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ANALYSIS OF FACTORS AFFECTING MARKETING CHANNEL CHOICE BY SMALLHOLDER FARMERS IN AFGHANISTAN

Ahmad Khalid SALAH*, Hideyuki KANO, Naoyuki YAMAMOTO

Department of Agricultural and Environmental Science, Graduate School of Agriculture, University of Miyazaki, Japan
*Corresponding author: aksalah786@gmail.com

ABSTRACT

This study aimed to analyze factors affecting marketing channel choice by onion smallholder farmers in the Parwan province of Afghanistan. The study used a random sampling technique for data collection, both primary and secondary sources were used. Primary data were collected through face-to-face interviews from 104 onion small-scale farmers in three main districts of Parwan province producing a high quantity onions. Data were analyzed through descriptive statistics such as mean, standard deviation, minimum and maximum. Multinomial Logistic Regression model (MNL) was used to analyze factors affecting marketing channel choice of onion smallholder farmers in Parwan province. The result of the study revealed that farmers sold their products to three main channels, which were: brokers at farm-gate, traders, and direct sale to Kabul market. Over 60% percent of the respondents sold to brokers at farm-gate, while, the rest of the farmers sold to Kabul market and traders' market channels accounted for 29.8% and 17.3% of total respondents, respectively. The multinomial logistic regression result indicated that farmers having a high level of education producing a high quantity of onion and having access to transportation facilities were more likely to sell to the Kabul market relative to the brokers' channel. Also, educated farmers producing a high quantity onions, and having access to information and storage facility were more likely to sell to traders rather than brokers. Moreover, the probability of choosing brokers increased when farmers had another source of income and faced long distances to market.

Keywords: *Smallholder farmers, Marketing Choice, Value Chain, Afghanistan.*

INTRODUCTION

The agriculture sector makes important contributions to the growth of the economy, food security, poverty reduction, employment creation, and the fiscal health of the nation. In Afghanistan, 72.4 percent of the population lives in rural areas (FAO, 2017). The vast majority of Afghanistan's farms are small, 60 percent of total farms are smaller than 1 hectare, and 90 percent are smaller than 5 hectares (World Bank, 2014). Accordingly, the majority of farmers are smallholders, hence

among smallholder farmers marketing plays a critical role in meeting the overall goals of food security, poverty alleviation, and sustainable agriculture in most developing countries (Altshul, 1988). Access to the market for smallholder farmers is crucial in increasing rural income and eradicating poverty. Channel choice decision is the important part of marketing agricultural products, on the other hand, channel choice decisions are among the most critical decisions facing any individual or an organization. The chosen channels intimately affect all other marketing decisions (Berry, 2010). Furthermore, onion smallholder farmers in Afghanistan are facing with lack of information about product prices and lack of access to credit (CARD-F, 2013). These problems in the form of market institutions are the most significant constraints, avoiding smallholder farmers from risk-taking and market engagement. This results in farmers having low bargaining power and mostly price takers rather than price setters. Powerful actors within the onion value chain manipulate prices and costs to their advantage (SLRC, 2014). Also, the onion market displays considerable price volatility, making it very risky and uncertain for smallholder farmers to engage.

Practically if farmers have a bearing on the profit, which they may make, they will use marketing channel to sell the products. Hence the profit should then drive the choice of marketing channel (Muthini et al., 2015). This is not often the case in Afghanistan. However, it is not clear what factors drive farmers' choice of marketing channel decision. There have been many studies on the choice of a marketing channel for vegetables in developing countries. Xaba and Masuka (2012) on vegetable in Swaziland, Bezabih Emana (2015) on potato producers in Ethiopia, Ferto and Szabo (2002) on Hungarian vegetable and many more. These authors determined various factors as institutional, technical and socio-economics, which influence channel choice decisions. Unfortunately, there has been no study has conducted in Afghanistan. This study, therefore, seeks to provide the first empirical information decision-making process of farmers on market channels.

The main objective of this study is to analyze factors affecting the choice of marketing channel by onion smallholder farmers in the Parwan province of Afghanistan.

MATERIALS AND METHODS

Data

The target population for collecting primary data was all smallholder farmers engaged in onion production in Parwan province. A sample of 104 farmers was randomly selected from the three major districts (Charikar, Jabulsaraj and Bagram) for onion production in August 2017. This study used multiple stages random sampling method and both primary and secondary data sources. Primary data were collected through personal face-to-face interviews with the aid of a semi-structured questionnaire consisting of both open and closed-ended questions. Demographical characteristics of households, Choice of marketing channels by households, Institutional factors, and socio-economics factors that influence the decision of marketing channel choice by households are the main four parts that the

questionnaire consisted. The Department of Agricultural Economics and Farmland Management reviewed the questionnaire to confirm its validity.
Collected data were analyzed using the SPSS statistical package (version 19.0) software. Descriptive Statistics such as means, percentage, standard deviation, minimum, maximum, and frequency were used. The Multinomial Logistic Regression model was applied to analyze factors affecting the choice of a marketing channel by onion smallholder farmers.

Analytical Framework and Empirical Model

The multinomial logistic regression (MNL) is used to relate the decisions to participate in the different channels and the factors that affect these choices. The model multinomial logit is widely used in studies involving multiple choices that define dependent variables (Gujarati and Porter, 2009). The multinomial logit model is also a standard method for unordered and multi-categorical dependent variables that assume independence across the choice. It does not allow correlation or substitution between variables (Wooldridge, 2012). The independent variables can be either dichotomous (dummy) or continuous (ratio in scale). In this study, the multinomial logistic regression was employed to analyze factors affecting marketing channel choice by onion smallholder farmers in the Parwan province of Afghanistan.
The general form of the multinomial logistic regression model is:

$$\mathbf{Pr}(y_i = j) = \frac{\exp(x_i\beta_j)}{1+\sum_{j=1}^{J}\exp(x_i\beta_j)} \quad \ldots\ldots (1)$$

And to ensure identifiability,

$$\mathbf{Pr}(y_i = 0) = \frac{1}{1+\sum_{j=1}^{J}\exp(x_i\beta_j)} \quad \ldots\ldots (2)$$

Where i^{th} is individual, y_i is the observed outcome, X_i is a vector of explanatory variables and β_j is a vector of regression parameter estimates associated with alternative j.
The model for this study was summarized following Greene (2003), assuming that the probability of the i^{th} farmer chooses the j^{th} of three choices or channels is P_{ij}, the probability that a smallholder farmer chooses alternative j can be explained as;

$$P_{ij} = \frac{\exp(x_i\beta_j)}{1+\sum_{j=1}^{3}\exp(x_i\beta_j)} \quad \text{(For j = 1, 2, 3)} \ldots\ldots (3)$$

P_{ij} is the probability of being in each of the groups 1 and 2.

$$P_{i0} = \frac{1}{1+\sum_{j=1}^{3}\exp(x_i\beta_j)} \quad \text{(For j = 0)} \ldots\ldots (4)$$

P_{i0} is the probability of being in the reference group or group 0.
When using the model, the coefficients of the reference group are normalized to zero (0), hence, for three choices only (3-1) distinct sets of parameters can be

identified and estimated (Greene, 1993). Estimated coefficients measure the estimated change in the MNL for a one-unit change in the predictor variable while other variables are held constant. The sign of the estimated coefficient indicates the direction of the influence of the variables. A positive estimated coefficient implies and increases the likelihood that onion farmers will choose the alternative marketing channel. A negative estimated coefficient indicates there is less likelihood that an onion farmer will change to an alternative channel.

The natural logarithms of the odds ratio of equations (1) and (2) give the estimating equation (Greene, 1993) as:

$$\ln = \frac{P_{ij}}{O_{i0}}(x_i\beta_j)$$

…… (5)

This equation indicates the relative probability of each of the groups 1 and 2 to the probability of the reference group. The estimated coefficient for each choice, therefore, reflects the effect of Xi's on the likelihood of the farmers choosing that alternative relative to the reference group.

In this model, market channel choice represents the dependent variable, (selling to brokers at farm-gate, selling to traders, and direct sale to Kabul market), where selling to brokers has been set as the reference group. By fitting explanatory variables into the multinomial logistic regression model, the model presented:

$$P_{ij} = \beta_0 + \beta_1 AGE + \beta_2 EDU + \beta_3 FRMEXP + \beta_4 OTHINC + \beta_5 MRKINFO + \beta_6 STRG + \beta_7 DSTMRK + \beta_8 QNT + \beta_9 MRKCST + \beta_{10} TRAN$$

…… (6)

Variables (Dependent and independent)

In this study, the marketing channels represent a dependent variable, the alternatives of onion smallholder farmers for the choice of marketing channel described as selling to brokers at farm-gate, selling to traders at the local market, and direct sale to the Kabul international market. Hence, the dependent variable for the model is a discrete variable taking a value of (1, 2, 3). The alternative channel "selling to brokers" had been set as the reference group because this channel was chosen by most of the farmers accounting for about 52% of total respondents. Therefore, the model used to assess the odds of selling to traders at local market compare to selling to brokers at farm-gate and direct sale to Kabul market against selling to brokers' market channel.

The independent variables (explanatory) and their expected relationship with dependent variables are described in Table 1. A positive sign for the estimated coefficient indicates a higher likelihood of choosing the alternative channel over the base category as that explanatory variable increases and a negative sign indicates a decrease in the likelihood of choosing the alternative channel over the base category as that variable.

Table 1. Description of dependent and independent variables used in MNL model

Dependent variable				
Variables	**Description**	**Measurement**		
Marketing channels for onion	Selling at farm-gate or direct sale to Kabul market	1=selling to brokers at farm-gate 2=selling to traders at local market 3=direct sale to Kabul market		
Independent Variables				
Variables	**Description**	**Measurement**		**Exp. sign**
AGE	Age of household head	continuous	Years	-/+
EDU	Education of household head	Dummy	1=Yes, 0=No	+
FRMEXP	Farming experience of household head	continuous	Years	+
OTHINC	Another source of income	Dummy	1=Yes, 0=No	-
MRKINFO	Market information about the price	Dummy	1=Yes, 0=No	+
TRAN	Possession of transport	Dummy	1=Yes, 0=No	+
STRG	Access to storage facility	Dummy	1=Yes, 0=NO	+
DSTMRK	Distance to Kabul market	Continuous	Kilometer	-
QNT	Quantity of onion for sale	Continuous	Ton	+
MRKCST	Cost of marketing	Dummy	1=Yes, 0=NO	-

**Source: Survey of 104 onion smallholder farmers*

RESULT AND DISCUSSION

Socio-economics characteristics of sampled household

Age, education, farming experience, another source of income, the quantity of Onion for sale distance to market, and cost of marketing, therefore, selected to determine factors affecting marketing channel choice (Table 2).

Table 2. Summary of socio-economic characteristics of households' heads

Variable	Mean	S.D	Min	Max
Age (Years)	47.5	12.1	21.0	73.0
Education (Years)	3.5	4.8	0.0	16.0
Farming experience (Years)	30.9	12.0	5.0	58.0
Other source of income (prs)	0.43	0.49	0.0	1.0
Family member (Person)	8.5	2.8	3.0	14.0
Total Land size (Hectare)	0.7	0.5	0.2	3.3
Land size under cultivation of onion (Hectare)	0.4	0.2	0.1	1.0
Quantity produced (Ton)	20.0	15.0	3.0	70.0
Distance to Market (Km)	63.0	7.5	54.0	76.0
Cost of Marketing (Channel)	0.5	0.5	0.0	1.0

**Source: Field survey 2017*

Multinomial Logistic Regression Result for Factors Affecting Marketing Channel Choice

The independent variables that were considered for this model tested for their significance. The multinomial logistic regression results on traders' market channel and Kabul market channel choice were compared to brokers' market channel and are presented in Table 3. The result shows the estimated coefficient (β values), significant value, and exponential betas (odds ratio) of the independent variable in the model. The result of Cox and Snell R^2 shows that 71% of the variation in the choice of marketing channel was the result of the independent variable. The log-likelihood and chi-square statistics indicate that the model is adequate to explain the relationship between an explanatory variable and farmers' choice of marketing outlets.

The level of education *(EDU)* was significant and has a positive relationship with the likelihood of choosing traders and the Kabul market at a 5 percent level of significance as expected compared to the base category (brokers). Farmer with more level of education are more likely to choose Kabul International market and traders at the local market channels over the farm-gate channel.

Another source of income *(OTHINC)* has a negative sign as expected. The odds of selling to the Kabul market channel were 0.044 times less than those of selling to brokers at farm-gate. Thus, the odds of selling to brokers at farm-gate would increase by the presence of another source of income.

The variable of the quantity of onion produced *(QNT)* was significant ($p<0.05$) with a positive sign traders market channel and Kabul market channel compared to

brokers at farm-gate. The possible reason is that farmers with a high quantity of products will afford transportation costs to the Kabul market and transaction costs of selling to traders.

Table 3. Factors affecting marketing channel choice by onion smallholder farmers

	Traders			Kabul Market		
Variable	**Coef.**	**Sig.**	**Exp(β)**	**Coef.**	**Sig**	**Exp(β)**
Intercept	27.176	0.030		26.174	0.031	
AGE	-0.096	0.673	0.908	-0.143	0.507	0.867
EDU	3.441	**0.053** **	31.219	3.529	**0.035****	34.106
FRMEXP	-0.057	0.810	0.944	-0.024	0.916	0.976
OTHINC	-20.922		$8.200*10^{-10}$	-3.119	**0.090***	0.044
QNT	0.578	**0.021** **	1.782	0.543	**0.029****	1.721
MRKCST	-0.624	0.638	0.536	19.196		$2.170*10^{8}$
DSTMRK	-0.519	**0.008*****	0.595	-0.457	**0.015****	0.633
TRAN	-1.271	0.341	0.281	3.345	**0.018****	28.349
STRG	4.312	**0.003*****	74.613	0.222	0.829	1.248
MRKINFO	4.623	**0.003*****	101.755	1.413	0.302	4.106

**Source: Field Survey 2017*

1. *Cox and Snell R^2 = 0.716; Nagelkerke R^2 = 0.828; McFadden R^2 = 0.628; -2loglikelihood = 77.421; Chi-square = 130.85; df = 20; p=0.0000*
2. **** Significant at 1%, ** Significant at 5% and * Significant at 10%*
3. *The reference group (Base category) is (2) selling to brokers at farm-gate*

The likelihood of choosing the Kabul market channel was positively and significantly ($p<0.05$) affected by access to better transportation *(TRANS)* at a 5 percent level of significance. This result indicates that households with better access to transportation or those who possessed a vehicle are more likely to travel and sell at the Kabul market channel in comparison to brokers at farm-gate.

Distance to market *(DSTMRK)* has a significant and negative relationship with the likelihood of choosing traders at a 1 percent level of significance. It also has a significant and negative relationship with the likelihood of choosing the Kabul market channel outlet at a 5 percent probability level as presented in Table 3. The result indicates that producers who face the longest distance to the market choose the farm-gate channel among others relative to the base category. The possible explanation might be related to the limitation on access and cost of transportation and bad road condition in which farmers want to sell to brokers at farm-gate.

A positive and significant ($p<0.01$) relationship was found between traders' market channel and access to a storage facility *(STRG)* as expected. Thus, the odds of selling onions to traders' market channels will increase with the presence of a storage facility.

The variable of market information *(MRKINFO)* is positively associated with a higher probability of selling to the trader's market channel as opposed to the broker's market outlet at a 1 percent level of significance. The traders usually pay a high price for the products. Therefore, farmers with information about prices will sell to traders more likely.

CONCLUSION

This study revealed that onion producers in Parwan province face three major channels; brokers, traders, and direct market. Majority of farmers sold to brokers at the farm-gate while traders account for the smallest percentage of farmers. Based on the result of multinomial logistic regression, among ten selected socio-economic and institutional factors, six factors significantly affected the choice of marketing channel. The factors education *(EDU)*, the quantity of onion produced *(QNT)*, and access to transportation *(TRANS)* significantly affect the probability of choosing Kabul Market over brokers' market channel. Having education *(EDU)*, quantity of onion *(QNT)*, market information *(MRKINFO)*, and access to a storage facility *(STRG)* significantly affected the probability of choosing traders over a broker's market channel. Moreover, the factors market distance *(MRKDIS)* and another source of income *(OTHINC)* significantly affected the probability of brokers over traders and the Kabul market.

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FOOD SECURITY–TRADE NEXUS IN TIMES OF COVID-19 PANDEMIC

Davide COLAFEMMINA[1*], Hamid EL BILALI[2], Sinisa BERJAN[3], Roberto CAPONE[2]

[1]Department of Political Science, University of Bari Aldo Moro, Bari, Italy
[2]International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM-Bari), Valenzano (Bari), Italy
[3]Department of Agroeconomy and Rural Development, Faculty of Agriculture, University of East Sarajevo, Lukavica (East Sarajevo), Bosnia and Herzegovina
*Corresponding author: david.colafemmina@gmail.com

ABSTRACT

Despite the increase in agri-food trade, food insecurity is still a pressing challenge in many world regions. This is an indicator of the multifaceted relationship between trade and food security. Moreover, it is not clear how the outbreak of COVID-19 affected this relation. In this context, this article explores the outbreak's impacts on food security-trade nexus starting from an analysis of the relations between agri-food trade and the four dimensions of food security (viz. availability, access, utilization, stability), and then by exploring how the pandemic has changed this relationship. It draws upon a systematic review of documents indexed in Scopus carried out in October 2020. Results show the central role of trade in ensuring food security and highlight that international trade has been disrupted due to border closures and the indirect consequences of the pandemic containment policies imposed on the industrial business sectors all over the world. Furthermore, we highlight that the current agricultural trade framework, defined by import dependencies and structural fragility, has exacerbated the outbreak's consequences on food security. Food-related impacts of the pandemic vary not only from a country to another – depending, among others, on the epidemiological situation – but also among socio-economic groups; under these circumstances, agri-food trade disruption has struck heavily on low- and middle-income countries. We underline the need for a more sustainable and regional model of international trade to overcome the weaknesses of the 'business as usual' model and ensure food security for all.

Keywords: *COVID-19, Food security, Food trade, Food import, Food export, Markets.*

INTRODUCTION

The world population is expected to reach 8.5 billion in 2030, 9.7 billion in 2050 and 10.9 billion in 2100 (Gillson and Fouad 2014; United Nations Department of Economic and Social Affairs Population Division 2019). At the same time, according to the current trends at the global level, demand for food will increase by 100–110% by 2050 (Cadillo-Benalcazar et al. 2020; Garnett 2013; Tilman et al. 2011). Therefore, food security remains among the most pressing development issues of our time. However, over the last decades, the scientific and political debate on the most effective ways to attain food security has polarized alongside two main visions: one which supposes food security to be best achieved through self-sufficiency or sustainable food systems, and one which supposes the former could be achieved through trade (Otero et al. 2013). Specifically, trade and markets have been seen either as a "threat" or as an "opportunity" (Borsellino et al. 2020). Advocates of "trade as an opportunity" claim that international food trade growth has helped many countries in reaching food security, by its positive impact on the four dimensions of food security (Batt 2019; Borsellino et al. 2020; D'Odorico et al. 2019; Dithmer and Abdulai 2017; Geyik et al. 2020; Smith and Glauber 2020; Sun et al. 2020). On the other hand, contestants of this narrative point out that food security achieved through trade is vulnerable to external shocks (Barlow et al. 2020; Distefano et al. 2018; Taghizadeh-Hesary et al. 2019) and is usually based on fragile balances and/or unsustainable situations (Beltran-Pea et al. 2020; Borsellino et al. 2020; Capitanio et al. 2020; Kremen et al. 2012; Sun et al. 2018; Valenzuela 2016).

The issue became increasingly central in recent years for two main reasons: the growing importance of agricultural trade for national food supplies (MacDonald et al. 2015), which has become increasingly interconnected and put under pressure to support the growing demand for food (Stokeld et al. 2020; Suweis et al. 2015); the emergence of COVID-19 pandemic and its consequences on social and economic life worldwide, which have shattered the core sustaining pillars of modern world economies (Ibn-Mohammed et al. 2021) and international trade. The debate has therefore been further exacerbated between those who argued that trade can alleviate the pandemic's harmful consequences for food security, and those who point to international trade as a cause, not a solution, of the food insecurity problems that emerged during the pandemic.

In order to understand the impacts of COVID-19 on agri-food trade, we will use the standard conceptual framework of food security, which encompasses the four traditional dimensions (i.e. availability, access, utilisation, stability). For people to be food secure, food must be both consistently available and accessible in sufficient quantities and diversity, and households must be able to utilize (store, cook, prepare and share) the food in a way that has a positive nutritional impact; these three dimensions (viz. availability, access and utilisation) should also be stable over time (FAO 2008; Global Network Against Food Crises 2020). Using this framework, we explore the linkages between trade and food security and subsequently analyse how they have been affected by the COVID-19 pandemic.

MATERIALS AND METHODS

The paper draws upon secondary data of scholarly literature as well as data from grey literature and databases. A search was performed on 30 October 2020 using Elsevier - Scopus database (Table 1). The search included all the documents that were indexed by that date, without defining any time range or excluding any document based on publication date. Furthermore, no geographical restrictions were posed. The initial search on the food security-trade nexus yielded 903 results. Following the review of titles and the screening of abstracts and keywords used, 823 documents were excluded, as they did not deal with the relationship between food security and trade. The search yielded more results when searching for literature written before the COVID-19 pandemic, focused on the linkages between food security and international trade although in recent months the number of articles and review papers concerning the consequences of COVID-19 on various aspects of social and economic life has been constantly increasing. There are also more and more articles that analyse in detail the impact of the pandemic in individual countries. However, the impact of the pandemic on trade continues to be a poorly covered topic, which this article will try to address. Grey literature included reports and other publications by United Nations (UN), United Nations Conference on Trade and Development (UNCTAD), Global Network Against Food Crises, and the Food and Agriculture Organization of the United Nations (FAO).

