}} : \frac{X_{iw}}{\sum_{i=1}^{N} X_{iw}}$$

where:

RCA_{ij} – revealed comparative advantage index in the jth country exports of the ith product group to the EU,

X_{ij} – the jth country exports of the ith product group (here: agri-food products in total and by HS chapters) to the EU,

X_{iw} – world exports of the ith product group to the EU,

N – number of product groups (here: total exports).

The essence of the RCA index is to determine whether the share of a given commodity group in the exports of a given country is higher/lower than the share of this commodity group in the world exports to the specific market. When the index is greater than 1 (the share of the given commodity group in the exports of a country is higher than the respective share in the world export) – a given country has revealed comparative advantage in the exports to the specific market. Otherwise, when the index is lower than 1 (the share of the given commodity group in the exports of the country in question is lower than the share of this product group in the world exports) – the analysed country does not have revealed comparative advantages in the exports to the specific market.

2. The obtained indices were normalized using the following formulas:

$$nTC_{ij} = \frac{TC_{ij} - 1}{TC_{ij} + 1} \qquad nRCA_{ij} = \frac{RCA_{ij} - 1}{RCA_{ij} + 1}$$

The normalised indices (nTC_{ij} and $nRCA_{ij}$) take values between -1 and 1 with 0 as a reference point. In both cases the value between -1 and 0 means that a given country does not have competitive advantages in trade in a given product group. In turn, the value of each index between 0 and 1 indicates the competitive advantages of a given country in trade in a given product group.

3. The synthetic trade competitiveness index (CI) was created using the following formula:

$$CI = \frac{nTC_{ij} + nRCA_{ij}}{2}.$$

The CI index takes value between -1 and 1 with 0 as a reference point. The value of the CI index between -1 and 0 means that a given country does not have competitive advantages in trade in products, while the CI index value between 0 and 1 indicates the competitive advantages of a country in trade in these products.

The CI indices were calculated for six countries of the Western Balkans and Poland in their trade in agri-food products in total and by HS chapters.
The study is based on the trade data from the World Integrated Trade Solution (WITS) database (Comtrade, HS – Harmonised System 2002), expressed in USD. Agri-food products are understood as products classified in chapters 01–24 of the Harmonised Commodity Description and Coding System (HS).

RESULTS AND DISCUSSION

In 2015, the value of agri-food exports of the six countries of the WB to the EU market amounted to USD 2.5 billion, whereas the value of Polish agri-food exports was 8 times larger, at USD 20.7 billion (table 1). The difference in agri-food imports was smaller. The Western Balkan countries imported from the EU agri-food products worth USD 4.2 billion, while the value of Polish agri-food imports amounted to USD 11.5 billion. Thus, the WB recorded a deficit in agri-food trade with the EU (USD 1.7 billion). In turn, Poland noted a surplus (USD 9.2 billion). Among the WB countries the largest exporters to the EU were Serbia and Croatia. However, only Serbia recorded a surplus in agri-food trade.

Table 1. Foreign trade in agri-food products of the Western Balkans and Poland in 2015

Country	Exports		Imports		Balance
	value in 2015 (US million)	changes 2015/2010; 2010=100	value in 2015 (US million)	changes 2015/2010; 2010=100	value in 2015 (US million)
Western Balkans	2,507.0	124.4	4,157.8	133.6	-1,650.9
incl. Albania	86.9	121.2	335.2	75.7	-248.3
Bosnia and Herzegovina	86.7	90.1	545.2	110.5	-458.5
Croatia	896.9	159.9	2,121.1	152.7	-1,224.2
Macedonia	206.0	92.7	299.1	115.0	-93.1
Montenegro	4.5	62.4	140.6	109.7	-136.1
Serbia	1,226.0	115.9	716.5	179.6	509.4
Poland	20,700.2	149.9	11,486.8	119.5	9,213.4

**Source: Own calculations based on Comtrade database.*

The EU is the main market in agri-food exports of Poland and of the WB countries (Stojanovic *et al.* 2013; Radosavac and Rosandic 2015; European Commission 2013; Bezhani 2013). In 2015, the share of the EU in Polish exports of agri-food products amounted to over 80%, whereas in the WB it was lower, at nearly 44% (Comtrade 2016). The EU was the most significant in exports of Albania (61%), Croatia (52%), Serbia (43%) and Macedonia (39%), while it was the least important in exports of Montenegro (7%) as well as of Bosnia and Herzegovina (20%) (European Commission 2013). As regards to the competitive position, only two countries, Serbia and Poland, had competitiveness advantages in agri-food trade with the EU. Although trade competitiveness indices clearly decreased in the period in question (the CI declined by 0.17 pps), Serbia had the strongest competitive position in 2015, followed by Poland (figure 1). In 2010–2015 Poland strengthened its competitiveness in agri-food trade with the EU by 0.09 pps. The strong competitive position of Poland in the EU market resulted from the domination of Polish agri-food exports by food industry products. In 2015 they accounted for 86% of Polish agri-food exports to the EU. The share of food industry products in exports was significantly higher than that in imports. An increase in the CI indices in Polish agri-food trade with the EU resulted from the growing surplus of trade in food industry products. In 2015, its value amounted to USD 9.2 billion. According to the previous studies, a high share of processed goods in agri-food exports of a country is beneficial for its economy and may confirm the thesis on the export-oriented nature of the national food industry (Ambroziak and Szczepaniak 2013). By exporting processed products, producers gain much higher value added benefits than by exporting only raw materials required for the manufacture of such products. Moreover, industrial food processing intended for export enables better use of resources, and thus allows to gain economies of scale. The export of processed (final) products is also conducive to promoting the food sector of a country in external markets, which is more difficult to pursue by exporting agricultural raw materials or industrial semi-finished products used in secondary food processing. In turn, the import of raw materials (most frequently from other climate zones), and then processing them in the country, is more beneficial than the import of finished products because it is conducive to improving the balance of foreign trade and also enables the generation of greater value added, better use of the economic potential and job creation (Szczepaniak, 2012).

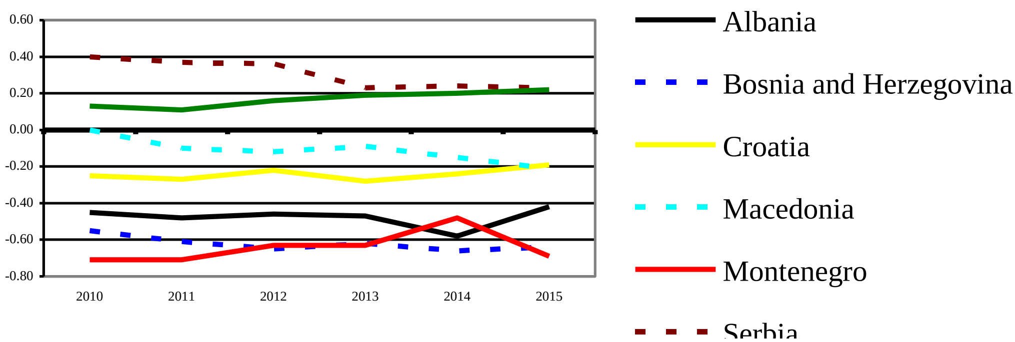

Figure 1. The synthetic trade competitiveness indices (CI) in agri-food trade of Western Balkans and Poland in 2010-2015

**Source: Own calculations based on Comtrade database.*

Other Western Balkan countries did not have competitive advantages in agri-food trade with the EU. In 2010–2015 the CI indices grew only in Croatia and Albania, whereas the remaining Western Balkan countries deteriorated their competitiveness. In 2015 the worst performers were Bosnia and Herzegovina, Montenegro and Albania. The CI indices in their agri-food trade with the EU were below -0.40. In Croatia and Macedonia the CI indices amounted to about -0.20.

Similar findings follow from the competitiveness analysis by group of agri-food products (by HS chapter). In 2015, Poland had competitive advantages in the export of 15 (out of the 24) groups of agri-food products. The most competitive ones were tobacco and tobacco products (CI = 0.68), preparations of meat and fish (0.53), meat and edible meat offal (0.44), preparations of cereals and pastrycooks' products (0.32), miscellaneous edible preparations (0.27) and cereals (0.26) – table 2. In 2015, products of the above-mentioned six groups generated nearly 60% of revenue from Polish agri-food exports to the EU.

Table 2. The synthetic trade competitiveness indices (CI) in agri-food trade of Western Balkans and Poland by HS chapters in 2015

HS chapter		Albania	Bosnia and Herzegovina	Croatia	Macedonia	Montenegro	Serbia	Poland
01	Live animals	-0.78	-0.91	-0.19	-0.93	-	-0.96	-0.59
02	Meat and edible meat offal	-0.90	-	-0.50	-0.57	-0.94	-0.92	0.44
03	Fish and seafood	0.10	-0.06	0.20	-	-	-0.76	0.24
04	Dairy produce	-0.81	-	-0.60	-	-0.95	-0.67	0.20
05	Products of animal origin n.e.s.	0.09	-0.69	-0.08	-0.56	-	0.04	0.19
06	Live trees and other plants	-0.90	-0.70	-0.82	0.03	-	-0.78	-0.56
07	Vegetables	0.02	-0.22	-0.65	0.64	0.15	0.16	0.13
08	Fruit and nuts	-0.46	-0.08	-0.61	-0.03	-0.54	0.71	-0.10
09	Coffee, tea and spices	-0.99	-0.58	-0.61	-0.67	-0.47	-0.27	0.25
10	Cereals	-	-0.98	0.39	-0.90	-0.99	0.86	0.26
11	Products of the milling industry	-	-0.62	-0.04	-0.98	-	0.16	-0.19
12	Oil seeds and oleaginous fruits	0.63	-0.67	0.31	-0.54	-	0.37	0.16
13	Vegetables saps and extracts	-0.64	-	-0.57	-0.99	-	-0.70	-0.82
14	Vegetable products n.e.s.	0.62	-0.32	-0.09	0.44	-	0.63	-0.43
15	Animal or vegetable fats and oils	-	-0.44	-0.31	-0.87	-0.94	0.31	-0.04
16	Preparations of meat and fish	0.68	-0.99	0.04	-0.78	-0.97	-0.96	0.53
17	Sugars and sugar confectionery	-	0.08	0.49	-0.41	-0.99	0.55	0.12
18	Cocoa and cocoa preparations	-	-0.90	-0.33	-0.67	-0.99	-0.70	0.23
19	Preparations of cereals and pastrycooks' products	-0.54	-0.64	-0.09	0.08	-0.72	-0.30	0.32
20	Preparations of vegetables and fruits	-0.29	-0.60	-0.55	-0.01	-0.99	0.12	0.20
21	Miscellaneous edible preparations	-0.99	-0.88	-0.01	-0.61	-0.98	-0.11	0.27
22	Beverages and spirits	-0.88	-0.81	-0.34	-0.13	-0.42	-0.28	-0.16
23	Residues and prepared animal fodder	-	-0.73	-0.32	-0.99	-	-0.07	-0.06
24	Tobacco and tobacco products	-	-0.91	0.00	0.73	-	-0.05	0.68

Agri-food products	-0.42	-0.64	-0.19	-0.21	-0.69	0.23	0.22

**Source: Own calculations based on Comtrade database.*

During the membership of the EU, Poland has strengthened its competitive position in the EU market. The basis for building competitive advantages in the agri-food sector has been lower product prices. Simultaneously, non-price advantages have become increasingly important due to progressive convergence of prices among the individual Community members. After the EU accession, there was a significant increase in the importance of the differentiation strategy based on efficient competition with product quality in Polish agri-food exports. However, the price factor still remains a prominent determinant of the international competitiveness of the Polish agri-food sector. In Serbia 9 groups of agri-food products were competitive. The highest CI indices were recorded in trade in cereals (0.86), fruit and nuts (0.71), vegetable products n.e.s. (0.63), sugars and sugar confectionery (0.55) and oil seeds and oleaginous fruits (0.37). Thus, the most competitive items were mainly agricultural products. The share of food industry products in Serbian exports to the EU was lower than that in Polish exports and amounted to 60%. Serbia had especially strong competitive advantages in exports of frozen raspberries, blackberries and blackcurrants as well as maize.

Albania and Croatia enjoyed competitive advantages in 6 agri-food product groups. In Albanian trade with the EU competitive goods included preparations of meat and fish (0.68), oil seeds and oleaginous fruits (0.63), vegetable products n.e.s. (0.62), fish and seafood (0.10), products of animal origin n.e.s. (0.09) and vegetables (0.02). The strongest competitive position of Albania characterised exports of preserved anchovies cuttle fish and squid. In turn, Croatia had competitive advantages in the EU market in exports of sugars and sugar confectionery (0.49), cereals (0.39), oil seeds and oleaginous fruits (0.31), fish and seafood (0.20), preparations of meat and fish (0.04) and tobacco and tobacco products (0.00). 5 product groups were competitive in Macedonian trade with the EU. Those were tobacco and tobacco products (0.73), vegetables (0.64), vegetable products n.e.s. (0.44), preparations of cereals and pastrycooks' products (0.08) and live trees and other plants (0.03). Among vegetables, the strongest competitive position characterised frozen mixtures of vegetables, pepper, cucumbers and cabbages. Montenegro as well as Bosnia and Herzegovina had competitive advantages only in one product group each. Vegetables coming from Montenegro and sugars and sugar originating in Bosnia and Herzegovina were competitive in the EU market.

CONCLUSION

No country from the Western Balkans had competitive advantages in the EU market in the 5 groups of agri-food products which were strong and competitive in Polish trade with the EU. Those were meat and edible meat offal, dairy products, coffee, tea and spices, cocoa and cocoa preparations as well as miscellaneous edible preparations. In 2015 these product groups constituted about 40% of Polish agri-food exports to the EU market. As for preparations of meat and fish as well as fish and seafood, Polish producers competed in the EU market with those from Albania and Croatia. Apart from Poland, Macedonia and Croatia were also competitive in trade in tobacco and tobacco products in the EU market. Poland competed with Serbia in trade in preparations of vegetables and fruits and with Macedonia in trade in preparations of cereals and pastrycooks' products. As for vegetables, besides Poland also Albania, Macedonia, Montenegro and Serbia enjoyed competitive advantages in the EU market. In trade in oil seeds and oleaginous fruits Albania, Croatia and Serbia competed with Poland. Similarly to Poland, Croatia and Serbia had strong competitive positions in the EU market in trade in cereals, whereas Serbia, Croatia as well as Bosnia and Herzegovina were competitive in trade in sugars and sugar confectionery.

REFERENCES

Aiginger K., Bärenthaler-Sieber S., Vogel J. (2013). Competitiveness under New Perspectives, WWWforEurope Working Paper, no 44.

Ambroziak Ł. (2015). The Competitive Position of the New Member States in Trade in Food Industry Products, in: Proceedings of the Competitiveness of Agro-Food and Environmental Economy (CAFEE'2015), Bucharest Academy of Economic Studies, Bucharest, http://www.cafee.ase.ro/?page_id=336.

Ambroziak Ł., Szczepaniak I. (2013). Monitoring and evaluation of the competitiveness of Polish food producers (4). Competitive position, "Multiannual Programme 2011–2014", No 74, IAFE-NRI, Warsaw.

Bezhani E. (2013) The Economic Impact of Agricultural Products in the Albanian Exports, Academic Journal of Interdisciplinary Studies, vol. 2, no 1.

Comtrade database (2016). https://wits.worldbank.org/WITS/WITS/Restricted/Login.aspx [11.05.2016].

European Commission (2013). Analysis of the impact of Croatia's accession to the EU on the agri-food sectors. A focus on trade and agricultural policies. JRC Scientific and Policy Report.

Farole T., Reis J.G., Wagle S. (2010). Analyzing Trade Competitiveness – A Diagnostics Approach, The World Bank, Washington DC.

Krugman P. (1981). Intra-industry Specialization and the Gains from Trade, Journal of Political Economy, no. 89.

Misala J. (2005). Wymiana międzynarodowa i gospodarka światowa. Teoria i mechanizmy funkcjonowania (International trade and world economy. Theory and mechanisms of operation), SGH, Warsaw.

OECD (2016), Glossary of Statistical Terms, https://stats.oecd.org/glossary/detail.asp?ID=399 [9.09.2016].

Peneder, M. (2001). Entrepreneurial Competition and Industrial Location, Edward Elgar, Cheltenham, UK.

Radosavac A., Rosandic A. (2015). Foreign trade of food products in Bosnia and Herzegovina, Conference Book of Proceedings: Sixth International Scientific Agricultural Symposium "Agrosym 2015", Jahorina, October 15 - 18, 2015.

Stojanovic Z., Mitrovic R.D., Petrovic I.P. (2013). Serbia's Food Trade Competitiveness and PTAS in the EU Integration Process. European Association of Agricultural Economists,135th Seminar, August 28-30, 2013, Belgrade, Serbia.

Szczepaniak I., ed. (2012). Monitoring and evaluation of the competitiveness of Polish food producers (2), “Multiannual Programme 2011–2014”, No 40, IAFE-NRI, Warsaw.

Szczepaniak I., ed. (2014) Assessment of the competitiveness of Polish food producers in the European, “Multi-Annual Programme 2011-2014”, No 126.1, IAFE-NRI, Warsaw.

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SIGNIFICANCE OF THE COMMON AGRICULTURAL POLICY FOR ORGANIC FARMS ECONOMICS IN POLAND

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ABSTRACT

Accession of Poland to the European Union (EU) has been connected with a number of benefits, but at the same time, the obligations have been imposed on the agricultural producers. Farmers are active economic units, that operate on the common european market, as well as they are beneficiaries of governmental support. Governmental programmes allowed to take part in measures directed to agricultural farms development. Farmers have been obliged to comply with European law and implementation of the desired production standards.Both regulations and governmental programs have determined the direction of agricultural holdings development. Especially in the last decade, organic farms make demanded and fast-growing form of environmental friendly agriculture. Organic methods use of agricultural production in accordance with soil, plants and animals requirements, taking care of the other environmental components. Organic farms fit in with the concept of sustainable development. According to this, organic production should at least not affect the ecosystems` sustainability and meet the economic purposes. The purpose of the article is evaluation of organic farms economics in Poland, taking into consideration influence of the Common Agricultural Policy (CAP). There were analysed production and economic condition of organic farms in comparison to all Farm Accountancy Data Network (FADN) farms. The research were conducted on the basis of indicator analysis, considering calculation reflected cost, production, economics and subsidies connected with the Common Agricultural Policy directed to farms. The analysis was based on FADN 2004 and 2013.

Keywords: *organic farms, farms` economics, sustainability, CAP, FADN, Poland.*

INTRODUCTION

A rapid development of an organic system of agricultural production, which was reflected in the number of organic farms, following Poland's accession to the EU, has slowed down in recent years. The number of (certified) organic farms in Poland in 2004 amounted to only 1.7 thousand and the area of organic crops – to 47 thousand hectares, and in 2013 – 26.6 thousand and 662 thousand ha, respectively, while at the end of 2015 – the number of organic farms decreased to 22.3 thousand

and the area – to 581 thousand ha[1]. This is primarily due to the fact that organic production became less profitable, despite higher prices of organic products. This situation is undesirable, as demand for organic products in the world, including Europe, is growing rapidly[2].

Leaving aside non-economic motives, the development of organic farming is determined primarily by demand and governmental support (subsidies). The former is driven by consumers' growing interest in healthy food and hampered by higher prices of organic products, while the latter depends on policy solutions (Wrzaszcz and Zegar, 2015; Zegar, 2007). Following Poland's accession to the EU, the organic production system received significant support under the Common Agricultural Policy. However, despite higher prices of organic products and subsidies from the budget, organic farms derive smaller economic benefits than conventional farms.

The purpose of the article is to evaluate the economics of organic farms in Poland, taking into consideration influence of the CAP.

MATERIALS AND METHODS

The study is based on a panel of farms covered by the FADN and keeping agricultural accounting on a continued basis in the years 2004-2013. This group consisted of more than 4.5 thousand farms. The period covered by the analysis is dictated by the objective of the study and the data availability. The first year of this period presents a situation in which the effects of the implemented CAP mechanisms were insignificant, while in the final year we may believe that those effects have already manifested themselves all their glory. The article focuses on the production and economic results of organic farms compared to all individual (private) farms covered by FADN.

Organic farms included also those which have an organic production certificate or are under reorganisation. The rules of functioning of farms in this system are fixed by law. The guiding principle in the organic system is to cultivate plants in compliance with the standards of the *Good agrienvironmental practices* with due attention to the phytosanitary condition of plants and soil protection.Agricultural production in these farms is based on the use of natural ecosystem processes and is conducted with the minimal use of industrial means of agricultural production. Such farms are obliged to keep an area of permanent grasslands and landscape elements not used for agricultural purposes[3].

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[1] According to Agricultural and Food Quality Inspection reports (www.ijhar-s.gov.pl/index.php/raporty-o-ekologii.html).

[2] According to IFOAM EU Group data, retail sales in the EU Member States in 2014 increased by 7.4% to EUR 24 billion (www.ifoam-eu.org/en/news/2016/04/05/new-publication-organic-europe-increased-demand-organic-food-production-not-moving).

[3] The list of legal regulations in the field of organic farming system can be found on the website of the Ministry of Agriculture and Rural Development: (http://www.minrol.gov.pl).

There are also analysed organic farms, that conducted this production system simultaneously in 2004 and in 2013. It allowed observed changes in the group of farms that were conducted according organic rules at least a few years.

The distinguished groups of farms have been assessed in terms of their economic sustainability, using indicators of productivity and profitability of the production factors. The productivity of the production factors is a basic element of the farm`s economic efficiency. It is defined as a ratio of a single output and a single input. It may refer to the individual factors of agricultural production (land, labour and capital) and also to those factors in general. Its level may result from increasing production (maximising outputs) or reducing costs (minimising inputs). The profitability of the production factors, on the other hand, is the basic output indicator of the agricultural activity, indicating the size of income earned from a unit of a given input. Farm income is a basic economic objective of the farmer's activity and is an important determinant of the standard of life of a farming family, hence it may be an important indicator of the economic sustainability (Wrzaszcz, Zegar, 2014). The size of income illustrates the level of remuneration for involving own factors of production in the farm's operations and for risk taken by the farm holder during the accounting year.

In order to examine the productivity and profitability of the factors of production in the selected groups of farms, the following selected indicators have been used[4]: Land Productivity (Total Output (TO)/Agricultural Land; Gross Farm Income (GFI) /Agricultural Land); Labour Productivity (Total Output (TO) /Annual Work Unit (AWU); Gross Farm Income (GFI)/Annual Work Unit (AWU); Land

[4] The Total Output of a farm represents the basic economic and production category that indicates the economic result of farming. It is the outcome of the sum of the value of crop and livestock production and other activities.

Gross Farm Income is the result of difference of Total Output and the Total Intermediate Consumption (Total specific costs – including inputs produced on the holding – and overheads arising from production in the accounting year), adjusted for the outcome of the balance of current subsidies and taxes (Goraj, 2009). This value indirectly makes it possible to verify the impact of farming efficiency measured by the level of costs and subsidies. Net value added adjusted for the cost of total external factors and the balance of subsidies and taxes on investments indicates the level of Family Farm Income (Bocian and Malanowska, 2014). Family Farm Income is the primary economic goal of farmer's agricultural activity and it is an essential determinant of a farmer family living standard, and hence it may be an important indicator of farm efficiency in agriculture. The issue of factor productivity is especially significant in the context of food security, thus profitability factor has particular importance in the evaluation of labour remuneration and farmer`s family general income. The volume of income illustrates the level of compensation for the involvement of their own factors of production in the farm's operations and for the risk taken by a farm manager in a given financial year.

1 AWU (Annual Work Unit) is equivalent to full-time own and paid labour, i.e. 2,120 hours of work a year.

1 FWU (Family Work Unit) is the equivalent of a full-time labour of a farming family member.

Profitability:Family Farm Income (FFI)/Agricultural Land; Labour Profitability: Family Farm Income (FFI)/Family Work Unit (FWU).

RESULTS AND DISCUSSION

Values of characteristics of total farms, total organic farms and a panel of organic farms are presented in Table 1. In the analysed period, the area of total farms increased significantly, so did – even more – the value of their assets[5]. A change in the production potential of farms was also reflected in production and economic results as well as the economic investments made.

The table 1 indicates that the number of organic farms was small both in 2004 (accounting for only 1.3% of total FADN farms) and 2013 (3%), although the number of organic farms in this period grew 2.2-fold. The growth in the population of organic farms should be interpreted as the direction of positive changes in agricultural production, predictive of an improvement in the natural environment.

Table 1. Farms` characteristic (average per farm)

No.	Specification	Total(T)			Organic Total (O)			OrganicPanel (OP)		
		2004	2013	C_%[1]	2004	2013	C_%[1]	2004	2013	C_%[1]
1	Farms` number	4 579	4 579	0.0	60	133	121.7	42	42	0.0
2	Agricultural Land (ha)	30.38	36.02	18.6	19.58	29.87	52.5	19.88	22.54	13.4
3	Labour Input (AWU)	2.04	2.08	2.1	2.06	1.84	-10.5	1.97	1.99	1.0
4	Livestock Unit (LU)[2]	27.72	30.20	9.0	10.90	12.59	15.5	9.44	10.94	16.0
5	Assets[3]	123.34	326.46	164.7	79.64	190.02	138.6	76.99	153.48	99.4
6	Total Output[3]	40.89	72.33	76.9	17.82	29.62	66.2	14.43	20.76	43.8
7	Gross Farm Income[3]	18.81	36.77	95.5	9.72	25.05	157.6	9.76	20.76	112.7
8	Family Farm Income[3]	11.81	25.28	114.1	4.63	17.88	286.1	4.75	13.79	190.3
9	Gross investment[3]	5.38	14.03	160.7	3.88	5.45	40.5	3.10	4.74	52.7

*[1] C_% - change in percentage (2013/2004*100-100); [2] 1 LU (Livestock Unit) is a standard unit of farm animals weighing 500 kg; [3] Value in thousand euro.Source: Prepared on the basis of2004-2013 FADN data.*

The average area of organic farms reached nearly 20 hectares in 2004 and 30 hectares in 2013. Total organic farms in 2004 and 2013 significantly differed also with regard to other elements of production potential as well as production and economic results. Most values for this group of farms in 2013 were much higher than those for 2004, except for labour inputs.