RESULTS AND DISCUSSION

Over the last decades, the debate on food security has polarized, and consequently, two main narratives on trade and markets have emerged viz. 'trade as an opportunity' and 'trade as a threat' (Borsellino et al. 2020). Therefore, trade has been regarded as an excellent tool for achieving food security or as a cause of food insecurity. The supporters of the 'trade as an opportunity' narrative call for trade openness as a means to enhance market efficiencies and to reduce distortions; in this view, the more trade is open, the more food is produced and flows between countries, allowing more and more people to be food secure (Borsellino et al. 2020). The core tenet is that on average, trade openness does have a positive and statistically significant net impact on food security (Dithmer and Abdulai 2017; Fusco et al. 2020; Petetin 2020). More trade means higher food supply via direct (e.g., imports of food) or indirect means (e.g., more efficient use of productive inputs thanks to the trade of intermediate inputs as seeds, machinery, etc.) (Borsellino et al. 2020; Dithmer and Abdulai 2017; Porfirio et al. 2018; Porkka et al. 2017; Svanidze et al. 2019), a positive effect on prices, productive inputs availability, economic growth, household incomes and employment (Dithmer and Abdulai 2017; Savary et al. 2020) a higher availability of macronutrients in low-income countries (Traverso and Schiavo 2020) and improvements in dietary diversity (Dithmer and Abdulai 2017) and finally, by reducing distortions in supply/demand balance and by diversifying supply sources, more trade can also contribute to reducing price fluctuations and volatility (Borsellino et al. 2020;

Dithmer and Abdulai 2017; Ly et al. 2020; Martin 2019) and stabilizing prices (Bren D'Amour et al. 2016; Dorosh 2001).

Table 1. Summary of literature searches carried out on Scopus

Search theme	**Search string**	**Number of records identified through the search**	**Number of selected records**
Linkages between food security and trade	*("food security" OR "food insecurity" OR "malnutrition") AND ("trade" OR "import" OR "export") AND (agri* OR agro OR food)*	903	89
Impacts of COVID-19 on food security - trade nexus	*"COVID-19" OR coronavirus OR "SARS-CoV-2"*	89	14

However, the supporters of the 'trade as a threat' narrative have a critical opinion towards the market and point out that international trade and agro-markets are actually a cause of food insecurity, especially in low-income countries (Asche et al. 2015; Borsellino et al. 2020; Oteros-Rozas et al. 2019). In general, the supporters of 'food sovereignty' have a critical stand towards markets and call for communities to have higher control of their food systems (Borsellino et al. 2020), in order to define their own agriculture, food and land use policies, which are ecologically, socially, economically and culturally appropriate to their unique circumstances (NGO/CSO Forum for Food Sovereignty 2020). The supporters of more sustainable food systems also claim that should the current food systems continue to exist and operate in a 'business as usual' mode, climate change and other existential threats will severely undermine the world capacity to secure food to the global population (Beltran-Pea et al. 2020). Proponents of this narrative claim that food availability is actually influenced by the actual capital available, and thus low-income countries can have lower access to agri-trade (Baer-Nawrocka and Sadowski 2019; Barlow et al. 2020). Indeed, trade can show a contradictory consequence: international agri-food trade can contribute to increasing social inequality in the form of food insecurity by facilitating food being exported/traded away from the hungry (Oteros-Rozas et al. 2019), thus reducing food access for the poorest sections of the population.

Trade can also impact domestic access to food by influencing food affordability, especially for the most vulnerable sections of the population (Arment 2020; Barlow et al. 2020; Capitanio et al. 2020; Tanyeri-Abur 2015). As for food utilization, globalization and internationalization of food markets contributed to the standardization and homogenization of dietary patterns (D'Odorico et al. 2018; Otero et al. 2013) and the diffusion of some practices that might be detrimental to

health (Albert et al. 2020; Borsellino et al. 2020; Qaim 2017). Lastly, the real problem from this perspective is when it comes to stability; several scholars point out that trade has led to a worldwide import dependency (Benton 2019) and the more countries rely on imports to sustain their food demand, the more the global food system loses resilience and becomes unstable and prone to shocks (Suweis et al. 2015). Food dependency leads to a dangerous situation: the effects of local production shocks can propagate in the international food trade network (Heslin et al. 2020). Climate change, political unrest and other production shocks are likely to further aggravate the situation (Bren D'Amour et al. 2016; Heslin et al. 2020).

The COVID-19 pandemic is another stark example of an external shock that has propagated in the international food trade network. The assumptions about the negative impact of trade on global food security have found sad confirmation in the consequences of the pandemic. In order to contain the outbreak, local and national governments have introduced a wide set of policies, like lockdowns, social distancing and movement restrictions, which impacted adversely international trade. The consequences of the reduced volumes of international trade on food security have been many: food availability has generally declined, due to labour shortages and losses (Stephens et al. 2020); shortage of production inputs (seeds, fertilizers, pesticides, machinery, etc.) (Devereux et al. 2020; Seleiman et al. 2020) and food loss due to the inability to transport products from the fields to points of distribution and falling consumer demand (Pérez-Escamilla et al. 2020; United Nations Secretary General & United Nations Sustainable Development Group 2020). Regarding access to food, the pandemic caused physical barriers (due to closure of informal food outlets, entry quotas and social distancing inside and outside the shops, panic buying, hoarding behaviours, etc.) (Bakalis et al. 2020; Galanakis 2020; Lazzerini and Putoto 2020). Economic access was also disrupted: an increase in food prices and loss of income due to economic recession undermined the purchasing power of the poorest sections of the population (Akter 2020; Galanakis 2020). Alongside these direct effects on people's livelihoods, COVID-19 also has meant the loss of several social measures to fight food insecurity (i.e. school meals, family/grandparents) (Altieri and Nicholls 2020; Bakalis et al. 2020; Patrick et al. 2020; Rippin et al. 2020). With limited purchasing power, families had to choose less elaborate or cheaper foods, and staple and simple food utilization rose (Bakalis et al. 2020; Pérez-Escamilla et al. 2020). The movement restrictions and resort to poorly nutritious foods adversely affected general health, with an increase in the incidence and risk of non-communicable diseases and obesity (Abbas et al. 2020; Béné 2020; Devereux et al. 2020; Jayawardena and Misra 2020; Rippin et al. 2020). Stability is affected by COVID-19-related prohibitions (Devereux et al. 2020) and their effects on supply chains, especially in developing countries (Erokhin and Gao 2020).

We can now trace links between food security and trade in times of COVID-19. A substantial number of countries are dependent on imports to meet their domestic food demand; this situation gave rise to huge agricultural flows, which contribute to making the world increasingly interconnected and increasingly vulnerable to

systemic failures and extreme events (Nesme et al. 2016). The COVID-19 pandemic, by affecting both domestic food producers and international supply chains, led food supply and distribution to be disrupted globally (Erokhin and Gao 2020). Border closures and trade restrictions jeopardized imports of valuable intermediate production inputs (i.e. fertilizers, seeds, machinery) reducing food production and thus availability (Nesme et al. 2016; Seleiman et al. 2020). This shock in the food supply reverberated in the food access dimension: less food available meant higher global food prices (Savary et al. 2020), which led to a purchasing power downgrade of the population and also undermined the capacity to produce and distribute food (Erokhin and Gao 2020; Woertz 2020). As food supply chains were stretched, production, transportation and consumption fell sharply (Hossain 2020); and household income was affected too (Fontan Sers and Mughal 2020). The lockdown of fresh food markets in many countries has changed the eating habits and diets of many individuals (Devereux et al. 2020; Heck et al. 2020; Roberton et al. 2020; Yaya et al. 2020).

However, the real issue arises when it comes to the role of trade in ensuring food security stability. In a report entitled *Impact of COVID-19 Pandemic on Trade and Development*, UNCTAD (2020) states that "*international trade has been an important vector by which the pandemic was transmitted, creating a global economic shock that has reverberated around the world*". In an already 'prone-to-shock' global food system, COVID-19 was the ultimate shock that heavily disrupted food security stability, as it was based on a heavy reliance on complex supply chains, imported food, and just-in-time delivery (Ibn-Mohammed et al. 2021; Pérez-Escamilla et al. 2020) Moreover, the zoonotic origin of the novel coronavirus highlights the structural inequality of the current trade structure, often referred as 'consumption – degradation paradox', which posits that more-developed countries externalize or displace their consumption-based costs to less developed countries through inequitable specializations in production and trade (Rice 2007), and thus cause impoverished rural populations to often be directly involved in the first instances of zoonotic spillover, which, in turn, risk to affect the whole trade system, as it has happened for the COVID-19 pandemic (Austin 2021). Therefore, the pandemic has remarked that a complete liberalization of agriculture is not a panacea for the global food system problems (Baer-Nawrocka and Sadowski 2019). Markets alone cannot guarantee food security, and only by improving agricultural markets functioning and governance, their inclusiveness and by carefully balancing elements of local capacity and self-sufficiency, and open and competitive world markets, food and nutrition security can be achieved for all (Margulis 2012; Mrdalj and El Bilali 2019).

COVID-19 pandemic has proven that global food systems and agricultural trade must evolve into more resilient or efficient ones, which could provide food and nutrition security to all in all plausible conditions (Kahiluoto 2020). Indeed, during the pandemic, the response of some countries indicates that different approaches, distant from the current narrative on trade, can mitigate the negative effects of an external shock, such as the current pandemic. In Singapore, a 'resilient' approach

to food importation has proven sound: diverse sources of imports from around the world have provided options to ensure food imports from alternative, geographically-spread sources (Teng 2020) and, at the same time, governmental investments were made to boost domestic food production (Teng 2020). In the Pacific, regional production boosting and intraregional trade have been proposed as a way to overcome import dependency and foster transition toward a more resilient food supply chain (Farrell et al. 2020). Transition to more circular and self-reliant systems has also been identified as a way to cope with international supply disruptions also in the case of Bangladesh response to COVID-19 (Amjath-Babu et al. 2020); although it won't be quickly and is likely to be only a partial solution. There are also other ways to cope with food insecurity. For example, Cabo Verde's experience highlights that if a government adopts legal and operative frameworks to increase domestic food production, there could be a positive and statistically significant correlation between government expenditure and agriculture production growth.

CONCLUSIONS

Food security is shaped, among others, by trade policies. International trade is considered either instrumental in achieving food security or an element of risk that threatens food security. The main criticism addressed to trade is that it promotes heavy import dependencies between different countries, often at the expense of low-middle income countries. The COVID-19 pandemic has highlighted the fact that the current highly interconnected and centralized global food system is extremely fragile to external shocks, which can affect all the dimensions of food security. Therefore, it is time to rethink the way we trade and recognize that a system based on fragile connections is unsustainable in the long run. The coronavirus crisis poses a challenge, but also a chance to revisit and redesign the relationship between trade and food security. Trade per se is not the problem, but it should be regulated in order to promote a more resilient and inclusive food system. Regional trade could reduce the geographical dispersion that stretches supply chains and creates circular economies that could be easier to control and more conveniently provide for the goods and needs of people. Domestic production should also be enhanced, in order to reduce import dependency; however, in doing so, countries should avoid the development of unsustainable food systems, as they simply postpone problems like soil degradation, biodiversity loss and others. Furthermore, governments should provide a legal framework for promoting green logistics and reducing food loss to incentivize local production. To put it simply, the world must adopt a more resilient trade system; structures that can sustain local shocks without worsening them into global ones. The global supply chain disruption is indicative of this imperative. Even though the topic is increasingly being covered, there is also a need for focused studies, because each country has its own trade nexus and there are many ways in which countries have reacted to the virus outbreak, although there are some common consequences. It would be

beneficial for policymakers and scholars to acquire best practices implemented by governments in order to attain food security with more sustainable trade nexus.

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A CONTROL SYSTEM FOR REMOTE MONITORING AND CONTROL OF THE TEMPERATURE IN CHICKEN EGGS HATCHING USING ARTIFICIAL INCUBATORS

Nataša POPOVIĆ* Božidar POPOVIĆ

University of East Sarajevo, Faculty of Electrical Engineering, Bosnia and Herzegovina
*Corresponding author: natasa.popovic@etf.ues.rs.ba

ABSTRACT

According to OACD/FAO Agricultural Outlook, poultry meat remains the primary driver of growth in total meat production. Its short production cycle allows producers to respond quickly to market needs, as well as rapid improvements in genetics, animal health, feeding practices, breeding conditions and breeding environment. Hatching process needs to be done properly in order to maximize the number of healthy chickens hatched and to minimize their death rate. When using artificial egg incubation, it is important to monitor and control ambient conditions in incubators, to obtain ventilation and egg turning. Ambient conditions are expressed in terms of temperature and humidity, where maintaining and controlling the temperature inside the incubator is of the greatest importance. This paper deals with the description of a control system developed for remote monitoring and control of the temperature in chicken eggs hatching using artificial incubators. The system consists of heater in a form of an incandescent light bulb, temperature sensor, relay, microcontroller, and communication module. For temperature control, a PID (proportional-integral-derivative) controller is designed, which maintains the temperature at 37.8 °C. Temperature readings are available through the web browser and are accessible using wired Internet connection. Proposed system represents a simple, low-cost but very efficient solution which provides the necessary conditions for proper development of chickens while growing inside the egg.

Key words: *temperature control, PID, hatching, artificial incubator, Internet of Things.*

INTRODUCTION

Poultry meat consumption is predicted to increase globally to 145 million of tons by the 2029, with poultry expected to account for 50% of the additional meat consumed. This provides the poultry meat to remain the primary driver of growth in total meat production, accounting for half of all additional meat produced over the next decade. Poultry meat short production cycle, rapid improvements in genetics, animal health, feeding practices, breeding conditions and breeding

environment allow producers to respond quickly to market needs (OACD/FAO Agricultural Outlook, 2020).

To achieve the stated predictions, it is necessary to provide optimal conditions for hatching process. This process can either be natural or artificial. In natural hatching, a hen provides all the conditions by sitting on few eggs, turning them regularly and incubating until they hatch. Artificial hatching involves the usage of artificial incubators which maintain necessary conditions for hatching a large number of eggs. During the incubation, the heat is being applied to fertilized eggs to keep them warm and allow proper development of the embryo into a chick. Besides the incubation, eggs collecting, storing and turning need to be done properly when using artificial incubators in order to maximize the number of healthy chickens hatched and to minimize their death rate.

In artificial incubation, successful hatching depends on maintaining proper environment conditions (temperature, humidity, air quality), especially in incubation stage, of which temperature has the strongest influence and is the most critical (Clauer, 2009). Optimal incubation temperatures result in high hatchability of healthy chicks with good post-hatch performance (Boleli et al., 2016). Incubation temperature needs to be set according to requirements of the embryo and fetus in different stages of incubation. Optimal ambient temperature for incubating poultry species should be between 37°C and 38°C (French, 2009). In order to keep eggshell temperature on appropriate level, incubator temperature has to be between 37.5°C and 38°C (Boleli et al., 2016). Smith (2004) states that the best hatching, when using forced-air incubators, is obtained by keeping the temperature at 37.8°C, with fluctuations less than 0.5°C, and when using still-air incubators it should be kept at 38°C. Similarly, Archer and Cartwright (2018) suggest that the incubator temperature should be between 37.5°C and 38°C for chickens during the set stage.

Modern automated artificial incubators are equipped with heating and cooling units, humidifiers, ventilation system and eggs turning mechanism (French, 2009). Large scale industrial incubators can store hundreds to thousands of eggs, while small hatcheries, intended for home production, usually store a couple of tens of eggs in artificial incubators. Small hatchery owners can build artificial incubators on their own, instead of purchasing commercial ones which are usually expensive, considering their specific requirements and needs, and control all the necessary incubation and hatching conditions. Some examples of such incubators and temperature control techniques are given as follows. Thermoelectric egg incubator is proposed in (Suriwong et al., 2016), while automatic temperature closed-loop control system for egg incubation is designed in (Lawal et al., 2014). The rapid development of Internet of Things (IoT) paradigm over the last decade enabled the production of smart egg incubators. These incubators are very easy and efficient to use in small hatcheries and provide controlling and monitoring incubation environment parameters easily. Besides this, they are provided with Internet connection, which is not the case with traditional incubators, so they enable chicken breeders to monitor these parameters anytime from anywhere. The most

important parts of a smart incubator are microcontroller and various sensors. IoT prototyping boards are very suitable to be used in eggs incubators, so Raspberry Pi was used in (Adnyana et al., 2018; Purwanti et al., 2021) and Arduino in (Shafiudin and Kholis, 2018; Bacalso and Sobejana, 2021, Gutierrez et al., 2019). When controlling the temperature, different control systems theory techniques can be used, such as PID (proportional-integral-derivative) control and fuzzy logic control. For example, PID control is used in (Ohpagu and Nwosu, 2016; Shafiudin and Kholis, 2018) and fuzzy logic control is used in (Alimuddin et al., 2012, Aborisade and Oladipo, 2014; Rakhmawati et al., 2019). Islam Juel and Ahmad (2019) proposed a smart auto-balanced system for incubation process with Android application and Bluetooth module for wireless communication, while Bacalso and Sobejana, (2021) developed temperature and humidity controller with GSM module and SMS notification.

This paper deals with the description of a control system developed for remotely monitoring and controlling the temperature in chicken eggs hatching using artificial incubator. For temperature control, a PID controller is designed, which maintains the temperature at 37.8 °C. Temperature readings are available through the web browser and are accessible using Internet connection. Proposed system represents a simple, low-cost but very efficient solution which provides the necessary conditions for proper development of chickens while growing inside the egg.

MATERIAL AND METHODS

The developed control system for remotely monitoring and controlling the temperature, given in figure1, consists of heater in a form of an incandescent light bulb, Arduino Uno board, digital temperature sensor module, relay, potentiometer, and communication module. The system reads and maintains the temperature values inside the incubator, stores these values in a database and enables the users to monitor them through the web browser, as shown in figure2. The Arduino Uno board (Arduino, n. d.) belongs to Internet of Things microcontroller-based devices. It provides power to the sensor module, reads temperature values generated at its output and generates a digital signal that turns the relay (heater) on and off. For reading the incubator temperature, a DS18B20 (Digital sensor, n. d.) digital sensor module was used. The role of the used SSR-25DA relay (Solid-state relay, n. d.) is to instantly switch the heater on and off, by which the temperature is changed and controlled. Connection between Arduino Uno and Internet is obtained by Arduino Ethernet shield. Potentiometer enables setting the reference temperature at the desired value manually. The reference temperature is, according to literature, chosen to be 37.8 °C. The software part of the system is written in Arduino IDE software tool. For maintaining the temperature at reference value, a PID controller is designed in Arduino IDE.

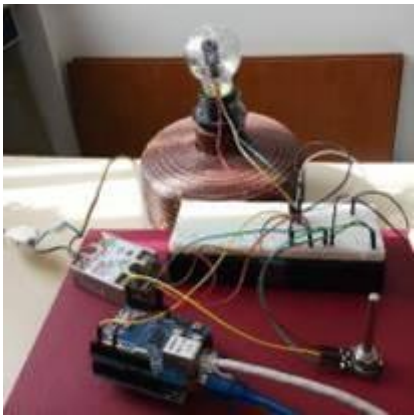

Figure 1: Experimental setup of a system for reading and controlling the temperature in egg incubator

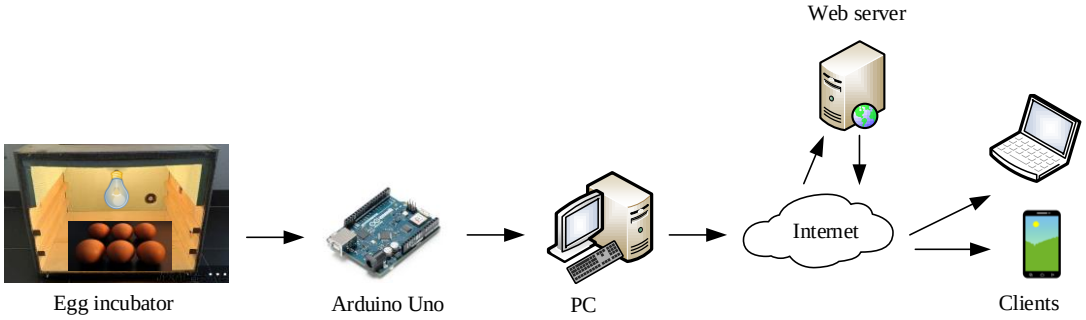

Figure 2: Functional diagram of remotely monitoring and controlling the egg incubator temperature

To make the system work properly, a database was created using MySQL (MySQL, n. d.) system. Within the database, a table was created in which relevant parameters are stored (reference temperature, incubator temperature, PID controller parameters). Several .php files were created to enable Arduino board to establish a connection with the database, to communicate with the database and send data to it, and for displayig the parameter values from the database in a web browser. The Apache HTTP server (Apache, n. d.) was used as a web server.

RESULTS AND DISCUSSION

Developed system was created and tested in Digital control systems laboratory at the Faculty of Electrical Engineering in East Sarajevo. The most important objective was to determine whether the system maintains the reference temperature in a proper way. Through the running the experiment many times, it was observed that the designed PID controller, with the parameters K_p=10, K_i=3 and K_d=1, maintained the temperature on the set value. Furthermore, in a case of presence of disturbances in the system, which violated temperature inside the incubator, the

controller was able to regulate the temperature value and achieve the reference quickly and very efficiently. Figure 3 shows the step response of developed system which, from the control systems theory point of view, means that designed system behaves in a desired manner. This response is generated based on the values of the parameters from the database.

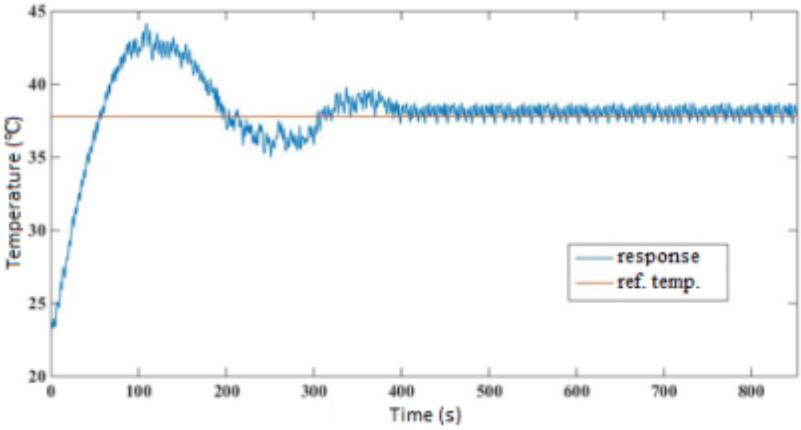

Figure 3: Step response of developed system

Temperature readings are available through the web browser and are accessible using wired Internet connection. A part of these readings is shown in Figure 4. It can be observed that when the incubator temperature is slightly less or more then the set one, PID controller, giving the command to the relay to switch the heater on or off, regulates the temperature and brings it on the desired value. This figure also shows that the temperature inside the incubator, when there are no disturbances, is within the limits found in literature.

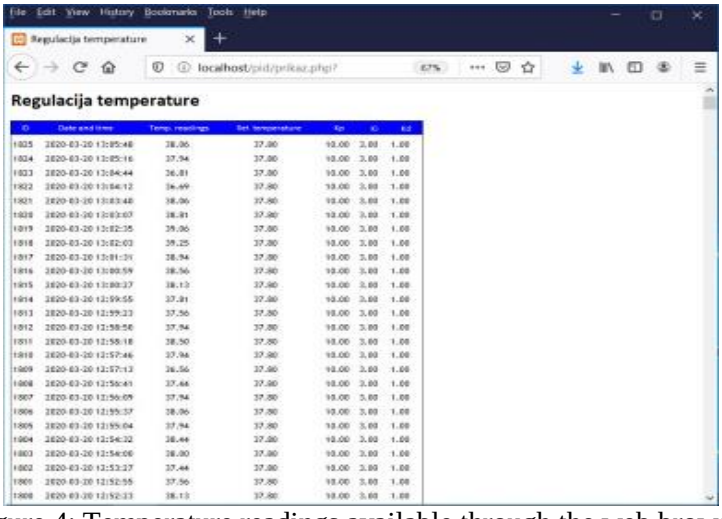

Figure 4: Temperature readings available through the web browser

CONCLUSIONS

Among various incubation conditions, temperature conditions are of the greatest importance and need to be satisfied to obtain maximum chicken production. Described control system for remotely monitoring and controlling the temperature in chicken eggs incubator represents a simple, low-cost, and efficient IoT based solution intended for use in small chicken farms. The system is based on IoT hardware components and uses Internet connection for monitoring the temperature values inside the incubator. The system users can access the temperature sensor readings through the web browser. The functionality of proposed system can be extended by adding humidity and air quality sensors, as well as Wi-Fi module which will be the subject of future research. Besides this, slight modifications of developed system can be performed with the aim of using it in another agricultural applications of interest (greenhouses, different warehouses, grain tanks, stables, etc.).

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EFFECT OF STATE SUBSIDIES GRANTED TO FARMERS FOR CERTIFIED SEEDS ON WHEAT YIELD IN TURKEY

Celal CEVHER[1]*, Şule COŞKUN CEVHER[2]

[1]Fields Crop Central Research Institute, Ankara, Turkey
[2]Department of Biology, Faculty of Science, Gazi University, Ankara, Turkey
*Corresponding author: celal.cevher@tarimorman.gov.tr

ABSTRACT

Wheat grown in many regions in the world and in Turkey; It is an important plant in terms of its large producer mass and being the basic food of people. Wheat is an important nutritional raw material because it ranks first in consumption of foodstuffs made from wheat in Turkey. Wheat takes the first place with a rate of 69% among the total grain cultivation areas in our country. Farmers in Turkey have been subsidized to use certified seeds since 2004. However, studies to determine the effect of certified seed subsidies given to farmers are limited. In this study, the effect of the use of certified seeds on wheat yield, quality, and production cost was investigated. Study data were collected from 318 farmers. The survey was carried out between October and November 2018. In the selection of sample villages, the purposive-sampling method was used. The yield following the use of certified seeds regarding wheat production in dry areas increased by 41.4%, and in irrigated areas by 23.8%. With this increase, $130.24 per hectare more in dry areas and $79.64 more in irrigated areas were obtained. However, it was determined that the production costs in wheat production decreased by $10.64 per hectare in dry and by $11.78 in irrigated areas. It was concluded that certified-wheat-seed support increased wheat production in dry areas more than in irrigated areas. In addition, it was found that it contributed to the reduction of the cost of wheat production and the improvement of wheat quality.

Keywords: *agricultural policy, farmer preferences, profitability, wheat productivity*.

INTRODUCTION

In Turkey and the rest of the world, people demand increasingly high-quality food, while planting areas are gradually reduced in hectares (ha). In this sense, the increase in efficiency in the unit area can be realized by using newly developed techniques. The first innovation that comes to mind in crop production is the use of certified-seed varieties. In Turkey, 66.4% of agricultural areas (15.5 million hectares) is devoted to field agriculture. In these areas, approximately 71.0% (11.1 million hectares) of grains are planted. Wheat takes the first place with a share of 69% of the total grain-cultivation areas. Wheat-yield level was 2116 kg/ha in 1990,

2234 kg/ha in 2000, and 2872 kg/ha in 2015. Despite the increase in wheat production and productivity levels, this was not sufficient to meet Turkey's needs. Therefore, wheat imports in Turkey are made but vary depending on the year (Anonymous, 2017). The majority of wheat agriculture is performed in dry climate conditions in Turkey. For that reason, yield is low, and wheat farmers' income is less than that of other farmers growing other products. Various studies have shown that certified seed support contributes to increased production, higher producer income, access to quality seeds, and the reduction of rural poverty (Engindeniz and Adanacıoğlu, 2011; Awotide *et al*., 2011; Dorward and Chirwa, 2011; Ali *et al*., 2015). Similar studies have shown a decrease in the number of certified seeds, and an increase in yields per hectare as a result of support policies (Tester and Langridge, 2010). Various researchers stated that, if farmers adopt certified seeds, it can contribute to productivity in agriculture, an increase in operating income, a decrease in food prices, and poverty reduction (Sofijanova *et al*., 2012; Laurance *et al*., 2014; Cevher and Altunkaynak, 2020). In Turkey, the Ministry of Agriculture and Forestry supports certified-seed users to increase crop production, increase yield and quality, ensure sustainability in production, and develop agricultural techniques. With this support, it aims to increase the use of quality certified seeds demanded in the markets. The aims of this study was to determine the effect of certified-seed use on production increase in dry and irrigated areas. This study is expected to contribute to support policies for wheat production, increase producer income, and fill the gap in the literature in this field.

MATERIAL AND METHODS

In the analysis of the benefits of certified-seed support policies, the seed amount used before and after support in dry and irrigated areas was examined. "Before" includes the period before the use of certified seed, and "after" covers the period after receiving support for using certified seeds. Physical data related to wheat cultivation practices, costs, and yield, use of physical input, sale quantity, and selling prices were collected for the 2018 production year. The population of the study consisted of 1750 farmers using certified seeds in Ankara. Data were collected by face-to-face surveys of farmers selected with the Stratified Sampling Method. The number of farmers who would be interviewed was set to 318 as a result of the calculation. After the selection of the subjects was determined, questionnaire forms were prepared in accordance with the purpose of the research. The final version of the questionnaire was reviewed by expert researchers on agribusiness and agricultural. There are 27 questions in the survey. The questions were considered in three categories. The questionnaire consists of the individual characteristics of the farmers, the infrastructure of the enterprise and before and after using certified seed. Primary information was collected by using a pretested interview schedule, with a face-to-face interview method between October and November 2018. Assumptions of normality and homogeneity of variance were examined with the Kolmogorov–Smirnov and Levene tests, respectively. Since assumptions were met, parametric tests were used to compare the groups. A paired

t-test was performed before and after support. The upper limit was 0.05 for significance.

RESULTS AND DISCUSSION

Effect of certified-seed use before and after yield support

The desired yield and quality level in grain production have not been reached in Turkey. To eliminate this situation, certified-seed users are supported by the Ministry of Agriculture and Forestry. In this study, the effect of certified seeds on production, quality, gross profit, and production cost was demonstrated. In this context, the production technique, by using or not certified seeds, was compared. As a result of this production comparison, the effect of certified-seed use on operating income was determined. For the subsidy given to producers to be effective, the used technology must have an impact on operating costs (Oluwatoba *et al*., 2019). Another study found that farmers who had access to certified wheat seeds had higher income than farmers who did not (Ali *et al*., 2015). It was determined that newly used technologies cause a decrease in average production cost and an increase in farm income (Challa, 2013).

The obtained yield from wheat production in dry areas before support was between 1500–3500 kg/ha, while yield amount was found to vary (3800–6500 kg/ha) in irrigated areas. In wheat production after support, yields in dry areas varied in the range of 2000–4100 kg/ha, and in irrigated areas in the range of 3500–8000 kg/ha. Distributions of yield amounts before and after support in dry and irrigated areas are shown in Table 1, which shows that the highest yield rate was in the 2010–2500 kg/ha yield range before certified-seed support, followed by the 2510–3000 kg/ha yield range. The ratio of producers in these two yield ranges was 70.7%. The rate of producers with yields of more than 3010 kg/ha was 6.1%. In these yield levels, gross production values to be obtained by the wheat producer were not sufficient. The average size of agricultural enterprises in Turkey is 600 hectares. Therefore, the income from agricultural enterprises is not sufficient for farmers' sustainable agricultural production. Consequently, it is necessary to increase the yields to be obtained in the research area. One of the most important factors in increasing wheat production is the spread of certified-seed use. In this context, the Ministry of Agriculture and Forestry initiated a certified-seed support project to promote the use of certified seeds. After subsidies, the amount of certified seeds used by producers began to increase. Therefore, yields of wheat production after certified-seed support were determined. The obtained yields are shown in Table 1, showing that the rate of producers producing wheat in the yield range of 2010–2500 kg/ha was 22.5%. The ratio of those who produce in the 2510–3000 kg/ha yield range was 28.0%. The ratio of producers in these two yield ranges was 50.5%. The ratio of producers in these two yield ranges decreased by 20.2% (70.7–50.5%) when compared to the support level. Therefore, we determined in which yield range the decrease in these two yield ranges shifts. Table 1 shows that the ratio of producers who received more than 3010 kg/ha before support was 6.1%, and this ratio increased to 47.1% after support. This result shows that producers in other yield ranges were in a yield range of more than 3010 kg/ha. As can be seen from the

table, there was a significant increase in yields above 3010 kg/ha, while the use of other certified seeds declined.

Although most wheat production is carried out in dry areas in the research area, it also occurs in irrigated areas. For this purpose, we determined the level of wheat production in irrigated areas. As can be seen in Table 1, producers in the 5010–6000 kg/ha yield range before support constitute half of total producers (50.0%). The rate of producers having yields more than 6010 kg/ha was determined as 10.0%. After the use of certified seeds, the maximal yield amount was 6010 kg/ha, which was in the 2090 yield range because change rates in other yield ranges varied between 2.7% and 1.8%. According to these results, the yield in dry areas was higher than the yield in irrigated areas and it can be said that the yield ratio obtained both before and after support is higher in dry areas.

Table 1. Wheat yield in dry and irrigated areas before and after support (%).

Dry Area Yield Amount (kg/ha)			Irrigated Area Yield Amount (kg/ha)		
Yield Range *	Before (%)	After (%)	Yield Range *	Before (%)	After (%)
≤2000	23.2	2.4	≤4000	11.8	9.1
2010–2500	35.5	22.5	4010–5000	28.2	26.4
2510–3000	35.2	28.0	5010–6000	50.0	33.6
≥3010	6.1	47.1	≥6010	10.0	30.9
Total	100.0	100.0	Total	100.0	100.0

* As yield increase was higher in irrigated areas, yield range was not taken at same level in dry and irrigated areas.

Amount of certified seeds used before and after support

The effect of certified-seed use on yield is 25.0%–30.0% on average, and we aimed to determine the level of this effect in the research region. We compared certified- and uncertified-seed yields, and Table 2 shows the yields of used wheat varieties before and after support. As seen from Table 2, the increase in production after the use of certified seeds in both dry and irrigated areas was found to be statistically significant ($p < 0.05$). In dry areas, an average of 2467 kg/ha was obtained before certified-seed support, and this amount increased to 3059 kg/ha after support, with an average increase in production of 592 kg/ha (3059–2467 kg/ha). This value was evaluated in 2018 current prices, and the amount of profit per hectare was calculated. According to December 2018 wheat prices (Turkish Grain Board (TMO) sales: $0.22), this amount showed that $130.24 (592 kg/ha x $0.22) more income is generated per hectare (kg/ha). In production in irrigated areas, an average of 5323 kg/ha was taken before support, and after support, this amount increased to 5685 kg/ha. Accordingly, certified-seed support has a positive effect on production in both dry and irrigated areas (Table 2). The average increase in efficiency after support is 362 kg/ha. When compared to wheat prices in December 2018 (TMO sales: $0.22), $79.64 more income was generated per hectare. Certified-seed support, therefore, increases the production amount and, thus, the income in both dry and irrigated areas. A study conducted in Nigeria found that rice production

increased by 18,5% and household income increased by 2.3% as a result of supported certified seeds. This increase contributed to the reduction of existing rural poverty (Awotide *et al*., 2011). Another study supported quickly providing quality seeds to farmers, and stated that the production income increased by 3.5% in 2006/7 and by 4.0% in 2007/8 (Srinivas et al., 2010). In our study, there was an increase in production income and a decrease in production inputs with the use of certified seeds. In wheat production, wheat yield and operating income increase with the adoption and use of productive varieties (Barkley *et al*., 2010). In their study, Hagos and Hsdush (2017) determined that the obtained yield from certified wheat seeds was 50% higher than that from traditional seeds. Farmers pay more for certified seeds than local and old varieties to obtain quality seeds. However, the additional obtained income with quality seeds is much higher than their cost (Hue *et al*., 2009). Our findings are similar to those mentioned above.

Efficient use of scarce resources is important to ensure competitiveness in production. From this perspective, it is important to determine the effect on production cost of the used resources in wheat production. In Turkey, the cost of wheat-seed production is 15.0%–20.0% on average. Therefore, this ratio is an important part of production cost. Seed amounts used before and after support were determined, and these results are shown in Table 2. As seen from Table 2, the decrease in the amount of used seeds after certified-seed support in both dry and irrigated areas was found to be statistically significant ($p < 0.05$). In dry areas, 235 kg/ha of seeds was used before support in production, while this amount after support decreased to 207 kg/ha. Thus, the use of seeds in dry areas after certified-seed use decreased by an average of 28 kg/ha (235–207). When this amount is evaluated according to average wheat-seed prices of 2018 (trader: $0.38), $10.64 more savings were achieved in terms of production costs. In production in irrigated areas, 229 kg/ha of seeds was used before support, and this amount decreased to 198 kg/ha after support. Thus, the use of seeds in irrigated areas after certified-seed use decreased by an average of 31 kg/ha. In other words, according to average wheat-seed prices (trader: $0.38) in 2018, there are $11.78 savings in production costs. Accordingly, certified-seed support reduces the amount of seed used in both dry and irrigated areas, and hence the cost of production. In a previous study on this issue, the average yield obtained from the use of certified seeds in wheat production was determined to be 22.5% higher than that of production with uncertified seeds. When certified seeds were used, gross profit was 36.0% higher than that of uncertified seeds. When certified seeds were used, net profit per hectare was also 26.5% higher than that with uncertified seeds (Sofijanova *et al*., 2012). With the use of certified seeds, a 33.0% increase in yield in irrigated areas and 28.0% increase in average yield were reported (Kugbei, 2011). A similar study found that average yield was 24.9%, and net profit in the unit area increased by 24.3% with the use of certified seeds in wheat production (Tanrıvermiş and Akdogan, 2007). There is, therefore, a similarity between the results obtained in our study and other studies on this subject.

Table 2. Comparison of wheat yield and seed amount in dry and irrigated areas.

			Wheat Yield (kg/ha)				Seed Amount (kg/ha)			
Condition		n	Mean	SD	*t*	*p*	Mean	SD	*t*	*p*
Dry areas	Before	292	2467	42.62	−47.5 **	<0.001	235	1.39	37.6 **	<0.001
	After	292	3059	46.70			207	1.45		
Irrigated areas	Before	107	5323	81.36	−15.6 **	<0.001	229	1.00	27.1 **	<0.001
	After	107	5685	91.58			198	1.04		

** Statistically significant at 1% level.

Although wheat production increased after support, and the used-seed amount decreased, examination of production according to used seeds gives healthier results. Therefore, the amount of increase or decrease in wheat production before and after support was determined, as well as the amount of increase or decrease in dry and irrigated areas. In this study, we calculated yield in terms of Yield = Production per hectare (kg)/Seed per hectare (kg). The yield values of farmers before and after using certified seeds in irrigated and dry areas are compared in Table 3. As seen from Table 3, the increase in yield after certified-seed use in both dry and irrigated production was found to be statistically significant ($p < 0.05$). In the production of dry areas, while 105 kg/ha per 1 kg of seed was obtained before certified-seed support, this amount increased to 149 kg/ha after support. With the use of certified seeds, there is a 41.4% increase in the total production per hectare in dry areas. In the production of wheat in irrigated areas, while an average of 235 kg/ha was obtained per one kg of seed before support, this amount increased to 290 kg/ha after support. The rate of increase in total production was 23.8%. Accordingly, certified-seed support has a positive effect on the yield of both dry and irrigated areas, and this effect is greater than that of production in dry areas.

Table 3. Comparison of yield before and after certified seeds (kg/ha)

Condition		n	Mean	SD	t	p
Dry Areas	Before	292	105	1.96	−54.55 **	0.000
	After	292	149	2.56		
Irrigated Areas	Before	107	235	3.83	−24.32 **	0.000
	After	107	290	5.32		

** Statistically significant at 1% level.

CONCLUSIONS

According to the obtained results for the amount of product per hectare before and after support, the use of certified seeds increased the production amount and, thus, the income in both dry and irrigated areas. The increase in production after support was 592 and 362 kg/ha for dry- and irrigated-land areas, respectively. In the performed analyses for the amount of seed per hectare before and after support, with the use of certified seeds, the amount of used seeds, and thus the cost of

production, in both dry and irrigated areas decreased. After the use of certified seeds, the average use of seeds in dryland decreased by 28 kg/ha, while this value was 31 kg/ha in irrigated fields. Therefore, farmers, researchers, traders, non-governmental organizations, and enterprises operating in the seed industry should co-operate. In this context, the continuation of certified-seed support for wheat seeds is important for the use of certified seeds by producers.

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THE QUALITY OF POTATO TUBERS DEPENDING ON APPLICATION OF ADSORBENTS

Slobodan ĐOKIĆ*, Radojka MARINKOVIĆ, Jovana KOVAČEVIĆ, Ljubiša MAKSIMOVIĆ, Jovana TODOROVIĆ, Jelena STANIŠIĆ, Rastko TODOROVIĆ

Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina
*Corresponding author: slobodandjokic@outlook.com

ABSTRACT

A potato is a field crop that is extremely important in Bosnia and Herzegovina, but according to all indicators the production is very unstable and unreliable (production volume and quality, average yields, range). For the research needs, the experiments were set up at two localities, Bijeljina and East Sarajevo, with use of superadsorbent of different composition (control variant; superadsorbent; superadsorbent enriched with growth stimulants; superadsorbent enriched with microorganisms; superadsorbent enriched with microorganism. The main goal of this research was to determine the influence of superadsorbent and locality on the chemical composition of the tuber.The analysis of the results showed that the use of different variants of the adsorbent had a highly significant effect on the examined properties, while the site influence had high significance for the dry matter, ash and starch content and significantly affected the nitrate content in the tuber. In the control variant, the tubers had the lowest dry matter content, the lowest starch content, but the highest in the variant with superadsorbent enriched with microorganisms. The highest ash content was in tubers in the variant with superadsorbent, and the lowest in the variant with superadsorbent enriched with growth stimulants, microorganisms and microelements. Using the superadsorbent enriched with growth stimulants, the lowest nitrate content in the tuber was determined, and the highest in the control variant. At the site in East Sarajevo, the tubers had a higher content of dry matter and starch, while the content of ash and nitrate was higher in Bijeljina.

Key words: *tuber, starch, ash, dry matter, superadsorbent.*

INTRODUCTION

A Potato (*Solanum tuberosum*) are among the most intensive and profitable cultivated crops. In terms of nutritional value and the areas it occupies in the world as well as in our country, it belongs to the order of leading cultures. Thanks to wide adaptive capabilities, high reproductive capacity (5-30 times) and good nutritional value of tubers, potatoes are grown in over 130 countries on about 18.5 million

hectares with an annual production of about 300 million tons. In the total food production in Bosnia and Herzegovina, potatoes occupy a significant place. The great economic importance of potatoes and over 37,000 ha of areas grown with an average yield of 11.0 t/ha (*The Agency for Statistics of Bosnia and Herzegovina*, 2019) and significantly lags behind the yields of potatoes in Europe and the world. In the conditions of climate change, the occurrence of more and more frequent droughts represents a threat to the sustainable production of agricultural crops, which can have a negative economic and sociological impact (*Rivero et al.*, 2007).Water scarcity is one of the main causes of declining crop yields worldwide and a decrease in average yields of more than 50% in the most important field crops (*Buchanan et al.,* 2000*; Wang et al.,* 2003). Therefore, water scarcity, especially in arid and semi-arid areas, is considered a major problem in food production (*Zhang et al.,* 2014). By applying of natural and synthetic enhancers such as super-adsorbent polymers, it is possible to provide good soil moisture in conditions of insufficient and unevenly distributed rainfall and thus enable the cultivation of plants in arid areas (*Szczerski et al.,* 2013). The yield and quality of potato tubers is influenced by water deficit and depends on the strength, time of occurrence and duration of drought during the vegetation period. Water stress during the vegetation growth phase reduces the leaf surface, the development of aboveground organs and roots as well as the height of the plant. In the tuber initiation phase, stress due to lack of water causes a decrease in the number of tubers formed per plant, which results in a smaller number of larger tubers at the end of the vegetation. The stress in the tuber filling phase reduces the yield and quality of potato tubers. In this phase, the deformations of tubers in the form of cracks and irregular shapes of tubers occur, the percentage of tubers of finer fraction increases and the specific density of tubers decreases. A lack of water during the ripening phase not only reduces the yield but also shortens the dormancy, reduces the specific density and increases the content of reducing sugars in the potato tuber. The two factors that mostly define the quality of potatoes are the dry matter content in the tuber and the structure of the tuber yield. The dry matter content increases during the vegetation from about 10% in the tuber initiation phase to 15-25% at the time of tuber extraction. The dry matter content is affected by a number of factors such as: length of vegetation, variety, average temperature during vegetation and water availability, especially in the period before the end of vegetation. Severe drought reduces the harvest index and in these conditions the dry matter content is lower compared to crops that are grown to full maturity. Moderate drought at the end of the vegetation usually leads to an increase in dry matter content. The aim of this research is to determine the influence of "hard water" superadsorbent and the locality on the quality of potato tubers.