Both in 2004 and 2013, the average organic farm was characterised by lower production potential (livestock population, utilised agricultural area, the value of assets) and results (the value of production, gross farm income, family farm

[5] All value categories were presented in current prices. The EUR/PLN exchange rate of EUR 1=PLN 3.90916 was used. This exchange rate is applied in the FADN system to determine the standard values in EUR.

income) than the average FADN farm. These differences were also evident in organic farms' smaller investment activity.
Total farms are superior to total organic farms as indicated by the difference in the value of production results for 2004 and 2013, but the situation is reversed as far as economic results are concerned. The productivity of agricultural production factors in organic farms is lower – which is determined by the volume and, to a lesser extent, value of agricultural production, the farms incur lower costs, including costs related to payment for external factors (*inter alia*, labour remuneration) and depreciation which is a derivative of a lower value of assets and a lower rate of their reconstruction. These relations were affected mostly by cash transfers, because organic farms are beneficiaries of numerous subsidies of different kinds, primarily area payments and agri-environmental payments, including organic subsidies, which significantly increased the income of an organic producer in 2013.

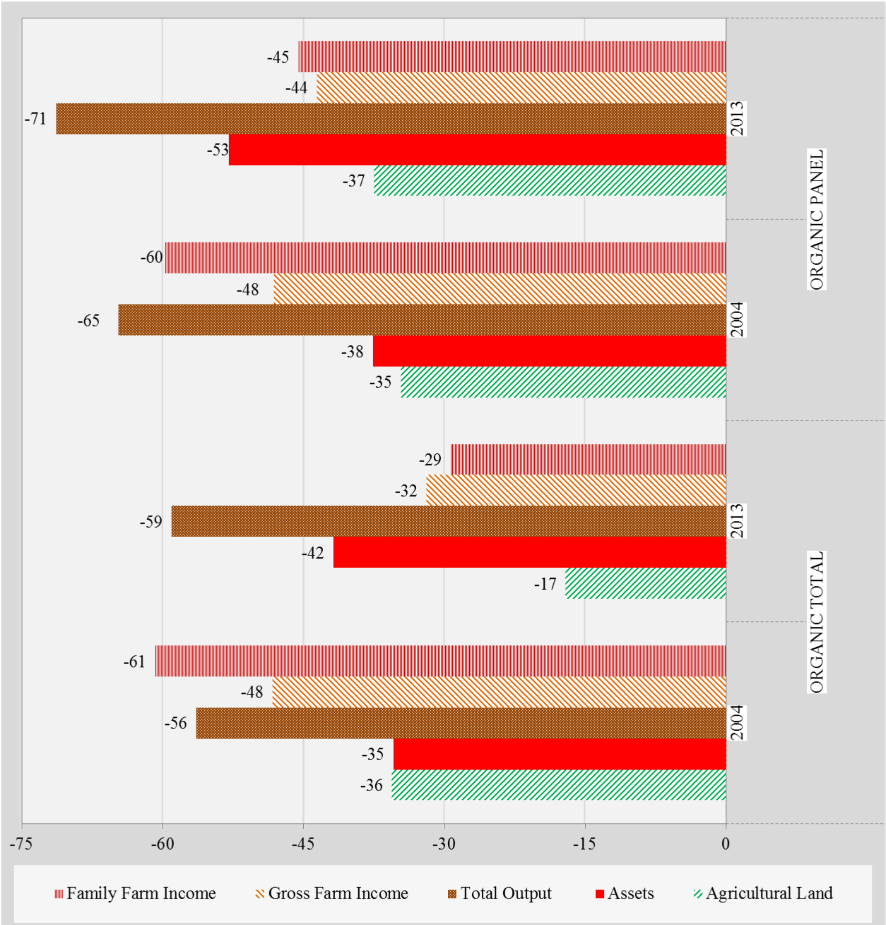

Figure 1. The relative difference (%) between organic farms (total and panel) and average FADN ones.

**Source: Prepared on the basis of 2004-2013 FADN data.*

However, the production and economic gap between organic farms and total FADN farms is very wide, as indicated by negative values in Figure 1. In the analysed period, the production gap between these groups of farms slightly widened, but the income gap nearly halved. This was undoubtedly due to subsidies for organic production. In the considered period, the gap in the value of assets between organic farms and total farms widened significantly. The level of economic results of organic farms makes it impossible to increase assets at a rate proportional to total farms.

Most **organic farms** covered by FADN in 2004 were operated in accordance with these principles in 2013. This indicates a strong motivation to further follow the organic system of agricultural production.

When comparing results of panel organic farms and total organic farms in 2004 and 2013, it may be concluded that, although the former increase production potential, the gap between them and total organic farms is widening. This indicates that organic farms, which have been operated in accordance with the principles of the system for a short period of time, are characterised by much larger area, smaller labour inputs, lower livestock density and they also hold far more assets compared to the average level for the panel of organic farms, i.e. the farms which have been covered by this production system for many years. In other words, "new" organic farms are basically large, more mechanised farms which are often oriented only towards crop production or which choose livestock production as their supplementary activity. Therefore, differences in production potential between the panel of organic farms and total organic farms became reflected in their production and economic results.

As indicated in Figure 1, the gap between panel organic farms and total FADN farms is even wider compared to that between panel organic farms and total organic farms. In the considered period, differences in production potential (measured by utilised agricultural area and the value of assets) and production results between these groups of farms deepened. However, the difference in the level of income shrank as a result of growing subsidies for organic production in 2004-2013. Nevertheless, the income of the average panel organic farm in 2013 was lower than that of the average farm keeping agricultural accounts by as much as 45%. The farms` economic sustainability includes productivity and profitability of factors production. The data presented in table 2 indicate the large gap with regard to the land productivity (based on Total Output) among average farms and organic ones, that increased in analysed period. In the case of panel organic farms, land productivity was the lowest,and it increased in smaller scope compared to the total farms between 2004-2013. It can be concluded that organic production brings lower benefits (described by land productivity), than conventional one. Organic farms (total and panel) achieved the lower economic results (described by land profitabilty) when compared to average farms, although the negative difference decreased. These relations were significantly affected by subsidies to the farm’s operations (used to a larger extent by organic farms), as well as by the costs, *inter alia*, related to payment for external factors.

Table 2. Productivity and profitability of land and labour

No.	Specification	Total (T)			Organic Total (O)			Organic Panel (OP)		
		2004	2013	C_%[1]	2004	2013	C_%[1]	2004	2013	C_%[1]
I	Land productivity and profitability in thousand €/ha									
1	Total Output	1.35	2.01	49.2	0.91	0.99	9.0	0.73	0.92	26.8
2	Gross Farm Income	0.62	1.02	64.9	0.50	0.84	68.9	0.49	0.92	87.6
3	Family Farm Income	0.39	0.70	80.6	0.24	0.60	153.1	0.24	0.61	156.0
II	Labour productivity and profitability in thousand €/AWU									
1	Total Output	20.09	34.79	73.2	8.66	16.08	85.7	7.34	10.45	42.4
2	Gross Farm Income	9.24	17.69	91.4	4.73	13.60	187.7	4.96	10.46	110.7
3	Family Farm Income	6.78	14.44	112.9	2.63	11.36	332.3	2.82	8.10	187.1

*[1] C_% - change in percentage (2013/2004*100-100). Source: Prepared on the basis of 2004-2013 FADN data.*

Just like in case of the land productivity, organic farms (total) were inferior to average farms in the case of labour productivity. However, the labour productivity of panel organic farms was lower than that of total organic farms and total FADN farms – as it was the case with land productivity. These results confirmed that farms, which deliver benefits to the social and natural environment, are characterised by lower land and labour productivity as well as slower productivity growth than total farms keeping agricultural accounts.

The situation is somewhat different for the profitability of factors of production, as the role of subsidies in shaping the economic result is significant and largely determines the growth rate of income and, to a lesser extent, land and labour profitability – primarily as regards organic farms. In the period considered, total and panel organic farms enjoyed the highest growth rate of profitability indicators. However, this does not undermine the fact that organic farms are hardly profitable and uncompetitive – in the classic point of view – compared to conventional farms.

In 2004, the average farm received subsidies in the amount of EUR 1.4 thousand which were in whole associated with its operations (at that time, subsidies supporting the investment activity have not been launched yet; table 3). They included mainly direct subsidies, while the rest accounted for transfers within the framework of the Rural Development Programme's measures (RDP). In 2004, some packages of the agri-environmental programme, addressed to organic farms, were introduced. The implementation of the CAP has significantly changed that situation – in 2013, the average farm received almost 8.5 times more than in 2004. In 2013, support for rural development covered various measures proposed to farmers. Farmers showed interest in taking environmentally-friendly measures – as evidenced by the high share of subsidies provided to farmers for agri-environmental projects – 24% of rural development subsidies.The indicators of the ratio of subsidies to the production and economic results illustrate their increasing role in shaping the farms`economic results. Linking subsidies with the observance of the environmental protection principles in agricultural production also affected the environmental sustainability of farms.

Table 3. Subsidies (average per farm, thousand €) and their relations to farms` outcomes (%)

No.	Specification*	Total		Organic_Total		Organic_Panel	
		2004	2013	2004	2013	2004	2013
1	Total subsidies (TS)	1.44	12.13	1.09	13.54	1.35	11.09
2	- to operational activities (OA)	1.44	10.94	1.09	13.00	1.35	10.61
3	- to investment activities (OI)	0.00	1.18	0.00	0.55	0.00	0.48
4	Direct payments	1.05	7.92	0.43	6.70	0.50	5.54
5	Subsidies to rural development	0.39	4.21	0.66	6.84	0.85	5.56
6	- agrienvironmental	0.01	1.03	0.37	4.62	0.51	3.62
7	- less favoured areas	0.05	0.77	0.04	1.15	0.05	0.99
8	Total subsidies /TO	3.52	16.77	6.13	45.73	9.32	53.44
9	Balance of OA and T*/GFI	6.92	27.17	8.46	49.35	11.80	48.74
10	Balance of TS and T*/FFI	7.95	35.99	7.33	66.84	11.39	70.79

*TO-Total Output; T-taxes; GFI-Gross Farm Income; FFI-Family Farm Income.

**Source: Prepared on the basis of 2004-2013 FADN data.*

The structure of subsidies in organic farms (total and panel) definitely differed from the same structure in average farms as over the analysed period organic farms received a greater part of the funds from the RDP – they were covered by the agri-environmental programme. Organic farms acquired relatively small subsidies for their investment activity, which may also indirectly indicate limited investments.The indicators of the ratio of subsidies to the results of organic farms show a definitely greater role of external transfers in shaping their economic situation in relation to average farms.

When comparing the situation of the panel of organic farms and total organic farms, it may be concluded that they differed significantly in terms of the amount of support in the form of subsidies. Panel organic farms had it higher in 2004 (by as much as 23%) and, being organised according to the principles of the organic production system, were better prepared to effectively use funds offered as part of government programmes and already met criteria for obtaining subsidies. Given that most subsidies are related to farm area, panel organic farms started becoming inferior over time to total organic farms which also covered conventional units under reorganisation, including those with large utilised agricultural area. The structure of subsidies by type did not contrast total organic and panel farms, while differences in their production potential as well as production and economic results were reflected in the value of ratios. Ratios of subsidies to the value of production and income revealed that subsidies were more significant in shaping results of panel organic farms than those of total organic farms and, all the more, total FADN farms. In other words, the economic situation of panel organic farms is the most dependent on external support.

CONCLUSION

Instruments of the Common Agricultural Policy contributed to dynamic growth in the number of organic farms – thus contributing to an increase in organic production in Poland. In the period considered, the group of total organic farms was enlarged to include new farms with relatively large area, a small livestock population, low labour inputs and a low value of agricultural production.

In subsequent years, most organic farms (2004) were operated in accordance with the principles of the agricultural production system. The panel organic farms were characterised by lower production potential as well as significantly less favourable production, economic and investment results than total farms of FADN.

In the period under analysis, panel organic farms improved their production potential as well as production and economic results. Utilised agricultural area, the value of assets, production and investment results changed to a lesser extent in the case of panel organic farms compared to the dynamics of changes observed in the entire population of FADN farms, while the farms achieved an advantage in the rate of changes in the livestock population, gross farm income and family farm income. Organic farms achieve particularly low results of factor productivity and profitability, which, although slightly improved, but the gap between them and average farms increased in the case of factor productivity. Reduction of differences in factor profitability was the result of subsidies, particularly connected with operational activity of farms.

The indicators of the ratio of subsidies to the production and economic results illustrate their increasing role in shaping the economic situation of farms (all analysed groups). Linking subsidies with the environmental protection principles in agricultural production also affected the environmental sustainability of farms.

Support for organic farms seems reasonable due to hardly intensive and specialised production (which determines their less favourable competitive position) and primarily non-marketable environmental and social benefits generated by them. The production of non-market goods requires proper commitment from various state institutions, as they are not covered by market transactions.

REFERENCES

Bocian M., Malanowska B. (2014). Wyniki Standardowe 2012 uzyskane przez indywidualne gospodarstwa rolne uczestniczące w Polskim FADN. Część I. Wyniki Standardowe, IERiGŻ-PIB, Warszawa [Standard results 2012 of individual farms in Polish FADN. Part I. Standard results, IAFE-NRI, Warsaw].

Goraj L. (2009). Rachunkowość i analiza ekonomiczna w indywidualnym gospodarstwie rolnym, Difin, Warszawa [Accountancy and economic analysis of individual farms, Difin, Warsaw].

Wrzaszcz W., Zegar J. St. (2014).Zrównoważenie ekonomiczne gospodarstw rolnych w świetle danych PSR 2010, Wiadomości Statystyczne, No. 11, Warszawa, 48-64 [Economicsustainability of the Polishfarms on the basis of Agricultural Census 2010].

Wrzaszcz W., Zegar J. St. (2015). Economic challenges of organic farms in Poland, Book of proceedings, Sixth International Scientific Agricultural Symposium, “Agrosym 2015”, Jahorina, October 15 - 18, 2015, 1132-1139.

www.minrol.gov.pl; Ministry of Agriculture and Rural Development, 2016, access: 10.05.2016.

www.ifoam-eu.org/en/news/2016/04/05/new-publication-organic-europe-increased-demand-organic-food-production-not-moving; Organic in Europe: Prospects and Developments 2016, IFOAM EU, FiBL, Marche Polytechnic University and Naturland, 2016, access: 20.04.2016.

www.ijhar-s.gov.pl/index.php/raporty-o-ekologii.html; Agricultural and Food QualityIspection, 2016, access: 02.05.2016.

Zegar J. St., Description of organic holdings in Poland, in: Sustainable agriculture – selected papers, IAFE-NRI, Warsaw, 139-155.

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CONSUMING QUALITY OF FRUITS OF NEW SWEET CHERRY FORMS SELECTED IN NIKITA BOTANICAL GARDENS

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ABSTRACT

The fruits of sweet cherry are valued for early maturing and high quality of a taste. The sweet cherry likes a warm dry climate. The steppe Crimea (Russia) is a favorable region for cultivation of sweet cherry varieties with high-quality fruits. The aim of research was to evaluate a consuming quality of fruits of new sweet cherry forms selected in Nikita Botanical Gardens. The study included 33 perspective forms and control zoned varieties, growing at the plots without irrigation in Simferopol region of the Republic of Crimea. As the rootstocks of studied forms we used seedlings of *Prunus mahaleb L. Mill*. The study was carried out during 2012-2015. Characteristics such as fruits size, attraction of appearance, density and succulence of a pulp, quality of a taste and fragrance of the fruits were valued. According to the results of evaluation, 12 forms were marked out: № 387, № 275, № 434, № 767, № 305 and etc. According to the results of evaluation of fruits size, all marked samples were evaluated at 4,7-5,0 points (according to 5 point scale). The fruits weight was ranging from 7.2 to 8.9 g. The evaluation of attraction of appearance of marked samples was ranging from 4.8 to 5.0 points. The evaluation of the quality of taste was 4.8-4.9 points.

Keywords: *fruits, new sweet cherry forms, quality of a taste, appearance, evaluation.*

INTRODUCTION

Ones of the most important indicators of promising cultivars of sweet cherry are high marketable qualities of the fruits. Characteristics, such as attraction of appearance and large size of fruits, play an important role for increase their market value. Consumers are ready to pay a higher price for high-quality fruits (Perez-Sanchez et al., 2010; Prichko et al., 2013). They prefer dense fruit with high quality of taste in their choice (San Martino et al., 2008). Significant works for quality improvement of sweet cherry fruits were carried out in southern regions of Russia, particularly, in North Caucasian Regional Research Institute of Horticulture and Viticulture (NCRRIH&V, Krasnodar) and Nikita Botanical Gardens-National Research Center (NBG, Yalta). In the southern zone of horticulture of Russia, Krasnodar region and Crimea are the most favorable regions for industrial

production of sweet cherry fruits with high taste quality. First of all, sweet cherry fruits are valued for early maturing – she opens the season of consumption of fresh fruits one of the first. Besides, sweet cherry is unpretentious culture. That's why it is possible to cultivate her and to get high-quality production even at minimal pesticide load. It is very important for south of Russia, as the resort area with a great number of health resorts and sanatoriums (Alehina, 2014).
The aim of research was to evaluate a consuming quality of fruits of new sweet cherry forms selected in Nikita Botanical Gardens, such as fruits size, attraction of appearance, density and succulence of a pulp, quality of a taste and fragrance; and to determine influence factors for these characteristics, if it possible.

MATERIALS AND METHODS

The study was carried out during 2012, 2013 and 2015 at the plots in a village Novy Sad in Simferopol region of the Republic of Crimea (Russia). Experimental plots are situated on southern black soil without irrigation. Agrotechnical measures were minimal. The study included 33 perspective forms of sweet cherry selected in Nikita Botanical Gardens. All studied forms were planted according to the scheme of landing 7×6 meters on the seedlings of *Prunus mahaleb (L.) Mill* as a rootstocks. Forms were distributed by three groups according to terms of their ripening. For each group we chose zoned cultivar as a control.
During evaluation we used "Program and methods of cultivars studying of fruit, berry and nuciferous crops" (Sedov et al., 1999). Evaluation included measuring of next fruits parameters: average weight, lengthwise (D_1) and transverse (D_2) diameter and height. Average weight of fruit was determined by weighing of 100 fruit and calculation of average weight of one fruit. Maximal weight implies maximum average weight during the studying period. Sugar-acid ratio was determined by calculation of percentage of sugar and free acid in the fruits (sugar and acid content data were received from biochemical laboratory). Degustation evaluation was carried out by commission according to 5-point scale. Statistical data processing was carried out using Microsoft Office and Statistica 6.0.

RESULTS AND DISCUSSION

Size of fruits is biological, constant feature, but it can vary in different years. Factors, which influence upon size of fruit, are: peculiarities of cultivars, quantity of precipitation during the formation of the fruits and temperature condition. As example, we can see influence of peculiarities of cultivars on average weight data of forms № 828, № 275, № 343, № 434, № 453, № 593, № 975, № 297 and № 305 (Tabl. 1). During the studying these forms had a minimal variability of fruit weight – variation ratio (measure of sign dispersion) of these forms was no more than 8%. In this instance, particularly valuable are medium ripening forms № 275, № 453 and № 975 – their average weight didn't decrease below 7,4 g during the years of study.

Table 1. Fruit weight and size of new sweet cherry forms selected in Nikita Botanical Gardens

Cultivar	Average weight, g	Max weight, g	Variation ratio, %	Average diameter		Average height, mm
				D_1, mm	D_2, mm	
Early ripening						
Valeriy Chkalov (control) 21-27 № 387 № 758 № 828 № 923	6,5 ± 0,4 6,8 ± 0,4 7,6 ± 1,0 7,3 ± 0,5 6,6 ± 0,1 7,2 ± 0,5	7,2 7,5 9,7 8,2 6,9 7,8	10 10 23 11 4 11	24 ± 1,2 24 ± 1,5 23 ± 1,0 24 ± 1,5 22 ± 0,7 23 ± 1,9	19 ± 0,6 22 ± 1,3 20 ± 0,4 21 ± 1,5 18 ± 0,9 20 ± 1,2	20 ± 0,7 22 ± 0,9 21 ± 0,7 21 ± 0,9 20 ± 0,3 20 ± 1,3
Medium ripening						
Melitopolskaya Chyornaya (control) № 270a № 272 № 275 № 294 № 320 № 343 № 355 № 434 № 453 № 471 № 537 № 593 № 601 № 602 № 607 № 613 № 760 № 762 № 767 № 963 № 964 № 975	7,2 ± 0,4 7,9 ± 0,6 7,9 ± 1,0 8,9 ± 0,2 7,6 ± 1,4 7,5 ± 0,8 6,4 ± 0,2 7,3 ± 0,7 7,3 ± 0,3 7,7 ± 0,2 8,2 ± 0,7 7,5 ± 0,6 7,3 ± 0,3 9,3 ± 0,9 7,3 ± 0,5 7,2 ± 0,9 6,2 ± 0,3 6,9 ± 0,4 7,2 ± 0,5 7,9 ± 0,7 7,4 ± 0,7 6,4 ± 0,3 8,1 ± 0,3 8,8 ± 1,3 8,3 ± 0,4	7,8 8,8 9,7 9,2 10,4 9,0 6,8 8,5 7,7 8,0 9,2 8,4 7,9 10,9 8,0 8,9 6,8 7,6 7,8 9,2 8,9 7,1 8,5 11,2 8,9	10 14 21 4 32 17 5 16 8 4 14 13 7 16 12 21 9 9 12 15 17 9 7 26 9	25 ± 1,2 26 ± 0,9 25 ± 1,5 27 ± 0,9 26 ± 1,2 24 ± 1,2 24 ± 0,0 24 ± 1,5 24 ± 0,9 26 ± 0,3 25 ± 1,2 22 ± 0,9 24 ± 0,9 27 ± 1,2	21 ± 1,2 22 ± 0,9 22 ± 1,2 22 ± 1,0 21 ± 0,9 20 ± 0,3 19 ± 0,3 20 ± 1,2 21 ± 0,3 21 ± 0,3 20 ± 0,7 19 ± 0,7 20 ± 0,9 22 ± 0,9	22 ± 0,7 23 ± 0,7 21 ± 0,9 23 ± 0,3 22 ± 1,2 22 ± 0,7 20 ± 0,6 21 ± 0,9 22 ± 0,3 20 ± 0,3 21 ± 1,2 20 ± 0,3 21 ± 0,3 23 ± 0,9 21 ± 0,3 21 ± 0,9 20 ± 0,9 20 ± 0,6 22 ± 0,7 21 ± 0,9 22 ± 0,6 23 ± 0,3 22 ± 0,3 24 ± 1,0 23 ± 0,9

№ 980 H-d 3/127				23 ± 1,8 23 ± 1,7 23 ± 0,3 24 ± 1,2 24 ± 0,7 25 ± 1,2 23 ± 1,0 23 ± 0,3 25 ± 0,6 24 ± 1,2 27 ± 1,5	20 ± 1,5 19 ± 1,2 19 ± 0,3 20 ± 1,2 21 ± 1,2 22 ± 1,2 21 ± 1,2 19 ± 0,3 21 ± 0,9 21 ± 1,5 22 ± 1,5	
Late ripening						
Karadag (control)	7,8 ± 0,5	8,7	10	26 ± 0,7	21 ± 0,9	23 ± 1,0
№ 297	7,7 ± 0,4	8,2	8	25 ± 0,6	21 ± 0,6	22 ± 0,3
№ 300	8,2 ± 0,4	8,8	9	25 ± 0,6	22 ± 1,2	22 ± 0,6
№ 305	7,5 ± 0,3	8,1	8	24 ± 0,3	21 ± 0,3	20 ± 0,3
№ 460	7,2 ± 0,6	8,4	15	26 ± 1,2	20 ± 0,9	22 ± 0,6

Meteorological conditions during research period allowed to analyse their influence on quality of fruits. We analyzed temperature indexes and quantity of precipitation during the period of formation of the fruits (period from ending of blossoming till ripening) in each group of ripening (Tabl. 2). In 2012 this period was the hottest (average daily main temperature was 19,1-19,7 °C, average maximum temperature – 26,1-26,7 °C) and rainy (51,6-56,6 mm of precipitation). In 2013 daily temperature fluctuations were more abrupt – nights were colder and day temperature was higher than year before (average maximum temperature was – 26,7-27,0 °C). Nevertheless, average daily main temperature of that period was lower than in 2012 – 18,0-18,6 °C. Medium and late ripening forms got a more quantity of precipitation (45,7-58,1 mm). 2015 was anomalous by quantity of precipitation – 96,6-230 mm of precipitation fell out during the period of fruits formation (when average annual norm of precipitation is 480 mm (Antyufeyev, 2002). In that year average daily main temperature was lower – 15,6-17,3 °C, and average maximum temperature was 22,3-24,2 °C. As a result, in 2015 period of fruits formation was more long (36-53 days), than in 2012-2013 (26-47 and 31-48 days accordingly).

Table 2. Influence of meteorological conditions on fruit weight and sugar-acid ratio of new sweet cherry forms selected in NBG

Year	Average max temp., °C	Average min temp., °C	Average daily main temp., °C	Precipitation, mm	Average fruit weight, g	Average sugar-acid ratio
Early ripening						
2012 2013 2015	26,5 26,7 22,3	12,8 11,6 10,8	19,1 18,0 15,6	51,6 28,1 96,6	6,7 ± 0,19 6,6 ± 0,22 7,8 ± 0,45	23,6 ± 1,6 22,6 ± 2,0 20,2 ± 1,9
Medium ripening						
2012 2013 2015	26,1 26,9 23,7	13,0 12,2 12,2	19,1 18,3 16,7	56,6 45,7 159,5	7,4 ± 0,20 7,0 ± 0,18 8,4 ± 0,24	23,4 ± 1,1 18,2 ± 0,5 18,0 ± 0,7
Late ripening						
2012 2013 2015	26,7 27,0 24,2	13,5 12,7 13,0	19,7 18,6 17,3	56,6 48,1 230,0	7,6 ± 0,39 7,3 ± 0,26 8,1 ± 0,25	22,8 ± 1,7 19,3 ± 1,5 19,8 ± 1,1

Results of research didn't allow to confirm that temperature condition have influence on the fruits size. While a quantity of precipitation has influence on this parameter unconditionally (Fig.1-3). As we can see, temperature curve tends down, while curve of fruits size tends upward by analogy with curve of precipitation quantity.

First of all, meteorological conditions have influence on biochemical composition of fruits and, accordingly, on a taste quality. That's why curve of sugar-acid ratio tends down by analogy with temperature curve (Fig.4-6). It confirms that accumulation of sugar in the fruits reduces in rainy cold weather.