MATERIAL AND METHODS

To examine the influence of superadsorbents and localities on the quality of tubers, tubers were taken from experiments that were monitored in 2019 in the areas of

East Sarajevo and Bijeljina. The tests included six variants of adsorbent application:
control variant (A_0); superadsorbent (A_1); superadsorbent enriched with growth stimulants (A_2); superadsorbent enriched with microorganisms (A_3); superadsorbent enriched with microelements (A_4) and superadsorbent enriched with growth stimulants, microorganisms and microelements (A_5) in the amount of 20 kg ha^{-1}.
The experimental plot on the territory of the city of East Sarajevo is located at an altitude of 550 m (43 ° 49'01 " NW and 18 ° 20'57 " E). It is characterized by strong influences of continental climate. The average annual temperature is 10.2 °C, and the average rainfall is about 900 mm. The experiment was set up on alluvial soil (*Fluvisol*). The experimental plot on the territory of Bijeljina is located at an altitude of 90 m (44 ° 41 ′ N; 19 ° 14 ′ E). The average annual temperature is 12.5 °C, and the average rainfall is about 757.2 mm. The experiment is set on semigley type land. From the qualitative properties of tubers, the following were analyzed: dry matter (%), by drying the plant material in an oven at a temperature of 105 °C to a constant mass; crude ash (%) by annealing the plant material at 550 °C to constant weight; starch (%), determined polarimetrically by Ewers (1908); nitrates (mg kg-1), was determined by molecular absorption spectrometry.
Statistical processing was done using the statistical program STATISTICA 10 (StatSoft, Inc. Corporation, Tulsa, OK, USA).

RESULTS AND DISCUSSION

Table 1 shows the analysis of the variance of adsorbent application influence and localities on the qualitative potatoes properties. The application of different adsorbent variants had a significant effect on the dry matter, ash, starch and nitrate contents in the tuber, while the site had a significant effect on the dry matter, ash and starch contents in the tuber and significantly affected the nitrate content in the tuber. The interaction of adsorbent x locality significantly affected the ash content in potato tubers.

Table 1. The Influence of adsorbent and locality on tuber quality

Factor		% of dry matter	% of ash	% of starch	Nitrate content
Adsorbent		**	**	**	**
Locality		**	**	**	*
A * B		nsd	nsd	nsd	nsd
A	$LSD_{0.05}$	0.6429	0.1436	0.6429	2.854
	$LSD_{0.01}$	0.8638	0.1929	0.8638	3.835
B	$LSD_{0.05}$	0.3712	0.0829	0.3712	1.648
	$LSD_{0.01}$	0.4987	0.1113	0.4987	2.214
A*B	$LSD_{0.05}$	0.9093	0.2030	0.9093	4.037
	$LSD_{0.01}$	1.2215	0.2727	1.2215	5.,423

(*)statistically significant difference, (**)statistically very significant difference , there is no statistically significant difference (nsd)

The dry matter

The dry matter content of tubers is significantly affected by ecological conditions and agrotechnical measures (*Geremew et al.*, 2007), while increasing the amount of nutrients, especially nitrogen to a certain extent leads to a linear increase in dry matter in potatoes (*Zebarth et al.,* 2004), which affects the increase in tuber quality (*Roinila et al.,* 2003).

Table 2. Average dry matter content in potato tubers depending on the adsorbent at selected localities (%)

Adsorbent / Locality	A_0	A_1	A_2	A_3	A_4	A_5	Average
E. Sarajevo (B_1)	24.80	25.78	25.20	26.48	25.94	25.77	25.66
Bijeljina (B_2)	23.89	24.86	24.29	25.56	25.04	24.87	24.75
Average	24.35	25.32	24.75	26,02	25.49	25.32	25.21

Adsorbent: Control variant (A_0); superadsorbent (A_1); superadsorbent enriched with growth stimulants (A_2); superadsorbent enriched with microorganisms (A_3); superadsorbent enriched with microelements (A_4) and superadsorbent enriched with growth stimulants, microorganisms and microelements (A_5).

The average dry matter content in potato tubers, regardless of the application of adsorbent and locality, is 25.21%. The control variant had the lowest dry matter content in potato tubers (24.35%), and the highest superadsorbent enriched with microorganisms (26.02%). The determined differences are statistically highly significant, as well as the differences of other variants of superadsorbent in comparison with the control variant, except for variant A_2 where the determined differences did not have statistical significance. The average dry matter content in potato tubers in East Sarajevo (25.66%) is significantly higher compared to Bijeljina (24.75%).

Ash content in the tuber

Of the total dry matter in the tuber, ash accounts for about 1.1% *(Lešić et al., 2002).* The average ash content in potato tubers regardless of the application of adsorbent and locality is 1.320%. The ash content in the tuber ranged from 1.145% to 1.558%. The application of different variants of superadsorbent had a highly significant effect on the ash content in the tuber. A highly significant influence of the locality was also determined, while the interaction of the adsorbent x locality significantly influenced the ash content in the tuber. In variants A1 and A4, a significantly higher ash content in the tuber was found, and in comparison with other examined variants.

The average ash content in potato tubers in East Sarajevo (1.445%) was highly significantly compared to Bijeljina (1.196%). At the locality of East Sarajevo, the highest ash content in potato tubers was in variant A4, and the lowest in the control

variant, while at the locality in Bijeljina, the highest ash content in potato tubers was achieved in variant A1, and the lowest in variant A5.

When comparing the ash content in the tuber between the examined localities, a significantly higher ash content in the tuber was found for all variants of adsorbents at the locality in East Sarajevo, except for variant A1 where the differences were only 0.005%.

Table 3. Average ash content in potato tubers depending on the adsorbent at selected localities (%)

Adsorbent / Locality	A_0	A_1	A_2	A_3	A_4	A_5	Average
East Sarajevo (B_1)	1.338	1.560	1.430	1.383	1.613	1.345	1.445
Bijeljina (B_2)	1.148	1.555	0.958	1.123	1.448	0.945	1.196
Average	1.243	1.558	1.194	1.253	1.530	1.145	1.320

Adsorbent: Control variant (A_0); superadsorbent (A_1); superadsorbent enriched with growth stimulants (A_2); superadsorbent enriched with microorganisms (A_3); superadsorbent enriched with microelements (A_4) and superadsorbent enriched with growth stimulants, microorganisms and microelements (A_5).

Starch content in the tubers

The starch content in tubers is influenced by the method of cultivation and genotype (*Geremew et al.*, 2007; *Tein et al.*, 2014; *Broćić et al.,* 2016), where late varieties stand out due to longer vegetation period and longer period of accumulation of photosynthetic substances. (*Singh and Lovedeep*, 2009).

The average starch content in potato tubers regardless of the application of adsorbent and locality is 17.15%. The control variant had the lowest starch content in potato tubers (16.29%), and the highest superadsorbent enriched with microorganisms (17.26%). The determined differences are statistically highly significant, as well as the differences of other variants of superadsorbent in comparison with the control variant, except for variant A_2 where the determined differences did not have statistical significance. The average starch content in potato tubers in East Sarajevo (18.40%) is significantly higher compared to Bijeljina (15.89%).

Table 4. Average starch content in potato tubers depending on the adsorbent at selected localities (%)

Adsorbent / Locality	A_0	A_1	A_2	A_3	A_4	A_5	Average
East Sarajevo (B_1)	17.54	18.52	17.94	19.22	18.69	18.52	18.40
Bijeljina (B_2)	15.03	16.01	15.43	16.71	16.18	16.01	15.89
Average	16.29	17.26	16.69	17.96	17.44	17.26	17.15

Adsorbent: Control variant (A_0); superadsorbent (A_1); superadsorbent enriched with growth stimulants (A_2); superadsorbent enriched with microorganisms (A_3); superadsorbent enriched with microelements (A_4) and superadsorbent enriched with growth stimulants, microorganisms and microelements (A_5)

In the experiment in Bijeljina, the tubers had less starch compared to the experiments in East Sarajevo, which is in accordance with the results of *Tein et al.* (2014) who state that larger tubers have a lower starch content, compared to smaller tubers in general.

Nitrate content in the tubers

The average nitrate content in potato tubers regardless of the application of adsorbent and locality is 151.89 mg kg^{-1}.

Table 5. Average nitrate content in potato tubers depending on the adsorbent at selected localities (mg kg^{-1})

Adsorbent / Locality	A_0	A_1	A_2	A_3	A_4	A_5	Average
East Sarajevo (B_1)	160.04	151,22	146.25	149.40	50.10	148.57	150.93
Bijeljina (B_2)	162.44	153.62	148.15	151.30	51.70	149.88	152.85
Average	161.24	152.42	147.20	150.35	50.90	149.22	151.89

Adsorbent: Control variant (A_0); superadsorbent (A_1); superadsorbent enriched with growth stimulants (A_2); superadsorbent enriched with microorganisms (A_3); superadsorbent enriched with microelements (A_4) and superadsorbent enriched with growth stimulants, microorganisms and microelements (A_5)

In the potato tuber, the control variant had the most nitrate (161.24 mg kg^{-1}), and the superadsorbent enriched with growth stimulants had the least (147.20 mg kg^{-1}). The differences found are statistically highly significant, as are the differences between variants A_1 and A_2. A previous research has shown that the application of polymers prevents pollution of the agro ecosystem and reduces the content of harmful substances in tubers, which increases the tubers economic value *(Islam et al.,* 2011ab). The average nitrate content in potato tubers in East Sarajevo is 150.93 mg kg^{-1}, and in Bijeljina 152.85 mg kg^{-1}. The differences found were significant.

CONCLUSION

The use of different variants of superadsorbent at both sites had a positive impact. In the control variant, the tubers had the lowest dry matter content, the lowest starch content, while the highest nitrate content. In the variant with adsorbent enriched with microorganisms, the tubers had the highest dry matter content and the highest starch content. In the superadsorbent variant, the tubers had the highest ash content. In the variant with superadsorbent enriched with growth stimulants, microorganisms and microelements, the tubers had the lowest ash content. The lowest nitrate content in the tuber was determined by applying a superadsorbent enriched with growth stimulants. At the site in East Sarajevo, the tubers had a higher dry matter content, the highest starch content, while the ash and nitrate content was higher in Bijeljina.

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RESOURCES OF WOODY PLANTS OF NORTH CAUCASUS BEECH FORESTS

A.V. GRYAZKIN[1], Marko GUTALJ[2*], A.B. BAZAEV[3], H.M. KHETAGUROV[4], I.A. NIKOLAEV[4], I.A. SYRNIKOV[1], Chang Chung THANH[1], Vu Van HUNG[1]

[1]Saint-Petersburg State Forest Technical University named after S.M. Kirov, Saint Petersburg, Russian Federation
[2]University of East Sarajevo, East Sarajevo, Republic of Srpska, Bosnia and Herzegovina
[3]Gorsky State Agrarian University, Vladikavkaz, Russian Federation
[4]North Ossetian State University after K. L. Khetagurov, Vladikavkaz, Russian Federation
*Corresponding author: marko.gutalj@ues.rs.ba

ABSTRACT

The aim of this study is to investigate material and monetary valuation of forest resources in the beech forests of the North Caucasus. The plots were selected in the Central part of the North Caucasus, on the territory of the Republic of North Ossetia-Alania (Kartcinsky ridge), between 1200-1350 m above sea level. Two objects are located on the northern macroslopes and two on the southern macroslope. The characteristics of phytocenoses on the experimental plots were established based on the results of a continuous enumeration of trees on a test area of 50x100 m. The number of undergrowth and undergrbrush, their composition and distribution by height groups, are established on circular areas of 10 m^2. The average wood volume is about 300 m^3/ha, and the average stand density is 248 trees per 1 hctare. The average number of undergrowth is 8988 per hectare, and underbrush 1998 per hectare. The average height of the young generation is 0.65 m, and the undergrowth is 0.86 m. The weight of one plant of average height in the air-dry state is 0.24 kg for undergrowth and 0.55 kg for undergrbrush. Phytomass of undergrowth and underbrush by species was set by weighing in a fresh and air-dry state. Prices for all types of wood resources used average market prices as of 2019. The main income can be obtained from the sale of wood – about 650 thousand RUB/ha. Undergrowth and underbrush can give in a total about 43 thousand RUB/ha. At the same time, the period of maturation for the harvest of beech and related species is 100-140 years. During this period, it can be carried out about 15-20 harvests of undergrowth and underbrush, which together can generate income comparable to the amount from the sale of wood.

Keywords: *The North Caucasus, the components of forest phytocenosis, the resources of the beech forests.*

INTRODUCTION

Mountain forests are special natural formations with many important ecological functions. One of these functions is there recource potential. The resource potential of mountain forests is often much more diverse than lowland forests. Moreover, that potentials are very heterogeneous due to the growing conditions, and that is well illustrated by mountain forests of the North Caucasus. (Albegov, 2001; Bazaev *et al*., 2008; Gryazkin *et al*., 2013; Khetagurov, Gryazkin, 2013; Khetagurov *et al.*, 2018; Bazaev *et al*., 2019). In this regard, one of the most important tasks of forestry is to organize the rational use of all available forest resources, taking into account their ability to reproduce itselves.

Mountain forests of the North Caucasus are represented by different tree species and the dominant forest community edificator is beech (Albegov, 2001; Bazaev *et al*., 2008; Andrew *et al.*, 2006; Gryazkin *et al*., 2019). Potential reserves of even the main types of forest resources in the current Forest Code of Russian Federation, have not yet been fully established. For the last 100 years, mainly wood has been extracted from the forest fund in North Caucasus, and value of other recources were underestimated (Khetagurov and Gryazkin, 2013; Development Strategy ..., 2018; Global Forest Resources ..., 2001; Wong *et al.*, 2001). Several attempts have already been made to comprehensively assess resource potencials in the diffrent forest ecosystems (Lebedev *et al.*, 2013; Gryazkin *et al.*, 2013; Khetagurov and Gryazkin, 2013; Khetagurov *et al.*, 2018; Bílek *et al.*, 2009; Bazaev *et al.*, 2019; Gryazkin *et al.*, 2019). Such researches were also undertaken in mountain forests in the North Caucasus (Bazaev *et al.*, 2008; Gryazkin *et al*., 2013; Khetagurov, Gryazkin, 2013; Khetagurov *et al.*, 2018; Bazaev *et al.*, 2019; Gryazkin *et al*., 2019; Gryazkin *et al.*, 2019), but the data of total availability and value of some resources are still inconclusive. The aim of this study is to investigate material and monetary valuation of forest resources in the beech forests of the North Caucasus.

MATERIAL AND METHODS

Investigation included stands with a predominance of beech in the first vegetation floor. The experimental plots are located between 1200-1350 m above sea level (Kartsinsky ridge, North Ossetia). In North Ossetia, beech grows between 600 to 2000 m above see level, on slopes of different aspects and different steepness. In total, four experimental plots have been selected, two on the northern macroslope of the Kartsinsky ridge (objects 1 and 2) and two on the southern macroslope (objects 3 and 4). The general characteristics of the research plots are presented in Table 1.

Table 1. General characteristics of research plots

Object number	Macroslope	Elevation (m)	Slope steepness, degrees	Slope aspect
1.	North	1250	15-20	NE
2.	North	1350	30-45	NE
3.	South	1300	15	SW
4.	South	1200	25-35	SW

Experimental plots are represented by two types of phytocenoses - *Fagetum festucosum* (plots 1 and 2) and *Fagetum asperulosum* (plots 3 and 4). In the structure of the first vegetation floor, at least 80% is represented by beech and hornbeam, while in the second floor, share of these species was 90-100%. The participation of other species in the composition of forest stands is less than 10-20 % (Table 2).

Table 2. Taxation characteristics of forest stands at the research plots

Plot No.	Stand composition by vegetation layers	Total number of trees (ex./ha)	Average		Relative density	Volume (m^3/ha)	Stand age	Bonitet class
			Diameter (cm)	Height (m)				
1	6B 3Hb 1Mn + L, Ag	269	38	23	0,84	306	90	II
	8B 2Hb	46	9	12	0,12	17	30	
2	6Hb 4B +Mn, Ash	251	38	21	0,81	262	80	II
	10B	29	11	13	0,11	18	30	
3	4B 4Hb 2O + Ab, As, Mn	180	47	20	0,93	263	80	II
	6B 3Hb 1Mn	16	12	10	0,10	3	40	
4	4B 4Hb 2Mn + Ab, Pe	148	52	23	0,86	313	90	II
	7B 2Hb 1Mn	52	13	12	0,28	19	40	

Notes. 1. The top line is the first vegetation layer of the stand, the bottom line is the second layer. 2. List of abbreviations: B= Beech, Hb = Hornbeam, Pe = Pear, O = Oak, Mn = Norway maple, L = Linden, Ag = Gray Alder, Ab = Black Alder, As = Aspen, Ash= Ash.

Taxation inventory of forest stands at the experimental plots was carried out in accordance with the accepted methodology in forestry and forest management. For this purpose, experimental plots of a standard size - 0.5 hectares each - were laid at each experimental stand. Wood volume by species and its structure was estimated after a continuous enumeration of each tree on the plots by using reference books (Standards for forest taxation, 1992 and Standards for forest taxation for RF, 1995). Counting the number of undergrowth and underbrush, estimation of their composition and distribution by height groups, was carried out on circular areas of 10 m^2 (Gryazkin, 1999). There were at least 30 circular areas at each experimental plot which ensured statistically acceptable accuracy of the experimental work.

The phytomass of undergrowth's and underbrush's branches was determined by weighing their mass in wet state (in field conditions) and air dry state (in laboratory conditions). In material and monetary valuation there were used average market prices in Russian Federation for all types of forest resources (prices for 2019).
Occurrence, projective cover, and species composition of the groundcover were determined on the same circular areas of 10 m^2. The dominant species in composition of the groundcover was *Anemone ranunculoides L.*, *Rubus hirtus Waldst. et Kit*., *Stellaria media (L.) Vill.*, *Athyrium distentifolium Tauschex Opiz*., *Urtica dioica L*., *Matteucia struthiopteris (L.) Tod*., *Galium odoratum (L.) Scop*. and *Festuca gigantea (L.) Vill*. The projective cover for the absolute majority of herbaceous species, as a rule, does not exceed 5%. The list of herbaceous plants that accompanying the beech (*Fagus orientalis Lipsky*) and berry yew (*Taxus baccata L*.) are included in the database developed with the participation of the authors (Bazaev *et al.,* 2016).

RESULTS AND DISCUSSION

Timber is the most demanded forest resource, as it was in the past. At the same time, other forest resources are used partially and insufficiently only. For example, undergrowth, underbrush and groundcover were rarely used, and that was noted by many researchers (Bazaev *et al*., 2008; Gryazkin *et al.*, 2020; Gryazkin *et al.*, 2019; Bílek *et al*., 2009; Andrew *et al*., 2006). For the material and monetary assessment of wood products at the experimental plots a continuous enumeration of trees of all species, starting from 6 cm diameter, was carried out. Wood volume reserves at the research plots are mainly represented by beech and hornbeam. The participation of other species in the composition of stand in the upper vegetation floor is less than 10%. Table 3 shows the distribution of wood volume by species in the first (upper) floor of forest stands.

Table 3. Wood volume at experimental plots by different species (m^3/ha)

Forest-forming species	Experimental plots				Average volume (m^3/ha)
	1	2	3	4	
Beech	200	137	117	147	150.3
Hornbeam	91.7	140	95	118	111.2
Pear	-	-	-	2.0	0.5
Oak	-	-	50	-	12.5
Norway maple	29.0	1.4	1.3	63	23.7
Linden	1.3	-	-	-	0.3
Alder gray	1.0	-	-	-	0.2
Alder black	-	-	1.4	2.0	0.8
Aspen	-	-	1.3	-	0.3
Ash	-	1.6	-	-	0.4
Total	323	280	266	322	297.8

Average composition of forest stands in experimental plots is 49 Beech, 38 Hornbeam, 8 Norway maple, 4 Oak + Pear, Linden, Gray Alder, Black Alder, Aspen, and the average wood volume is 297.8 m^3/ha. The structure of wood products by species is presented in Table 4.

Table 4. Distribution of wood volume by species and marketability categories (m^3/ha)

Stand-forming species	Wood volume by product categories			Total volume
	Sawlog	Semi-sawlog	Firewood	
Beech	92.2	37.1	21.0	150.3
Hornbeam	74.6	25.6	11.0	111.2
Pear	0.3	0.1	0.1	0.5
Oak	7.5	2.9	2.1	12.5
Norway maple	13.8	6.3	3.6	23.7
Linden	0.1	0.1	0.1	0.3
Alder gray	-	0.1	0.1	0.2
Alder black	0.4	0.2	0.2	0.8
Aspen	-	0.2	0.1	0.3
Ash	0.2	0.1	0.1	0.4
Total	189.1	64.7	31.9	297.8

Growing conditions for beech between 1200-1350 m above sea level are characterized by excess moisture, lack of heat and lack of illumination. These unfavorable factors primarily affect the tree species of the second stand's floor such as hornbeam. For these reasons, the most intense tree mortality is observed in the second floor of a stands (Table 5).

Table 5. Number of dry trees on experimental plots (m^3/ha)

Plot number - Elevation (m, above see level)	Beech	Hornbeam	Maple	Oak	Total
1-1250	33	14	2	-	49
2-1350	7	28	-	-	35
3-1300	16	24	1	1	42
4-1200	23	17	2	-	42
Average	19.7	20.8	1.3	0.2	42.0
Percentage of dry trees in total growing volume %	11.6	15.8	5.2	1.6	12.4

The high proportion of dry trees at the experimental plots (on average more than 12%) indicates a deterioration in the sanitary condition of forest stands. Hornbeam and beech in these forest areas require selective sanitary cuts.

The distribution of trees by different timber categories was carried out using the reference book Standards for Forest Taxation (1992). Timber prices are differentiated by assortment. The dominant share of wood volume per hectare is represented by beech wood, the cost of oak, pear and ash wood to the price of beech was conditionally accepted: sawlog – 3000 RUB/m^3, balance wood – 1800 RUB/m^3, and firewood – 1000 RUB/m^3.

Wood of other species - aspen, linden, alder can be sold at the price of hornbeam: sawlog –2500 RUB/m^3, balance wood – 1400 RUB/m^3, and firewood – 800 RUB/m^3.

The calculation results and the total cost of wood by categories of marketability are presented in the Table 6.

Table 6. Timber cost by marketability category RUB/ha

Forest-forming species	Timber categories			Total
	Sawlog	Balance	Firewood	
Beech	276600	66780	21000	364380
Hornbeam	186500	35840	8800	231140
Pear	900	180	100	1180
Oak	22500	5220	2100	29820
Norway maple	41400	11340	3600	56340
Linden	250	140	80	470
Alder gray	-	140	80	220
Alder black	1000	280	160	1440
Aspen	-	280	80	360
Ясень Ash	600	180	100	880
Total	492850	120380	36100	649330

Stands with a predominance of beech in the composition have great potential, which in current prices reaches 650 thousand RUB/ha. More than 76% of this amount is the cost of high-quality wood materials - sawlogs.

Table 7 presents data on the composition and number of undergrowth and underbrush. The undergrowth on the plots consists of the same forest-forming species as the stands in the upper floors. The underbrush consists of 7 different species that were discovered on the plots. Undergrowth and underbrush are sources for wood-chemistry industry (pulp and paper) and animal food. In addition, undergrowth and underbrush can be used to make brooms, panicles, etc.

Table 7. Composition and number of undergrowth and underbrush on experimental pots

Plot number	Undergrowth and underbrush composition	Number/ha
1	Undergrowth – 84Pe 9B 7Mn Underbrush – 54Bar Euo 46Elb	12563 2281
2	Undergrowth – 79Pe 14Mn 6B 1Ash + Ulm Underbrush – 51Euo 25Cur 14Bar 6Mas 4Hsu	9239 1461
3	Undergrowth – 70Pe 21Mn 5Ash 2B 1Ab 1Pe +L, As Underbrush – 60Haz 24Bar 5Ros 11Mas	5775 1250
4	Undergrowth – 50Mn 41Pe 9B + An, Ash Underbrush – 69Bar 19Euo 12Mas	8375 2600

List of abbreviations: Bar = Barberry, Euo = Euonymus, Elb = Elderberry, Wbe = Wolfberry, Pe = pear, Hsu = Honeysuckle, Haz = Hazel, Mas = Mountain ash, Cur = Currant, Bch = Bird cherry, Che = cherry, Ros = Rose hips

The height structure of the undergrowth is very heterogenic; and it changes significantly on the different plots. The category of small undergrowth (up to 0.5 m) prevails. The average number of undergrowth on the experimental plot is 8988 per hectare. The average height of the undergrowth is 0.65 cm, and the air-dry weight of one plant of this height is 0.24 kg.

In summer, undergrowth and underbrush can be used to produce animal food, by harvesting branch collected in the form of bunches about 1 m long and about 10 cm in diameter at the tying site. An average about 30 plants is needed to make this kind of a bunch. For this purpose, it can be used only small and medium-sized plants (up to 1.5 m). The average price for branch bunch is 60 RUB/bunch. Any species can be used as animal feed, except Berry yew. All parts of Berry yew are poisonous. In addition, this species is in the Red Book of the Russian Federation.

Undergrowth and underbrush can be used as raw material for wood destination, as well. The cost of one ton of such raw material is 6500/RUB.

The large undergrowth and underbrush (brushwood, 10% of the total) is used for the construction of hedges and as small ornamental material. The cost of a bunch of 10 plants is on average 15 RUB. Based on the number of undergrowth by species and its distribution by height groups, it is possible to determine the output of marketable products (Table 8).

Table 8. Output of marketable products from undergrowth

Name of product	Undergrowth (number/ha)	Number of finished products	Revenues from sales (RUB/ha)
Branch feed (number/ha)	8988	300	18000
Panicles (90% of the total undergrowth) (number/ha)	8098	405	14175
Brushwood (10% of the total), (bunches/ha)	899	45	675
Wood greenery for destination (T)	8988	2 157	14020
Total without wood = greenery	-	-	32850
Total without branch feed	-	-	28870

The underbrush, as well as the undergrowth, is not uniform both in composition and in height. This vegetation floor of phytocenoses with predominance of beech is represented by 7 species of shrubs. The average composition of the undergrowth is 37 Barberry, 31 Euonymus, 19 Hazel, 8 Mountain ash, 3 Currant, and 2 Rose hips. The average number is 1898 per hectare. The distribution by height groups is 50% small, 40% medium and the remaining 10% is large. The average height is 0.86 m, and the weight of one plant in air-dry state is 0.55 kg. From the underbrush, as well as from the undergrowth, in the summer period it is possible to harvest branch fodder in the form of bunches about 1 m long and about 10 cm in diameter at the tying site. For producing of one feed bunch average 25 plants from the underbrush (its average height is slightly higher than the average height of the undergrowth) is needed. The average price for bunch is 60 RUB/bunch. Based on the number of underbrush and its distribution by height groups, it is possible to determine the output of marketable products (Table 9).

Table 9. Output of marketable products from the underbrush

Name of product	Undergrowth (number/ha)	Number of finished products	Revenues from sales (RUB/ha)
Branch feed (number/ha)	1898	76	4560
Panicles (90% of the total undergrowth) (number/ha)	1708	85	2975
Brushwood (10% of the total) (bunches/ha)	190	19	285
Wood greenery for destination (T)	1898	1 044	6786
Total without wood greenery	-	-	7820
Total without branch feed	-	-	10046

The amount of incomes from the sale of the underbrush is less than from the undergrowth. However, due to the greater mass of one plant of underbrush it gives more revenue than the same wood products of undergrowth. At the same time,

labor costs for harvesting the undergrbrush is less, because the average height of the underbrush is greater than the average height of the undergrowth.

CONCLUSION

The resources of the forest found, concentrated in the stand, undergrowth and underbrush, can bring the maximum total income of about 700 000 RUB/ha. The share of timber is 650 000, and undergrowth and underbrush 43 000 RUB/ha. The final results are highly dependent on the number of trees, undergrowth and underbrush, as well as on the composition of the tree species and the total wood volume. Under the canopy of a stands with predominance of beech, the composition and reserves of the lower vegetation floors (undergrowth and underbrush) can be recovered in 5-8 years, and by active care of stands this time can be shortened. Logging of mature beech and related species can be carried out once in 100-140 years, depending on the forest type category. Consequently, during the period of maturation of beech, it can be carried out about 15-20 harvests of undergrowth and underbrush, which together can generate income comparable to the amount from the sale of wood. Complete removal of undergrowth and underbrush does not reduce the water-regulating and soil-protecting properties of beech stands, and it is without environmental risks. The positive effect can be manifested in the improvement of conditions for self-renewal of some forest-forming species, because removal of undergrowth and underbrush excludes competition from these vegetation floors of the phytocenosis.

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YOUNG FARMERS IN PORTUGAL: ASSESSMENT OF POLICY EFFECTS

Fátima OLIVEIRA[1*], Pedro REIS[2], Ana Bela LOPES[1]; M Leonor da Silva CARVALHO[3]

[1]Polytechnic of Coimbra, Coimbra Agriculture School, CERNAS, Portugal
[2]National Institute of Agrarian and Veterinary Research, Oeiras, Portugal
[3]Independent Researcher, Lisbon, Portugal
*Corresponding author: foliveira@esac.pt

ABSTRACT

This work aimed to evaluate the effects of agricultural policies, between 2005 and 2016, on the settlement of the young farmers and the changes in the Portuguese agricultural structure by age group of the farmers. The results show the ageing of agricultural holdings managers and the impossibility of generational renewal. Despite the provision of support for young farmers aiming at generational renewal, in Portugal it does not seem to have had the same effect as it has had in other countries of the European Union (EU). It is worth noting the significant decline in young farmers between 2010 and 2016, despite the new entrants supported by the rural development programme. The arising question is the relationship between young people supported by policies and young people who remained in the sector as managers of agricultural holdings. Farms run by young farmers are more profitable and market oriented. These factors increase the sector competitiveness, but they do not seem to be sufficient to keep youth in the sector. It is important to identify young people supported by agricultural policy aimed at this age group that were able to demonstrate clear business competitiveness and modernization capacity, and the public policies that promote the success of their settlement.

Keywords: *Young farmer, Agriculture, Policies, Rural Development Programme.*

INTRODUCTION

This work aims to evaluate the effects of agricultural policies on the development of agricultural employment and on the changes in the Portuguese agricultural structure, namely, on the development of the entry of young farmers. The question to be answered is whether agricultural policies help the entry of new farmers or whether other factors will boost their entry into the agricultural sector. A considerable volume of work and studies has been carried out in the last two decades in relation to the migration of labor and payments made by governments to stimulate agricultural activity, both in the United States of America (USA) as the work of D'Antoni and Mishra (2010) and in the European Union (EU). In their bibliographic review, Berlinschi et al. (2011) highlight the different results of the

policies. With the increase in farmers' incomes, through subsidies and other incentives, they can invest in the education of their children and they may have access to other non-agricultural activities that may be financially more attractive, thus making agriculture less attractive for these young people. Petrick and Zier (2012) found that direct payments, measures for the development of rural areas, transfers to disadvantaged areas and agri-environmental measures had no effect on agricultural employment. The effect of education on agricultural employment was already referred to by Huffman (1980), who pointed out that more educated farmers reallocate their labor services from autonomous agricultural work to work outside the farm more quickly than less educated farmers. Other authors demonstrate mixed effects of policies (Mattas et al. 2010; Olper et al. 2012). Several works underline the effect of policies on youth and agriculture (OECD, 2010; Susilowati, 2014). The demographic challenge in the case of small-scale agriculture, social isolation and the lack of incentives to innovate are issues mentioned in several works (Matthews, 2013; Davidova and Thomson, 2014). However, Zagata and Sutherland (2015) state that this is an emotional discussion and is directly related to the sustainability of European agriculture. The EU focused its attention on the needs of young farmers, seeing that the need for land and land issues, such as income, land fragmentation, followed by issues related to subsidies, credits and quality of hand labor, seem to be the most important needs in the countries analyzed (Zondag et al. 2015). These concerns had already been highlighted by Matthews (2013) and Olper et al (2012).

MATERIALS AND METHODS

This article presents the results of surveys of EU28 agricultural households throughout the Common Agricultural Policy (CAP) program and explores the impacts of CAP measures to stimulate and support the entry of young farmers. The issue is to identify what are the results of agricultural policies in the entry of new farmers in the short and medium term. Knowing the effect will help reshape these policies if they haven't had the medium-term result. Descriptive statistical analysis instrument was applied and indicators were produced to assess the effects The sources of information are the National Statistics Institute (INE), the European Rural Development Network, the National Reports of the Portuguese Rural Program and EUROSTAT. The issue is wehte

RESULTS AND DISCUSSION

For the past ten years, the agricultural, forestry and fisheries sector has remained a major employer in the EU; about 9.9 million people work in agriculture, forestry and fisheries, accounting for 4.2% of total employment in the EU in 2019. Agriculture is a particularly important employer having represented, in 2019, in Romania, about 22% of the employed population, in Bulgaria 17% of the total employment, in Greece 11% and in Poland 9% (Eurostat DataBase; 24/04/2021).

The replacement rate of the legal and economic responsibility for the agricultural holding, called the “holder replacement rate", according to the methodology of

Regidor (2012) is the relationship between the number of holdings managed by farmers under the age of 35 and the number of holdings managed by farmers over 65 (number of farmers <35 years old / number of farmers ≥ 65 years old). This replacement rate was 16% for the EU28 in 2016. If we consider, as a denominator, the total number of farmers aged between 55 and 64, the rate increases to 20% (Table 1).

Table1: Replacement rates (by countries)

Age Group	Farmer <35 / Farmer between 55 -64 years old					Farmer <35 / Farmer≥ 65 years old				
Years	**2005**	**2007**	**2010**	**2013**	**2016**	**2005**	**2007**	**2010**	**2013**	**2016**
Portugal	0.10	0.09	0.10	0.10	0.08	0.05	0.05	0.06	0.05	0.04
EU-28	0.31	0.27	0.32	0.24	0.20	0.22	0.19	0.25	0.19	0.16

Source: Eurostat Database, accessed: 20/04/2021

Portugal is the second country with the lowest replacement rate after Cyprus, with a replacement rate for the ages between 55 and 64 years of 8% and, considering the most real substitution for those over 65 years old that rate drops to 4%. In Austria, Germany and Poland, substitution appears to be ensured. Despite the low rate of substitution, in Portugal there was a considerable number of young farmers entering in the period 2007/10, as a result of the start of the Rural Development Program (2007-2013). It supported 8,199 young farmers to settle as individual producers or as agricultural company's members, between 2008 and 2014. However, the data analyzed indicate that this growth didn't stay, we don't have the number of young farmers who left the activity.

Between 2013 and 2016, in the EU, the number of young farmers responsible for agricultural holdings, under the age of 35 years old, decreased by 17% and, in Portugal, the decline was 24%. In the previous period 2010/13, the decrease was 17%, lower than that observed in the EU28, which was -29%. In the EU28, the decline continued in 2016, but with a lower rate of decrease (17%) (Table 2). The results show that young farmers suffered a higher mortality rate on their farms than other age groups. One can always ask the question of passing between age groups. The number of holdings managed by farmers aged 35 years (<35 years) and the number of holdings operated by farmers in the 35-40 age group can be seen. In the year 2016, the 40-44-year-old rate had to be applied due to a lack of data in the previous age group.

It appears that between 2010 and 2013 and between 2013 and 2016 the rate of change of the age group between 40-44 years decreased more than in the previous age group. There does not seem to have been a transfer between these two age groups (Table 3). We can also explain this reduction by transferring the latter to the next age group. The analysis of the data does not seem to indicate this movement, except for the last age group in which there seems to have been an increase of the number of farmers due to natural ageing.

Table 2: Number of holdings by age group of the Farmer (holding manager) in the EU28 and Portugal

European Union (EU-28)											Rate of change				Change Rate
	2005		2007		2010		2013		2016		2005/	2007/	2010/	2013/	2005
Age Group	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	2007	2010	2013	2016	2016
<25	81,380	1%	72,300	1%	96,980	1%	57,560	1%	48,770	0%	-11%	34%	-41%	-15%	-40%
≥25 e ≤ 34	916,580	6%	788,300	6%	815,860	7%	586,800	5%	487,000	5%	-14%	3%	-28%	-17%	-47%
≥35 e ≤ 44	964,390	7%	2,087,670	15%	2,031,220	17%	1,654,510	15%	891,090	9%	116%	-3%	-19%	-46%	-8%
≥45 e ≤ 54	3,318,440	23%	3,154,630	23%	2,788,500	23%	2,489,490	23%	2,398,920	23%	-5%	-12%	-11%	-4%	-28%
≥ 55 ≤ 64	3,218,020	22%	3,131,950	23%	2,882,260	24%	2,683,630	25%	2,621,470	25%	-3%	-8%	-7%	-2%	-19%
≥65	4,616,810	32%	4,527,440	33%	3,631,020	30%	3,366,290	31%	3,436,000	33%	-2%	-20%	-7%	2%	-26%
TOTAL	14,482,010	91%	13,808,470	100%	12,245,700	100%	10,838,290	100%	10,467,850	94%	-5%	-11%	-11%	-3%	-28%
	Portugal										Rate of change				Change Rate
<25	380	0%	350	0%	580	0%	450	0%	450	0%	-8%	66%	-22%	0%	18%
≥25 e ≤ 34	7,250	2%	5,630	2%	7,280	2%	6,060	2%	4,540	2%	-22%	29%	-17%	-25%	-37%
≥35 e ≤ 44		0%	22,470	8%	25,080	8%	19,130	7%	10,520	4%		12%	-24%	-45%	-53% (**)
≥45 e ≤ 54	58,730	18%	48,350	18%	54,440	18%	44,020	17%	40,220	16%	-18%	13%	-19%	-9%	-32%
≥ 55 ≤ 64	79,010	24%	69,920	25%	75,960	25%	62,410	24%	62,370	24%	-12%	9%	-18%	0%	-21%
≥65	149,420	46%	128,360	47%	141,940	46%	132,350	50%	134,370	52%	-14%	11%	-7%	2%	-10%
TOTAL (*)	323,920	91%	275,080	100%	305,270	100%	264,420	100%	258,980	97%	-15%	11%	-15%	-2%	-20%

Note: (*) It is not considered 100% because there are several farms in which age is not considered. (**) The years 2007 and 2016 were considered.

Source: Eurostat Database, accessed in 03/20/2022

Table 3: Evolution of the number of holdings between two age groups

Group Class	2005	2007	2007/05	2010	2010/2007	2013	2013/2010	2016	2016/13
Portugal <35 anos	7630	5980	-22%	7860	31%	6510	-17%	4920	-24%
Portugal 35-40 Years *		22.470		25.080	12%	19.130	-24%	10.520	-45%
UE <35 years	997960	860600	-14%	912840	6%	644360	-29%	535770	-17%
UE 35-40 years *	964390	2087670	116%	2031220	-3%	1654510	-19%	891090	-46%

Note: (*) In 2016 the 40-44-years-old group was excluded. Source: Eurostat Database, accessed in 24/11/2020

Table 4: Variables of agricultural holdings by age group of the manager, per year in EU28 and Portugal

Countries	European Union (28)					Portugal				
Years	2005	2007	2010	2013	2016	2005	2007	2010	2013	2016
Variables per holding (all age groups) in total holdings										
UAA (Ha/Hold)	12	13	14	16	17	11	13	12	14	14
Nº farms with livestock/hold	0.6	0.6	0.6	0.6	0.5	0.7	0.7	0.7	0.6	0.7
self-consumption> 50% Final Prod /Hold	0.4	0.4	0.5	0.4	0.4	0.1	0.1	0.2	0.2	0.4
SO/HOLD: 1000 Euros/Hold	20	21	25	31	35	12	13	15	17	20
Farm variables managed by farmers <35 years of age in total age group holdings										
UAA (Ha/Hold)	16	17	20	25	22	30	35	31	27	31
Nº farms with livestock/hold	0.7	0.7	0.6	0.6	0.5	0.7	0.7	0.6	0.6	0.6
Self-consumption> 50% Final Prod /Hold	0.4	0.3	0.4	0.4	0.3	0.0	0.0	0.1	0.1	0.1
SO/HOLD: 1000 Euros/Hold	29	29	30	42	56	40	44	45	42	58
Farm variables managed by farmers aged ≥55 and ≤64 years in the total of age group holdings										
UAA (Ha/Hold)	12	13	15	17	17	10	12	11	14	15
Nº farms with livestock/hold	0.6	0.6	0.6	0.6	0.5	0.7	0.7	0.7	0.7	0.7
Self-consumption> 50% Final Prod /Hold	0.4	0.4	0.5	0.4	0.4	0.1	0.1	0.2	0.2	0.4
SO/HOLD: 1000 Euros/Hold	19	20	25	31	36	11	13	14	18	21
Farm variables managed by farmers aged ≥65 years in the total of age group holdings										
UAA (Ha/Hold)	5	5	6	7	8	8	8	7	9	8
Nº farms with livestock/hold	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.6	0.6	0.7
Self-consumption> 50% Final Prod /Hold	0.5	0.5	0.6	0.5	0.5	0.1	0.1	0.2	0.2	0.5
SO/HOLD: 1000 Euros/Hold	7	7	9	11	13	7	7	7	8	9

Source**:** Eurostat Database, accessed in 24/11/2020

To assess the role and relative importance of the young farmers in the EU28 agricultural sector, a number of key variables were analyzed, such as: the number of holdings, the useful agricultural area; the number of farms with livestock and the Total Agricultural Standard Output (SO) (Regidor, 2012). Farms presenting a self-consumption rate higher than 50% of the final production were also analyzed. This variable is an indicator of the business objectives of the farms and their relationship with the market.

In addition to observing the values for young farmers (<35 years), a comparison was made with farmers aged 55 to 64 years old (inclusive) who represent farmers established in the market and full working capacity. It was also compared with farmers aged 65 or over who are established farmers, but likely to be or will be retired, having reached retirement age (Table 4). The results show the relative importance of the young farmers (under the age of 35 years) in the EU28, for the agricultural transformation. The farms managed by young farmers are in many ways different from those managed by farmers of higher age groups.

The key variables are better for young farmers than for farmers in general. Considering income, in the age group <35 years, its importance in relation to the total universe and in relation to the other two age groups analyzed for farmers aged > 55 years and ≤ 64 years, it appears that the relative importance of Standard Output (SO) in young farmers is higher than their relative weight in the universe studied (Table 4). It should be noted that, in 2013 and 2016, this figure was lower than the European average. In the other age groups, between 55 and 64 years old, the importance of SO is similar to the relative weight of these farms, in the EU28 and in Portugal. In the age group of farmers over the age of 65, the importance of the SO is lower than the relative weight of the holdings, but in Portugal it is higher than the weight found in the EU. It should be noted that the relative weight of self-consumption in relation to the universe is much lower in young farmers who thus seem to have a productive orientation directed towards the market.

The Utilized Agricultural Area (UAA) has a relative weight greater than the relative weight of the number of holdings in the case of young farmers. In Portugal, between 2013 and 2016, the increase in almost all variables should be noted, except for the number of farms if we consider all age groups. For young farmers, between 2013 and 2016, it is worth noting the increase in farms aimed at self-consumption and the increase in SO. For the same period, and for the age group between 55 and 64 years old, there was an absolute increase in UAA, in farms with livestock, in farms directed towards self-consumption and a significant increase in SO. In the case of those over 65, there was an absolute increase in all variables apart from the UAA, which suffered a reduction. The increase in SO is higher than the increase in farms for this age group. Young farmers in Portugal have higher incomes than in the EU, in relation to the other age groups and in general. The values of self-consumption in Portugal seem to be lower than in the EU for young people, which is an interesting factor to analyze.