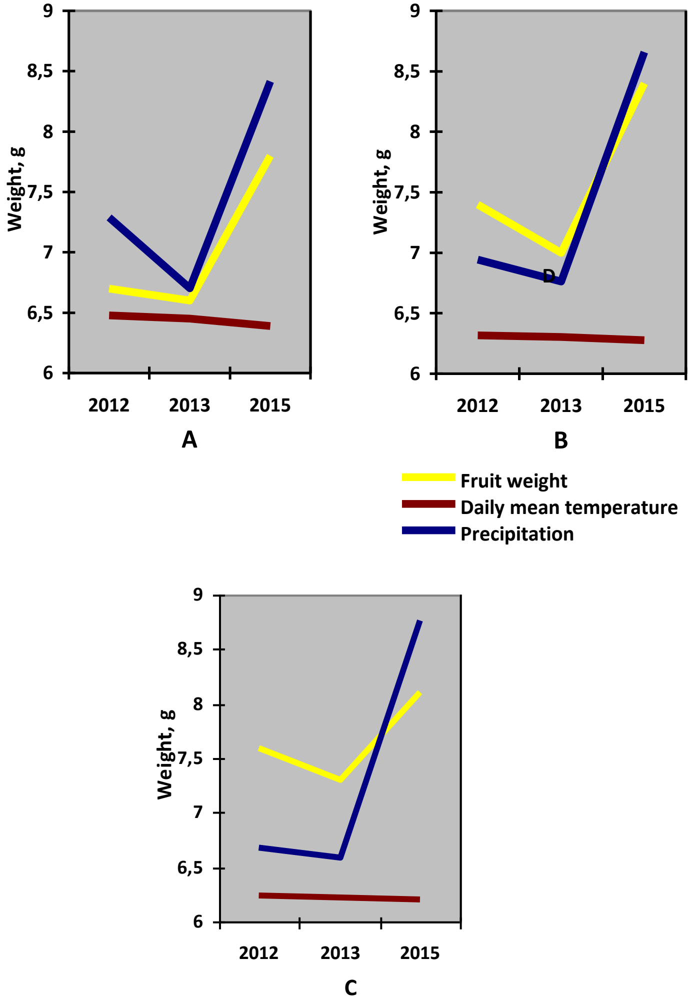

Figure 1-3. Variation of fruits weight with changing of daily main temperature and quantity of precipitation during the formation of the fruits in each group: A – early ripening; B – medium ripening; C – late ripening.

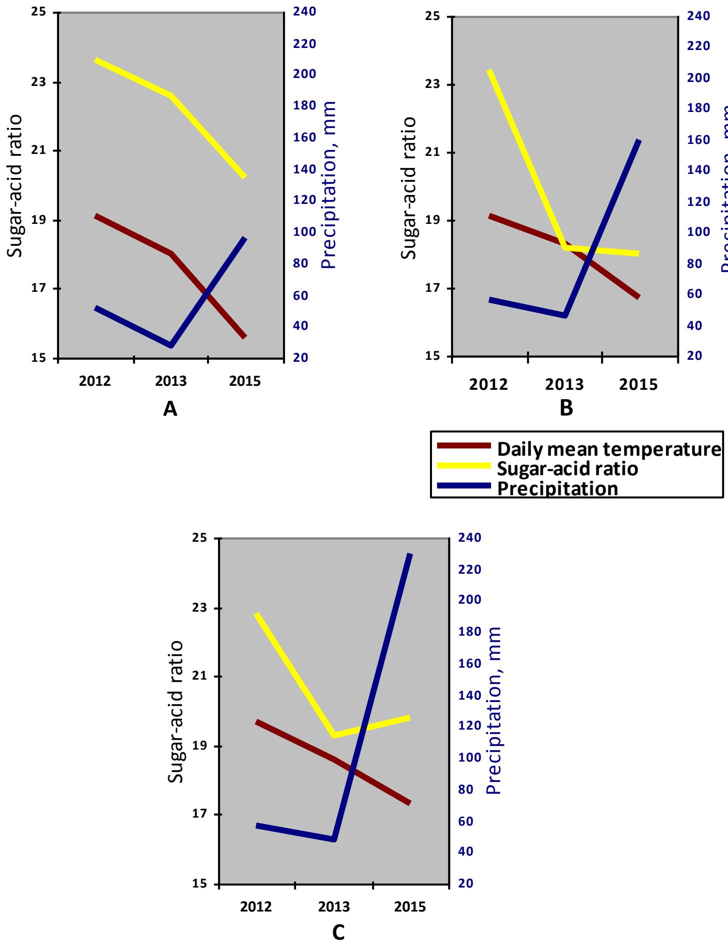

Figure 4-6. Variation of sugar-acid ratio with changing of daily main temperature and quantity of precipitation during the formation of the fruits in each group: A – early ripening; B – medium ripening; C – late ripening.

In our region the mean destination of sweet cherry is for fresh consumption. That's why degustation evaluation has a great importance. We carried out evaluation of fruits size, attraction of appearance, quality of taste and gave general assessment of the fruits (Tabl. 3). All studied forms were valued on 4-5 points as the fruits from medium till large sizes; from attractive till very beautiful form and coloring; from good till excellent taste.
According to the results of evaluation, 12 forms were marked out, which exceeded control zoned varieties. These are forms of early ripening – № 387, №758; medium ripening – № 275, № 434, № 593, № 762, № 767, № 975, H-d 3/127; late ripening

– № 297, № 300, № 305. The evaluation of quality of a taste of these forms was 4,82-4,92 points, and average assessment of the fruits was 4,82-4,96.

Table 3. Degustation evaluation of new sweet cherry forms selected in NBG (in points, according to 5-point scale).

Cultivar	Fruit size	Attraction of appearance	Quality of taste	Average fruit assessment
Early ripening				
Valeriy Chkalov (control)	4,60±0,21	4,74±0,14	4,81±0,07	4,72±0,12
21-27	4,83±0,06	4,86±0,02	4,76±0,01	4,81±0,02
№ 387	4,92±0,02	4,95±0,02	4,86±0,04	4,90±0,04
№ 758	4,81±0,08	4,81±0,08	4,83±0,07	4,82±0,08
№ 828	4,16±0,34	4,38±0,38	4,42±0,36	4,31±0,36
№ 923	4,30±0,37	4,37±0,21	4,43±0,29	4,37±0,29
Medium ripening				
Melitopolskaya Chyornaya (control)	4,39±0,21	4,65±0,14	4,48±0,14	4,50±0,16
№ 270a	4,67±0,13	4,79±0,11	4,77±0,18	4,76±0,14
№ 272	4,82±0,15	4,76±0,11	4,69±0,11	4,75±0,12
№ 275	4,97±0,01	4,97±0,02	4,88±0,04	4,94±0,02
№ 294	4,76±0,14	4,66±0,08	4,61±0,10	4,69±0,10
№ 320	4,57±0,40	4,63±0,34	4,70±0,25	4,63±0,33
№ 343	4,48±0,41	4,53±0,30	4,55±0,33	4,52±0,28
№ 355	4,74±0,04	4,77±0,01	4,78±0,0003	4,76±0,01
№ 434	4,99±0,001	4,95±0,03	4,92±0,05	4,96±0,03
№ 453	4,80±0,09	4,83±0,09	4,79±0,09	4,81±0,09
№ 471	4,85±0,04	4,86±0,03	4,78±0,02	4,83±0,03
№ 537	4,42±0,34	4,55±0,38	4,45±0,36	4,47±0,36
№ 593	4,85±0,05	4,85±0,05	4,82±0,02	4,84±0,03

№ 601	4,86±0,03	4,84±0,02	4,67±0,03	4,79±0,01
№ 602	4,55±0,33	4,48±0,41	4,56±0,18	4,53±0,30
№ 607	4,12±0,23	4,24±0,21	4,38±0,18	4,25±0,20
№ 613	4,57±0,08	4,73±0,10	4,63±0,09	4,64±0,03
№ 760	4,76±0,15	4,78±0,13	4,74±0,02	4,77±0,08
№ 762	4,87±0,05	4,89±0,03	4,90±0,02	4,88±0,03
№ 767	4,94±0,06	4,95±0,04	4,85±0,05	4,91±0,05
№ 963	4,76±0,14	4,82±0,11	4,69±0,08	4,76±0,11
№ 964	4,56±0,24	4,40±0,02	4,49±0,20	4,48±0,15
№ 975	4,92±0,06	4,88±0,07	4,82±0,10	4,88±0,08
№ 980	4,61±0,17	4,58±0,13	4,62±0,11	4,60±0,13
H-d 3/127	4,86±0,10	4,85±0,08	4,82±0,10	4,84±0,09
Late ripening				
Karadag (control)	4,85±0,09	4,86±0,09	4,78±0,07	4,83±0,08
№ 297	4,80±0,11	4,78±0,10	4,80±0,09	4,80±0,10
№ 300	4,98±0,02	4,97±0,01	4,88±0,02	4,94±0,02
№ 305	4,94±0,03	4,87±0,07	4,85±0,04	4,89±0,04
№ 460	4,70±0,15	4,80±0,14	4,79±0,10	4,76±0,13

Besides these features, during degustation we evaluated density and succulence of a pulp, fragrance, character of taste and coloring of the fruit. Character of taste, mainly, depends on combination of sugar and acid, and determined by the following terms: *sweet* (acid is not felt), *acidulous-sweet* (sweetness dominates, there is a slight acidity), *sour-sweet* (acidity and sweetness are felt good, sweetness dominates), *sweetly-sour* (acidity and sweetness are felt good, acidity dominates), *sweetish-sour* (acidity dominates, there is a slight sweetness), *sour* (sweetness is not felt). According to the results of evaluation, all studied forms were distributed on groups by each characteristic (Fig. 7). The samples with maroon coloring of fruits, with dense or very dense, succulent sour-sweet pulp and weak or medium intensity of fragrance constitute the main group among studied forms.

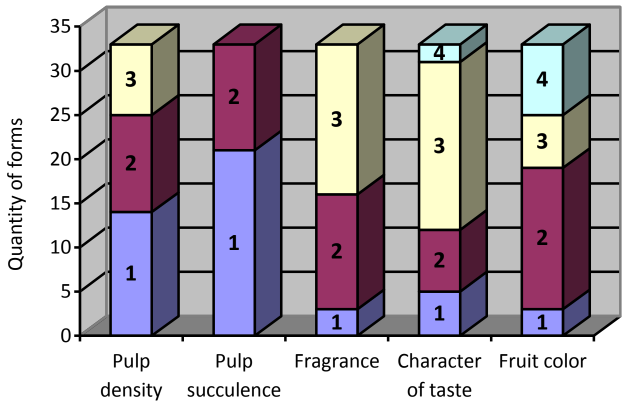

Figure 7. Distribution of studied forms by characteristics according to results of degustation evaluation. *Pulp density:* 1 – very dense, 2 – dense, 3 – medium density. *Pulp succulence and fragrance:* 1 – intense, 2 – medium, 3 – weak. *Character of taste:* 1 – sweet, 2 – acidulous-sweet, 3 – sour-sweet, 4 – sweetly-sour. *Fruit color:* 1 – blackish, 2 – maroon, 3 – from red to dark-red, 4 - yellow with reddish blush.

CONCLUSION

According to the results of research 6 forms, which have stable high quality of fruits, were marked out: № 275, № 434, № 593, № 975 (of medium ripening), № 297 and № 305 (of late ripening). These forms are recommended for use in the breeding and for transmission to the state tests of cultivars.

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REFERENCES

Alehina E. (2014). Promising sweet cherry varieties, forming fruits of high commodity quality. Plodovodstvo i vinogradarstvo yuga Rossii. Vol. 28(04). P. 27-37.

Antyufeyev V., Vazhov V., Ryabov V. (2002). Guide to climate of Steppe branch of Nikita Botanical Gardens. Yalta. 88 p.

Perez-Sanchez R., Gomez-Sanchez M.A., Morales-Corts M.R. (2010). Description and quality evaluation of sweet cherries cultured in Spain. Journal of Food Quality. 2010. Vol. 33. P. 490-506.

Prichko T., Zhukov G., Karenik V. (2013). Qualitative evaluation of sweet cherry fruits of promising varieties grown in the south of Russia. Plodovodstvo i vinogradarstvo yuga Rossii. Vol. 19(1). P. 1-6.

San Martino L., Manavella F.A., García D.A., Salato G. (2008). Phenology and fruit quality of nine sweet cherry cultivars in South Patagonia. Acta Horticulturae (ISHS). Vol. 795. P. 841-847.

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PREPARATION AND PROPERTIES OF CHITOSAN FROM CRAB SHELL CONTAINING RAW MATERIAL BY ELECTROPHYSICAL PROCESSING

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ABSTRACT

Traditional technologies of chitosan producing involve the use of hard alkali-acid treatment of crab shell raw materials, which negatively affects the main quality parameters of chitosan (molecular weight, the degree of deacetylation). We propose an alternative technical approach. It involves the use ofelectrohydraulicshocks,whichuseextra-long bits.Theproposed approach has the following advantages:the stages of grinding and deproteinizationof the raw materialsare combined,the additional use ofalkaliis excluded at the stage of deproteinization.For comparative characteristics of the structure of the polymer the IR-spectra of the samplesof chitosanwere removed. Chitosan, obtained using electrohydraulic treatment is not inferior in its physico-chemical parameters of chitosan, obtained by using alkaline reagents. It is possible to organize the process of chitosan production on the base of the enterprises for shrimp processing. Specific requirements for physico-chemical and functional properties of chitosan-containing substances make the actual means and methods of control of the target parameters, the key of which are qualitative identification and comprehensive determination of chitosan in the composition of film-forming compositions and films coatings. As the chromophore to measure the surface potential of the chitosan substances, we used 1-aniline-8-naphthalenesulfonate (ANS). The maximum fluorescence of the dye in chitosan films is shifted to longer wavelengths compared to chitosan gels, because of the increased polarity of the medium of films on the attitude to gel-like chitosan substances. The data obtained by thefluorimetric studies can be used in the development of methods for the detection of chitosan.

Keywords: *chitin, chitosan, electro-shocks, the degree of deacetylation, shrimp shell.*

INTRODUCTION

The issues of intensification of processes for the production of structural biopolymers – chitin and chitosan, occupy a central place in the works of domestic and foreign researchers(Cho et al, 2000; Viarsaghl et al, 2009; Gartman et al, 2013). This trend reflects the global direction of development of all processing industries, including food and pharmaceutical production. The traditional technology of obtaining the chitosan involves the use of the shell crustaceans. The main role in the traditional technologies played by the transfer of the matterfrom one phaseto another.

The technology of obtaining the chitosan from chitin-containing raw material includes the following main stages: grinding of raw materials; removing the protein fractions (deproteinization); translation the mineral components of raw materials in the soluble form (demineralization); deacetylation of chitin with obtaining the chitosan.

The priorities in this area are the technological solutions that reduce the consumption of aggressive reagents at the stage of the deproteinization of the shell crustaceans. For example, the replacement of the sodium hydroxide solution to the ammonium hydroxide solution is allowed to obtain the volatile components as the reaction products (Kasyanov, 2013).

The purpose of the work is to develop the technique and technology of obtaining chitosan with the use of electrophysical processing of chitin-containing rawmaterials of the crustaceans.

MATERIALS AND METHODS

We used crab shell containing raw material (SCRM) obtained in the industrial processing of freshwater crayfish, Arctic shrimp (*Ledovo* Company,Schelkovo, Moscow region). The catch season was from March to October, 2015.Shrimps have been caught in Okhotsk Sea (the Far East fishery basin).

We received and investigated the experimental samples of chitosanin the laboratory of Technology and Merchandizing Faculty in Voronezh State Agricultural University from April to December, 2015.

The fluorimetric studyof chitosan substances we carried out in the laboratory of Institute of Cell Biophysics of the Russian Academy of Sciences(Pushchino, Moscow region) in May, 2015.

The quality of the obtained chitosan was adjusted on a complex of indicators. The content of minerals was established by dry ashing.

The molecular weight of chitosan was determined by a standard viscometric method. The measurements were carried out at 250 °C in a capillary viscometer Ubbelohde, the diameter of which is equal to 0.54 mm. A sample of chitosan we previously dispersed in succinic acid. Calculation of molecular weight was carried out according to equation of Mark-Kuhn-Houwink (Gartman*et al*, 2013).

The degree of deacetylation was determined by potentiometric titration on universal ionometer EV-74 using a glass electrode. The method is based on the titration of the chloride hydrogen connected with a molecule of a chitosan. The researches were carried out by the titration of solution of a chitosan by sodium hydroxide solution.

Microbiological parameters were determined according to standard procedures.

The comparative evaluation of structural changes of products of chitin-containing raw material subjected to various types of preliminary treatment with chemical reagents was carried out with the use of a method of IR-spectroscopy (Vasilyev*et al*, 2007). The IR spectra of chitosan are removed on the spectrophotometer Vertex70 (*Bruker, Germany*) in the rangeof 4000-400 cm^{-1}. The preparations were prepared by drawing a thin film of a sample on a silicon substrate.

Spectral properties of chitosan dispersions and films was studied using the fluorescent double-beam scanning spectrophotometer PERKIN ELMER Lambda 800. We recorded the fluorescence spectraat 20 °C in a mirrored cuvette with optical path length 1 cm in the range of 400-550 nm (upon excitation at 370 nm) and 430-500 nm (upon excitation 380 nm). The light-transmitting slit was set at 8 mm. The samples for fluorescence studies containing chitosan and hydrophobic dye with the concentration of $1*10^{-6}$mol/dm^3, were incubated for 2-3 hours at 20 °C. Fluorescence ranges of dye solutions and chitosan containing compositions weresubtracted from the fluorescence spectra of the samples. In determining the degree of polarization we used the wavelength of excitation 380 nm and emission of 430 nm.

The magnitude of light scattering was measured on a spectrofluorimeter similar to the previous tech experience (in the mirror cells) in the crossed monochromators: at the same wavelength of 560 nm (slit of 8 nm in the first monochromator and 1 nm in the second).The channel got ambient light in proportion to the size of the particles and their number.

Chitosan films were prepared from chitosan substances with the addition of 1-aniline-8-naphthalenesulfonate (ANS) with a concentration of $1.56*10^{-6}$mol/$dm^3$by the method of spreading on the glass substrate with subsequent evaporation of the acid in the air. The films were kept to evaporation of the acid at the ambient temperature for 36 - 48 h. To study the films were deposited on cover glasses and placed in a glass cuvette on the diagonal. Fluorescence spectrum was removed in the range of 430-500 nm, at the excitement wavelength310 nm. The light-transmitting slit size was set at 5 nm for excitation and 2.5 nm for emission.

RESULTS AND DISCUSSION

Electrohydraulic shock allows transformingthe electrical energy into mechanical energywithout the intermediate mechanical links. In the case of implementation of electrohydraulic shock in the volume of the liquid which is in a tank under the influence of specially created pulse electric spark discharge around a zone of its education there are extreme hydraulic pressures capable to make the useful mechanical operation and followed by a complex of the physical and chemical effects.

The technological capabilities of electrohydraulic shock are provided at the expense of superlong discharges in the carrying-out liquids by the limit reduction of the activearea of the positive electrode (that is adjoining to liquid). At the same time increasing the active area of the negative electrode(Yutkin, 1986).

For reproduction of the electrohydraulic shocks in the volume of the compound consisting of the the shell of crustaceans and water in the ratio 1:15 we used the installationwhich is turning on the source of energy with the condenser as the accumulator of electrical energy (Figure 1).This scheme is implemented in the original technical solution of the apparatus for producing chitin and chitosan(Figure 2).

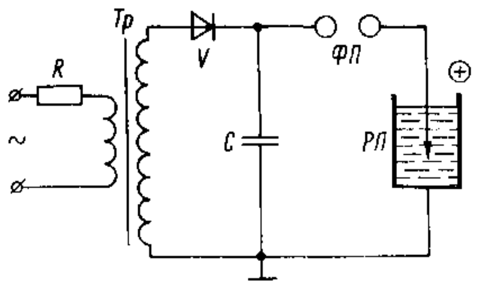

Figure 1. An electric circuit of installation for reproduction of electrohydraulic shocks: R - charge resistance; Tp - the transformer; V - rectifier; ФП - the creating spark interval; РП – a work space; C – the capacitor

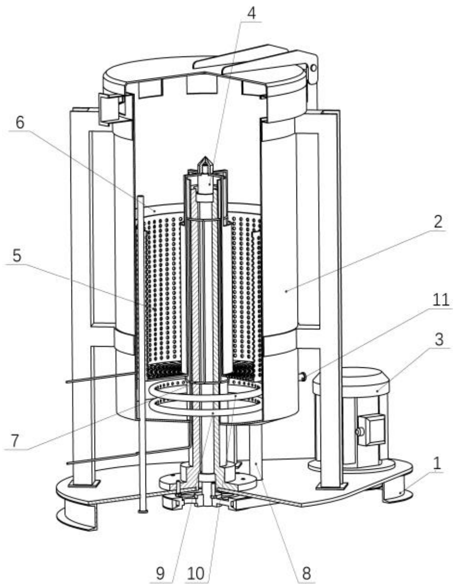

Figure 2. General view of the installation for obtaining of chitin and chitosan: 1 – base box; 2 – reactor tankage; 3 - electric motor; 4 - vertical shaft; 5 - perforated removable container; 6 –externalnegative electrode; 7 - central positive electrodes; 8 - drain pipe; 9, 10, 11 -the nozzles for supplying process media

We established experimentally that the processing of shell crustaceans is advantageously to carry out with an average mode of operation of the electro-hydraulic setup, the capacitance of the capacitor (*C*) = 0.1 μf; voltage U= 50 kV; the distance between electrodes (*l*) = 25 mm; the temperature of the mixture (*t*) = 20 °C. In the result there is a grinding shellcrustaceans in suspension to a particle size of 0.05-0.1 mm. The resulting suspension is passed through a suction filter, the precipitate is placed inthe reactor with a mixer and a shirt. The precipitate is treated with hydrochloric acid with volume fraction of 2-4% at the hydraulic module of 1:10, a temperature of 20-25 ^{o}C and stirring for 2 h.Further the solid and the liquid fraction were separated, the precipitate was washed with distilled water to pH 7.0. Depending on the kind of used shell crustaceans, next a solution of sodium hydroxide with a mass fraction of 35-45% was added to the obtained chitin and the mixture was incubated at a temperature of 95-98 °C during 1-2 hours. Table 1 presents the physico-chemical characteristics of chitosan which was obtained by the proposed method in comparison with the the traditional way.

Table 1. Physico-chemical characteristics of chitosan samples obtained by different methods

Physico-chemical characteristics of chitosan	The chitosan from the carapace of a crab(the producer is "Bioprogress", Schelkovo, Moscow region)	The samples of chitosan obtained by the proposed method	
		from the shell of a shrimp	From the carapace of the freshwater crayfish
Characteristic viscosity (in the 2 % solution of acetic acid), dl/g	25.0	24.1	22.9
Molecular mass, to	260	300	270
Degree of deacetitisation, %	82	92	90
Mass share of ash, %	0.7	0.4	0.5
Protein residue,%	0.05	0.05	0.03
Mass share of moisture , %	9	9-10	8-10
Particle size (granulometry-cal composition), mm	0.1-0.2	0.05-0.1	0.05-0.1

The microbiological characteristics of chitosan obtained by the proposed technology under laboratory conditions, were determined. Data are presented in the table 2.

Table 2. Microbial attributes of chitosan

The nameof an indicator	The threshold value	Actual measure value
Mesophilic aerobic and facultative anaerobic microorganisms, Units forming colonies /g	$4 \cdot 10^4$	$3.9 \cdot 10^4$
Coliform bacteria	Prohibited	Not discovered
Pathogenic microorganisms	Prohibited	Not discovered
Mold fungi, Units forming colonies /g	$2 \cdot 10^4$	$1.7 \cdot 10^4$

Organoleptic characteristics of chitosan derived from shrimp shell by the developed technology in comparison with the commercial sample are presented in the Table 3.

Table 3. Organoleptic parameters of chitosan

Indicator name	Characteristics for the samples of chitosan	
	from the carapace of a crab (the producer is "Bioprogress", Schelkovo, Moscow region)	from the shell of a shrimp
Appearance	Fine-fibrous particulates	Fine powder
Colour	Yellow	White
Smell	No smell	No smell

Organoleptic characteristics of chitosan from shrimp shell is almost identical to the biopolymer obtained by the traditional method. The contrast of chitosan according to the traditional technology is the white color due to the presence in the production stage of bleaching.

For comparative characteristics of the structure of the polymer was removed IR spectra of chitosan samples (Figure 3) obtained from the shell of shrimp (the proposed technology) and crab (traditional technology).

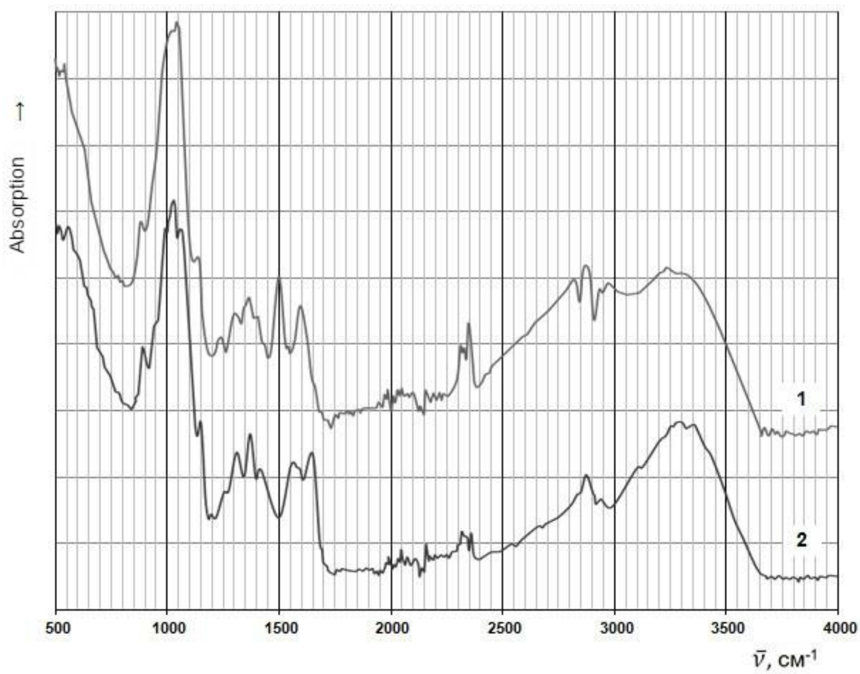

Figure 3. IR-spectra of chitosan from the carapace of a crab, the manufacturer is the closed joint-stock company "Bioprogress" (1) and from the shell of shrimp (2)

In the IR-spectra of chitosan samples presented in the Figure 3, pronounced absorption bands 1010-1050 and 1310-1360 cm^{-1}. They characterize the deformation fluctuations of hydroxyl group of primary and secondary alcohols.In the range of 3250-3350 cm^{-1} there is a broad absorption peak corresponding to the stretching vibrations of the hydrogen atoms in hydroxyl and amine groups (Otto, 2003; Tarasevich, 2012).Absorption peaks in the 2880-2950 cm^{-1} correspond to the stretching vibrations of methylene groups.
Analysis of IR spectra, in general, showed both the identity of the chemical structure of the chitosan samples. But attention is drawn to the presence of a second sample in the spectrum absorption bands 1550-1560, 1650 cm^{-1} characteristic to a greater degree the oscillations NH-links the primary amino groups, and their displacement in the long wavelength region for the first sample to 1510 and 1600 cm^{-1}, corresponding to vibrations of secondary amide linkages. The presence of additional absorption peaks of 2820, 2980 cm^{-1} in the spectrum of the first sample may be due to variations in the CH-bond methyl acetyl groups of chitin fragments. Thus, these data indicate incomplete deacetylation of chitin in the preparation of the sample 1 by the acid-alkali treatment.
To use the chitosan substances in various branches they have to possess the specific physical, chemical and functional properties. In this regard, the actual task is to develop the means and methods of control of target parameters, key of which are qualitative identification and quantitative determination of chitosan in the composition of the functional compositions and products with their use.As the chromophore to measure the surface potential of the chitosan substances, we used 1-aniline-8-naphthalenesulfonate (ANS). The maximum fluorescence of the dye in chitosan films is shifted to longer wavelengths compared to chitosan gels, because of the increased polarity of the medium of films on the attitude to gel-like chitosan substances(Vekshin, 2015).The data obtained with the use of fluorometric studies can be used in the development of methods for the detection of chitosan.