The UAA per farm is much higher in young farmers both in the EU and in Portugal, compared with the total of farms and with the other age groups analyzed. This variable is important because larger areas allow more competitive companies, with the application of economies of scale and modernization. However, the relationship between competitiveness, innovation, and the dimension of farms in terms of physical dimension is the subject of discussion in several studies (Latruffe, 2010; Sauer, 2017). It can be considered that young farmers who remain in the system have variables that allow them to have greater competitiveness in the market in relation to the older age groups and already established in the sector.

CONCLUSION

The lack of young people in agriculture is not only a problem for the sector but also for territorial development. It is imperative to promote territorial cohesion, reducing depopulation in rural areas, and the decline of the active population. Agriculture could play a key role in the development of the less favored areas but needs workers especially young and dynamic farmers.

Public policies are critical to respond to the challenges of the demographic crises, social inequalities, and territorial cohesion. The settlement of young farmers contributes to the solution of these problems, but the incentives are neither attractive nor adequate to take the desirable effect. Also, it is worth discussing the succession in the agricultural family farms, namely the availability of the elderly producers to leave or allow their successors to become the decision-makers of the family holding. Public policies can help breaking this cycle. Employment, to be created in rural areas should be public as well as private. In any case, the population is needed.

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SOCIOECONOMIC STATUS AND AGROFORESTRY READINESS: A CASE STUDY OF SELECTED COMMUNITIES IN THE OR TAMBO DISTRICT, EASTERN CAPE IN SOUTH AFRICA

Phokele MAPONYA[1*], Dean OELOFSE[1], Casper MADAKADZE[2], Nokwazi MBILI[3], Zakheleni DUBE[4], Thabo NKUNA[1], Meshack MAKHWEDZHANA[1], Takalani TAHULELA[5], Kgosi MONGWAKETSI[5]

[1]Agri. Res. Council-Vegetable, Industrial and Medicinal Plants, Pretoria, South Africa
[2]University of Pretoria, Faculty of Agriculture and Natural Science, South Africa
[3]University of KwaZulu-Natal, College of Agriculture, Engineering and Science, South Africa
[4]University of Mpumalanga, Faculty of Agriculture and Natural Science, South Africa
[5]South Africa Forestry Company Limited (SAFCOL) Research, SAFCOL (Pty) LTD, Sabie, South Africa
*Corresponding author: maponyap@arc.agric.za

ABSTRACT

This study pointed to the state of the community in terms of their socio-economic and agroforestry readiness in the OR Tambo District, which receives a median annual rainfall ranging between 800 and >1000 mm. In addition to favourable climatic conditions, the district has two plantations, namely the Mkambathi and Gqukunqa Forestry Enterprises, offering fertile ground to revive existing plantations, meaning that the community could immediately reap the benefits from the clear felling of the existing timber and agroforestry practices. Furthermore, the Agricultural Research Council conducted an assessment in collaboration with the Department of Agriculture, Land Reform and Rural Development aimed at identifying the community's socio-economic status. Fifty-six community members from five local municipalities were selected, using a purposive sampling technique, and assessed. Quantitative and qualitative research designs were employed, as a structured questionnaire in English was developed, focus group and stakeholder discussions were held, as well as field observations to elicit information for the study. Data were coded, captured, and analysed using the Software Package for Social Sciences. The decantal 1km X 1km approach was followed to determine the climatic conditions of the two plantations. Currently, profitable and suitable crops like dry beans, sugar beans and groundnuts were recommended to the stakeholders for agroforestry integration. The study recommended the establishment of agroforestry in the OR Tambo District as it satisfied the basic requirements for agroforestry readiness, i.e. good climatic conditions, land availability, availability of production inputs and the community's socio-economic status and involvement, towards food security.

Keywords: *Socio-Economic, Agroforestry, OR Tambo District, Eastern Cape Province, South Africa.*

INTRODUCTION

According to Nair (1985), several criteria can be used to classify and group agroforestry systems (and practices). The following are the most commonly used criteria: the system's structure (composition and arrangement of components), its function, its socio-economic scale and level of management, and its ecological spread. According to Nair (1985) structurally, the system can be grouped as agrosilviculture (crops - including tree/shrub crops - and trees), silvopastoral (pasture/animals + trees), and agrosilvopastoral (crops + pasture/animals + trees).

According to Maponya et al. (2019a; 2019b; 2021), agroforestry systems play a major role throughout human history in supporting livelihoods, assisting various communities to generate income, create job opportunities, as well as meeting food security and nutritional needs in the Limpopo Province. The researchers further indicated evidence of the importance of agroforestry systems (and timber-based mixed farming systems), especially silvipasture and agrosilvipasture, for supporting food production and income generation in the Limpopo Province. Some farmers in the Limpopo Province highlighted that they are generating income through renting of farms for grazing, selling trees to the communities to build shelters and kraals, medicinal purposes, fuelwood, etc.

Furthermore, South Africa is considered a semi-arid country vulnerable to water stress, particularly drought (Hassan, 2013). In the previous 7 years, South Africa has experienced the worst droughts in history, where some provinces were declared as disaster areas. The threshold for rain-fed agriculture is averaged at 250mm annually, and in terms of forestry, the rainfall needs to be higher than 750mm per annum to sustain commercial forestry. According to the ARC-SCW (2020), the OR Tambo District receives a median annual rainfall that ranges mostly between 800 and > 1000 mm. Climatically, the area is thus well suited to rain-fed arable agriculture where slopes and soils permit. A moderate summer peak in rainfall is evident. Summer rains start in September and the wettest months are November and December, and the driest months are May to August. In addition to good climatic conditions, the district has two plantations, namely, the Mkambathi and Gqukunqa Forestry Enterprises, which offers fertile ground to revive the existing plantations, meaning that the community could immediately reap the benefits from the clear felling of the existing timber and agroforestry practice.

Furthermore, the ARC conducted an assessment in collaboration with the Department of Agriculture, Land Reform and Rural Development (DALRRD) and the Department of Forestry, Fisheries and Environment (DFFE) aimed at identifying the community's socio-economic status and the rainfall conditions.

MATERIALS AND METHODS

According to Backeberg and Sanewe (2010), participatory action research is the most appropriate research method, since people, especially farmers, benefit while the research is ongoing. A participatory action approach was also recommended by various researchers who emphasised that this approach is a good alternative to the traditional “transfer of technology" or “top-down approach" to agricultural research and extension. Coordinates were received from the DFFE to plot the climate maps. As indicated in Figure 1, two forestry enterprises participated in the study, namely, the Mkambathi and Gqukunqa Forestry Enterprises.

The Mkambathi forestry project is situated about 60km from Flagstaff and 290 kilometres from the SAPPI pulp mill at Mkomaas in KwaZulu-Natal. It is located in the Ingquza Hill Local Municipality in the OR Tambo District Municipality. The Mkambathi community already had a gum plantation which was established by the then Transkei Agriculture Corporation (TRACOR) in 1980, making it easy to rehabilitate the existing plantation because the community would immediately reap the benefits from the clear-felling of the existing timber and agroforestry. The project employs 127 people from the eight villages (ECRDA, 2020). A total of 668,8ha was planted with *Eucalyptus dunnii*, which is suitable for the pulp market (ECRDA, 2020). Gqukunqa is situated in Qumbu in the north of the Eastern Cape about 40km from Maclear on the R56 Maclear/Mount Fletcher road. The project lies 60km from the PG Bison board mill at Ugie. Its total area is 1,578ha in extent. It is located in the Mhlontlo Local Municipality in the OR Tambo District Municipality. The area planted is approximately 605ha, resulting in the creation of 211 jobs from 18 villages. The area was planted with *Eucalyptus nitens*, which is suitable for the pulp market and pole market (ECRDA, 2020).

Quantitative and qualitative research designs were employed, as a structured questionnaire written in English was developed to elicit information for the study. More so, the study incorporated group discussions, stakeholders’ discussions, as well as field observations. As part of the standard protocol for conducting the study, meetings were held with all stakeholders namely: DALRRD, the DFFE and local community members. The goal of the meetings was intended to introduce and further explain the aims of the study.

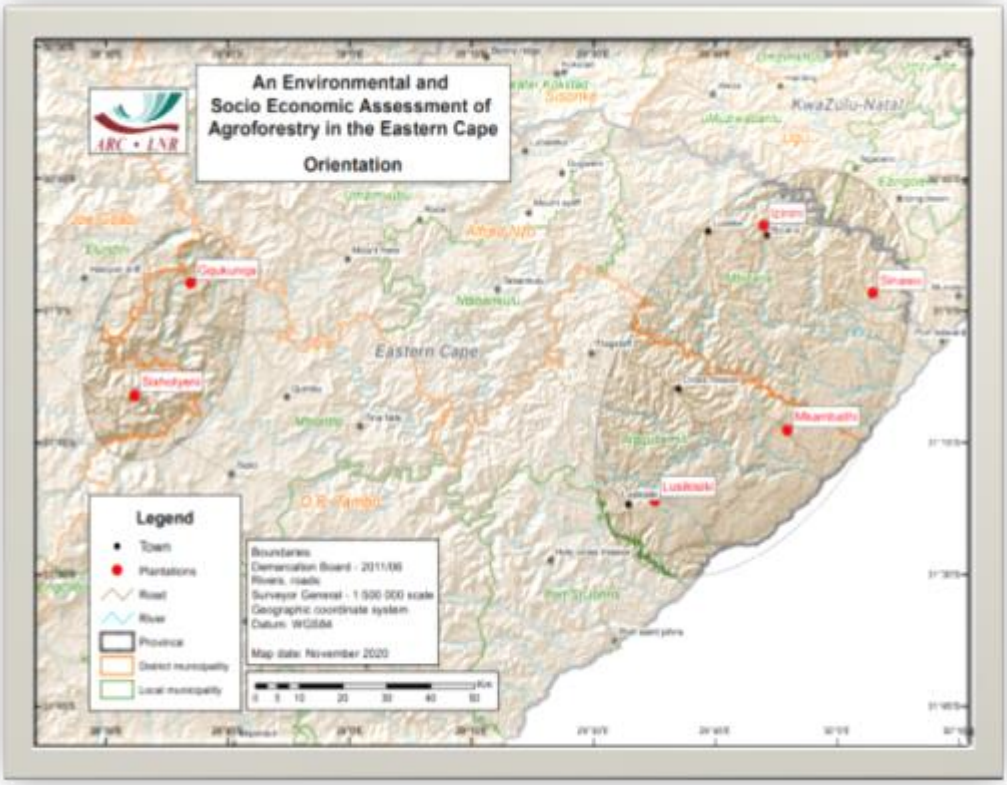

Figure 1: Agroforestry sites in the Eastern Cape, South Africa.
Source: ARC-SCW (2020).

A purposive sampling technique was employed in selecting 56 community members, in order to cover their uniformity and homogenous characteristics, such as infrastructure requirements, skills availability, production challenges, agricultural training needs, amongst other factors. The following approach was used to determine the average monthly rainfall (Malherbe and Tackrah, 2003): Decadal (ten day period) 1km x1km surfaces were created from rainfall data (1920-1999) downloaded from the AgroMet databank at the Agricultural Research Council- Soil, Climate and Water (ARC-SCW) (South African Weather Service and SCW weather stations), with a recording period of 10 years or more. Regression analysis and spatial modelling were utilized taking into account topographic indices such as altitude, aspect, slope and distance to the sea during the development of the surface. The socio-economic data was captured and analysed with Statistical Package for Social Sciences (SPSS).

RESULTS AND DISCUSSION

As indicated in Table 1, 56 community members from five local municipalities were assessed: King Sabata Dalindyebo (25%), Ngquza Hill (18%), Mhlontlo (16%), Nyandeni (25%) and Port St John (16%). The age distribution of the community members indicated that the majority (50%) fell within the age group of 46-60. Furthermore, as indicated in Table 1, the rest of the age categories were 18-35; 36-45 and >61, at 9%, 14% and 27%, respectively. In terms of education, 27% had incomplete primary education, 36% had completed primary education, 21% had incomplete secondary education, 5% had completed secondary education, and 9% had completed tertiary education, while 2% had incomplete tertiary education. The results in Table 1 further indicate that the gender composition consisted of 39% females and 61% males. As indicated in Table 1, all (100%) community members were farming full time and in terms of farming experience, about 45% of the community members had 1-5 years, 34% had 6-10 years, 20% had 11-20 years, and 2 % had >21 years of farming experience. Generally, OR Tambo community members had good farming experience, which makes them efficient in their decision-making processes and they are willing to take on the risks associated with the adoption of improved technologies, and they are ready for agroforestry integration.

Table 1 Distribution of community members according to their socio-economic characteristics

	Number of Community Members	**% Community Members Socio-Economic Characteristics**
Local Municipalities		
King Sabata Dalindyebo	14	25
Ngquza Hill	10	18
Mhlontlo	9	16
Nyandeni	14	25
Port St John	9	16
Total	56	100
Gender		
Female	22	39
Male	34	61
Total	56	100
Age Categories		
18 – 35	5	9
36 – 45	8	14
46 – 60	28	50
>61	15	27
Total	56	100
Level of Education		
Primary Education Incomplete	15	27
Primary Education Completed	20	36

Secondary Education Incomplete	12	21
Secondary Education Completed	3	5
Tertiary Education Incomplete	1	2
Tertiary Education Completed	5	9
Total	56	100
Employment Status		
Unemployed and community grower/farmer	56	100
Total	56	100
Farming Experience		
1 - 5	25	45
6 - 10	19	34
11 - 20	11	20
21>	1	2
Total	56	100

Figure 2. Community growers at the Gqukunqa Forestry Enterprise planting Eucalyptus trees and indicating their readiness for agroforestry integration.

In addition, timber-based mixed farming and agroforestry systems that have commercial timber species such as Eucalyptus as the woody component, are only suited in areas that receive sufficient rainfall to support the production of the trees (Maponya et al. 2021). In such areas, it is likely that there will be sufficient rainfall to support the other components of the system.

The rainfall maps were plotted during the 2020 planting season as follows: the average rainfall for September was fairly good (75-100mm) for most parts of the Eastern Cape Province agroforestry sites, as compared to the agricultural open field areas. The situation improves during October (101-150mm) with an increase in

rainfall in the areas in which the agroforestry sites are located. This situation is not surprising, as the DFFE had identified those sites as good for the establishment and expansion of agroforestry. The long-term increases in rainfall from November to December (see Figure 3) are experienced in the agroforestry sites. The agroforestry sites namely Mkambathi and Gqukunqa Forestry Enterprises were experiencing increased rainfall at 125-175mm and 125-175mm, respectively.

In terms of future estimates, three rainfall maps that show the 33rd percentile, the median (50th percentile) and the 67th percentile were drawn. To explain what these maps depict, one can consider the 33rd percentile. *If there were 100 years of recorded data arranged in sequence from dry to wet, then the 33rd percentile would be the value of the 33rd year. In other words, the chances are good that this rainfall figure would be exceeded, or the chances are small that you will have less rain*. The model estimated annual rainfalls for the broad study area at 801- >1000mm for the 33rd percentile; 901- >1000 at the 50th percentile and >1000mm at the 67th percentile (see Figure 4). These agroforestry sites will allow for timber production and will thus support agroforestry / timber-based mixed farming systems.

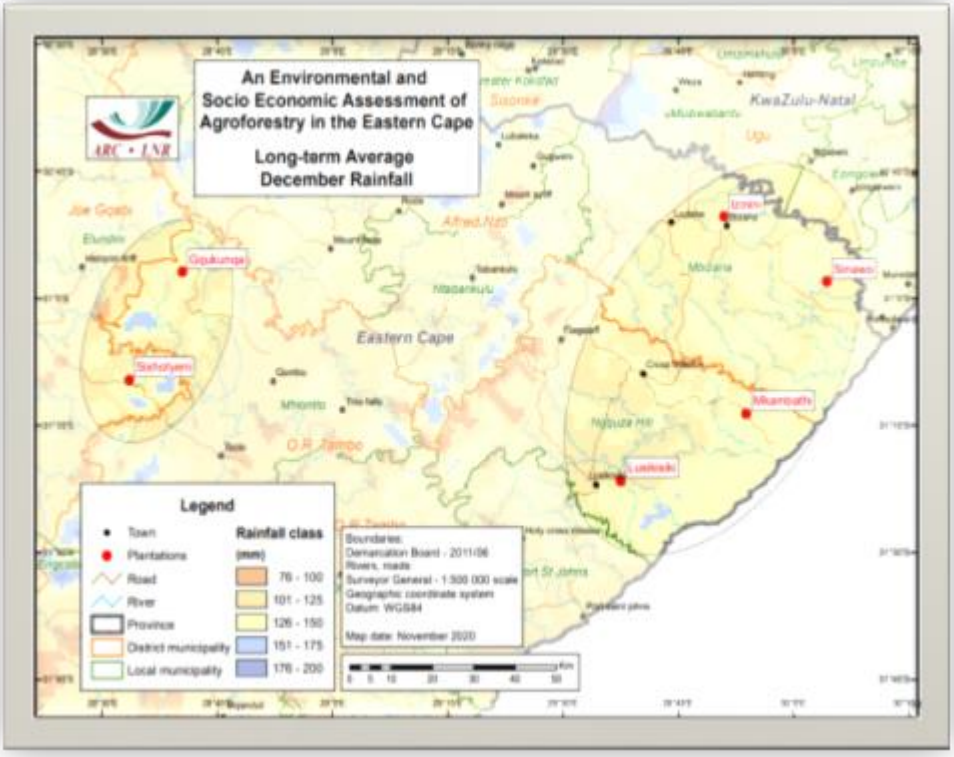

Figure 3. Eastern Cape Province long-term average December rainfall.
Source: ARC-SCW (2020).

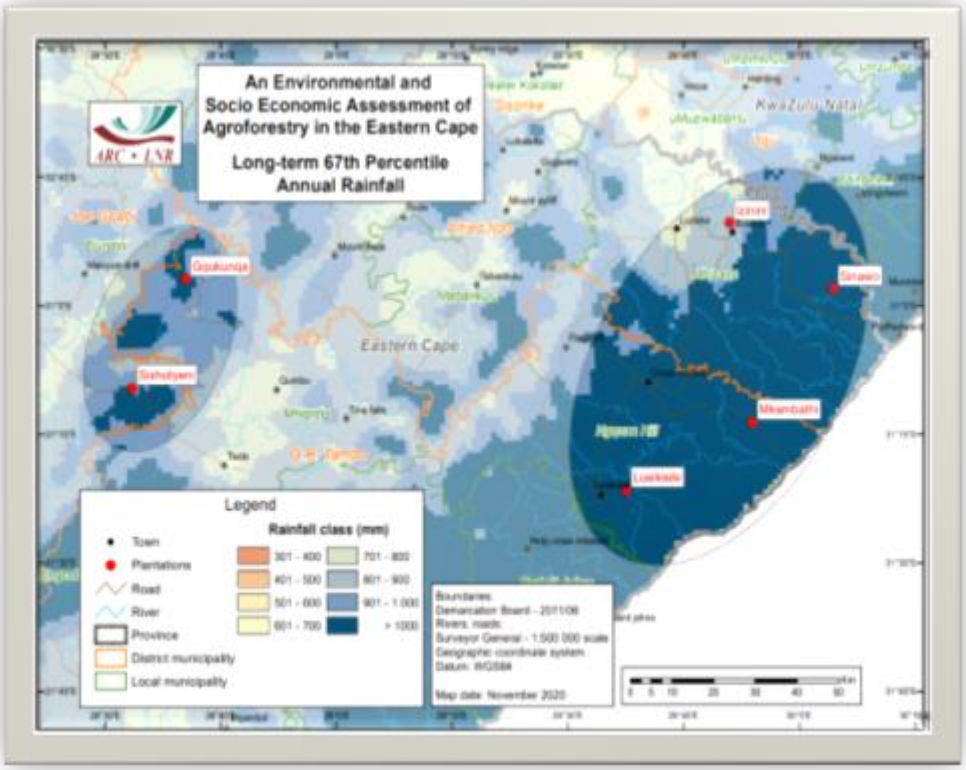

Figure 4. Eastern Cape Province long-term 67th percentile annual rainfall
Source: ARC-SCW (2020).

CONCLUSION

In conclusion, the most important socio economic factors associated with variation in levels of motivation to conserve trees on farms included gender, age, education level, experience and employment status to name a few. The research also indicated that communities have moved away from their villages to the study area in search of its good climate and land. Furthermore, the communities indicated that they are ready to practice agroforestry, as it will improve their livelihood through income generation, job creation and food security as seen in Limpopo and Mpumalanga Provinces. Hence, the research concluded that an agroforestry project will be more successful if the diversity of community socio-economic characteristics, climate and their perceptions are considered in its design.In addition, profitable and suitable crops like dry beans, sugar beans and groundnuts were recommended to the DFFE for agroforestry integration in the OR Tambo District and other agroforestry sites in the Eastern Cape Province. The research recommends that the establishment and expansion of agroforestry be carried out in the identified suitable areas and in line with the Department of Agriculture, Forestry and Fisheries Agroforestry 2017 Implementation Strategy, as these

satisfied the basic requirements for agroforestry readiness, i.e. good climatic conditions, land availability, production inputs availability and the communities' socio-economic issues and involvement, towards food security.