CONCLUSIONS

We have developed an alternative technical approach to obtaining chitosan from crustacean shell.It is designed to combine the stages of grinding and deproteinization, avoids the use of alkali at the stage of deproteinizationthrough the use of electro-hydraulic shock is carried out using extra-long bits (Balabaev, 2015; Glotova, 2015). The proposed method of obtaining chitosan has the following advantages: the possibility of organizing the recycling process of shellscrustaceans on the production base of processing of the main raw material; reducing the consumption of alkaline and sewage the volume of waste waterthrough the use of electro-shock on the stage of the deproteinization. Thus it can be concluded that the chitosan obtained by electro-processing is not inferior in its physical and chemical indicators from the samples of chitosan obtained with traditional alkaline reagents. By the combining of the processes of grinding and deproteinization of the shellsofcrustaceans,it is possible to reduce the total duration and labor input of the process, to improve the ecological state of the production.

REFERENCES

Balabaev, V., Izmailov, V., Glotova, I., Yarovoy M., Shakhov S. (2015). Innovative technologies and technical means for agriculture.Proceedings of the international scientific-practical conference of young scientists and specialists.Voronezh State Agrarian University, Russia, pp. 319-323.

Cho,Y.-W., Jang, J., .Park, C., KoS.-W. (2000). Preparation and solubility in acid and water of partially deacetylated chitins.Biomacromolecules, Vol.1, No. 4, pp. 609-614.

Gartman, O., Vorobyeva, V. (2013). Technology and properties of chitosan from the gammarus. Fundamental research, No 6-5, pp. 1188-1192.

Glotova I., Balabaev V., Izmailov V., Chudinova L. (2015). Approaches to the intensification of chemical-engineering processes in the preparation of chitosan. Modern problems of science and education.No 2. URL: www.science-education.ru/122-20602. Accessed on 28/06/2015.

Kasyanov, G., Kubenko, E. (2013). The development of technology of obtaining chitosan from shell of gammarus crustacean's of the Azov. News of higher educational institutions. Food technology.. No. 1 (331),pp. 69-72.

Otto, M. (2003). Modern methods of analytical chemistry. Vol. 1.Technosphere.Moscow.

Tarasevich, B. (2012). IR spectra of the main classes of organic compounds.Reference.Publishing house of Moscow state University, Moscow.

Vasilyev, A./Grinenko, E., Shchukin, A., Fedulina, T. (2007). Infrared spectroscopy of organic and natural products. Textbook. Saint-Petersburg state forest technical Academy. Saint Petersburg.

Vekshin, N., Glotova, I., Balabaev, V., Izmailov, V. (2015). Fundamental research, No 6-3, pp. 447-451.

Viarsaghl, M., Janmaleki, M., Falahatpishehl, H., Masoumi, J. (2009). Chitosan preparation from persiangulfshrimp shells and investigating the effect of time on the degree of deacetylation. Journal of Paramedical Sciences (JPS), vol. 1, pp. 2–7.

Yutkin, L. (1986). Electrohydraulic effect and its application in industry.Mashinostroenie, Leningradbranch, Leningrad.

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INNOVATION DIRECTIONS OF EFFECTIVE AGRO-INDUSTRIAL ACTIVITIES

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ABSTRACT
The bodies of the Russian Federation's state management, scientific society, agri-business face the challenges of searching for new directions to provide effective development of agro-industrial activities in the modern conditions of increased competition. Severity of problems in development of the Russian agro-industry is caused by the complex of climatic, historical, economic factors. The need for creation and justification of conceptual alternatives based on forming innovative directions for support of effective development causes application of both new and improved management decisions technologies and updated basis criteria and parameters of their introduction with appropriate adoptive mechanisms on territorial levels and in the industry. The objective of the paper is to justify innovative directions of provision effective agrarian activities. The analysis of economic literature, regulatory basis shows the certain reserve with potential to increase the efficiency of domestic agro-industrial production. Analysis of the Russian Federation's agro-industrial complex condition allows assuming that the main hindrance factor in extended introduction of innovations is persistent non-solvency of agrarian enterprises and lack of required means at research institutions to promote their developments. Implementation of innovative directions for effective development of agro-industrial complex enables proving conceptual alternatives and forecasting result capacity of their use for aspects of rural development, improving mechanism of reducing negative anthropogenic influence on environment and ecosystem rehabilitation.

Keywords: *agro-industrial complex, innovations, sustainable development of rural areas, biotechnologies, import substitution.*

INTRODUCTION
The problems of agrarian production were considered by classical economists, Smith (2008) and Ricardo (2008). The works of A. Marshall contain the detailed analysis of their views on this issue (Marshall, 2008). The leader in the study on qualitative changes in the sphere of economy caused by introduction of different technological, innovative, management and consumer innovations into various economical activities is I. Schumpeter. In 1911 in his work "The theory of

economic development" the pioneer of the scientific direction described the influence of market demand and supply on innovations. Under latter he understood qualitative changes characterizing and determining the appropriate stage of production relationships in society (Schumpeter, 1982). Later this theory, applying to agriculture, was developed and complemented by many outstanding economists; among them we can point out McConnel and Brue (1992).
The current state of agro-industrial complex enables us to suggest that the main inhibitory factor for large-scale innovations introduction is persistent non-solvency of agrarian enterprises and lack of required means at research institutions to promote their developments.
In the regions there are no or undeveloped management structures whose functions are to supervise the bank of innovative products and their state appraisal, marketing assistance for agricultural producers, paperwork to purchase and pay for innovative technologies and stuff to enter grant competitions, scientific and technical maintenance. There are no mechanisms and tools of close interaction between agrarian business community and regional government.
At the same time at the federal level, executive authorities identified and set down in normative documents main directions for development of agro-industry taking into account innovation component, their financial maintenance. Thus, the Russian Federation Food Safety Doctrine determines risks for stable functioning of agro-industry, among which low investment appeal and technological lagging behind developed countries, as well as agro-ecological risks caused by unfavorable climatic conditions, and low innovation and investment activities in agrarian production.
One of the most important supportive directions for effective development of the industry is forming of favorable investment climate as a main factor for competitiveness of agrarian economy enabling the sector to apply advanced technologies (Zvyagina, 2014). Under conditions of economic uncertainty, forming of such climate is a necessary requisition for import substitution and food sovereignty, and transition to new technological modes.

MATERIALS AND METHODS

After the time of intensive agriculture, biotechnologies belong to innovation directions of development of agro-industry. The innovation projects aimed at biologization and ecologization of the agricultural activities in Permskii krai were investigated in 2012-1026. Permskii krai is a subject of the Russian Federation with the total area 160,600 square kilometers with moderate continental climate, rich on forest and water resources. Empirical, analytical and statistical methods were used in the investigation. Combination of fundamental and methodological knowledge, theories and results of interdisciplinary and applied Russian and foreign scientific society's research on institutional environment formation and effective development of agro-industry, placement of productive forces in agro-industrial territorial-economic systems served as theoretical and methodological basis for the investigation.

RESULTS AND DISCUSSION

Existing scientific results in the field of improving technological processes in agro-industrial complex can be grouped in the following categories in general: breeding and application of highly productive sources including seed, youngster, embryo transplanting technology, feeding technology; improvement of logistics, storage and transport infrastructure, pre-sale preparation and marketing; engineering-technical technologies based on energy-saving and increasing energy efficiency of agro-production; deep processing of agricultural raw materials, non-waste production and environment-friendly technologies; soil and water cleanup by biotechnological processes; organization of agro-clusters; financial support of innovative directions; training of innovative human resources, etc.

In the scientific literature it is noted that the level of bioclimatic potential in rural areas of Russia constitutes 60 % of European level and 40% of the USA's.

At the same time in a number of West-European countries with analogue climatic conditions and soil characteristics (Scandinavian countries), scientifically justified agrarian politics provides better involvement of natural potential into intensification of rural economy based on ecological paradigm of agro-industrial activities (Balandin, 2015).

The paradigm refers to application of eco-system approach and lies in attainment of reproduction processes efficiency at preservation and improvement of natural potential, i.e. complies with global principles of sustainable development. The understanding of necessity of nature's participation in agro-production, waste recycling and water cleanup, use of natural biomaterial for pollination and fight against agricultural pests in required amounts and at optimal time lies in the ecosystem approach.

Evolutionary transition to organic methods of agrarian production, mainly in EU countries and in Germany particularly, reflects society's attention to issues of ecology and decrease in negative consequences of intensive agriculture and anthropogenic load on environment. Unfortunately, such measures in Russia take place spontaneously and do not have appropriate state support and provision.

The conclusion of scientific community that production and technological modernization of agriculture, social development and profitability of agrarians, ecologization in rural areas and production processes are interconnected and not interchangeable is not embodied (Ushachev, 2015).

The most important criterion of intensification and effectiveness of agricultural production is energy efficiency. Non-renewability of carbon pursued world community to search for new types of fuel. Thus, experts estimate that currently the share of renewable energy sources in the world amounts 2.5% of total energy production. It is forecasted that by 2025 this figure will reach 40%, and in fifty years – 60%. Some EU countries are active in this direction; they implement appropriate programmes enforced with donations and subsidies of the European Union. Cost of energy production using renewable sources decreases, capital investment reduces due to introduction of scientific and technical achievements. But also EU countries are guided by the need for decrease in anthropogenic load on environment and do not scale back their energetics development programmes even in the periods of sharp price reduction for energy carriers. Expenditures for fuel resources in agricultural production vary from 12% to 40% in the Russian Federation. Exploitation of biological types of fuel, recycled organic and inorganic wastes for biogas, particularly for introduction of means of small-scale energetics and stand-alone energy supply for localities and agro-industrial objects, introduction of energy-efficient technological processes is still not the priority of state agrarian policy. Modernization of domestic agro-industrial complex and its step-by-step transition to innovative way of development are complicated due to degradation consequences and unprecedented retirement of agricultural land.

According to experts' estimation for the entire existence of humankind above two billion hectares of arable land have been irrevocably lost, more than half of land resources undergo degradation processes, and organic matter removal from soil constitutes up to one ton per hectare.

Nowadays, the Russian Federation's share it the production of mineral fertilizers reaches 10%, at the same time domestic consumption constitutes 1-2%. In recent years their application in Russia decreased almost fivefold, calculated per hectare – from 88 to 35 kilograms. Liming of acid soils was 17 times reduced; 50% of land areas irrigated in 1990 are almost not irrigated nowadays, and more than 30% of dried land areas fell out of turnover. Degradation covers more that half of agricultural land; however, in fertile chernozem soils regions ploughed area 1.5 times exceeds ecologically permissible level. That is reason why biodiversity decreases, and organic matter layer reduced almost twice (Balandin, 2014).

The processes are also characteristic for Permskii krai, where one third of population lives in rural areas. Unfortunately, we should confess that post-reform indicators of agricultural areas reduction exceeded average indicators in Russia and reached almost 50% of the level of 1990. And it is connected not only with common systematic tendencies of the Russian agrarian industry but also with the entire complex of mistakes of regional management including issues of ecologization of agrarian production.

Enough to say, that the regional fund of abandoned land has more that 440 thousand hectares and this amount grows continually. Herewith 11 million tons of soil and more than 60 thousand tons of organic matter are carried off annually from agricultural lands (Pytkin, 2012). The volume of liming and manure introduction is reduced continually. The share of areas fertilized with manure constitutes less than 2% of all cultivated areas; only a quarter of all sowings receive mineral top-dressing.

Nowadays agriculture is not possible without irrigation measures reducing the risks of unfavorable climatic conditions and increasing intensity of use of modern land management technologies. And one of the largest in the world water supplies is crucial prerequisite for plant growing development.

Currently, despite the substantial lagging behind the countries with developed agriculture (USA, China, India) on irrigated land share in total agricultural land area – from 36% to 45%, Russian Federation with less than 8% of irrigated arable land has become the largest producer of grain and sunflower. At the same time, reduction of irrigated and drained land area from 11.5 million hectare in 1990 to 9.1 million hectare in 2010 was the cause of additional damage from abnormal drought in central territories of Russia in 2010. Then experts noted that at the average decrease in grain by 35%, on irrigated land decrease constituted no more than 12%. Modern situation worsens by the fact that 30% of land from total number of irrigated objects are in unsatisfied condition (Balandin, 2014).

Measurement complex aimed at the industry's efficiency increase was developed and is implemented with the Federal target programme "Development of irrigation of agricultural land in Russia for 2014 – 2020" for solving similar risks and for sustainability of plant growing.

The Programme determined the tasks on exploitation of more than 800 thousand hectares of irrigated land, protection of agricultural land against water erosion during anti-flashflood measures, involvement into use 300 thousand hectares of abandoned agricultural land (Federal target programme, 2013).

The issues of implementation of efficient innovative development directions of agro-industry are linked with the transition to advanced technologies including household and agricultural waste recycling. Modern biotechnologies belong to the advanced technologies; their application can provide a great impetus for modernization of agrarian economy, transition to new technological modus; can significantly decrease ecological problems of rural areas and restore natural balance.

In international community, biotechnologies refer to technologies applying biological systems, live organisms or their derivatives to produce or modify products and processes (Bobylyov, 2014). The role of biotechnological methods in production processes of household waste recycling is continually increasing. Nowadays in EU countries, more than 60% of animal and vegetable waste in agriculture and forestry have been used or neutralized. However, the share of the Russian Federation comprises less than 0.1% in the structure of global biotechnologies market. At the same time, scientific society justified and achieved inclusion of measurement on biotechnological processes introduction, including in agro-industrial complex, into federal programme documents (Table 1).

Table 1. Indicators of biotechnologies development in the Russian Federation's agro-industrial complex

Measurement on introduction of biotechnologies in the Russian Federation's agro-industrial complex	2012	2015	2018
Number of innovative projects with application of biotechnologies	12	60	120
Number of implemented innovative projects in the field of alternative energetics including production of bio-fuel from agricultural waste	2	10	20
Share of agricultural waste treated with biotechnologies	6%	40%	65%
Share of ferments produced in Russia	1%	10%	15%
Share of food protein produced in Russia	10%	30%	50%
Share of agro-industrial complex and wood processing waste utilization in total volume of agro-food and wood waste	3%	30%	80%

**Source: Measurement plan («Road map») "Biotechnology and gene engineering development » dated 18, 2013, No. 1247-p*

Indicators in the table show that at the relative increase in innovative projects number based on use of biotechnologies by 2018 tenfold in agro-industry, their absolute value remains low – 120 projects.

Let us consider biotechnologies application in agrarian economy more detailed at the region level. Nowadays in the agro-industry of Permskii krai, huge amounts of waste from animal production have a significant technogenic influence on the environment. Drainage of their moist component through filtering ground and sides of waste repositories causes pollution of underground waters with organic substances and nitrates. For instance, discharge of liquid manure happened in one of the farming enterprises in Chernushinskii district of Permskii krai in 2012. The polluted area exceeded 160 hectares. The environment damage and expenditures on its elimination were obviously not proportional to the administrative fine. And it is not an isolated incident. Bark storage resulted from forest-industry activities also cause substantial damage to the environment of the region and particularly to the agricultural areas, as well as to water. Terricones of bark storage and chemical and biological decomposition of concentrated in them wood rests lead to the pollution of arable land and waters with phenol compounds and heavy metals. To eliminate such sources of technogenic environment pollution different measures are proposed based, as the rule, on the use of chemicals, and this does not exclude the possibility of secondary pollution and can result in negative consequences for agro-industrial activities.

A group of Perm researchers offered an alternative technology, which allows preventing biological influence of heavy metals that can occur in bark storage through converting them into inactive form by means of biological transformation into organic fertilizer – bio-humus. The transformation processes are accompanied with microbiological distortion of phenols. The technology consists in microbiological treatment of bark storage substrate and its transformation into bio-humus; its application for technical crops enables biological re-cultivation of agricultural land and yield increase. The novelty of the practical proposal lies in the application of micro-organisms complex that enable to create a continuous chain of biological processing of forestry, agriculture and household waste and its involvement into the rural areas ecosystems rehabilitation. The use of biological preparation enables avoiding chemical pollution of environment and substantially improves ecological condition, does not require construction of permanent buildings and training of highly qualified specialists.

Unfortunately, examples of innovative projects are solitary. Practical implementation of such projects is based on enthusiasm of some experts and faces difficulties of bureaucracy and lack of financial support from regional government. At the same time, assignments for science and research, finance of the Russian State Science Foundation (Rus.: РГНФ) and Russian Foundation for Fundamental Research (Rus.: РФФИ) are distributed among highly specialized projects. There is no direct connection between fundamental and applied science, no complex approach to solutions for mentioned above tasks; and major recommendations are too general, impersonalized.

CONCLUSION

The topicality of development problems in the agro-industry is caused by the complex of climatic and economic factors and reasons. Overcoming them determines the search for new approaches, requires theoretical and methodological justification of entire, logical and conceptual solution of system problems in agro-industry. Implementation of innovative development directions in agro-industrial complex enables us to justify conceptual alternatives with a great degree of confidence and forecast results of their application in aspects of sustainable rural development, to improve the mechanism of decrease in negative anthropogenic influence on environment and ecosystems rehabilitation.

REFERENCES

Balandin, D.A., Krasilnikova, L.E. (2014). Biotechnologies as innovative development direction for agro-industry of the region. Scientific review. No. 9, Part 2, pp.,535-539.

Balandin, D.A., Pytkin, A.N., Tarasov, N.M. (2015). Management of biologization processes in agro-industry to reach a new technological modus: monograph. Yekaterinburg, 176 p.

Bobylyov, S.N., Mikhailova, S.Yu., Kiryushin, P.A. (2014). Bioeconomics: genesis issues. Economy. Taxes. Law. No. 6, pp. 20-25.

Federal target programme "Development of irrigation of agricultural land in Russia for 2014 – 2020" approved by Russian Federation Government decision of 12 October 2013, No. 922. Information-consulting system "KonsultantPlus»

Marshall A. (2008). Principles of economics. Translated from English. M.: Exmo. 832 c.

McConnel K., Breu S. (2008). Economics: principles, problems, and policies: Translated from English. Issue 11, M.: Respublika. 917 p.

Pytkin, A.N., Balandin, D.A. (2012). Social and economic aspects of functioning of municipal formations in Permskii krai: monograph. Yekaterinburg: Publishing house of RAS Economy Institute Ural Department. 176 p.

Ricardo D. (2008). On the Principles *of Political Economy and Taxation*. Translated from English. M.: Exmoo. 960 c.

Schumpeter I.A. (1982). The theory of economic development. Translated from English. M.: Progress.

Smith A. (2008). An Inquiry into the *Nature and Causes* of the *Wealth of Nations*. Translated from English. M.: Directmedia Publishing.

Ushachev, I.G. (2015). Main directions of import substitution of agro-industry's produce in Russia. Applied economic investigations. No. 5, pp. 4-16.

Zvyagina, O.V., Ionova I.G. (2014). Cluster approach to reach stability in problematic areas of the region. Scientific opinion. No. 2, pp. 113-116.

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OPTIMIZATION MODEL OF VEGETABLE PRODUCTION STRUCTURE IN SERBIA

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ABSTRACT

Indoor vegetable production, or production in greenhouses enables year-round production, the combined off-season production, greater control of diseases and pests, but also significantly greater production value compared to open field crop production. The aim of this paper is to determine such a structure of vegetable production in greenhouses that will realize the maximum financial result considering various biotechnological, production, technological and market constraints. In this context, model for optimization of vegetable production structure in greenhouses was formulated, and at the same time, model analysis and model solving was made using the method of linear programming and the software package "LINDO". Model was analyzed in three variants, depending on the selected optimality criterion: maximization of net income (variant I), maximization of economics of production (variant II), minimum deviation from the extreme values (variant III). The results show the optimal sowing - planting structure for all three variants of defined model; the participation of certain groups of crops in the overall sowing - planting structure; the required number of working hours in the observed months of working peaks; that variant I achieves the highest net income for defined limiting conditions (4.216.867 din); that variant II achieves the highest economics of production (2,25), while variant I and variant III generate the same economics of production (2,20).Moreover, variant I realized the greatest value ofproduction (7.080.300 din), but also the highest variable (2.863.433 din) and total costs (3.263.433 din). Published data of various experimental paperworks were used for this analysis, as well as data from the accounting records of the farms and data of Statistical Office of the Republic of Serbia.

Keywords: *vegetable production, optimization, model, greenhouse.*

INTRODUCTION

Vegetable production has great economic importance for agricultural development, but also for the overall economic development of the Republic of Serbia. Different methods and production systems, such as indoor vegetable production, enables year-round production, the combined off-season production, greater control of diseases and pests, but also significantly greater production value compared to open field crop production. In this context, model for optimization of vegetable production structure in greenhouses was formulated, and at the same time, model analysis and model solving was made using the method of linear programming and the software package "LINDO", which proved to be very successful instrument for optimizing the vegetable production structure in greenhouses.

Given the importance of vegetable production, a great number of authors dealt with the problem of determining the optimal structure of vegetable production.Nikolić (2014) in the master's thesis analyzed the vegetable production on family farms in Vojvodina, in order to define the optimal structure of vegetable production that will give the best economic effects, that will meet the market needs and that will enable the intensive land use. Krasnić (2004) tested models for optimizing the production structure for industrial processing and for consumption of fresh vegetables, in order to determine the optimal structure of vegetable production using the method of linear programming. Novković et al. (2011) have paid special attention to the optimal structure of vegetable production on family farms. They defined the general model oflinear programming for optimizing the sowing structure of vegetables, in order to meet internal and external conditions of production and trade, to ensure maximum use of capacity and to be economically most efficient.

Stamenkovska et al. (2013) applied the model for optimizing the vegetables production on the hypothetical farm - family farm in the Republic of Macedonia, in order to improve decision making process on family farms in Macedonia. For this purpose, a general linear programming model was used which is quite flexible, thus offers the possibility of adding more companies engaged in this type of production.

Radojevic (2003) presented a model of linear programming for optimal planning of vegetables structure production, intended for industrial processing, in order to point out the possibility of rational land use and achieve better economic effects.

The aim of this paper is to determine such a structure of vegetable production in greenhouses that will realize the maximum financial result considering various biotechnological, production, technological and market constraints.

MATERIALS AND METHODS

The paper presents an analysis of the defined model in three variants, depending on the selected optimality criterion: maximizing net income (variant I), maximizing economics of production (variant II), minimum deviation from the extreme values (variant III). Considering the defined optimality criterion, in addition to the classical method of linear programming, optimization of vegetable production based on multiple criteria of optimality will be applied, which will, among other things, resolve the issue of the optimal production structure based on maximum efficiency, i.e.,economics of production. Multi-criteria optimization indicates that the optimum of a phenomenon or a process is determined based on several criteria, whereby the mutual independence of the set criteria is assumed. That means that the obtained optimal solutions will differ from each other, and therefore it is necessary to establish the compromise solution which would mostly satisfy specific criteria. Therefore, the specificity of this model compared to the classic model of linear programming is the complexity of limiting conditions matrix and the existence of multiple optimality functions. For optimization the vegetable production structure based on maximum effectiveness, the classic linear programming model is applied, while maximizing the production efficiency (due to nonlinearities of relation), fractional linear programming is applied. Since the two optimality criterion is defined, it is necessary to find a solution that will satisfy both of functions criteria. Such a solution is a compromise solution and represents determination of the production structure satisfying each of the defined optimality criteria (Novković, 1989). Since the two main economic criteria are defined, a compromise solution is determined by a combination thereof, based on the maximum effectiveness and maximum production efficiency. If we take into account these criteria, then a compromise model between maximizing the effectiveness and efficiency, based on minimum differencesis as follows:

$$min\ d_1 + d_2$$

$$npy + d_1 - \gamma\, Np_{max} = 0$$

$$vpy + d_2 = Ep_{max}$$

$$vty + \gamma Ft = 1$$

$$Ay_i - \gamma b \begin{matrix}\langle \\ - \\ \rangle\end{matrix}\ 0$$

$$x_i = \frac{y_i}{\gamma}$$

d1 = maximum effectiveness deviation

d2 = maximum efficiency deviation

np = planned net income per unit of independent variable

Np max = maximal net income

vp = planned production value per unit of independent variable

vt = variable costs per unit of independent variable

Ft = total fixed costs

Ep max = maximal production efficiency

A = matrix of technical coefficients

b = vector constraints

γ = additional variable

yi = independent variable in the model

xi = the actual value of independent variable.

Activities in defined model are independent variables, and refer to different types of vegetables. At the same time, vegetable types from the model can be repeated several times, as a result of crop rotation, previous crop types, and the seeding order. Constraints relate to limiting conditions of land area, workforce, and of course, the time of sowing - planting. Considering that the study relates to family farms, the optimality function criteria includes gross margin, representing the difference between the production value and variable costs. Using these categories as determinants to maximize optimality functioncriteria, the negative impact on the allocation of fixed costs is eliminated, which can cause some incorrect solutions (Novković et al., 2008). Defining mathematical model indicates converting the actual relations in the observed object of research in the set of logical relations, defined by mathematical symbols (Novković, 1989). In this way, model solving enables the use of certain mathematical methods. Accordingly, for the purposes of this study, six basic groups of vegetable crops were defined, and list of all the independent variables, as well as their respective symbols are shown in Table 1.

Table 1. Symbols and names of independent variables in optimization model of vegetable production structure in greenhouses

Symbols	**Crops**	**Preceding crop**	**Group of crops**
	i	j	X
X101	Early carrots	/	Root vegetables X1 (101-106)
X102	Beetroot	/	
X103	Spring radish	/	
X104	Winter radish	Cucumber	
X105	Autumn radish	Green beans	
X106	Early chard	/	
X201	New onion	/	Bulb vegetables X2 (201-203)
X202	Spring garlic	/	
X203	Leek	Early potato	
X301	Early potato	/	Tubers vegetables X3 (301)
X401	Tomato (seed)	Spring lettuce	Fruit-bearing vegetables X4 (401-405)
X402	Tomato (seedlings)	Spring spinach	
X403	Pepper(seed)	Spring radish	
X404	Pepper(seedlings)	New onion	
X405	Cucumber	Lettuce	
X501	Peas	/	Leguminous vegetables X5 (501-502)
X502	Green beans	/	
X601	Cabbage	Spring garlic	Leafy vegetables X6 (601-609)
X602	Cauliflower	Early potato	
X603	Spring spinach	/	
X604	Autumn spinach	Tomato	
X605	Winter spinach	Cucumber, Tomato	
X606	Winter spinach	Early carrots	
X607	Spring lettuce	/	
X608	Autumn lettuce	Early carrots	
X609	Winter lettuce	Beetroot, Pepper	

After determining independent variables or activities, the limiting factors in the mathematical model for optimization of vegetable production structure in greenhouses are also defined. The matrix of these constraints includes four groups of limiting conditions characteristic for vegetables production in greenhouses:

1. Constraints on land capacity in the first sowing (1 hectare)
2. Constraints on land capacity in the second sowing
3. Constraints on land capacity in the third seeding
4. Biotechnological limits - minimum / maximum
5. Constraints on direct workforce

In order to solve defined mathematical model, it is necessary to define the optimality function criteria. As already mentioned, as a determinant for optimization the criterion function in this paper, gross margin will be used. As a second criterion for optimization, maximization ofeconomics of productionwill be used, and a compromise solution is determined by combining these two criteria, based on minimum differences.

RESULTS AND DISCUSSION

Table 2 summarizes the optimization results- obtained solutions for all three defined optimality criteria are shown, referring to vegetables production in greenhouses.

Table 2. Optimal vegetables production based on maximizing net income, maximizing economics of production and minimum deviation from the extreme values

Indicators	Variant I	Variant II	Variant III
	Maximization of net income	**Maximization of economics of production**	**Minimum deviation from the extreme values**
NET INCOME (din)	4.216.867	3.256.471	4.156.591
VALUE OF PRODUCTION (din)	7.080.300	5.147.049	6.891.219
VARIABLE COSTS (din)	2.863.433	1.890.578	2.734.628
FIXED COSTS (din)	400.000	400.000	400.000
TOTAL COSTS (din)	3.263.433	2.290.578	3.134.628
ECONOMICS OF PRODUCTION	2,20	2,25	2,20

CONCLUSION

Based on defined mathematical model and defined optimality criteria, and using the software package "LINDO", a solution relating to optimal vegetables production structure in greenhouses was obtained, where all of this leads to the following important conclusions:

• land area of certain types of vegetables that provide optimal sowing - planting structure for all three model variants,

• the share of individual groups of vegetables in the overall sowing - planting structure,

• optimal vegetables production structure in greenhouses according to the time of sowing - planting,

• the required number of employees working hours in the observed months,

• the maximum values of defined optimality function for all three model variants, wherein the variant I achieves the greatest net income, variant II achieves the highest economics of production (2,25), while variant I and III generate the same economics of production (2,20),

• variant I realized the greatest value of production (7.080.300 din), but also the highest variable (2.863.433 din) and total costs (3.263.433 din).

• the reliability of obtained optimal solution, which indicates competitiveness between individual production lines, as well as the limits within the coefficients can be changed, whereby the current optimal solution will remain optimal.

REFERENCES

Krasnić, T. (2004). Model for optimizing the structure of vegetable production. Doctoral thesis. Faculty of Agriculture, University of Novi Sad, Serbia.

Nikolić, G. (2014). The organization of vegetable production in Vojvodina. Magister thesis, University of Novi Sad, Faculty of Agriculture.

Novković, N. (1989). "Optimization of agricultural production based on multiple optimality criteria ", Doctoral dissertation, Faculty of Agriculture, Novi Sad.

Novković, N., Rodic, V., Vukelic, N. (2008). Linear programming - examples and tasks. Faculty of Agriculture, Novi Sad.

Novković, N., Ilin, Ž., Ivanisevic, D. (2011). Model for optimizing the vegetables production. Proceedings of the International Scientific Symposium on Agriculture, Agrosym 2011, Faculty of Agriculture in East Sarajevo and Zemun, Jahorina, p. 555-559.

Radojević, V. (2003). Possible effects of irrigation systems implementation in vegetable production, Water Management 2003 vol. 35, no. 3-4, p. 217-220.

StamenkovskaJaneska, I., Dimitrievski, D., Erjavec, E., Žgajnar, J., Martinovska-Stojceska, A. (2013). Optimization of production on vegetable farm in the Republic of Macedonia, Agroeconomia Croatica 3:2013 (1) 1-8.

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GENOMIC DETERMINATION OF THE MOST IMPORTANT FATHER LINES OF SLOVAK PINZGAU COWS

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ABSTRACT

The aim of this study was to assess genetic structure of Slovak Pinzgau population based on polymorphism at molecular markers using statistical methods. Female offspring of 12 most frequently used bulls in Slovak Pinzgau breeding programme were investigated. Pinzgau cattle were found to have a high level of diversity, supported by the number of alleles observed across loci (average 5.31, range 2-11) and by the high within-breed expected heterozygosity (average 0.66, range 0.64-0.73). The state of genetic diversity is satisfying and standard for local populations. Detection of 12 possible subpopulation structures provided us with detailed information of the genetic structure. The Bayesian approach was applied, detecting three, as the most probable number of clusters. The similarity of each subpopulation using microsatellites was confirmed also by high-throughput molecular data. The observed inbreeding (F_{ROH}=2.3%) was higher than that expected based on pedigree data (F_{PED}=0.4%) due to the limited number of available generations in pedigree data. One of the most important steps in development of efficient autochthonous breed protection programs is characterization of genetic variability and assessment of the population structure. The chosen set of microsatellites confirmed the suitability in determination of the subpopulations of Pinzgau cattle in Slovakia. The state of genetic diversity at more detailed level was successfully performed using bovineSNP50 BeadChip.

Keywords: *genetic differentiation, microsatellites, Pinzgau cattle, SNP chip, structure.*

INTRODUCTION

Slovak Pinzgau cattle belong to the traditional livestock breeds, mainly in upland regions in Slovakia. Nowadays, this breed belongs to the endangered populations (Kadlečík et al., 2004) due to drastic decreasing of the animal counts. Currently loss of genetic resources concerns not only the extinction of traditional breeds, but also the loss of genetic diversity within breeds. Most of the endangered breeds are specialized in a particular habitat or production system and represent, in both developed and developing countries, a unique resource to meet present and future breeding objectives. Therefore, thorough information on diversity and population structure in cattle is urgently needed to serve as a rational basis for the conservation and possible use of indigenous cattle breeds as genetic resources to meet potential future demands (Taberlet et al., 2008).

Markers are used by population geneticists to investigate the origin, genetic diversity and population structure of alleles, by evolutionists to describe genetic relationship among species or populations and by geneticists to study linkage disequilibrium within or between genes (Liu and Muse, 2005). Molecular markers based on DNA have a very high polymorphism level, and they have been successfully used for evaluation of genetic diversity and variation in breeding programs with an impact on the level of genetic conservation schemes (Židek and Kasarda, 2010).

The inbreeding coefficient is defined as the probability that a pair of alleles is identical by descent (IBD). Historically, geneticists have estimated this probability using pedigree data though genomic information should lead to a more accurate depiction (Bjelland et al., 2013). Increased levels of inbreeding would appear genomically as an increase in the frequency of homozygous alleles. A problem with this method is that alleles that are IBD and identical by state (IBS) cannot be distinguished and are both included in this measure of inbreeding. An alternative method involving genomic runs of homozygosity (ROH) attempts to distinguish these differences and has been used in human (Kirin et al., 2010) as well as cattle genomics (Bjelland et al., 2013; Ferenčaković et al., 2013), examining population history. The ROH are consequence of inbreeding and relatively close relationships between parent pairs, especially in small endangered populations (Mészáros et al., 2015).

The aim of this study was to evaluate the genetic diversity and population structure of Slovak Pinzgau cattle based on polymorphism in genotyping data using statistical programs.

MATERIALS AND METHODS

Selected cows of Pinzgau cattle originated from Slovakia were analysed. DNA of 140 animals was isolated from hair roots and amplified in one multiplex PCR with 10 microsatellites. To determine the polymorphism of microsatellite DNA sequences fluorescent fragmentation analysis by capillary electrophoresis (ABI PRISM 310 Genetic Analyser) was used and the alleles' sizes were evaluated using software Gene Mapper 4.0. Average number of alleles per subpopulation of fathers, Shannon information index, observed heterozygosity, gene diversity (expected heterozygosity) and inbreeding coefficient (F_{MST}) were calculated by GenAlex 6.5 (Peakall and Smouse, 2012).

The most important fathers of cows were genotyped using BovineSNP50 v2 BeadChip (Illumina Inc., San Diego, CA). Only 12 bulls (fathers of 140 cows) with minimum of 5 and maximum of 34 daughters were chosen. SNP markers with more than 10% of missing genotypes, SNPs with less than 0.01 minor allele frequency (MAF) as a threshold to declare a polymorphic SNP and individuals

with low genotyping (< 95%) were excluded. The inbreeding coefficient was calculated first by GenAlex 6.5 software (Peakall and Smouse, 2012; F_{SNP}) and then as ROH-based estimates of autozygosity (F_{ROH_MAF}). Pruning SNPs that show low MAF can affect the results (Albrechtsen et al., 2010) thus quality control setting GeneCall ≤ 0.7 and GeneTrain ≤ 0.4 score was used to evaluate inbreeding coefficient as well ($F_{ROH\_GC\_GT}$). In our analysis autozygosity was defined by ROHs that were > 4 Mb following the study of Ferenčaković et al. (2013).
Subsequently, estimation of subpopulation structure using prior information about fathers was performed. Mixture partition based on pre-defined clustering using Bayesian Analysis of Population Structure (BAPS v. 6.0) software was executed, further described in Cheng et al. (2013). For analysis of relatedness and principal component analysis (PCA) of SNP data a high-performance computing toolset gdsfmt and SNPRelate (R packages for multi-core symmetric multiprocessing computer architectures) were used according to Zheng et al. (2012).

RESULTS AND DISCUSSION

All evaluated cows were divided to 12 groups by fathers and summary statistics for each group were calculated (Table 1). The number of alleles over subpopulations and loci ranged from 2-11 with the mean 5.31±0.15. Regarding the Shannon's information index (I), all groups of fathers presented a value distant from zero with an overall mean of 1.31±0.03. The overall average of observed heterozygosity (H_o=0.77±0.02) has reached higher values than expected (H_e =0.66±0.01) and indicated the presence of high level of heterozygosity in native local cattle breeds. Expected heterozygosity and mean number of alleles calculated here were similar to those obtained in endangered German Pustertaler Sprinzen (0.69 and 5.3), Pinzgauer (0.71 and 6) and Simmental (0.58 and 5.2; Edwards et al., 2000).
The average value of F_{MST} reached a negative number (-0.17±0.02), generally it can be concluded there is no reduction of heterozygosity in daughters of evaluated bulls, whereas the inbreeding in bull Nero was F_{SNP} = 0.003. Positive F values could be derived from inbreeding or from the presence of a substructure within the population. The ROH greater than 4 Mb cover on average 2.3% of genome (F_{ROH_MAF} = 0.0225 and $F_{ROH\_GC\_GT}$ = 0.0234). The observed inbreeding was higher than that expected based on pedigree data (F_{PED}=0.4%). According to pedigree data only 5 animals have arisen by breeding of related animals, whereas based on $F_{ROH>4}$ even 11 animals were inbred. Ferenčaković et al. (2013) showed higher inbreeding level in Pinzgau from Austria (F_{ROH4} = 0.037) compared to Slovak Pinzgau (F_{ROH4} = 0.023) from this study. The Austrian bull Nero had the highest inbreeding $F_{ROH\_GC\_GT}$ = 5.1%. (4.6% calculated using F_{ROH_MAF}), while Carlo with Canadian origin had zero inbreeding. It was noticeable that sires with Austrian origin had overall higher F_{ROH} levels.

Table 1. The number of daughters (N) and alleles (N_A), information index (I), observed (H_o) and expected (H_e) heterozygosity and inbreeding coefficient based on microsatellite data (F_{MST}), based on high-throughput molecular data (F_{SNP}), based on runs of homozygosity (F_{ROH_MAF} and $F_{ROH\_GC\_GT}$) values per subpopulation of fathers

Father	N	N_A	I	H_o	H_e	F_{MST}	F_{SNP}	F_{PED}	F_{ROH_MAF}	$F_{ROH\_GC\_GT}$
ATLAS	13	6	1.408	0.754	0.707	-0.105	-0.020	0.0001	0.045	0.045
CARLO	16	6.3	1.448	0.806	0.725	-0.147	-0.111	0	0	0
GOMOL	13	5.8	1.325	0.723	0.672	-0.115	-0.081	0	0.002	0.002
LODRON	5	4	1.171	0.82	0.693	-0.299	-0.021	0.004	0.033	0.035
LOLTEL	6	4.1	1.114	0.667	0.638	-0.167	-0.032	0	0.025	0.027
LUTGO	13	5.2	1.262	0.769	0.668	-0.204	-0.009	0.008	0.043	0.046
LUTLUX	13	5.6	1.366	0.754	0.707	-0.116	-0.033	0.008	0.015	0.014
NERO	34	7.8	1.543	0.824	0.738	-0.131	0.003	0	0.045	0.051
NOBMON	7	4.7	1.227	0.786	0.669	-0.255	-0.057	0.031	0.007	0.012
NOBTELO	7	4.5	1.195	0.771	0.677	-0.203	-0.037	0	0.020	0.020
ROMIL	7	4.9	1.31	0.771	0.721	-0.157	-0.073	0	0.027	0.026
SAMFO-ET	6	4.8	1.344	0.8	0.747	-0.188	-0.082	0	0.007	0.007

Further analysis was performed using prior information about subpopulations from microsatellite markers. Partitioning of Pinzgau cows according father of cows is visible in figure 1. Each individual that was clustered is represented by a vertical bar having the colour corresponding to the cluster where it was placed. From 12 fathers 3 main clusters was created based on Bayesian approach. Red colour marked cluster represents line COS, bull Carlo with Canadian origin. Austrian bull Nero representing line NUS, Atlas (Austrian origin) representing AER line and Slovak bull Loltel from line LOZ belong to the second cluster (green colour).

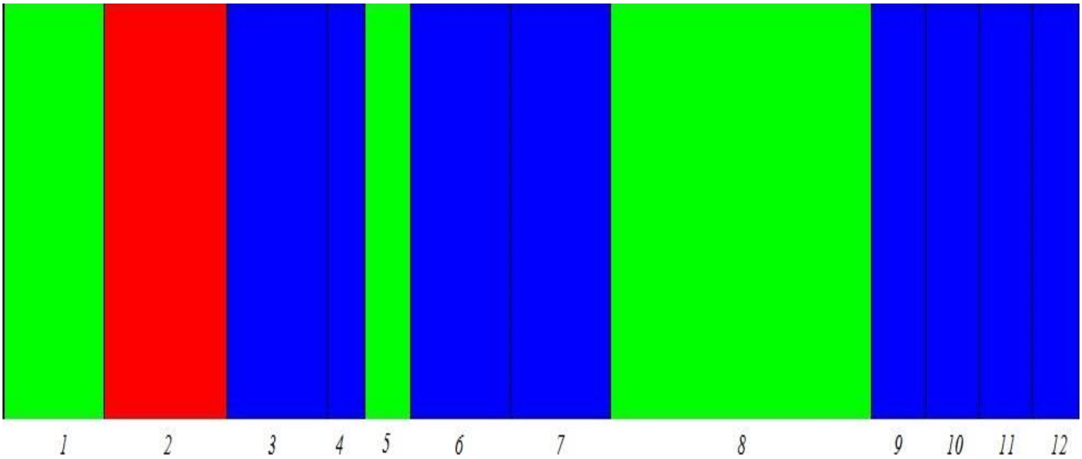

Figure 1. Graphical presentations of the population structure analyses for a sample of 140 Pinzgau cows (using prior information about subpopulations) based on father of cows. Atlas (1), Loltel (5) and Nero (8) in green; Carlo (2) in red; Gomol (3), Lodron (4), Lutgo (6), Lutlux (7), Nobmon (9), Nobtelo (10), Romil (11) and Samfo-et (12) in blue colour.

The most important 12 Pinzgau bulls used in breeding were successfully genotyped using Illumina BovineSNP50 BeadChip with total call rate 99.95%. Genotyping results revealed that 43,068 SNPs (78.87%) were polymorphic (MAF>0.01) with average minor allele frequency ranged from 0.2588 ± 0.1433 on chromosome 2 to 0.2766 ± 0.1403 on chromosome 23. The average values of MAF groups are summarized in table 2.

Table 2. Minor allele frequency (MAF) across autosomes in 12 Slovak Pinzgau bulls with 95% confidence interval (CI) of the mean

MAF	Number of loci	Mean	SD	Min	Max	Lower 95% CI	Upper 95% CI
0.01-0.1	7380	0.0620	0.0208	0.0417	0.0909	0.0615	0.0625
0.1-0.2	7266	0.1459	0.0209	0.125	0.1818	0.1455	0.1464
0.2-0.3	10773	0.2507	0.034	0.2083	0.2917	0.2500	0.2513
0.3-0.4	7664	0.3544	0.0209	0.3182	0.375	0.3539	0.3548
0.4-0.5	9985	0.4505	0.0314	0.4091	0.5	0.4498	0.4511

The PCA and ancestry models were used to cluster animals, to explore the relationships within breed using high-throughput molecular data. First three principal components (PC) are explaining 21.21% of genetic variability (1.PC = 8.44%, 2.PC = 7.38%, 3.PC = 5.39%. Using the three first PC, the mean pairwise distance between the individuals from the Pinzgau population was plotted (Figure 2). First three PC are the most informative plotting on a three-dimensional scatter diagram to allow visual inspection of the relationships among the breed (Dixit et al., 2012). The PCA is used to characterize how different multiple populations are, often using only the two first PC (Albrechtsen et al., 2010). Nobtelo and Nobmon representing line NOB, Lutgo, Lutgo representing line LUZ, Romil and Samfo-et created separate clusters while theirs daughters using microsatellite data were in common cluster also with Gomol and Lodron. Nero, Loltel and Atlas created one cluster by microsatellite analysis and also by SNP Chip data were genetically more similar.

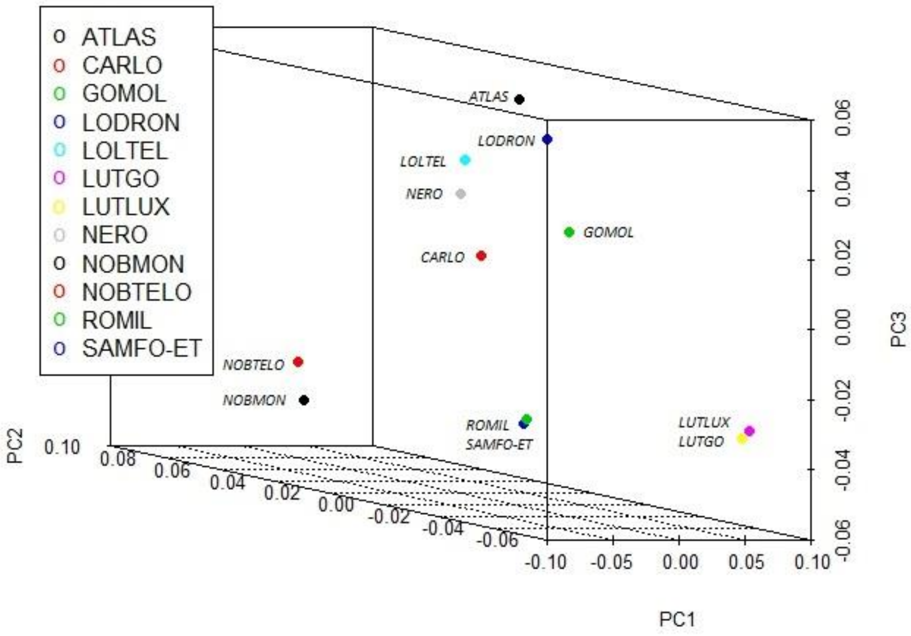

Figure 2. The principal component analysis of 12 Slovak Pinzgau bulls. First 3 principal components (PC) are explaining 21.21% of genetic variability

CONCLUSION

Basic parameters of genetic diversity in traditional Slovak cattle were analysed to determine the level of heterozygosity and inbreeding within population. In spite of significant decrease of population, the state of genetic diversity is satisfying and standard for local populations in comparison to the generally accepted numbers. The proportion of the genome present in ROH provides a good indication of inbreeding levels. The observed inbreeding (F_{ROH}=0.023) was higher than that expected based on pedigree data (F_{PED}=0.004). Genetic structure of Pinzgau cattle has been characterised using set of 10 microsatellites. The similarity of each subpopulation of fathers using microsatellites was confirmed also by high-throughput molecular data. Genomic confirmation of existence of separated breed specific substructures as bull lines allows for more accurate mating strategy and control over inbreeding increase in the breeding programme. Deeper analysis of high-throughput data could provide us with bull line specific regions or SNPs, for which more animals to be sequenced as a basis for preservation of the breed in the original phenotype.

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REFERENCES

Albrechtsen A., Nielsen F.C., Nielsen R. (2010). Ascertainment biases in SNP chips affect measures of population divergence. Molecular Biology and Evolution, vol. 27, pp. 2534-2547. doi: http://dx.doi.org/10.1093/molbev/msq148

Bjelland D.W., Weigel K.A., Vukasinovic N., Nkrumah J.D. 2013. Evaluation of inbreeding depression in Holstein cattle using whole-genome SNP markers and alternative measures of genomic inbreeding. Journal of Dairy Science, vol. 96, pp. 4697-4706. doi: http://dx.doi.org/10.3168/jds.2012-6435

Cheng L., Connor T.R., Sirén J., Aanensen D.M., Corander J. (2013). Hierarchical and spatially explicit clustering of DNA sequences with BAPS software.

Molecular Biology and Evolution, vol. 30, no. 5, pp. 1224-1228. doi: http://dx.doi.org/10.1093/molbev/mst028

Dixit S.P., Verma N.K., Aggarwal R.A.K., Vyas M.K., Rana J., Sharma A. (2012). Genetic diversity and relationship among Indian goat breeds based on microsatellite markers. Small Ruminant Research, vol. 105, no. 1-3, pp. 38-45. doi: http://dx.doi.org/10.1016/j.smallrumres.2011.11.026

Edwards C.J., Dolf G., Looft C., Loftus R.T., Bradley D.G. (2000). Relationship between the endangered Pustertaler-Sprinzen and three related European cattle breeds as analysed with 20 microsatellite loci. Animal Genetics, vol. 31, no. 5, pp. 329-332.

Ferenčaković M., Hamzić E., Gredler B., Solberg T.R., Klemetsdal G., Curik I., Sölkner J. (2013). Estimates of autozygosity derived from runs of homozygosity: empirical evidence from selected cattle populations. Journal of Animal Breeding and Genetics, vol. 130, pp. 286-293. doi: http://dx.doi.org/10.1111/jbg.12012

Kadlečík O., Swalve H.H., Lederer J.A., Grosu H. (2004). Development of dual – purpose Pinzgau cattle. SPU, Nitra, Slovak Republic, 128 p. ISBN 80-8069-439-7.

Kirin M., McQuillan R., Franklin C., Campbell H., McKeigue P., Wilson J. (2010). Genomic runs of homozygosity record population history and consanguinity. PLoS One, vol. 5, e13996. doi: http://dx.doi.org/10.1371/journal.pone.0013996

Liu K., Muse S.V. (2005) Integrated analysis environment for genetic marker data. Bioinformatics, vol. 21, no. 9, pp. 2128-2129. doi: http://dx.doi.org/10.1093/bioinformatics/bti282

Mészáros G., Boison S.A., Pérez O´Brian A.M., Ferenčaković M., Curik I., da Silva M.V.B., Utsunoomiya Y.T., Garcia J.F., Solkner J. (2015). Genomic analysis for managing small and endangered populations: A case study in Tyrol Grey cattle. Frontiers in Genetics, vol. 6, pp. 173. doi: http://dx.doi.org/10.3389/fgene.2015.00173

Peakall R. and Smouse P.E. (2012). GenAlEx 6.5: genetic analysis in Excel. Population genetic software for teaching and research-an update. Bioinformatics, vol. 28, pp. 2537-2539. doi: http://dx.doi.org/10.1093/bioinformatics/bts460

Taberlet P., Valentini A., Rezaei H.R., Naderi S., Pompanon F., Negrini R., Ajmone-Marsan P. (2008). Are cattle, sheep, and goats endangered species? Molecular Ecology, vol. 17, no. 1, pp. 275-284. doi: http://dx.doi.org/10.1111/j.1365-294X.2007.03475.x

Zheng X., Levine D., Shen J., Gogarten S.M., Laurie C., Weir B.S. (2012). A high-performance computing toolset for relatedness and principal component analysis of SNP data. Bioinformatics Applications Note, vol. 28, no. 24, pp. 3326-28. doi: http://dx.doi.org/10.1093/bioinformatics/bts606

Židek R., Kasarda R. (2010). Distribution of genetic distance within groups with different relationship coefficient. Acta fytotechnica et zootechnica, vol. 13, pp. 73-76.

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THE EFFECT OF SELENIUM ON MERCURY TRANSPORT ALONG THE FOOD CHAIN

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ABSTRACT

More than 500 years of mercury (Hg) production in Idrija (Slovenia) resulted in a considerable pollution of Idrija region with Hg. Although the mine is closed for more than 20 years, the total soil concentration of Hg may still reach up to several hundred mgkg^{-1}dry weightin local gardens and more that thousand inother urban regions. Hg in soil undergoesdifferent chemical transformations and in some formsit may enterplants and higher trophic levelsin food chains, also with biomagnification pattern.The local population is, besides air and dust, thus exposed to mercury also via consumption of locally produced food.Several studies showed that the increased level of selenium in soil may reduce the uptake of mercury in plants but very few include other trophic levels in a food chain as well.In our pilot study we followed an impact of Seon Hg transport from soil to plants (*Lactucasativa*) and further to soil dwelling animals (*Porcellioscaber*). Lettuce was planted in a contaminated soil from Idrija and in soil with added $HgCl_2$. The leaves of half of the plants weresprayed with Sesolution (5µg L^{-1})threeand five weeks after planting.After six weeks plants were analyzed for Hg and Se and offered as food to terrestrial isopods for two weeks. Our preliminary results revealed that foliar treatment of plants with Se may affect Hg accumulation in plants and therefore further transport of Hg across the food chain.