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MEDITERRANEAN DIET IN THE WESTERN BALKANS

Hamid EL BILALI*, Gianluigi CARDONE, Francesco BOTTALICO, Giovanni OTTOMANO PALMISANO, Antonia ACQUAFREDDA, Roberto CAPONE

International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM-Bari), Valenzano (Bari), Italy
*Corresponding author: elbilali@iamb.it

ABSTRACT

The Mediterranean diet is considered an example of sustainable diets and an intangible cultural heritage of the whole humanity. However, attention to the Mediterranean diet changes from a country to another even within the Euro-Mediterranean region. In this context, this paper analyses the state of research on the Mediterranean diet in the Western Balkans (viz. Albania, Bosnia and Herzegovina, Croatia, Kosovo, North Macedonia, Montenegro, and Serbia). In particular, it explores whether and how environmental, economic, sociocultural, and nutrition-health aspects related to the sustainability of the Mediterranean diet are addressed. A search performed in June 2021 on the Web of Science returned 68 documents, and 41 of them were included in the systematic review. Most of the selected documents deal with Croatia, especially island regions, and focus on health-nutrition aspects while other sustainability dimensions are generally overlooked. The scholarly literature shows that higher adherence to the Mediterranean diet is associated with reduced risk of obesity, different non-communicable diseases (e.g. diabetes, cardiovascular diseases, cancers, metabolic syndrome) as well as mental illnesses. However, it also highlights a decrease in the Mediterranean diet adherence even in Mediterranean/Adriatic territories. Interestingly, some recent studies showed a shift towards the Mediterranean diet during the COVID-19 lockdown even among adolescents. The analysis suggests the need to adopt a holistic approach in studies on the Mediterranean diet to better understand the relationships between the sustainability dimensions and operationalize its contribution to the transformation of food systems and the achievement of the Sustainable Development Goals in the Mediterranean region.

Keywords: *Mediterranean, COVID-19, health, nutrition, sustainable diets.*

INTRODUCTION

The Mediterranean diet (MD) is considered nowadays as an example of sustainable diets (Burlingame & Dernini, 2011). It was first presented by Ancel Keys in the seven countries study (Keys, 1970; Keys et al., 2017), and it was inscribed in 2010 by the United Nations' Educational, Scientific and Cultural Organization

(UNESCO) on the Representative List of the Intangible Cultural Heritage of Humanity (UNESCO, 2010). The Mediterranean diet is the result of the millennial history of the Mediterranean (Berry et al., 2011) and is characterized by its strong links to the food cultures and traditions of the different Mediterranean countries. The general term 'Mediterranean diet' implies a common dietary pattern in Mediterranean countries, although there are differences in the dietary patterns of the Mediterranean populations. Indeed, Mediterranean diets are far from homogeneous, since they involve a wealth of typical products and are extremely varied. This 'dietary polymorphism' partially reflects religious and cultural differences (Berry et al., 2011). The Mediterranean diet not only offers considerable health benefits (Kastorini et al., 2011; Keys et al., 2017; Serra-Majem et al., 2006; Sofi et al., 2008) but also respects the environment (Aboussaleh et al., 2017, 2020; Galli et al., 2017). Indeed, the Mediterranean diet, as highlighted in the Med Diet 4.0 framework (Dernini et al., 2017), has multiple sustainability benefits: 1) recognized and well-documented major health and nutrition benefits, 2) low environmental impacts and richness in biodiversity, 3) high positive local economic returns, and 4) high social and cultural value of food.

Despite its well-documented multiple and multifaceted benefits, recent data show a decline in adherence to the Mediterranean diet in Mediterranean countries (Belahsen & Rguibi, 2006; da Silva et al., 2009; León-Muñoz et al., 2012; Naja et al., 2021). Paradoxically, just as the Mediterranean diet is becoming more popular in the world and increasingly recognised by the international scientific community, the Mediterranean populations are moving away from this dietary model (Lacirignola & Capone, 2009; Naja et al., 2021). In this context, Dernini et al. (2017), and more recently Dernini and Capone (2021), called for a revitalization of the Mediterranean diet by improving its current perception (especially among the young) not only as a healthy diet but also as a sustainable lifestyle model.

In this context, the present article analyses the state of research on the Mediterranean diet in the Western Balkans (viz. Albania, Bosnia and Herzegovina, Croatia, North Macedonia, Montenegro, Kosovo and Serbia). Most of the target countries in this article (viz. Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia and Serbia/Kosovo) were part of the Former Yugoslavia and included in the seven countries study by Ancel Keys (Keys, 1970; Keys et al., 2017). However, interest in the Mediterranean diet does not only change from a country to another but also over time. In particular, the article explores whether and how environmental, economic, sociocultural, and nutrition-health aspects related to the Mediterranean diet sustainability are addressed in the scholarly literature.

MATERIAL AND METHODS

The article is based on a systematic review of all documents indexed in the Web of Science (WoS). A search was performed in June 2021 on WoS using the search query *"Mediterranean diet" AND (Balkan OR "Southeast* Europe" OR Albania OR Bosnia OR Croatia OR Macedonia OR Montenegro OR Kosovo OR Serbia)*

and returned 68 documents. Three eligibility criteria were considered: geographical coverage (viz. dealing with at least one Western Balkan country), thematic focus (viz. addressing the Mediterranean diet), and document type (viz. research articles, book chapters or conference papers; reviews were excluded). Following the analysis of titles, abstracts and full-texts, 27 documents were excluded. Therefore, 41 documents were included in this systematic review (Table 1).

RESULTS AND DISCUSSION

The analysis of the geography of research shows that different attention is devoted to the Mediterranean diet in all Western Balkan countries. Indeed, the lion's share of studies deals exclusively with or include Croatia i.e. 30 out of 41 studies (Table 1). This is rather normal and somehow expected as Croatia is the only big country with a long Adriatic coast and a large share of land area with Mediterranean climate in the region; Albania and Bosnia and Herzegovina have Adriatic coasts, but the remaining countries (viz. North Macedonia, Kosovo, Serbia) are landlocked ones. Many of the articles dealing with Croatia provide comparisons between island regions (e.g. Dalmatia) and continental ones (e.g. Slavonia). The landlocked countries are generally considered only in multi-country studies where they are taken as examples of non-Mediterranean countries e.g. North Macedonia (Quarta et al., 2021) and Serbia (Novak et al., 2017; Willey et al., 2020).

Most of the analysed studies refer to adults but some address specifically non-adults such as children (Salcin et al., 2019) or adolescents/teenagers (Cena et al., 2021; Dragun et al., 2020). As for the studies on adults, while most address the whole population, others focus on specific groups such as pregnant women (Havaš Auguštin et al., 2020), breastfeeding women (Krešić et al., 2013), workers (Jovanović et al., 2020; Žeželj et al., 2018) or elderly people (Vrdoljak et al., 2014).

Table 1. Overview of studies on the Mediterranean diet in the Western Balkans.

Study	**Country/Region**	**Subjects/Target group**	**Disease(s)**
Sulejmani et al. (2021)	Kosovo	Adults	Obesity
Quarta et al. (2021)	Europe[1]	Adults	Obesity
Marendić et al. (2021)	Croatia	Adolescents and adults (students)	--
Sadiku et al. (2021)	Albania	Adults	Erosive reflux esophagitis
Cena et al. (2021)	Euro-Mediterranean[2]	Adolescents and young adults (health sciences students)	Obesity
Dragun et al. (2020)	Croatia	Adolescents/Medical Students	Psychological well-being

Study	Country/Region	Subjects/Target group	Disease(s)
García-Conesa et al. (2020)	Europe[3]	Adults	--
Havaš Auguštin et al. (2020)	Croatia	Pregnant women	---
Willey et al. (2020)	Global[4]	Adults	Obesity and type 2 diabetes
Veček et al. (2020)	Croatia	Adults	Metabolic syndrome
Jovanović et al. (2020)	Croatia	Working population	Metabolic syndrome
Guiné et al. (2019)	Mediterranean[5]	Adults	--
Ahmed et al. (2019)	Global[6]	--	--
Salcin et al. (2019)	Croatia	Preschool children	Obesity
Salvatore et al. (2019)	Croatia	Adults	Mental distress
Žeželj et al. (2019)	Croatia	Working population	--
Božina et al. (2018)	Croatia	Adults	Metabolic syndrome
Žeželj et al. (2018)	Croatia	Working population	Cardiovascular diseases
Sikic et al. (2017)	Croatia	Adults	Cardiovascular diseases
Chang et al. (2017)	Global[7]	--	--
Štefan et al. (2017)	Croatia	Young adults/university students	Obesity
Novak et al. (2017)	Lithuania and Serbia	Adolescents	Obesity
Bosanac et al. (2016)	Croatia	Adolescents	Obesity
Kolčić et al. (2016)	Croatia	Adults	--
Mone et al. (2016)	Albania	Adults	Gastroesophageal reflux
Papandreou and Tuomilehto (2014)	Global[8]	Adults	Coronary heart disease (CHD)
Vrdoljak et	Croatia	Elderly population	--

Study	Country/Region	Subjects/Target group	Disease(s)
al. (2014)			
Višković et al. (2013)	Croatia	Adults (HIV-infected patients)	Subclinical atherosclerosis
Ivezić-Lalić (2013)	Croatia	Adults	Metabolic syndrome
Sahay et al. (2013)	Croatia	Adults	Metabolic syndrome
Krešić et al. (2013)	Croatia	Breastfeeding women	--
Missoni (2012)	Croatia	--	Various diseases
Dzono-Boban et al. (2012)	Croatia	0-64 years	Cardiovascular diseases
Damjanović et al. (2009)	Bosnia and Herzegovina	Adults	Rheumatoid arthritis
Materljan et al. (2009)	Croatia	Adults	Multiple sclerosis and cancers
Kolcić et al. (2009)	Croatia	Adults	Hypertension and obesity
Deka et al. (2008)	Croatia	Adults	Metabolic syndrome
Buretić-Tomljanović et al. (2007)	Croatia	Adults	Body height and craniofacial traits
Pucarin-Cvetković et al. (2006)	Croatia	Adults	Obesity and cardiovascular diseases
Noah and Truswell (2003)	Global[9]	--	--

[1] Spain, Portugal, Italy, Greece, Cyprus, Bulgaria and North Macedonia.
[2] Croatia, Italy, Lebanon, Poland, Romania, Spain and Turkey.
[3] Greece, Portugal, Italy, Spain, Cyprus, North Macedonia and Bulgaria.
[4] Argentina, Germany, Poland, Serbia, Slovakia, Slovenia, Spain, Turkey and USA.
[5] Croatia, Egypt, Italy, Greece and Portugal.
[6] Albania, Australia, Brazil, Grenada, Qatar, Netherlands, Sweden, Thailand, UK and USA.
[7] Finland, USA, Netherlands, Italy, Greece, Japan and Former Yugoslavia (Croatia and Serbia).
[8] Finland, USA, Netherlands, Italy, Greece, Japan and Former Yugoslavia (Montenegro and Serbia).
[9] Australia, Spain, France, Italy, Malta, Croatia, Bosnia, Albania, Greece, Cyprus, Turkey, Syria, Lebanon, Israel, Egypt, Libya, Tunisia, Algeria and Morocco.

The selected documents focus on health-nutrition aspects while environmental, economic and socio-cultural issues are generally overlooked. One of the few exceptions is the study of Ahmed et al. (2019) that analyse whether and how sustainability is integrated into National Dietary Guidelines in randomly selected high-income and upper-middle-income countries, including Albania, by developing and applying a sustainability framework scoring tool comprised of four key dimensions (environmental, economic, human health, and sociocultural and political). Their results show that human health is by far the most represented while the environmental, economic, and socio-cultural and political dimensions of sustainability are underrepresented in the dietary guidelines examined (Ahmed et al., 2019). Guiné et al. (2019) investigate the issues related to food choice and consumption patterns (e.g. health, economic, emotional, social, cultural and religious, marketing, environmental) in different countries (viz. Croatia, Egypt, Italy, Greece and Portugal) and conclude that "*in all five countries the motivations related to health as well as environment and politics were the more relevant to determine people's eating habits*" (p. 1126).

As for health-nutrition aspects, the scholarly literature deals with the association between the Mediterranean diet and obesity (Salcin et al., 2019; Willey et al., 2020); different non-communicable diseases (NCDs) such as diabetes (Willey et al., 2020), cardiovascular diseases (Papandreou & Tuomilehto, 2014; Sikic et al., 2017; Žeželj et al., 2018), cancers (Materljan et al., 2009), metabolic syndrome (Veček et al., 2020); as well as mental health and psychological well-being (Dragun et al., 2020; Salvatore et al., 2019). The results of the studies confirm that higher adherence to the Mediterranean diet is associated with reduced risk of diseases such as metabolic syndrome (Božina et al., 2018), cardiovascular diseases (Sikic et al., 2017), gastroesophageal reflux (Mone et al., 2016), subclinical atherosclerosis (Višković et al., 2013) and rheumatoid arthritis (Damjanović et al., 2009). For instance, Jovanović et al. (2020) found that the pro-inflammatory diet (i.e. inflammatory potential of the diet), which is significantly related to the metabolic syndrome, was statistically associated with lower adherence to a Mediterranean diet. Salvatore et al. (2019) point out that the Mediterranean diet compliance was associated with lesser mental distress in Dalmatia (Croatia). Buretić-Tomljanović et al. (2007) analyse the effects of environmental factors on body height and craniofacial variability in Croatia and conclude that "*Higher body height measures in both sexes were significantly correlated with Mediterranean diet type*" (p. 296).

The adherence to the Mediterranean diet was evaluated using various scores and metrics such as the Mediterranean Diet Adherence Screener (MEDAS) (García-Conesa et al., 2020; Quarta et al., 2021), the Mediterranean Diet Serving Score (MDSS) (Kolčić et al., 2016; Marendić et al., 2021; Salvatore et al., 2019; Veček et al., 2020), the Mediterranean Diet Quality Index (KIDMED) (Novak et al., 2017; Salcin et al., 2019) and the Mediterranean Adequacy Index (MAI) (Chang et al., 2017). In this respect, several studies point out the moderate to weak adherence to the Mediterranean diet (Havaš Auguštin et al., 2020; Kolčić et al., 2016; Quarta et

al., 2021). Kolčić et al. (2016) report that in a cross-sectional study encompassing 2768 Dalmatians from Korcula and Vis islands and Split city (Croatia) only 23% of the participants were classified as being adherent to the Mediterranean diet. Therefore, Quarta et al. (2021) suggest that "*the campaigns carried out to support and reinforce the MD and to promote plant-based foods have limited success across Southern Europe, and that more hard-hitting strategies are needed*". The low Mediterranean diet adherence is exemplified, among others, by low scoring for plant-based foods (Quarta et al., 2021).

More recently, some studies analysed the effects of the COVID-19 pandemic, and the related lockdown and confinement measures, on diets (Dragun et al., 2020; Sulejmani et al., 2021). For instance, Sulejmani et al. (2021) argue that female survey participants as well as those in family home residence or with professional educations reported a higher likelihood of turning into a higher adherence to the Mediterranean diet during the lockdown in Kosovo. Dragun et al. (2020) found an increased adherence to the Mediterranean diet pyramid for fruit, legumes, fish and sweets during the COVID-19 lockdown among adolescents and medical students in Split (Croatia).

CONCLUSIONS

The present article provides a comprehensive analysis of the scholarly literature on the Mediterranean diet and its sustainability (environmental, economic, sociocultural, and nutrition-health) in the Western Balkans. Most of the selected documents deal with Croatia, especially the island regions of the country. The selected documents focus on health-nutrition aspects while environmental, economic and socio-cultural issues are generally overlooked. As for health-nutrition aspects, the scholarly literature deals with the association between the Mediterranean diet and obesity, different NCDs (e.g. diabetes, cardiovascular diseases, cancers, metabolic syndrome) as well as mental health. The considered studies confirm that higher adherence to the Mediterranean diet is associated with reduced risk of diseases such as metabolic syndrome, cardiovascular diseases, gastroesophageal reflux, subclinical atherosclerosis and rheumatoid arthritis. However, the scholarly literature also highlights a decrease in adherence to the Mediterranean diet even in Mediterranean/Adriatic territories. Interestingly, some recent studies showed a shift towards the Mediterranean diet during the COVID-19 lockdown even among adolescents, which can represent a turning point towards more sustainable diets that are more aligned with the Mediterranean dietary model in the region. All in all, the analysis suggests that there is a need to adopt a holistic approach in studies on the Mediterranean diet in order to highlight its multiple and multifaceted benefits as well as synergies and trade-offs among them. The Mediterranean diet should be considered no more merely as a healthy diet but also as a sustainable diet with environmental, economic and socio-cultural benefits. This is crucial to better conceptualize and operationalise the contribution of the Mediterranean diet to the transformation of food systems and the achievement of the Sustainable Development Goals (SDGs) in the region.

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UNDERSTANDING THE ROLE OF THE COMMON AGRICULTURAL POLICY IN ACHIEVING SUSTAINABILITY AND RURAL DEVELOPMENT GOALS

Valeria SODANO[1*], Maria Teresa GORGITANO[2]

[1]Department of Political Science, University of Naples Federico II, Napoli, Italy
[2]Department of Agricultural Sciences, University of Naples Federico II, Portici, Italy
*Corresponding author: vsodano@unina.it

ABSTRACT

In view of the forthcoming Common Agricultural Policy (CAP) reform, it is important to add information on the results of the current CAP in relation to the objectives it tried to achieve so far. The paper endeavors to understand whether in Italy the CAP has reached the stated societal and environmental goals, with emphasis on sustainability and rural development. In order to achieve such aim, we built a set of descriptive statistics using the data set which reports information on the beneficiaries of CAP payments, in accordance with the transparency rules set by Regulation (EU) No 908/2014. The results indicate that CAP interventions in Italy have not been able to achieve all the objectives set by the Ciolos reform for correcting the weaknesses of the previous CAP. First, we found that neither the correction of the excesses of aid to large beneficiaries nor the aid redistribution towards the weaker farmers have been achieved, due to the strong asymmetry in the distribution of direct aid. Second, we found that environmental objectives, received scarce resources. Third, our results also showed the inability of the CAP in supporting small traditional farmers and maintaining a living and healthy economic and social fabric in the rural areas of the country. These results are interesting as regards the debate on the new CAP, which seems not able to overcome the old CAP shortcomings in terms of sustainability and rural development.

Keywords: *Common Agricultural Policy, Sustainability, Rural Development.*

INTRODUCTION

Over the years, the CAP has undergone important changes in order to be tuned with the new institutional, economic and societal contexts. The Ciolos reform (Swinnen, 2015), which shaped the policies that were carried out from 2015 to 2021, was defined by the EU as a "partnership between agriculture and society, and between Europe and its farmers" with the following objectives (European Commission, 2021): agricultural productivity, ensuring a stable supply of affordable food; safeguard European Union farmers to make a reasonable living;

help tackle climate change and the sustainable management of natural resources; maintain rural areas and landscapes across the EU; keep the rural economy alive by promoting jobs in farming industries and associated sectors and fighting poverty.

While the new focus of Ciolos reform on societal and environmental goals increased the acceptance of the high CAP costs on the part of European citizens, it is not clear how much these new goals were actually reached (Pe'er *et al.*, 2020). The common monitoring and evaluation framework appointed to assess the performance of the CAP and also independent studies (IPES-Food, 2019; Walls *et al.*, 2016) have shown that there is scant evidence that the CAP has contributed to increasing the sustainability of EU agriculture. Many doubts have also been casted on the positive social outcomes, due to the unfairness in the distribution of farmers' income support and the persisting poverty in many low developed rural areas (European Commission, 2018a; Garrone *et al*., 2019; Quiroga *et al*., 2017). In view of the forthcoming CAP reform, it is important to add information on the results of the current CAP in relation to the objectives it would have liked to achieve.

The goal of this paper is to understand whether in Italy CAP funds reached farmers, territories and agricultural sectors in a way which is consistent with the stated CAP objectives. Stemming from the information on CAP beneficiaries available on the EU website, statistical indicators were built to assess the achievements with respect to the main CAP goals.

MATERIALS AND METHODS

The aim of our analysis is to tentatively exploring whether the implementation of the Ciolos reform in Italy has been able to reach its three main goals: 1) Correcting the unequal distribution of farm income support; 2) addressing the environmental issues; 3) increasing resources for rural development (balanced territorial development).

In order to achieve such aim, we built a set of descriptive statistics using the data set which reports information on the beneficiaries of CAP payments, in accordance with the transparency rules set by Regulation (EU) No 908/2014. This information is published, all on one website, by the EU countries themselves from the 31 May of the year after the payments were made and is publicly available for two years after its publication. For funding from the European agricultural fund for rural development (EAFRD), the amounts published include both the money received from the EU funds and from the EU countries. Available information in the data set include: the name of the beneficiary; the municipality where the beneficiary is resident or is registered; the type of company; the breakdown of the amounts of payments for each individual measure received by each beneficiary in the financial year; details of the measures financed by the funds, including the nature and the objective of each measure. Used data refer to Italy and to the financial year 2017.

For each of the three aforementioned investigated objectives the following indicators were used.

For the first objective, we used as main indicator the distribution of payments to farmers by payment category; using Lorenz curves, we tested whether the rule 80-20 (80% of beneficiaries receiving 20% of payment amounts) applies.

In order to assess the achievement of environmental goals, we investigated the payments made for those measures (hereafter environmental measures) which, within the PAC second pillar (i.e. structural aids), are aimed at reaching the two priorities devoted to environmental issues. According to the EC working paper "Elements of strategic programming for the period 2014-2020" (European Commission, 2012), we considered the following environmental measures (M): M8, investments in forest area development and viability of forests; M10, Agri-environment-climate; M11, Organic farming; M13, Payments in Areas facing Natural or other specific Constraints (ANCs); M12, Natura 2000 and Water Framework Directive payments; M15, Forest environment and forest conservation.

With respect to the goals of increasing resources for rural development (balanced territorial development), we considered payments for the following measures which, according to the already quoted EC working paper (European Commission, 2012), are aimed at reaching priority 6 (promoting social inclusion, poverty reduction and economic development in rural areas): M6, Farm and business development; M7, Basic services and village renewal in rural areas; M19, LEADER.

RESULTS AND DISCUSSION

Reports on the distribution of direct payments to farmers, periodically published by the European Commission, show that payments tend to be uneven with about 80% of the farmers receiving 20% of the direct payments, which means that the remaining 20% receives the considerable share of 80% (European Commission, 2018b). Therefore, the distribution follows the "power law" that was used by Pareto as a simple rough indicator for measuring wealth inequalities within societies. For the financial year 2017 our data confirm the 80-20 power law as shown in figure 1, that draws the cumulative share of beneficiaries against the cumulative share of paid amounts for the direct payments aids (section *a*, reg. 1307/2013) and rural development program aid (section *b*, reg. 1305/2013). In both graphics data for the five groups of Italian regions (North-East, North-West, Center, South, Islands) are shown. Even with some differences in their slope all the curves indicate an uneven aid distribution with 70% to 85% of beneficiaries receiving around 20% of total amounts.