Keywords: *mercury, selenium,isopods, Lactuca Sativa, food chain.*

INTRODUCTION

Mercury exists in different forms: inorganic mercury, which includes elemental mercury, mercurous and mercury salts; and organic mercury, where mercury is bound to a methyl, ethyl, phenyl, or similar groups (Bernhoft 2012). Toxicity of mercury to wildlife and humans varies with the form, the dose and the rate of exposure (Wolfe et al., 1998; Tchounwou et al., 2003; Bernhoft, 2012). Elemental mercury is usually inhaled while other forms are usually ingested. Organic (methyl) mercury, which is known as the most toxic form, can be inhaled or absorbed through skin as well. Elemental and methyl mercury react with sulfhydryl groups and sulphur-containing amino acids, therefore potentially interfering with the function of any cellular or subcellular structure. In contrast, mercurous and mercury salts are poorly soluble and poorly absorbed and cause damage predominantly to the gastrointestinal tract or kidney (Bernhoft 2012).

In the last decades many large Hg mines had been abandoned worldwide because of lower demand for Hg. The primary concern about former Hg mines is the accumulation of Hg in soil and sediments, its transfer and biomagnification over food webs and the conversion from inorganic to organic Hg during these paths. Near the former world’s second largest mercury mine in Idrija, Hg concentrations still range from 7 up to 1550 mg kg^{-1} in urban soil and from 22-320 mg kg^{-1} in garden soil (Bavec and Gosar 2016). There are two major exposure pathways for the local population: exposure to atmospheric Hg and to Hg in food. In 2003, the estimation for daily intake of Hg was 0.05-0.1 μg Hg per kg body weight by inhalation and 0.66 μg Hg per kg of body weight via food (other than fish)(Horvat et al., 2003). It would therefore be very advisable to reduce Hg uptake via foodstuff, predominantly of locally produced vegetables. Due to the difficult economic situation in the region and to the desire of the population to produce organic food locally, it is impossible to prohibit the consumption of locally produced vegetables and other ways will have to be found. One possibility is to reduce the uptake of Hg by plants as well to reduce the bioavailability of Hg in plants to consumers. In the last decades several studies showed the antagonistic action of Se in soil on the uptake and translocation of Hg in plants (Shanker et al., 1996a,b; Thangavel et al., 1999; Mounicou et al, 2006; Zhang et al., 2012). Mercury has a high affinity to bind with Se and form insoluble mercury selenides, whichcan prevent negative effects of mercury in animals (rev in Raymond et al 2004). Selenium is also an important essential micronutrient in humans and other animals (Rayman 2000). It has a structural and enzymatic role, among others it acts as an antioxidant and catalyst for the production of active thyroid hormone and is important for the proper functioning of the immune system. At high concentrations, however, it causes toxicity (Yang et al 1983). By adequate application of Se to plants we might therefore decrease the transport of Hg across the food web as well as enrich the food with Se.

The aim of this study was a) to get some information about the impact of controlled foliar application of Se on the uptake and translocation of Hg in *Lactucasativa*from spiked and natural Hg-contaminated soil and b)to evaluate the impact of Se on Hg transport from lettuce to terrestrial isopods (the consumers), the next trophic level.

MATERIALS AND METHODS

Plant experiment

Three weeksold lettuce plants (*Lactucasativa*cv.Exquise) were planted into pre-prepared substrate - non-contaminated mixture of pot and field soil (C), mixture of pot and field soil spiked with 50 μg g^{-1} of $HgCl_2$ (Hg 50) and garden soil from Idrija (Idrija). For each treatment 10 plats were planted. Non-contaminated soil was prepared by mixing an organic potting substrate (Biobrazda, Slovenia) with sieved soil collected in the field near the Biotechnical Faculty, Ljubljana Slovenia (ratio 1:1). The first half of the mixture was left untreated, while the second half wasspiked with 50 μg g^{-1} of $HgCl_2$ (Merck, Germany) in a form of solution and mixed thoroughly. The spiked soil was left in a closed plastic bag for five days to achieve equilibrium. Hg concentration was below the limit of detection of ICP-MS (<0.1 μg g^{-1}), pH=7, organic matter=13%. Soil collected in the garden in Idrija that was naturally contaminated with Hg, contained 140±5 μg g^{-1} of total Hg as determined by XRF (Nečemer et al., 2008), pH=6, organic matter =10%.

Lettuce plants were grown in climate chambers (24°C, 60% relative humidity, 16/8 day/night photoperiod, photon flux = 300 μmol m s^{-2}) for six weeks. After three and five weeks of growth the plants were sprayed with Se solution (selenateas K_2SeO_4 (Alfa Aesar), 5 μg L^{-1}). Estimated total dose of applied Se was 1 μg g^{-1} fresh weight.

At the end of the experiment the plants were harvested, the shoots were detached from the roots and the roots and shoots were thoroughly washed in tap and distilled water. Plant material was then packed in Al foil, rapidly frozen in liquid nitrogen and freeze-dried (freeze-drier 2-4Alpha-Christ) for one week. After freeze drying the dry plant biomass was determined. Aliquots of 100 mg were used for Hg and Se analysis by ICP-MS.

Animal experiment

The plant material was groundin a mortar with liquid nitrogen and pellets ((ϕ =1 cm) were pressed from the root:shoot mixture (1:1) using a pellet die and a hydraulic press to feed the animals*ad libitum*. The pellets contained on average 3.92, 3.12, 0.56 and 0.23 μg Hg g^{-1} dry food in 50Hg, 50Hg+Se, Idrija and Idrija+Se treatments, respectively.

Twenty animals of laboratory bred terrestrial isopods (*Porcellioscaber*) (weight 30-50 mg) were selected per treatment and put individually into Petri dishes (ϕ =14 cm) on moist filter paper. Food pellets were offered in small plastic dishes (Ø=5cm) that separated food from moist filter paper and were changed every 5 days. Animals were kept for 14 days in climate chambers at 20 °C, 80 % relative humidity and 12/12 day/ night photoperiod. At the end of the experiment the animals were fed for three days with non-contaminated food to clean the gut. Afterwards the animals were frozen in liquid nitrogen, freeze-dried (freeze-drier 2-4Alpha- Christ) for three days, and weighted.

Hg and Se analysis with ICP-MS

Hg and Se concentrations in plants(4 per treatment)and Hg concentrations in animals(10 per treatment) were determined by ICP-MS (Agilent 7500ce, Palo Alto, CA USA) after microwave assisted digestion (MarsXPress, CEM, 15 min ramp to 180°C, 30 min hold at 180°C, 1000 W) in concentrated HNO_3 and stabilization of digests by HCl(Debeljak et al., 2013). The results were validated by measuring standard reference materials (BCR/CRM-061 Aquatic plant, NIST; ERM Tuna fish, Sigma Aldrich).

Statistical analysis

ANOVA and Duncan's pot hoc testwereperformed by StatisticaStatsoft 7.0 software.

RESULTS AND DISCUSSION

Plant growth parameters

The shoot biomass was the most affected by Hg treatment and significantly decreased in 50 Hg and 50 Hg+Seplants (Fig. 1). Although the roots were the organs that were directly exposed to Hg,their biomass in the 50 Hg treatment even increased (Fig. 1). The total plant biomass (roots + shoots) was the highest in C+Se treatment and the lowest in 50 Hg+Se treatment.

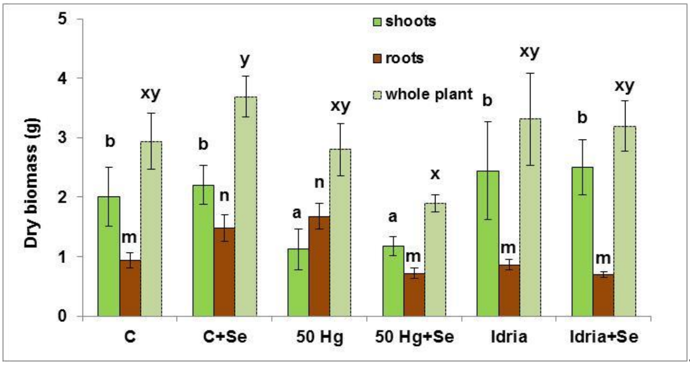

Figure 1. Dry biomass of roots, shoots and whole lettuce plants (*Lactucasativa*) (avr±SE, n=4) that were grown in mercury contaminated soil with or without foliar spraying with selenium solution (5µg L^{-1}).
Different letters above the columns represent statistically significant differences (a, b - shoots; m, n -roots; x, y - whole plant), Duncan's post hoc test, $p<0.05$.

In non-stressed plants Se may act as a growth promoter and increase plant growth (White, 2016), while in stress conditions the effects of Se spraying may induce adverse effects (Sors et al., 2005). The plants grown in the substrate collected in Idrija were not affected by Hg orby Se treatment. Although garden soil from Idrija contained higher total amounts of Hg than in the 50 Hg treatment, Hg was more bioavailable and more toxic in the latter substrate, where Hg was present as $HgCl_2$ (ionic Hg^{2+} form). In the soil collected in Idrija, however, Hg is present mainly as cinnabar (HgS) (more than 80%) or metal mercury (Hg^0) as shown by fractionation studies (Kocman et al., 2004). It has to be also emphasized that the used substrates had different pH, amounts of organic matter and different element composition (data not shown), which may affect the plant growth from the perspective of mineral nutrition, as well as synergistic/antagonistic effects of different ions present in the substrate (e.g. Ca, Fe) (Sarwar et al., 2010).

Hg and Se concentrations in plant tissues

Hg accumulated mainly in plant roots with concentrations that were on average up to seven times higher in the roots compared to the shoots (Fig. 2a). This partitioning of mercury was observed also in other plants, such as *Rumexinduratus*, *Marrubium vulgare*, *Medicagosativa* and maize (Carrasco-Gil et al., 2013; Debeljak et al., 2013; Moreno-Jiménez et al., 2006). The highest Hg concentrations were seen in the 50 Hg treatment. Foliar application of Se decreased Hg concentrations in the roots of both the 50 Hgand Idrija treatments. In the shoots, however, this trend was not seen in the 50 Hg treatment, while in Idrija treatmentthe Hg concentration in the plants sprayed with Se decreased (Fig. 2a). Shoot Hg concentration reflects the Hg that is transported from the roots to the shoots, as well as volatile Hg that vaporizes from the contaminated substrate and adsorbson the leaf surface or enters the leaves through the stomata (Moreno-Jiménez et al., 2006). Therefore it is very hard to determine the portion of Hg transported from the root to shoot, especially at suchlow concentrations, where any contamination from dust or soil particles may significantly influence the final values.

A)
B)

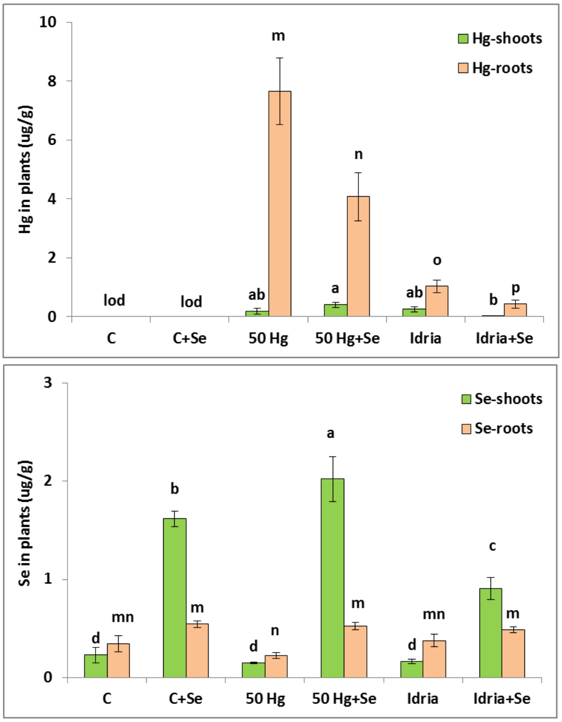

Figure 2. Concentrations of Hg (A) and Se (B) in shoot and root (avr±SE, n=4) as determined by ICP-MS. Different letters above the columns represent

statistically significant differences (a, b, c - shoots; m, n, o - roots), Duncan's post hoc test, $p<0.05$. lod - the Hg concentrations were below the limit of detection.

Se concentration in Se treated plants was significantly higher than in non-treated plants, but still below the toxicity threshold, since no symptoms of toxicity such as chlorosis or necrosis were seen. A trend of Se increase in the shoots was reflected also in the roots (Fig. 2b), indicating that a small proportion of the applied selenate was absorbed in the leaves, reduced in chloroplasts and incorporated into seleno-organic compounds that were transferred to the roots via phloem (White, 2016).Although approximately the same Se contents were applied on the leaves, Se concentrations differed between the Hg treatments (Fig. 2b).

Hg concentration in animals

Animals fed with lettuce that grew in Hg-spiked soil and treated with Se assimilated less Hg compared to solely Hg-treated lettuce (Fig. 3), although Hg concentrations in their food were comparable (3.92 vs. 3.12 $\mu g\ g^{-1}$). This difference was not observed in animals fed Se-treated lettuce grown in Idrija soil. Interestingly the levels of absorbed Hg were comparable to that of the 50 Hg+Se treatment; although the food concentrations were much lower (0.56 - Idrija vs. 0.23-Idrija+Se). The differences could be linked to differentialHg speciation and consequently bioavailability in the plants grown in spiked soil vs. plants grown in the soil from Idrija. If there were more reactive/mobile Hg forms in the spiked soil and consequently lettuce, this would lead to higher absorption rates and also Se would be more efficient in binding these species. To confirm this assumption, however, Hg speciation would have to be studied in all the samples. In addition the concentrations of Hg in animals depend also on the animal's biomass (dilution and concentration effects) and feeding rate, which should be taken into account to be able to draw more firm conclusions.

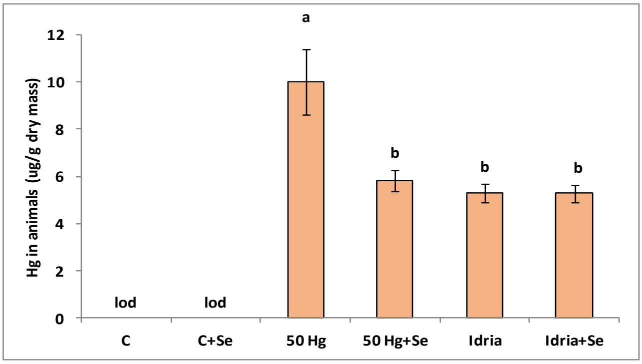

Figure 3: Concentrations of Hg in animals (*Porcellioscaber*) (avr±SD, n=4) fed with Hg burdened lettuce, part of which was sprayed with selenium. Different letters above the columns represent statistically significant differences (Duncan's post hoc test, $p<0.05$. lod - the Hg concentrations were below the limit of detection.

CONCLUSIONS

We have observed that under certain conditions, foliar treatment of plants with selenium could reduce the bioaccumulation of mercury in herbivores. In order to understand the mechanisms that regulate these processes and the potential benefits of using Se to reduce the Hg burden along the food chain, further studies will have to be conducted.

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REFERENCES

Bavec, Š., Gosar, M., Miler, M., Biester, H., 2016. Geochemical investigation of potentially harmful elements in household dust from a mercury-contaminated site, the town of Idrija (Slovenia). Environ. Geochem. Health 1–23.

Bernhoft, R.A., 2012. Mercury toxicity and treatment: A review of the literature. J. Environ. Public Health.

Carrasco-Gil, S., Siebner, H., Leduc, D.L., Webb, S.M., Millán, R., Andrews, J.C., Hernández, L.E., 2013. Mercury localization and speciation in plants grown hydroponically or in a natural environment. Environ. Sci. Technol. 47, 3082–90.

Debeljak, M., van Elteren, J.T., Vogel-Mikuš, K., 2013. Development of a 2D laser ablation inductively coupled plasma mass spectrometry mapping procedure for mercury in maize (Zea mays L.) root cross-sections. Anal. Chim. Acta 787, 155–62.

Horvat, M., Nolde, N., Fajon, V., Jereb, V., Logar, M., Lojen, S., Jacimovic, R., Falnoga, I., Liya, Q., Faganeli, J., Drobne, D., 2003. Total mercury, methylmercury and selenium in mercury polluted areas in the province Guizhou, China. Sci. Total Environ. 304, 231–256.

Kocman, D., Horvat, M., Kotnik, J., 2004. Mercury fractionation in contaminated soils from the Idrija mercury mine region. J. Environ. Monit. 6, 696–703.

Moreno-Jiménez, E., Gamarra, R., Carpena-Ruiz, R.O., Millán, R., Peñalosa, J.M., Esteban, E., 2006. Mercury bioaccumulation and phytotoxicity in two wild plant species of Almadén area. Chemosphere 63, 1969–73.

Mounicou, S., Shah, M., Meija, J., Caruso, J.A., Vonderheide, A.P., Shann, J., 2006. Localization and speciation of selenium and mercury in Brassica juncea - implications for Se-Hg antagonism. J. Anal. At. Spectrom. 21, 404–412.

Nečemer, M., Kump, P., Ščančar, J., Jaćimović, R., Simčič, J., Pelicon, P., Budnar, M., Jeran, Z., Pongrac, P., Regvar, M., Vogel-Mikuš, K., 2008. Application of X-ray fluorescence analytical techniques in phytoremediation and plant biology studies. Spectrochim. Acta Part B At. Spectrosc. 63, 1240–1247.

Rayman, M.P., 2000. The importance of selenium to human health. Lancet 356, 233–241.

Raymond, L.J., Ralston, N.V.C., 2004. Mercury : selenium interactions and health implications 7, 72–77.

Sarwar, N., Malhi, S.S., Zia, M.H., Naeem, A., Bibi, S., Farid, G., 2010. Role of mineral nutrition in minimizing cadmium accumulation by plants. J. Sci. Food Agric. 90, 925–37.

Shanker, K., Mishra, S., Srivastava, S., Srivastava, R., Dass, S., Prakash, S., Srivastava, M.M., 1996. Study of mercury-selenium (Hg-Se) interactions and their impact on Hg uptake by the radish (Raphanussativus) plant. Food Chem. Toxicol. 34, 883–6.

Sors, T.G., Ellis, D.R., Salt, D.E., 2005. Selenium uptake, translocation, assimilation and metabolic fate in plants. Photosynth. Res. 86, 373–89.

Tchounwou, P.B., Ayensu, W.K., Ninashvili, N., Sutton, D., 2003. Review: Environmental exposure to mercury and its toxicopathologic implications for public health. Environ. Toxicol. 18, 149–175.

Thangavel, P., Sulthana, A.S., Subburam, V., 1999. Interactive effects of selenium and mercury on the restoration potential of leaves of the medicinal plant, Portulacaoleracea Linn. Sci. Total Environ. 243-244, 1–8.

Wang, Y., Dang, F., Evans, R.D., Zhong, H., Zhao, J., Zhou, D., 2016. Mechanistic understanding of MeHg-Se antagonism in soil-rice systems: the key role of antagonism in soil. Sci. Rep. 6, 19477.

White, P.J., 2016. Selenium accumulation by plants. Ann. Bot. 117, 217–35.

Wolfe, M.F., Schwarzbach, S., Sulaiman, R.A., 1998. Effects of mercury on wildlife: A comprehensive review. Environ. Toxicol. Chem. 17, 146–160.

Yang, G.Q., Wang, S.Z., Zhou, R.H., Sun, S.Z., 1983. Endemic selenium intoxication of humans in China. Am. J. Clin. Nutr. 37, 872–81.

Zhang, H., Feng, X., Zhu, J., Sapkota, A., Meng, B., Yao, H., Qin, H., Larssen, T., 2012. Selenium in soil inhibits mercury uptake and translocation in rice (Oryzasativa L.). Environ. Sci. Technol. 46, 10040–6.

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IMPACT OF LAND SIZE ON PRODUCTIVITY, INCOME AND PROFITS FROM PEPPER CULTIVATION IN SRI LANKA

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ABSTRACT

Pepper is an important spice crop grown in Matale District of Sri Lanka, for exports and domestic consumption. Varieties of pepper grown are Sri Lankan local variety and 'Panniyur'. Pepper production had shown variations over the years due to poor management and low productivity. This study analyzed and compared the production levels and costs, income and profitability of pepper cultivation among small and large scale pepper farmers. A stratified random sample of 120 farmers, consisting of 76 small famers (<5 acre farms) and 44 large farmers (>5 acre farms) were selected for study. A pre-tested questionnaire was used for data collection. Descriptive statistics and mean comparisons were performed. The average extent of land under pepper cultivation was significantly different ($P<0.01$) with 3.49 acres for small farms and 8.85 acres for large farms, and 66% of lands were under local pepper varieties. Fertilizer was the only input applied by both group of farmers. The mean yield of pepper was 636 kgs and 560 kgs per acre for small and large farms respectively and did not differ significantly. Mean comparison showed that there was a significant difference ($P<0.01$) in cost of production, income from pepper sales and profits from pepper between small and large farmers. There were no significant differences in farm gate prices received for raw and processed pepper by small and large scale farmers. It can be concluded that there is significant differences between small and large scale pepper farmers in the extent cultivated, incomes received, cost of production and profits earned, while there is no differences in the prices received for raw and processed pepper.

Keywords: *pepper, productivity, income, profits, Sri Lanka.*

INTRODUCTION

Pepper is the most widely used spice in the world and known as "King of the Spices". Pepper crop is native to South Asia and historical records reveal that pepper originated in South India. In Sri Lanka pepper growing is done under rainfed conditions. The Department of Export Agriculture (DEA) reported that in 2012 the total extent of pepper in Sri Lanka was 32,291 ha. Pepper is mainly concentrated in mid-country region of the country especially in Matale and Kandy districts, where approximately 38% of pepper is cultivated. Total extent of pepper in Matale District is 6,433ha. Pepper export from Sri Lanka was about 12,218 Mt in 2012 (DEA, 2014). Sri Lankan pepper is an annual agricultural rainfed crop that has an intrinsic quality in terms of high oil and piperine contents. There is a possibility to increase export share through understanding the factors interrupting the pepper production and marketing. Malaysian farms yield 3,000 Kg per hectare, whereas the Sri Lankan average is less than 500 kg per hectare. Sri Lankan share in the global pepper market has varied from 2 to 3%. There is a possibility to increase export share further by highlighting intrinsic quality of Sri Lankan pepper in terms of high oil and piperine contents. Since the availability of land is a limitation for expansion of pepper area, the focus was placed on the improvement of the productivity of the existing pepper cultivations (Seneviratne, 2011).

Pepper cultivation takes place in home gardens with mixed cropping. Farmers often do not apply chemical fertilizer or agro chemicals. Pepper is harvested manually, dried in the sun and packed in jute and poly-sacks. In manufacturing value-added products, locally developed pepper threshers, graders and blanchers are the machinery used in industry (Rupasena, 2007). Smallholders play an important role in the spice sector in Sri Lanka; nearly 70% of spice production comes from units of less than 1 ha of land. There are many initiatives implemented by the Department of Export Agriculture to promote pepper industry in Sri Lanka, especially distributing planting materials, farming equipment and even loan facilities to prepare the farm lands. However, despite these initiatives small scale producers are struggling, many of them are moving out of the industry and some are diversifying the farm lands to other crops (Rodrigo,2014). *Gliricidia* is the predominantly used support tree for pepper vines in Sri Lanka. Lopped parts of *Gliricidia* tree provide green manure. Experimental evidence support that half of the fertilizer requirement can be met by applying 10 kg of fresh *Gliricidia* leaf matter (Seneviratne, 2011). Pepper growers do not have the capacity to add value to the raw produce, they always sell the raw green pepper to the urban traders. Majority of them are price takers with little or no bargaining power over pepper prices. They are tied between formal and informal credit sources, and have not introduced innovation to their businesses and are caught up in the vicious cycle of poverty for a long time (Rodrigo, 2014). In some countries, such as India, Sri Lanka and parts of Indonesia, pepper is cultivated on live supports, under mixed cropping systems. In most of Sarawak, Malaysia and on Bangka Island in Indonesia, dead wood supports are used. In Vietnam, most pepper vines grown on concrete or brick supports. When pepper is grown on live supports, the number of plants per unit area,_and sometimes yield per plant, are lower than for a pure crop raised on non-living supports. Productivity or yield varies according to the intensity of cultivation (George, 2005). Average pepper yields in Sri Lanka are in the region of 140 to 200 kg/acre with prices fluctuating between Rs.130–280/kg, giving a gross income between Rs.18,200 to Rs.56,000/acre (SEPC, 2010). For the pepper industry to remain competitive, the cost of production per unit output has to be reduced. Labor is the most expensive input in pepper cultivation. Other than during first year for planting, most labor is required for harvesting. There is need to identify labor efficient operations in pepper production, including introduction of mechanical devices. Research should also be undertaken on the use of natural resources such as bio-fertilizers and bio-control agents to reduce dependence on synthetic fertilizers and chemicals for pest and disease control. This would have the advantage of lowering costs, while addressing issues related to chemical residues in pepper (George, 2005; Perera *et al*, 2013). There are enough policies to advocate and guide farmers on how to maximize production in the pepper industry, under the Department of Export Agriculture. Published documents exist to educate farmers on how to manage a pepper plantation, harvest and process (Rodrigo,2014). This study attempts to provide better understanding of pepper production, costs involved, income obtained and profitability for large and small scale pepper growers in Matale district, Sri Lanka.

MATERIALS AND METHODS

Matale district was purposively selected for the study because it’s the largest pepper producing district in Sri Lanka. Matale district with an extent of 1,993km^2 of total land and 141,179 families living has very conducive soils for pepper cultivation. Matale District is characterized by its natural diversity as it spreads across all major ecological regions of Sri Lanka. Climatically its variation from Dry zone, to wet zone, through a wide belt of intermediate conditions (Bandara, 1991). A random sample of 120 farmers, consisted of 76 small scale farmers (<5 acre farms) and 44 large scale farmers (>5 acre farms) was selected from highest pepper producing DS divisions Palapathwala, Ambanganga, Yatawatta and Pallepola for the study. The field survey was conducted using a pretested structured questionnaire for data collection. Data were collected on the years of experience, yield, processing activities, variable cost of the production, support services available, problems faced and suggestions. Secondary data were extracted from sources such as the Annual Reports of the Central Bank of Sri Lanka and DS office records. Data was analyzed by using descriptive statistical methods. Simple statistical analysis was performed to get frequency distribution, descriptive statistics and mean tests of variables. Descriptive statistics and mean comparisons were performed with SPSS software. For estimating cost the average expenditure on various inputs like fertilizer, planting material and human labor was worked out. The returns were calculated based on the actual price received by the growers. The returns over variable cost and net returns were calculated by deducting the respective cost from the gross returns. Gross income of pepper farmers was calculated by multiplying the pepper harvest per season by the price they received per kilogram of pepper sold. Profit from pepper cultivation was calculated by deducting Gross Income from the total cost involved in pepper cultivation per annum. Mean comparison between small and large scale pepper farmers was done by segregation based on the land extent owned into two groups as follows; Group 1- Small scale farmers cultivating less than 5 acres (<2 ha) of land. Group 2-Large scale farmers cultivating more than 5 acres (>2 ha) of land. Mean comparisons were done for these groups of farmers on yield, land extent, profit per acre, income per acre, farm gate price for raw pepper, farm gate price for black pepper and total cost.

RESULTS AND DISCUSSIONS

The results indicated that the average extent of land under pepper cultivation was significantly different ($P<0.01$) with 3.49 acres for small scale farms, while it was 8.85 acres for large scale farms, and 66% of these lands were under local pepper varieties. Fertilizer was the only input applied by both small and large scale farmers. Only 29% of them were applying fertilizer for pepper cultivation and 18% of them had used new planting materials to increase production. The rest 71% of pepper farmers were not applying artificial fertilizers to the pepper vines, they only use chopped parts of the support tree (*Gliricidia sepium* cuttings-leaves) as a source of nitrogen fertilizer. It was observed that the farm gate price for raw pepper (fresh green pepper beans) did not vary between the small and large scale farmers, whereas it varied for processed black pepper.

Table 1. Statistical comparison of large and small scale pepper farmers

Variables	Land category	N	Mean	Std. Deviation	Std. Error of Mean
Pepper income per acre (Rs.)	Small farmer	76	6.1257E4	42232.067	4844.350
	Large farmer	44	2.5766E4	16981.271	3466.287
Cost of Production per acre (Rs.)	Small farmer	76	1.2654E4	6710.189	769.711
	Large farmer	44	5.5439E3	3380.422	690.026
Profits per acre (Rs.)	Small farmer	76	4.8604E4	37123.612	4258.370
	Large farmer	44	2.0222E4	14626.971	2985.718
Yield per acre (Kgm)	Small farmer	76	636.18	319.958	36.702
	Large farmer	44	560.42	260.426	53.159
Extent of Pepper land (acs)	Small farmer	76	3.49	0.975	0.112
	Large farmer	44	8.85	8.930	1.823
Farm Gate price for raw pepper (Rs./kg)	Small farmer	76	304.21	12.571	1.442
	Large farmer	44	305.42	9.771	1.994
Farm Gate price for processed Black pepper (Rs./kg)	Small farmer	76	422.38	591.621	67.864
	Large farmer	44	541.67	604.991	123.493

*1= Small scale farmers (<5 acres) and 2= Large scale farmers (>5 acres). N=120
**Source: Author data analysis, 2015*

The cost of production for small farmers was higher than large farmers due to the use of fertilizers to the pepper vines and also higher labor costs involved. The annual mean yield of pepper was 636 kgs and 560 kgs per acre for small and large scale farms respectively, which did not differ significantly, but were higher than the values estimated in an earlier study of SEPC (2010) but lower than yields in other countries (Seneviratne, 2011, George, 2005). Mean comparisons showed that there was a significant difference (P<0.01) in the income from pepper cultivation, cost of production of pepper and profits per acre between small scale and large scale farmers. There were no significant differences in the farm gate prices for raw and processed pepper and yield per between small scale and large scale pepper farmers.

Table 2. Independent Samples Test for Means between Large and Small Pepper farmers

Test Variables	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	T	df	Sig. (2-tailed)
Pepper income per acre land	3.556	0.062	4.005	98	0.000***
Cost per acre land	2.717	0.102	4.983	98	0.000***
Profit per acre land	4.104	0.046**	3.647	98	0.000***
Yield per acre (kg)	0.357	0.551	1.054	98	0.294
Extent of pepper Land (acres)	11.232	0.001***	-5.192	98	0.000***
Farm Gate price for raw pepper (Rs./kg)	0.064	0.801	-0.430	98	0.668
Farm Gate price for Black pepper (Rs./kg)	0.588	0.445	-0.857	98	0.394

Significance at **P<0.05 & *** P< 0.01; N=120.
**Source: Data analysis, 2015*

It was also observed that there is a very low level (39% farmers) of processing and value addition activities performed by the pepper farmers for market sales, which was similar to findings of Seneviratne (2011) and Rodrigo (2014). The DEA has developed published materials for pepper farmers to manage production and process pepper (Rodrigo, 2014) which farmers have to be made aware through better dissemination approaches.

CONCLUSIONS

The average extent of land under pepper cultivation was significantly different between small scale and large scale farmers. Fertilizer was the only input applied by both group of farmers. The annual mean yield of pepper for small and large scale farms did not differ significantly. There was a significant difference in annual cost of production of pepper, income from pepper production and profits received between small scale and large scale farmers. There were no significant differences in the farm gate prices received for raw and processed by small and large scale pepper farmers. It can be concluded that there is significant differences between small and large scale pepper farmers in the extent cultivated, incomes received, cost of production and profits earned, while there is no differences in the prices received for raw and processed pepper. There is also a low level of value addition to pepper for market sales.

REFERENCES

Bandara, C.M. (1991). An environmental profile of Matale district, Department of Geography, Universitry of Peradeniya, Peradeniya, Sri Lanka.

DEA (2014), Annual Report, Dept of Export Agriculture-2014. DEA, Peradeniya, Sri Lanka.

George, C. K., Abdullah, A. & Chapman, K. (2005). Pepper Production Guide for Asia and the IPC Pepper Project, Newsletter, March /19/2007.

Perera, S.A.A.S, Weerahewa, J. & Dissanayake, S.N. (2013). Factors Affecting the Quality Pepper Production among Smallholder Farmers in Udunuwara DS Divison in Kandy District, Sri Lanka.

Rodrigo,C. (2014). Learning from the Best Practices: Pepper smallholder sector of Sri Lanka, *The Island*, Aug/08/ 2014. Colombo.

Rupasena,L.P, Rathnayaka,B, & Ravichandran,T.(2007). Structure conduct and performance analysis of Cinnamon, Pepper, Coconut and Tea Market, Research Study No. 119, Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo.

SEPC (2010). "Cost of Cultivation of Agricultural Crops", Socio-Economic & Planning Centre, Dept. of Agriculture, Peradeniya, Sri Lanka.

Seneviratne,M.A.P.K(2011). An integrated approach towards productivity improvement in black pepper: Sri Lankan experiences. Report of Pepper Tech Meeting, Senggigi, Indonesia.

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EFFECTS OF GROWING CONDITIONS ON CROSSING SUCCESS IN DIFFERENT POTATO (*Solanum tuberosum* L.) CROSSES

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ABSTRACT

This study was carried out to determine the effect of growing conditions under different altitudes on seed production in different potato crosses in Tokat Province of Turkey in 2015. Plants were grown and crosses were made in open field or net house in Tokat location (altitude 600 m asl.), open field or net house in Artova location (altitude 1200 m asl.), or controlled polycarbonate greenhouse. Fifteen different crosses were made between 12 parent cultivars. Production of hybrid potato seed was considered "crossing success". Results showed that parent cultivars and cross combinations affected crossing success and no seeds were produced from some combinations while some combinations produced abundant seeds. The highest number of seeds were produced in controlled polycarbonate greenhouse, whereas very low amount of seeds were produced under low altitude (600 m asl.) open field conditions. Polycarbonate greenhouse produced 47.3% of all seeds, while low altitude net house produced 19.8%, high altitude open field produced 15.8%, high altitude net house produced 13.6% and low altitude open field produced 3.5%. It was concluded that for a high crossing success, potato crossing should be made by controlled polycarbonate greenhouse conditions and 23 C^0 day / 17 C^0 night temperatures produced more hybrid seeds.

Keywords: *crossing,crossing success, combination, growing condition.*

INTRODUCTION

Hybridization studies are important for the development of new potato varieties. The success rate in hybridization is influenced by several factors such as day-night temperature difference and the developmental state of plants during pollination period depending on mainly genotype, day length, temperature and altitude (Kurt, 2004; Muthoni *et al.,* 2012; Esendal, 1990). Genotype, day length, temperature are the main factors determining flowering and fruit formation in potato. In addition, there are some other factors affecting flower production and fruit formation such as flowering position plant stem density (Almekinders, 1992), competition between flower and tuber formation, rainfall and irrigation conditions (Jauhnl, 1954), nutrient levels (Bamberg and Hanneman, 1988; Otazu and Amoros, 1991) and the number of plants (Jauhnl, 1954). Parent characteristics should be known so that a suitable crossbreeding program can be administered.

In recent years, some researchers have implemented several experimental methods to determine parent characteristics. They also determined that the methods developed for hybrid prediction had value appropriate and practical enough to be employed in potato breeding programs as well (Mendoza, 1987; Brown and Caligari, 1989). In cases where hybridization is implemented in potato breeding, it may not always be possible to obtain fruit or seeds depending on various reasons. This can stem from such factors as ploidy differences of parents, infertility, divergence or flowering. Flowering in potato is particularly important in parent lines to be used in breeding. In order for flowering to occur in potato, a temperate climate plant, a cool climate or longer photoperiod is needed. When potato is grown in high altitudes in long summer days, flowering occurs easily under natural conditions (Gupta *et al.*, 2004). Similarly, Gopal (1994) reported that more flowering and fruit formation occurred in tropical and subtropical plants grown in areas with high altitudes (>1500 m asl.).

In order to be more successful in breeding process, more flower formation and longer flowering period is favored. In addition to the above mentioned procedures to ensure flowering in potato plant, gibberellic acid (GA_3) can be administered to the plant. This application can create the effect of long day conditions (Esendal, 1990). Nitrogen, applied in high doses and at certain periods more than recommended for tuber production, increases flowering, delays maturing of the plant and lengthens the fruit development period (Pallais, 1985). Light intensity and light exposure time (day length) are effective in fruit formation and developing more seeds within the fruits following hybridization in potato. 14-18 hours of day time and temperatures of 15-20°C are suitable for flowering and fruit formation (Clarke and Lombard, 1939; Bodlander, 1963; Almekinders, 1992).

Turner and Ewing (1988) studied the effect of some environmental factors on falling of flower bods in some potato clones and found that photoperiods longer than 12 hours lowered the fall of flower buds compared to shorter photoperiods and night temperatures higher than 20°C lowered more than 10°C did. Thus, longer photoperiods and higher night temperatures promoted flower development while lower light intensity (50% of day light) suppressedit.

Weber *et al.* (2012), reported that no seeds were obtained in some crossing studies of potato due to various factors including pollen-pistil incompatibility, where some parents are incompatible with each other and no seeds were produced in reciprocal crosses of some parents. They reported that F_1 hybrids produced no seeds when used as female in crosses with wild potatoes whereas no seeds were obtained when used as male. In addition to pollen-pistil incompatibility, obstacles due to embryo and cytoplasmic male sterility were also mentioned to be the causes of problem to produce seeds in potato crossings (Camadro and Peloquin, 1981; Erazzu *et al*., 1999; Ispizua *et al*., 1999; Camadro *et al*., 2004).

The aim of this study isto determine the effect of growing conditions under different altitudes on hybrid seed production and crossing success in different potato crosses in Tokat Province of Turkey.

MATERIALS AND METHODS

This study was carried out in 2015 under Tokat Artova conditions. 15 Cross combinations (A2/11 x T6/28, A3/110 x A2/11, A10/15 x A3/223, A7/12 x A10/15, A8/34 x A13/1, T4/4 x T6/28, A2/11 x Melody, A7/12 x Van Gogh, A3/223 x Megusta, Başçiftlik Beyazı x A13/1, Başçiftlik Beyazı x Megusta, Başçiftlik Beyazı x Van Gogh, Aleddiyan Sarısı x Megusta, Aleddiyan Sarısı x A2/11 and Aleddiyan Sarısı x T6/28) were made in polycarbonate greenhouse, net house or open field in Tokat Kazova (altitude 600 m asl.), and open field and net house in Tokat Artova (altitude 1200 m asl). Crossings in polycarbonate greenhouse in Tokat Kazova were carried out during winter and summer of 2015, while other crossings were carried out during 2015 summer.

Growing Parent Plants

Planting was made in different dates to get flowers from different genotypes at the same time and to get more seeds. Planting dates were as follows; Tokat net house: April 21st,May 13rd,June 24th, Tokat open field; April 30th, June 3rd, Tokat Artova open field; April 4th, May 21st, June 17th, Tokat Artova net house; April 18th, June 10th. For plantings in greenhouse, 33x26 cm pots containing 1/3 torf, soil and perlit each were used. Planting open fields were made in 100x70 cm hills. Three plant were grown for each parent in each planting period. Plantings for 2015 winter period in polycarbonate greenhouse were started in November 11th and December 3rd, and plantings for 2015 summer were continued until February 27th, May 5th and July 1st. After the emergence, plants were monitored and necessary weeding, watering, fertilization, side branch removing, stolon cutting and pesticide application were performed.

Crossing and Production of Hybrid Seeds

Parents were monitored carefully after the formation of flower buds. Emasculation and crossing were made according to Poehlman and Sleeper (1995). Before the flowers opened, petals were opened carefully without stigma and 5 anthers removed without damaging sacs using fine-tip forceps early in the morning. Other flowers were removed to make emasculation easier and to prevent possible contamination. No isolation of emasculated stigma was applied to prevent damage to female organ (Fehr and Hadley, 1980). Pollinaton was made by applicaiton of polen to the stigma of female plant. Polen was obtained from pollen sacs of mature male plants. If the pollen was not ready, pollination was made the following day. Pollination were started after flowering on June 15th 2016 in Tokat net house, on July 1st 2015 in Tokat open field, on July 3rd in Artova open field on july 15th in Artova net house and on February 10th in polycarbonate greenhouse. In order to promote plant growth, flowering and to increase the succes of crossing, long day conditions were created using artifical light in greenhouse conditions and temperature of greenhouses were adjusted to 16°C night/22°C day using temperature control mechanisms. When fertilization occured in pollinated flowers, swelling was observed in ovarium about 5 days after the pollination. Mini berries were seen after another 3-5 days and remnant of petals in the upper part fell. Berrieswere prevented from falling and getting last by special net sacs prepared for this purpose. Developing crossed berriesgot larger as their growth prolonged. Seeds in berrieswhich completed the physiological development were separeted from berry in a container filled with water. Findings were subjected to correlation analysis using SPSS-20 statistical package programme.

RESULTS AND DISCUSSIONS

Seed set success of different potato combinations was different. Some combinations produced many berries and seeds while some produced none. Number of crosses madefor each combinations varied between 36 and 415 and seeds were produced from all combinations except for three (3, 4 and 15). The highest berry ratio was obtained from combinations 5, 10, 11 and 12. Number of seeds per berry was highest for combinations 2,5 and 9, (Table 1). The highest number of seeds were produced by combinations 5, which had 37.5 of berry set and a high seed set per pot. Higher berry set and seed production in combinations 10, 11 and 12 shows the good combination ability of parents in these combinations.

Table 1. Number of crosses made, seed set ratio and number of produced seeds

No	Combinations	Number of crosses	Berry set ratio (%)	Number of seeds produced	Number of seeds per berry
1	A2/11 X T6/28	71	1.4	26	26
2	A3/110 X A2/11	180	17.7	3014	94.1
3	A3/110 X A3/223	392	-	-	-
4	A7/12 X A3/110	415	-	-	-
5	A8/34 X A13/1	165	37.5	6711	108.2
6	T4/4 X T6/28	114	17.5	195	97.5
7	A2/11 X Melody	65	12.3	682	85.25
8	A7/12 X Van Gogh	264	7.1	994	52.3
9	A3/223 X Megusta	189	1.5	586	195.3
10	Başçiftlik B. X A13/1	251	49.8	7651	61.2
11	Başçiftlik B.X Megusta	138	44.2	942	15.4
12	Başçiftlik B. X Van Gogh	301	38.8	2634	22.5
13	Aleddiyan S. X Megusta	36	22.2	295	36.8
14	Aleddiyan S. X A2//11	107	19.6	939	44.7

15	Aleddiyan S. X T6/28	37	-	-	-
Total / avarage		2725	17.8	24669	53.7

Relations between number of crosses made and numbers of hybrid berries and seeds were given in Table 2. Based on the results, there were negative correlations between combinations and number of crosses made, number of hybrid seeds and berries, and a positive correlation between combinations and berry set ratio.

Table 2. Correlations between number of crosses, berry set ratio and number of hybrid seeds according to combinations

	Combinations	Number of crosses made	Berry set ratio (%)	Number of hybrid seeds
Number of crosses made	-,341*			
Berry set ratio (%)	,315*	-,046		
Number of hybrid seeds	-,020	,137	,731**	
Seeds/berries	-,133	-,200	,030	,258

CV%: 1.6,*p<0,05, **p<0,01

A total of 24,669 hybrid seeds were produced from five different conditions (Table 3). The highest number of seeds were produced from polycarbonate greenhouse. It was followed by net house in Tokat (4899 seeds) and high elevation areas. Number of seeds produced varied from 26 to 7651 in different growing conditions. Combination 2, 5, 10 and 12 produced more seeds than others. Combination 10 produced higher number of seeds in all growing conditions. Berry set ratio was highest in Artova open field condition but the highest number of seeds were produced in controlled polycarbonate greenhouse because of higher number of crosses which could be made in the latter condition. Although the success was low in lower altitude Tokat open field conditions, here net house of preferably controlled polycarbonate greenhouse gave better results. Seed production was better in open field conditions of high elevation Artova, where net house also gave satisfactory results.

Table 3. Number of hybrid seeds in different growing conditions

Combinations	Tokat open field	Tokat net house	Artova open field	Artova net house	Polycarbonate greenhouse	Total
1. A2/11 x T6/28					26	26
2. A3/110 x A2/11					3014	3014
3. A3/110 x A3/223						-
4. A7/12 x A3/110						-
5. A8/34 x A13/1		3378	537	428	2368	6711
6. T4/4 xT6/28					195	195
7. A2/11 x Melody	370		112	160	40	682
8. A7/12 x Vangogh		194			800	994
9. A3/223 x Megusta				489	97	586
10. Başçiftlik Beyazı x A13/1	418	1246	2243	1503	2241	7651
11. Başçiftlik Beyazı x Megusta		2	-	225	715	942
12. Başçiftlik Beyazı x Van Gogh	85	79	270	471	1729	2634
13. Aleddiyan Sarısı x Megusta					295	295
14. Aleddiyan Sarısı x A2/11			717	72	150	939
15. Aleddiyan Sarısı x T6 /28						-
Total	873	4899	3879	3348	11.670	24.669

Table 4. Number of berries and seeds produced in different growth conditions

Conditions	Number of crossed flower	Number of hybrid berry	Berry set ratio (%)	Number of hybrid seed	Hybrid seed ratio (%)	Seeds /berry
Tokat open field	89	24	26.9	873	3.5	36.3
Tokat net house	410	82	20	4899	19.8	59.7
Artova open field	306	89	29	3879	15.8	43.5
Artova net house	267	60	22.4	3348	13.6	55.8
Polycarbonate greenhouse	1653	204	12.3	11670	47.3	57.2
Total / average	2725	459	17.8	24669		53.7

Polycarbonate greenhouse where the highest number of flowers were crossed (1653) produced higher number of hybrid seeds (11670) (Table 4). Flower development was affected by growing medium. Controlled conditions or higher elevation open fields produced more flowers, and consequently more berries and seeds. Berry set ratio, another parameter affecting crossing success, was high in open field conditions (26.9 and 29.0% in Tokat and Artova, respectively). However, number of crosses made was low in open field conditions (Table 4). The results showed that number of flowers crossed and number of seeds produced were significantly and positively correlated (Table 5).

Table 5. Correlations between number of flowers crossed, number of hybrid berries, seeds sets /berry based on combinations

	Combination	Number of flowers crossed	Number of hybrid berries	Berry set ratio	Number of hybrid seeds	Hybrid seed ratio
Number of flowers crossed	,749**					
Number of hybrid berries	,790**	,974**				
Berry set ratio	-,656**	-,903**	-,846**			
Number of hybrid seeds	,783**	,982**	,991**	-,907**		
Hybrid seed ratio	,784**	,982**	,990**	-,906**	,998**	
Number of seeds /berry	,587*	0,487	,529*	-,717**	,607*	,601*

CV%:0.4, *p<0,05, **p<0,01

It was found that especially combinations, elevation where the crossing was made and growing conditions affected the success of crosing in potato. The fact that some combinations produced no seeds while others produced many hybrid seeds clearly showed the importance of compatibility of parents in each crossing. With this respect, Weber *et al.* (2012), reported that no seeds were produced when pollen and pistil were incompatible. Erazzu´*et al.* (1999) and Camadro *et al.* (2004), on the other hand, reported that in addition to pollen – pistil incompatibility obstacles due to embriyo and cytoplasmicmale sterility negatively affected seed set in crossing studies of potato.

Relationship between number of flowers and hybrid seeds and pots were significant and positive. This fact could be due to the fact that environmental conditions and especially long day conditions and temperate conditions in which temperature was not very high led to the formation of many flowers. Similarly, Esendal (1990) and Muthon *et al.* (2012), mentioned that longer day conditions promoted flower development in potato and produced more branches and flowers. Higher number of flowers increase number of crossed flowers. However, in addition to day length, temperature and light intensity are also known to be important in prevention of berry loss after crossing. Similarly, Gopal (1994), showed that loss of flower buds and pots produced were lower in places of higher elevation. Turner and Ewing (1988), on the other hand, mentioned that bud loss was higher and berry set was lower in conditions where day length and light intensitiy were smaller. The same authors reported that 20 °C suppressed bud and berry loss more compared to 10°C and that temperate conditions were more favorable compared to higher or lower temperature conditions.

CONCLUSION

The present study revealed that compatibility of parent, elevation and growth conditions affected the success of potato crosing through temperature and day length and that long day conditions facilitated by conrotolled growing conditions and 23°C day/17°C night temperatures produced more hybrid seeds. In addition, it was found that 1200 m elevation open field conditions and net house conditions resulted in higher crossing success compared to low altitude areas.If it is crossing in potato, high altitude must be selected. Furthermore, greenhouse should be used to make regularhybridization.

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REFERENCES

Almekinders C.J.M. (1992). The effect of photoperiod on flowering and TPS production in the warm tropics . Potato Research 35 :433-442.

Bamberg J .B., R.E. Hanneman J. (1988). Enhanced production of botanical seed of tuber bearing Solanumspecies via supplemental fertilizer applications . Am . Potato J. 65: 470.

Bodlaender K.B.A. (1963). Influence of temperature, radiation and photoperiod on development and yield . In: J. D. Ivens & F.L. Milthorpe (Eds) . The Growth of Potato, p. 199-2 10. Butterworth,London.

Brown J, Caligari P.D.S. (1989) Cross prediction in a potato breeding programme by evaluation of parental material. Theor Appl Gen. 77:246-252.

Camadro E.L., Peloquin S.J. (1981) Cross-incompatibility between two sympatric polyploid Solanum species. Theor Appl Genet 60:65–70

Camadro E.L., Carputo D., Peloquin S.J. (2004). Substitutes for genome differentiation in tuber-bearing Solanum: interspecific pollen-pistil incompatibility nuclear-cytoplasmic male sterility and endosperm. Theor Appl Genet 109:1369–1376

Clarke A.E., Lombard P.M. (1939). Relation of length of day to flower and seed production in potato varieties. Am. Potato J. 16: 236-244.

Esendal E. (1990). Nişasta ve Şeker Bitkileri ve Islahı, Cilt. 1. Patates. 19 Mayıs Ün. Ziraat Fak. Yayınları, Samsun.

Erazzu´ L.E., Camadro E.L., Clausen A.M. (1999). Pollen-style compatibility relations in natural populations of the wild diploid potato species Solanum spegazzinii Bitt. Euphytica 105:219–227.

Fehr W.R., Hadley H.H. (1980). Hybridization of Crop Plants. American Society of Agronomy and Crop Science of America. p. 420.USA.

Gopal J. (1994). Flowering behaviour, male sterility, and berry setting in tetraploid *Solanum tuberosum* germplasm. Euphytica. 72:133-142.

Gupta V.K., Thakur K.C., Kumar S., Pandey S.K., Sah U. (2004). True Potato Seed- An alternative technology for potato production in North eastern hill region. Technical bulletin, no 64, Central Potato Research Institute, Shimla. pp. 1.

Ispizua V.N., Camadro E.L., Clausen A.M. (1999). Pre-zygotic breeding barriers between the wild diploid potato species Solanum maglia and S. kurtzianum from Argentina. Genet. Resour Crop Evol 46:243–249.

Jauhnl G. (1954). Zur Kenntnis des Bluuhverhaltens der Kartoffel .Verouff. Bundesanst. alp. Landw. Admont, 9: 40-74.

Kurt O. (2004). Bitki Islahı Ders Kitabı. OMÜ. Ziraat Fakültesi. Ders Kitabı No: 43. Samsun.

Mendoza H.A. (1987). Advances in Population Breeding and Its Potential Impact on The Efficiency of Breeding Potatoes for Developing Countries, In Production of New Potato Varieties, Cambridge University Press, Cambridge, P. 235–245.

Muthoni J., Shimelis H., Melis R., Kabira J. (2012). Reproductive biology and early generation's selection in conventional potato breeding, Australian Journal of Crop Science, AJCS 6(3):488-497.

Otazu V., Amoros W. (1991). Potato berry blackening and prematüre drop due to boron deficiency. Am. Potato J. 68: 849-856.

Pallais N., Fong N., Berrios D. (1985). Research on the physiology of potato sexual seed production. In: Innovative methods for propagation of potatoes. CIP, Peru, pp. 149- 168.

Poehlman J.M., Sleper D. (1995). Breeding field crops. 4th ed. Iowa State University Pres, P: 419, Ames, IA.

Weber B.N., Hamernik A.J., Jansky S.H. (2012). Hybridization barriers between diploid Solanum tuberosum and wild Solanum raphanifolium.Genetic Resources and Crop Evolution , Volume 59, 1287-1293.

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ORGANIC AGRICULTURE IN PROVINCE OF USAK IN TURKEY

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ABSTRACT
Organic agriculture consists of environmental and human friendly production systems in order to reestablish the natural balance which is lost as a result of inaccurate and excessive farming practices. In others words, instead of using synthetic chemical pesticides and fertilizers, organic agriculture promotes organic and green fertilization, crop rotation, soil conservation, increasing plant resistance as well as benefitting from parasites and predators. In addition, organic farming refers to improving not the amount of production but the quality of it. Due to the spread of diseases caused by pesticide and hormone residue on the products, people show great interest in organic agriculture so as to lead a healthier life. Total organic agricultural production in the world is 4.516.810 tons, while in Turkey it is 353.173 tons. As for Turkey's organic agriculture, Uşak province has little share in it despite its favourable climate and location. In this study, as a methodology, we analyzed the existing data on organic agriculture in Uşak province and in Turkey as well as in the total production in all over the world. And then, we compared those statistics with each other, finding that Uşak province, however great potential it has, hasn't been able to reach the desired level in terms of organic agriculture. We focus on determining the potential of Uşak province for organic agriculture. Furthermore, we aim to define the problems of organic agriculture and to find solutions to them in order to make organic agriculture more widespread and more practicable.

Key words: *organic agriculture, Uşak province, potential.*

INTRODUCTION
Man, afraid of his population and nutrition being under danger, have populated soil and underground water to the extent which deteriorates human health and put the ecological sustainability of the environment under threat in terms of living organisms. Therefore, while human beings must meet their needs of sufficient, balanced, healthy and economical nutrition, taking measure for protecting natural balance will not be enough but they also have to reestablish agricultural production

systems, especially in developed countries. The efforts of reclamation planning and production techniques conducted in order to obtain more output from unit area have ignored natural and environmental resources. The heavy use of chemical fertilizers and herbicides, although they provide productivity increase, has caused many problems such as quality loss, soil deterioration, organic substance loss from the soil, soil erosion, proliferation of different diseases and harmful substances, high rates of environmental pollution (Walaga at al, 2005; Popović et al, 2013a, 2013b, 2013c; Glamočlija et al., 2015; Filipović et al., 2015). The possibility of cancer and other health problems caused by residues of chemical fertilizers and herbicides lead researches to improve production methods which can prevent these calamities. Therefore, in order to get health food with high nutritional value without degrading the environment, which have no harmful effect on human and animal healthy and which minimize the environment pollution, evolutionary agricultural systems have been investigated and a system called organic agriculture has been improved.

MATERIAL AND METHOD

In this study, the current state of organic agriculture in Turkey and Uşak province has been presented and some suggestions have been put forward for future improvements in organic agriculture. In doing so, literature based analyses were conducted, interpreting the instructions used as methods and by evaluating and synthesizing the sources based on statistical data.

RESULTS AND DISCUSSION

In organic agriculture, soil improvement and protection of organisms within it must be provided; moreover, soil must not be exploited. On the contrary, its natural productivity must be enhanced. To achieve these goals, crop rotation and organic fertilization has been applied and also appropriate soil processing techniques has been used. For instance, the compost prepared under aerobic conditions with farm fertilizers and organic wastes has been utilized in a way most suitable for this aim. Besides, rock flour and algae product can be used as well as green fertilization. With the help of these practices, biological processes of soil are promoted, driving some food nutrition to be activated indirectly and thus providing convenient circumstances for plants to grow healthy and in a balanced way (Anonymous, 2005).

The efforts throughout the world to develop alternatives to conventional agriculture until 1970 gained a new dimension with the foundation of international federation of organic agriculture movement (IFOAM), which first defined and wrote the rules of ecological production. These rules were modified as ‘IFOEM Basic Standards’ in 1998 and were enacted after having been approved by general assembly.

The total area on which organic agriculture is performed accounts for 43.1 million hectares and Australia ranks as the first with 17.3 million hectares and Europe as the second with 11.5 million hectares. And then commes Latin America, Asia, North America and Africa with 6.6 million hectares, 3.4 million hectares, 3 million hectares and 1.2 million hectares respectively.

As for the countries, Australia ranks as the first with 17.2 million hectares, Argentina as the second with 3.2 million hectares and USA as the third with 2.2 million hectares (FİBL-IFOEM, 2015).

Turkey has great potential for organic agriculture with its geographical location, unpolluted agriculture lands, diversity of its plant kinds, local plant kinds well-adapted to regional conditions and with its having abundant young labor force.

Organic agriculture areas have been increasing day by day in the world. The countries with this increase pace are Argentina, Turkey and Spain. Organic agriculture production in Turkey started with the demands by foreign companies working in Europe in the years 1984 and 1985. After legal regulations in 1994, a rapid improvement in this realm was recorded (Özbilge, 2007).

Organic agricultural production started, in Aegean Region in 1985, with raisin, dried figs and dried apricots of 8 kinds which are some of the most important export products. In later years, organic agriculture expanded to other regions with products such as hazelnut and cotton (Ataseven and Aksoy, 2000) and reached 208 products according to 2014 data (TUİK, 2015). In 2014, organic agriculture was performed by 71.472 farmers on 842.216 hectares land and with the production amount of 1.642.235 tones (Anonymous, 2015).

In Turkey, among most produced field plants as organic production, cool and hot climate grains rank as the first. Among the grains with 70 % share of total organic production, wheat ranks as the first accounting for 57.5 % with 1.365 tones corn as the second accounting for 41.7 % with 990 tones, barley as the third accounting for 3.3 % with 77 tones, oat as the fourth accounting for 7 %, tane and rye accounting for 1 % and 0.5 % respectively (Anonymous, 2014). Because especially the demand for floury products is high, production of wheat in vast lands organically has increased. Of all the organic field plants, the lowest share belongs to industrial plants such as potato with 82.6 %, sunflower with 13.7 %, beet with 6.4 % and sesame with 3.9 % (Anonymous, 2014).

When production group of garden plants are examined, it is found that total 31 crops are produced, the 79.9 % of which include fruits, 17.8 % of which are vegetables and 2.3 % of which is grape. Among the most production plants as organic production fruits occupy the first place with 40864.62 tones. Apple ranks as the first with 31019.74 tones accounting for 75.9 %, sour cherry ranks as the second with 3032.06 tones accounting for 7.41 %, strawberry as the third with 2993,11 tones accounting for 7.32 %, almond, pear, cherry, apricot follows the order accounting for 2.1 %, 2.02 %,1.93 %, 1.92 % respectively (Anonymous, 2014). 13 products in fruit group haven't been mentioned due to their low share less than 1 %.

Uşak province has 5.341.000 decares of surface area, 2.313.517 decares of which is reserved for agricultural area accounting for 44 % of total land. In 2.145.413 hectares of agricultural land, 44.280 tons of field products are raised and 64.788 tones of fruit are grown in 86.067 decares, 17.713 tons of vegetable are grown in

71.919 decares. The most produced crop in garden plants group is grape on cultivated 26.995 decares of land and then cucumber, almond, cherry, strawberry, nut are produced on 23.604 decares, 16.56 decares, 16.6 decares, 6.747 decares and 1.876 decares of land respectively. When it comes to field plants, barley rank as the first with 198.000 tons. Wheat, sugar beet, potato and chickpea follow it with 167.000 tons, 63.000 tons, 10.000 tons and 26.000 tons respectively (Anonymous, 2015).

CONCLUSION

Turkey's general location, unpolluted environment and its climate characteristics make Turkey's all geographical regions a source for organic agriculture. Domestic consumption of organic products has great significance in the health of local people. Health and nutritional values of organic products must be widely known. Moreover, Uşak's proximity to Izmir harbor and its widespread opportunity to use railroads, motorway and airway provide great opportunities to market organic products both as exports and as domestic product. Thanks to geothermal water sources existing in the region, greenhouses can be built so that organic vegetable production can be made widespread. Because Uşak has a number of lakes, organic agriculture can be achieved in irrigatable farming land without giving any harm to water flora and fauna richer. Producers must be informed about using organic input instead of using wrong and heavy chemical input.

The producers performing organic agriculture must be supported with incentive credit and be given education. Because organic agriculture is more costly than conventional ones, building up markets in order to promote production in organic agriculture is great necessity.

In organic agriculture, unconscious use of fertilizers and pesticides leads to environmental pollution. Therefore, the use of biological and biotechnological methods must be made widespread in line with organic agriculture while at the same time these applications must protect the human health and nature.

REFERENCES

Anonymous, 2015. Food Agriculture and Husbandry Ministry, Uşak province, Agricultural Investment Guide, strategy Development Executives, Strategic Management Presidency, February 2015.

Anonymous, 2014. Organic agriculture. http//www.agriculture.gov.tr

Anonymous, 2005. Ecological agriculture organization. http//www.eto.org.tr

Ataseven, y., Aksoy, F., 2000. A study on prevalence and adaptation organic agriculture in Turkey, Ankara University faculty of Agriculture, Farming Economy Department graduation thesisis.

Glamočlija, Đ., Janković, S., Popović, Vera, Kuzevski, J., Filipović, V., Ugrenović, V., (2015): Alternatively crop plants in conventional and organic growing systems. Monograph. IPN Belgrade. P. 1-355. 20-50. ISBN 978-86-81689-32-5;

FİBL-IFOEM. The world of organic agriculture statistic & Emerging trends 2015. ISBNFİBL 978-3-03736-271-6-ISBN IFOEM 978-3-944372-12-9.

Filipović, V., Popović, Vera (2015): Organic production of horseradish in Serbian metropolitan regions / Producţia organică de hrean în regiunile metropolitane din Serbia – IDESPERAS2L386. Elsevier Procedia Economics and Finance 22, 105 – 113. DOI:10.1016/S2212-5671(15)00232-4.

Özbilge, Z., 2007. An analysis of organic agriculture in Turkey: the current situation and basic constraints. Journal of central European agriculture, volume 8, 2007. pp 213-222.

Popović Vera, Miladinović J., Glamočlija Đ., Ikanović J., Đekić V., Đorđević Snežana, Mickovski Stefanovic V. (2013a): Effect of foliar nutritions on morphological characteristics and soybean yield in organic cropping system, 4th International Agronomic Symposium "Agrosym 2013", 3-6 October 2013, Jahorina, 713-718. DOI 10.7251/AGSY1303713P

Popović, Vera, Sikora, V., Ikanovic, Jela, Rajičić, Vera, Maksimović, Livija, Mickovski Stefanovic, Violeta, Katanski Snezana (2013b). Production, productivity and quality of buckwheat in organic growing systems in course environmental protection, 17th International Eco-Conference®, 10th Eco-Conference on Environment protection of urban and suburban settlement, Novi Sad, 25–28.09.2013,395-404.

Popovic, Vera, Sikora, V., Glamočlija, Đ., Ikanović, Jela, Filipović, V., Tabakovic, M., Simić, D. (2013c). Influence of agro-ecological conditions and foliar fertilization on yield and yield components of buckwheat in conventional and organic cropping system. Biotechnology in Animal Husbandry 29 (3), p 537-546, DOI: 10.2298/BAH1303537P

TUİK, 2015. http//www.tuik.gov.tr

Walaga, C., Hauser, M., Devle, R. Nagawa, F. (2005). Promoting Organic agriculture in Uganda. LEISA, Magazine on low external input and sustainable agric., December 2005, (21) 4:9-11.

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SENSITIVITY ANALYSIS OF AQUACROP EVAPOTRANSPIRATION TO WEATHER STATION DISTANCE

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ABSTRACT

Water balance calculation is essential for reliable agricultural management, and the actual evapotranspiration (ET) is the most complicated balance term to estimate. In agriculture, the most common method used is based on Penman-Monteith reference evaporation is determined from weather conditions for an unstressed grass cover, further multiplied by crop specific and soil water availability coefficients to obtain the actual evapotranspiration. This approach is also used in the AquaCrop model. This model has proven to be accurate when all weather data are locally available. However, in many cases, weather data can't be collected on the site due to the limited number of stations and the vast region covered by each of them. Instead, data are often collected at many kilometers from the study site. The question we want to study is: how does evapotranspiration accuracy evolves with respect to weather station distance? A winter wheat plot in Lonzée (Belgium) was studied during the 2014-2015 agricultural seasons. Actual evapotranspiration was simulated with AquaCrop thanks to the weather data collected at 3 different distances from the study site: on the site (data collected by a fluxnet station), 20 km, 50 km and 70km from the site. The non-on-site weather data were derived from spatially interpolated 10 km grid data. These results were then compared to the fluxnet station evapotranspiration measurements to assess the impact of the weather station distance. Substantial differences, which were found between the four cases, evoking the importance of assimilating satellite derived ET products (e.g. MSG) into AquaCrop.

Keywords: *agrometeorology, evapotranspiration, AquaCrop, weather data.*

INTRODUCTION

Agriculture production relies greatly on the timing and volume of water fluxes across the soil, plant and atmosphere domains. These fluxes are strongly related to the spatio-temporal patterns of evapotranspiration (ET). Therefore, evapotranspiration estimation is crucial for efficient agricultural production monitoring and water resources management. For example, it allows the detection of early drought and the estimation of crop yield (Penman 1948;Allen et al. 1998).

But evapotranspiration is the most difficult term to estimate. In agriculture, the method described by FAO (Allen et al. 1998) is the most commonly used: the Penman-Monteith method (Monteith 1965) is applied to an unstressed grass cover, and multiplied by two coefficients to reflect the specific behavior of the particular crop and soil water availability. Based on this model, the FAO developed a software named AquaCrop (Steduto et al. 2012).

If accurate weather variables, crop-specific coefficients and soil conditions needed are not available, this method can lead to errors up to 20% of the actual value (Paço et al. 2006). This inaccuracy leads agricultural managers (particularly in irrigated area) to use large safety factors. The consequences can be large: a waste of up to hundreds of millions of m^3 of water per year in big irrigated perimeters in arid regions experiencing food insecurity. (www.FAO.org 2016)

Indeed, in most cases, crop evapotranspiration is calculated with weather data from the nearest weather station that can be situated at several kilometers from the crop. In this study, we want to explore on a test case the evolution of the evapotranspiration accuracy with the distance of the data source used as forcing.

MATERIALS AND METHODS

To achieve the targets set, we predict ET through the combination of models (AquaCrop and B-CGMS weather data), and control the results with in-situ measurements (Fluxnet tower)

Fluxnet station:

FLUXNET is a network of micrometeorological tower sites. The flux tower sites provide local weather data and use eddy covariance methods to measure the exchanges of carbon dioxide (CO_2), water vapor, and energy between terrestrial ecosystems and the atmosphere.

Indeed, ET fluxes can be retrieve directly from water vapor measurement or calculated by energy budget from the heat flux measurement (www.fluxnet.ornl.gov 2016). For this work, we calculated ET from energy budget. It is important to note that the lack in energy balance closure with the eddy covariance technique may lead to an uncertainty on fluxes measurement around 20% (Wilson et al. 2002).

AquaCrop model:

AquaCrop is a model developed by FAO to increase water efficiency practices in agricultural production (Raes et al. 2012).

Indeed, AquaCrop simulates the yield of herbaceous crop as a function of water crop consumption. Therefore yield is calculated as a function of evapotranspiration. The estimation of evapotranspiration is based on the Penman-Monteith equation (Monteith 1965). According to this model, the reference evapotranspiration (ET0) is calculated from four daily weather variables: net radiation, air temperature, wind speed and relative humidity.

ETo is multiplied by two coefficients to adapt the standard result to the reality. The first coefficient reflects the specificity of each crop (phenology, canopy cover, rooting depth, crop transpiration, soil evaporation, biomass production, and harvestable yield). The second coefficient is used to reflect the soil water availability in the root zone. This coefficient is calculated from a water balance that keeps track of incoming and outgoing water fluxes at the boundaries of the root zone. That includes the processes of run-off, infiltration, redistribution (or drainage), deep percolation, capillarity rise, uptake and transpiration (Raes et al. 2012).

B-CGMS weather grid (Belgian Crop Growth Monitoring System):

Off-site weather data were provided by the B-CGMS weather grid. This grid is based on daily meteorological data from a hundred weather stations covering Belgium which were spatially interpolated at the grid level 10km x 10km., http://b-cgms.cra.wallonie.be).

This study was conducted over a winter wheat crop plot in Lonzee (Belgium) during the agricultural season 2014-2015. This plot is equipped with a Fluxnet station which records both weather and fluxes measurement. (www.fluxnet.ornl.gov 2016, http://fluxnet.ornl.gov/site/49)

For this work, we wanted to address operational conditions of ET calculation. Therefore, crop and soil input were set up with default parameters values proposed by AquaCrop (on Irrigation and Drainage paper No 56).

Frist, we compared ET measurement from Fluxnet station and ET calculated with AquaCrop thanks to Fluxnet tower weather data. The objective of this initial step is to control if AquaCrop leads to reliable ET values.

Secondly, we used the B-CGMS weather grid to envisage weather conditions in several distances around the crop. We calculated ET with AquaCrop thanks to grid weather data. As can be seen in Figure 1, we selected daily weather data at 3 different distances from the site (20km, 50km, 70km) for 8 geographical directions from the crop (North, North-East, East, South-East, South, South-West, West, North-West) to determine if the distance between the weather station (where weather data are collected) and the crop has an impact on AquaCrop ET accuracy.

And finally, we explored the impact of the weather data source on the crop ET accuracy.

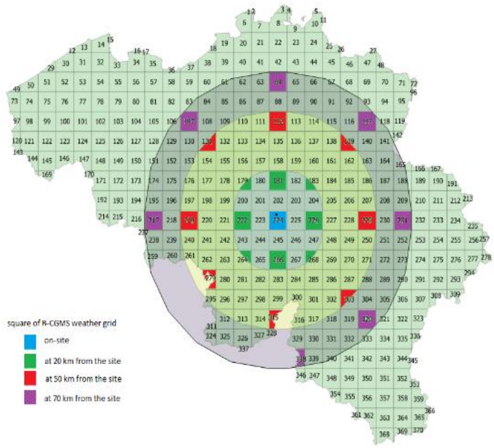

Figure 1: B-CGMS weather grid and squares used in AquaCrop

RESULTS AND DISCUSSION

We first compared ET measurement and AquaCrop ET calculation using weather data collected on the crop site). Figure 2 shows the good agreement between AquaCrop ET and ET measurement during the agricultural season. This is also confirmed by the scatter plot presented at Figure 3. We observe that the regression line (red) has a good R^2, and is close to the the ideal 1-1 line (blue).

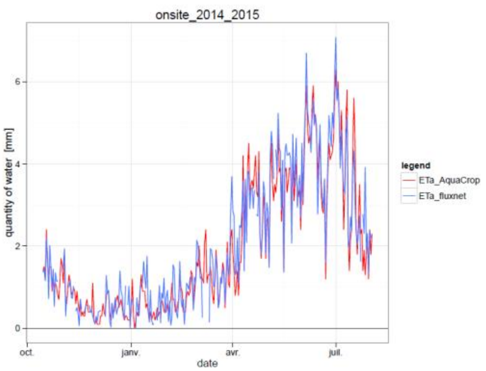

Figure 2: Evolution of ET measured by Fluxnet (blue) and calculated with AquaCrop (red) during the agricultural season 2014-2015 at Lonzée (BE).

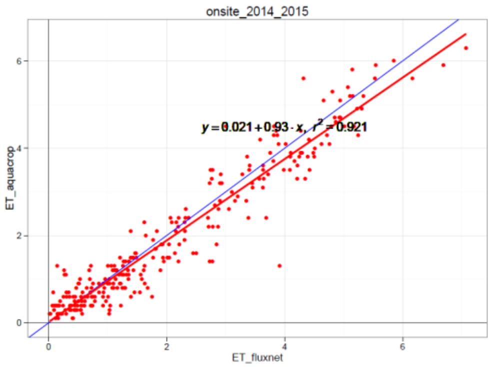

Figure 3: Relation between the Fluxnet measurement and AquaCrop calculation.

The ET model presents a bias of 0.1 mm/day and a root mean square error of 0.5 mm/day. This uncertainty is usually considered as acceptable for agriculture purposes.

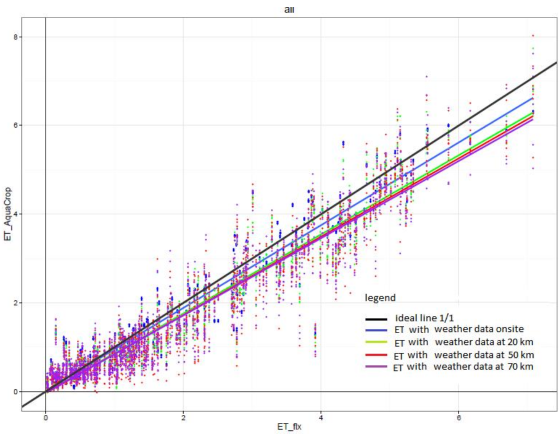

Figure 4: Comparison between ET measured with Fluxnet tower and ET calculated thanks AquaCrop with weather data from different distances from the crop site

To evaluate the impact of weather source distance on the AquaCrop ET accuracy, we compared the ET calculated with AquaCrop for the 8 grid points at 20km, 50km and 70km. The figure 4 shows that ET underestimation increases with the distance of the data source. But the gap between the ET with on-site weather data and distance of 20 km is the most important.The evolution of the bias and RMSE as a function of the distance (Table 1) confirms the visual interpretation of Figure 4.

Table 1. Used Fluxnet station for ET validation. Bias and RMS of AquaCrop ET calculation for each distance between weather data collection and crop site

	Bias (mm/day)	**RMSE (mm/day)**
On site	- 0.12	0.45
20km	- 0.25	0.50
50km	- 0.28	0.55
70km	-0.29	0.59

The third part of the study consists in the analysis of the direction impact.

The figure 5 presents the comparison of the root mean square error (RMSE) between the 8 directions around the plot as a function of distance.

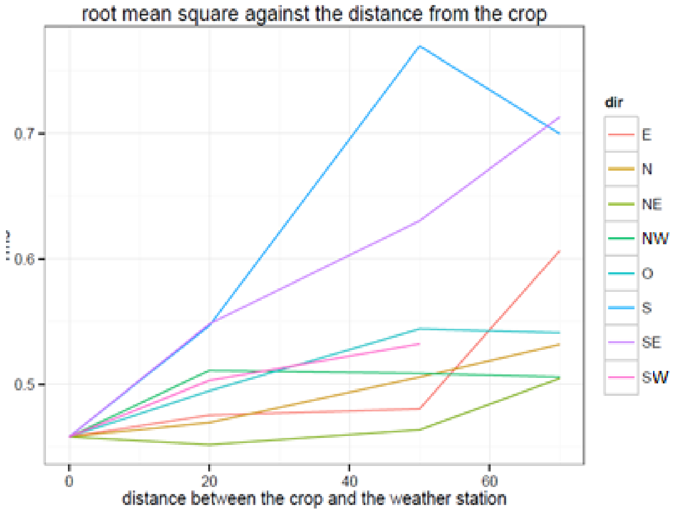

Figure 5: Root mean square errors for 8 directions in function of the distance between crop site and weather data collection site

For most of the directions, the errors increase smoothly from the on-site situation. The largest increase of the error occurs in the S and SE directions which correspond to the most hilly part of Belgium. In such conditions, the highest discrepancies between local weather data and remote interpolated forcing can be expected and have the highest impact on the AquaCrop results.

CONCLUSION

The purpose of this work is the accuracy assessment of ET calculation with AquaCrop when the weather data are collected out of the site. We use as reference in-situ ET measurement from a Fluxnet station available on the site. Weather data are obtained from the B-CGMS grid. To mimic the operational conditions, AquaCrop is used with standard parameterizations for crop and soil.

We conclude that 1) AquaCrop provides accurate results in Lonzée during the 2014-2015 agricultural season; 2) the accuracy of ET calculated by AquaCrop with weather data collected at distance from the site can make ET results less reliable. The results become less accurate with increasing distance of data source used as forcing. The detailed results are site specific and they depend substantially on the chance to have the same weather conditions in the crop site and in the data collection place. The rainfall is probably the most influencing factor, being largely dependent on the topography. Those results are especially meaningful taking into account the scarcity of dense weather observation networks in most parts of the world. We anticipate an increasing sensitivity of AquaCrop with factors such heterogeneous site environment, changing climate conditions, unavailable weather data in the vicinity of the considered site or input data with poor quality.

REFERENCES

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M., 1998. Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56. FAO, Rome, 300(9), p.D05109.

Monteith, J.., 1965. Evaporation and environment. In 19th symposia of societyfor experimental biology. ambridge: Universiy Press, pp. 205–234.

Paço, T.A., Ferreira, M.I. & Conceic, N., 2006. Peach orchard evapotranspiration in a sandy soil : Comparison between eddy covariance measurements and estimates by the FAO 56 approach. Agricultural Water Management, 85, pp.305–313. Available at: http://ac.els-cdn.com/S0378377406001478/1-s2.0-S0378377406001478-main.pdf?_tid=0222c57c-3c3e-11e6-aea5-00000aacb360&acdnat=1467014950_73acb17f1e7a13b50ff9447e41279d0c.

Penman, H., 1948. : Natural evaporation from open water, bare soil and grass. Proc. Roy. Soc. London, A193, pp.120–146.

Pereira, L.S., Allen, R.G., Smith,M., Raes, D. 2015. Crop evapotranspiration estimation with FAO56 : Past and future. Agricultural Water Management, 147, pp.4–20. Available at: http://dx.doi.org/10.1016/j.agwat.2014.07.031.

Raes, D., Steduto, P., Hsiao, T.C., Fereres,E., 2012. Reference Manual AquaCrop Version 4.0. Available at: http://www.fao.org/nr/water/docs/AquaCropV40OutlineAndSymbols.pdf.

Steduto, P., Hsiao, T.C., Fereres,E., Raes, D., 2012. Crop yield response to water. FAO irrigation and drainage paper, 66.

Wilson, K.B., Goldstein, A., Falge, E., Aubinet, M., Baldocchi, D., Berbigier, P., 2002. Energy Balance Closure at FLUXNET Sites. Agricultural and Forest Meteorology - Journal, 113, pp.223–243.

www.FAO.org, 2016. Food and Agriculture Organization of United Nations. Available at: www.FAO.org.

www.fluxnet.ornl.gov, 2016. Fluxnet a global network. Available at: http://fluxnet.ornl.gov.

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The conclusion should present a clear and concise review of experiments and results obtained, with possible reference to the enclosures.

- ACKNOWLEDGMENTS

If received significant help in designing, or carrying out the work, or received materials from someone who did a favour by supplying them, their assistance must be acknowledged. Acknowledgments are always brief and never flowery.

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