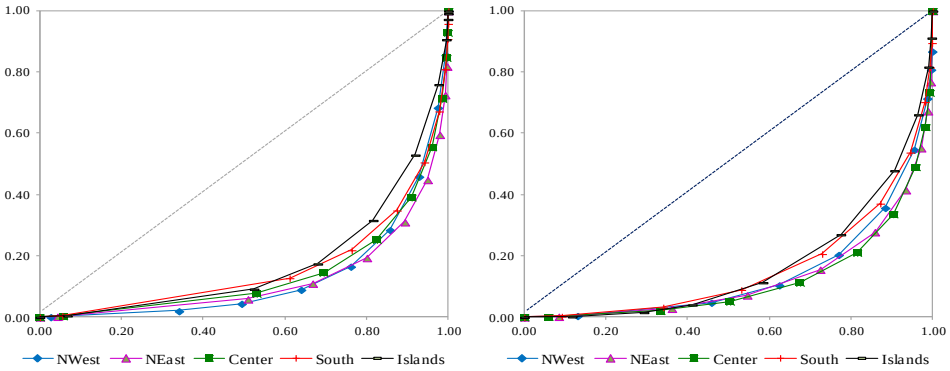

Figure 1. Lorenz Curve for Direct Payments (section *a*, on the left) and RD Programs (section *b*, on the right).

With respect to the environmental measures in Italy in the financial year 2017 (see table 1), only three measures, M10, M11 and M13 received significant aid amounts. M10 (Agri-environment-climate) and M11 (Organic farming) received about 327 and 329 million euros respectively, accounting together for 40% of all rural development payments (RDPs); M13 (ANCs) received about 330 million (20.2%). The other three measures M8, M12 and M15 received respectively only 4.25%, 0.03% and 0.15% of all RDPs. While M13 accounts for considerable resources, it cannot be deemed to directly provide incentives for a more environment friendly agriculture. Although it is classified as an environmental measure, it mainly helps reach goals of social sustainability, by maintaining activities and population in disadvantaged areas. M10 and M11 therefore represent the only instruments of the CAP for achieving environment goals, but only the measure M11 has been widely recognized as being able to achieve significative environmental goals (Adewale *et al*., 2018; Meemken, Qaim, 2018; Cristache *et al*., 2018). In Italy, as shown in table 2, recipients of M10 were concentrated in more developed regions (mostly in northern Italy), where there were about 41,773 recipients for M10 and only 15,326 for M11. On the contrary recipients of M11 were prevalent in less developed regions (all in the southern Italy), where there were 19,483 beneficiaries for M11 and 10,599 for M10. Overall, in Italy, the average aid per farm was much higher for M11 (8,827) than for M10 (5,790). These results indicate that organic agriculture seems to be used by southern regions for improving their economic results. Instead, it is not widely used to genuinely reach a more sustainable agriculture, especially in the rich northern regions where, moreover, the more polluting intensive agriculture is concentrated. With respect to the goals of rural development, in 2017 (see table 1) for rural development policies were spent in Italy 1,630 million euros, which amounts to about 27% of the 2017 total CAP expenditure (the remaining expenditure is made up of 62% by direct payments and 10% by Common Market Organizations - CMOs and other payments.

Table 1. Italy - 2017. CAP beneficiaries and financial support.

CAP Measures	Beneficia	Financial Supports			
		Total		Mean	SD
	number	million euros	%	euros	
DIRECT PAYMENTS*	**838,134**	**3,751**	**100**	**4,475**	**17,454**
Small farmers scheme+	291,118	173.5	4.6	596	288
Basic payment +	551,046	2,095.9	55.9	3,803	11,811
Greening +	548,087	1,044.2	27.8	1,905	6,015
Young farmers +	27,878	32.6	0.9	1,169	2,565
Voluntary coupled support ++	310,954	405.0	10.8	1,303	7,060
CMO*	**20,555**	**640**	**100**	**31,148**	**376,328**
RURAL DEVELOPMENT** (a)	**219,220**	**1,630**	**100**	**7,436**	**37,865**
M1 - Knowledge transfer and information actions	239	10.4	0.6	43,723	182,013
M2 - Advisory services, farm management and farm relief services	311	0.4	0.0	1,225	364
M3 - Quality schemes for agricultural products and foodstuffs	1,013	7.6	0.5	7,467	40,879
M4 - Investments in physical assets	4,088	276.9	16.9	67,745	173,071
M5 - Restoring agricultural production potential /prevention	100	3.3	0.2	33,392	40,462
M6 - Supporting farm and business development	2,264	86.1	5.3	38,019	47,206
M7 - Basic services and village reveal in rural areas	165	9.5	0.6	57,766	109,882
M8 - Investments in forest area and viability of forests	11,506	70.4	4.3	6,115	89,224
M10 - Agri-environment-climate	56,439	326.8	20.0	5,790	15,110
M11 - Organic farming	37,273	329.0	20.1	8,827	14,028
M12 - Natura 2000 and WFD payments	228	0.6	0.0	2,578	5,517
M13 - Payments of areas facing natural and other specific constraints	124,181	330.4	20.2	2,661	4,012
M14 - Animal welfare	10,656	49.4	3.0	4,631	8,077
M15 - Forest-environmental /climate services /foret conservation	79	2.3	0.1	29,273	63,573
M16 - Cooperation	84	7.4	0.5	88,197	137,501
M17 - Risk management	35,268	90.3	5.5	2,561	6,622
M19 - Leader	576	21.7	1.3	37,739	78,529
M20 - Technical assistance in Member States	23	7.5	0.5	326,742	656,810

Legend: *European EAGF financial support.**National and European EAFRD financial support. +Decoupled direct aids. ++Coupled direct aids. (a) Measure 9 - No payments were made during the this administrative year. Measure 18 - It was not planned.

Table 2. Italy - 2017. CAP and regions' development level

CAP Measures		Regions Development Level	Benefici	Financial Supports			
			number	Total million euros	%	Mean euros	SD euros
DIRECT PAYMENTS*		Developed Regions	344,622	2,221	59.2	6,445	25,173
		Transtion Regions	76,105	282	7.5	3,703	579,978
		Less Developed Regions	417,383	1,248	33.3	2,989	8,460
CMO*		Developed Regions	14,975	443	69.3	29,615	432,422
		Transtion Regions	1,922	35	5.4	18,147	78,301
		Less Developed Regions	3,658	162	25.3	44,255	163,849
RURAL DEVELOPMENT**	All Measures	Developed Regions	125,876	956	58.6	7,591	45,119
		Transtion Regions	26,185	160	9.8	6,122	18,912
		Less Developed Regions	67,159	514	31.5	7,656	26,914
	M10	Developed Regions	41,773	234	71.7	5,606	15,182
		Transtion Regions	4,062	24	7.4	5,946	7,158
		Less Developed Regions	10,599	68	20.9	6,455	6,455
	M11	Developed Regions	15,326	131	39.9	8,563	16,229
		Transtion Regions	2,464	14	4.3	5,759	7,415
		Less Developed Regions	19,483	184	55.8	9,423	12,679
	M13	Developed Regions	60,054	166	50.3	2,765	4,410
		Transtion Regions	20,528	51	15.5	2,491	2,208
		Less Developed Regions	43,597	113	34.3	2,597	4,090

Legend: * European EAGF financial support. ** National and European EAFRD financial support.

This expenditure shows that there is still a long way to go to a substantial shift of funds from the first to the second pillar. This is true even if it is taken into account that part of the funds allocated to rural development are generally spent towards the end of each programming period, as they financed structural projects often lasting longer than one year. There are some differences among territories with different level of development (table 2). More developed regions and transition regions allocated to RD policies 35% and 33% respectively of their total 2017 CAP funds (respectively 2,720 and 477 million euros). In less developed regions, instead, RDPs represented only 26% of their total CAP funds (1,924 million euros). That means that RDPs do not represent a highly effective engine to boost the development of disadvantaged territories.

CONCLUSION

The results indicate that the CAP interventions in Italy have not been able to achieve the objectives set by the Ciolos reform for correcting the weaknesses of the previous CAP. Although the study refers to a single year, it roughly reflects the structure of the expenditure of the entire programming period since many items of expenditure have a constant annual frequency. The strong asymmetry in the distribution of direct aid shows that neither the correction of the excesses of aid to

large beneficiaries nor the aid redistribution towards the weaker farmers have been achieved. With regard to environmental objectives, we found that they received scarce resources and did not help the less sustainable Italian agriculture (that is intensive agriculture in Northern Italy) to move towards better environmental models. As for rural development, it seems to still be a less important field of intervention. The main orientations for the new CAP and the related budgetary framework have been outlined, through a package of regulations, in the Commission's proposal for the multiannual financing framework (MFF) for 2021-2027. The key words found in the presentation of the new CAP are modernization (i.e. digitization), simplification and compatibility with the 10 priorities of the Commission (European Commission, 2019). The very hope for the European countryside is that the forthcoming CAP will be actually able to correct the many shortcomings of the previous one, consistently with the innovation patterns (Sodano, 2019) useful to build a more sustainable agriculture.

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NUTRITIVE VALUE OF RIPARIAN COMMON REED BIOMASS FOR RUMINANTS

Fokion PAPATHANASIOU[1*], Konstantinos ZARALIS[1], Irene KOUTSERI[2], Myrsini MALAKOU[2], Angelos PAPADOPOULOS[1], Anastasia PLIANTSA[1], Marialena AGGELAKI[1], Vasiliki KARETSA[1], Ioannis PAPADOPOULOS[1]

[1]University of Western Macedonia, Department of Agriculture, Terma Kontopoulou, 53100 Florina, Greece
[2]Society for the Protection of Prespa, Agios Germanos, 53150, Prespa, Greece
*Corresponding author: fpapathanasiou@uowm.gr

ABSTRACT

The extensive reedbeds, especially *Phragmites australis*, that spread around the perimeter of the lake Mikri Prespa, a Ramsar protected lake in the northwest of Greece, serves beneficially for several human activities and wildlife needs. Nevertheless, the apparent overgrowth and removal of this vegetation is often problematic and imposes difficulties in management and increases costs. Recent research is focusing into the use of *P. australis* as an alternative or complementary feed for ruminants. The aim of the present study was to evaluate the nutritive value of *P. australis* biomass derived from the riparian vegetation as a potential animal feed. Biomass samples were collected from six different sites of the Mikri Prespa lake in two different time periods (i.e. early August and late October 2020). The samples were analyzed for macro- and trace elements, total protein, NDF, fat and nitrogen-free extracts. Location and sampling date had a significant effect on all macronutrient concentrations with significant reductions in the second sampling period. For the trace elements zinc, copper and boron higher concentrations were observed in August, while the concentration of iron increased significantly in October. Dry matter and NDF content of *P. australis* was particularly high, 67.08% and 46.3% respectively; while protein content was rather moderate (8.38%, August sampling) to low (5.06%, October sampling). The results show that the nutritive value of *P. australis* is comparable to feeds widely used in ruminant nutrition such as wheat straw or marc, indicating a potential use as an alternative or complementary coarse feed with appropriate administration or treatment.

Keywords: *Reed beds, P. australis, Quality characteristics, Ruminant nutrition.*

INTRODUCTION

The riparian areas of Lake Mikri Prespa are surrounded by extensive reedbeds that spread almost all around the perimeter of the lake. Although reedbeds, especially *Phragmites australis*, are beneficial for many human activities as well as wildlife needs (Cronk and Fennessy, 2001), the apparent overgrowth of vegetation that predominates in some aquatic habitats is often considered a potential threat for some ecosystems. For this reason, different methods have been applied worldwide to manage the overgrowth of *P. australis* either individually or in combination, including removal of aboveground biomass by cutting, grazing, or burning (Marks *et al.,* 1994; Hazelton *et al.,* 2014; Volesky *et al.,* 2016).

In recent years the reed has been widely used as feed for buffaloes, cows, sheep, goats and donkeys in many different countries (*Al*-Sodany *et al.,* 2012). Its high content of fiber, nitrogen, potassium and manganese among others makes it particularly important (Kadi *et al.,* 2012). The nutritional value of about 13.31 kilos of reed is equivalent to that of one kilo of oats (Köbbing *et al.,* 2013) while according to the guide of nutritional requirements of dairy cows it has a similar nutritional value to sorghum (NRC 2001). Although it has a lower nutritional value than other forage plants, it is cheap and easily available in some parts of the world while large animals can consume *in situ* shoots up to 50-75 cm tall.

In the Prespa area, farmers use the reed from the lake vegetation as animal feed mainly in the summer months or until mid-autumn, but so far there is no study on the chemical composition and quality of the fodder. The aim of the present study was to evaluate the quality characteristics of reed biomass that can be used as animal feed which results from the management of lakeside vegetation in different areas of Lake Mikri Prespa. The ultimate goal of the study was to contribute to the development of lakeside vegetation management strategies for sustainable use of *P. australis* reed.

MATERIALS AND METHODS

Plant material and experimentation

Lakeside phytomass samples were collected from six different areas [Karyes (KAR), Mikrolimni (MIK), Mikros Kampos (MKA), Opaya (OPA), Slatina Lemou (SLL) and Slatina Plateos (SLP)]. These areas were selected as management was implemented in them for the restoration and maintenance of wet meadows. To study the effect of different cutting times, samples were taken in two different seasons: early August and late October 2020. The samples collected were four per region and date and contained mainly *P. australis* reed. Biomass was cut for each sample from an area of approximately 2 x 2 m that had not been previously grazed. The reed plants were cut over 40 cm in order for the samples to be representative of the plant biomass that the animals would utilize by grazing.

Sample analysis

The samples after being properly processed (drying, grinding, etc.) were analyzed for macro and micronutrients. Sub-samples were placed in a furnace at 515 °C for 5 hours. The ash was dissolved in 3 ml of 6 N HCL and distilled water until it reached a volume of 50 ml. Concentrations of P, K, Ca, Mg, Fe and Zn were determined by the method of inductively coupled plasma-ICP spectrophotometer (Allen, 1976). The concentration of N was determined by the Kjeldahl method and that of B according to the method of azomethine-H (Wolf, 1974). Macronutrient concentrations were expressed in % dry weight while trace elements in mg/kg or ppm dry weight. Total protein (P = N x 6.25) was determined by the Kjeldahl method in a nitrogen analyzer by Gerhardt, total fibrous substances (NDF) according to Weende using a Fibertech apparatus, fat by the Soxhlet method using a Foss apparatus and on the basis of the percentage contents of the analyzed sample in total nitrogenous substances, fats, fibrous substances, the nitrogen-free extracts (NFE) was determined.

Statistical analysis

The statistical analysis of the results was performed with Analysis of Variance (ANOVA) with two factors (location and date of sampling) while comparison of means was conducted by Least Significant Difference (LSD) at significance level $p < 0.05$.

RESULTS AND DISCUSSION

The analysis of variance of various parameters of the reedbed vegetation that were measured in six different locations of Lake Mikri Prespa showed a significant effect of the location on the concentrations of macronutrients N, P and K and trace elements B and Fe (data not shown). Also, the location significantly affected the concentrations of most quality characteristics such as proteins, fat, fibrous substances (NDF), ash and NFE. The sampling date factor had a statistically significant effect on all concentrations of macronutrients and trace elements except the concentration of boron, while from the qualitative characteristics the percentages of ash and NFE did not differ statistically significant between the two sampling dates.

Table 1. Concentrations of macronutrients in reed (*Phragmites australis*) samples collected in two sampling dates (S1, August 2020 and S2, October 2020) at six locations of the lake Mikri Prespa.

Location	N%*		P%		K%		Ca%		Mg%	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
KAR	1,81a	1,03a	0,19a	0,10a	0,71c	0,52a	0,62a	0,33a	0,27a	0,15a
MIK	1,22b	0,68a	0,15abc	0,10a	0,86bc	0,35ab	0,59a	0,30a	0,18a	0,11a
MKA	1,35ab	0,75a	0,12c	0,11a	1,34a	0,52a	0,99a	0,47a	0,23a	0,14a
OPA	1,08b	1,01a	0,19a	0,10a	1,07ab	0,26b	0,47a	0,41a	0,17a	0,13a
SLL	1,18b	0,69a	0,14b	0,09a	1,12ab	0,33ab	0,68a	0,31a	0,21a	0,15a
SLP	1,40ab	0,71a	0,18ab	0,08a	0,93bc	0,29b	0,63a	0,52a	0,19a	0,17a

*means in the same column followed by the same letter are not significantly different (t-test, P<0,05).

Nitrogen concentration differed statistically significant between the different sites in the August sampling with the KAR area having the highest percentage of 1,81% and the OPA location the lowest with 1,08% (Table 1). In the October sampling, no statistically significant difference was observed between sites in nitrogen concentration. In phosphorus levels there were differences between the different locations in the August sampling with the KAR and OPA areas having the highest percentage of 0,19% and the MKA region having the lowest with 0,12%. In the October sampling, no statistically significant difference was observed between sites in P concentration. The area of MIK had the highest concentration of potassium on both sampling dates with 1,34% and 0,52% while the lowest levels showed the samples from KAR with 0,71% in August and from the area of OPA with 0,26% in October. Between the two sampling dates the K concentration decreased from 27% to 75% in the different locations. Calcium and magnesium concentrations did not differ statistically between the different sampling sites on both dates (Table 1). In August the concentration of Ca ranged from 0,47-0,99% and of Mg from 0,17-0,27% while in October they decreased significantly in all areas from 0,30-0,52% and from 0,11-0,17% respectively. The concentrations of most trace elements differed statistically between the two sampling dates with the exception of boron (data not shown). Higher concentrations were observed in August, mainly for the trace elements zinc, copper and boron, while the concentration of iron increased significantly in October. The concentrations of the macronutrients and trace elements found in this study were similar to concentrations found in *P. australis* samples in other studies (Van der Werff, *et al.,* 1987; Baran *et al.,* 2002; Toumpeli *et al.,* 2013; Carson *et al.,* 2018) depending on the stage of development and the sampling season. After August, the macro and trace elements concentration in the aboveground part decreases significantly, as our results showed, while they increase in the underground part, especially N in the rhizomes, due to the internal displacement in the plant during the winter months (Van der Linden, 1980).

The dry matter percentage did not differ between the different sampling sites on both dates but increased significantly from 53-95% in October (data not shown). The protein concentration in the August sampling ranged from 6,74% (OPA) to 11.33% (KAR) (Table 2) while in the October sampling there were significant reductions of up to 50% in the protein concentration in almost all sampling areas. Fibrous substances in the August sampling ranged from 29,48% (MKA) to 36,83% (SLP) while in the October sampling there were increases from 15-37% in their concentration at all locations with concentrations varying between regions with levels from 39,18% up to 46,13% in the SLL area. The fat concentration in the August sampling differed statistically significant between the sampling locations and ranged from 0,98% (KAR) to 1,91% (MKA). In the October sampling there were also significant differences with the majority of concentrations falling by up to 46% with the exception of samples from the MIK area where a very small increase was observed. The NFE differed significantly between sites in the first sampling and ranged from 45,5% in the SLP area to 52,92% in the MKA area samples, while in the October sampling the concentrations decreased from 3-19% depending on the area.

Table 2. Concentration (%) of quality characteristics in *P. australis* samples collected in two sampling dates (S1, August 2020 and S2, October 2020) at six locations of the lake Mikri Prespa.

Location	NDF%		Proteins%		Fat%		Ash%		NFE%	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
KAR	34,80a	42,42ab	11,33a	6,43a	0,98c	0,75bc	6,90b	6,91c	45,99b	43,50ab
MIK	32,14ab	39,18b	7,65b	4,28a	1,12bc	1,15a	9,32a	10,52a	49,77ab	44,88a
MKA	29,48b	40,35ab	8,43ab	4,66a	1,91a	1,07ab	7,27b	6,99c	52,92a	46,94a
OPA	34,84a	41,79ab	6,74b	6,29a	1,00bc	0,54c	7,05b	6,90c	50,38ab	44,49a
SLL	35,27a	46,13a	7,39b	4,30a	1,50abc	0,85abc	7,84ab	9,74ab	47,98ab	38,99b
SLP	36,83a	42,19ab	8,78ab	4,43a	1,66ab	1,06ab	7,23b	8,27bc	45,50b	44,06a

*means in the same column followed by the same letter are not significantly different (t-test, P<0,05).

The location factor significantly affected most of the quality characteristics and this may be due to the different soil composition around Lake Mikri Prespa but also to the different levels of nutrient runoff from neighboring bean crops (Kosmas *et al.*, 1997). The results of the present study showed that *P. australis* could be considered as a fibrous feed due to its high content of dry matter and fibrous substances. Indeed, at the stage of maturity, as shown by the October sampling, the dry matter and the concentration of fibrous substances reached 67,08% (data not shown) and 46,3% respectively (Table 2) percentages which are comparable to the most fibrous feed, such as is wheat straw or marc (Maertens *et al.*, 2002). The high fiber content of *P. australis* during flowering may have an inhibitory effect on food intake as the high fiber content increases chewing time (Mertens, 1994). *P.*

australis could be an alternative feed as a source of fibrous substances in ruminant diets, however it is doubtful whether it may be the only coarse feed in the diet (Kadi *et al.,* 2012; Monllor *et al.,* 2020). In a recent study Mokhtarpour and Jahantigh (2018) showed that *P. australis* can't meet the nutritional requirements of sheep even if it is enriched with urea. The protein content of *P. australis* is close to that reported by Kadi *et al.,* (2012). It is not characterized as particularly high and is rather considered moderate, 8,38% in the August sampling, to a low of 5,06% in the October sampling (Table 2). However, it is higher than that of some fibrous feeds used in the diet of ruminants such as e.g. the wheat straw. The results of the present study and other studies show that reed could be an alternative coarse feed with the appropriate administration or treatment. Its low digestibility also makes it imperative to add energy for a better nutritional balance, especially in large animals, in case *P. australis* will be the only food source for long periods of time (Volesky *et al.,* 2016).

Direct grazing is a proven successful practice for the use of *P. australis*. Reedbeds provide large amounts of grazing material, which can be used for grazing mainly by large ruminants or even provided to them as winter feed. The grazing of *P. australis* by cattle such as the buffalo, in practice has proven to be a highly successful and efficient practice for feeding buffaloes but also for controlling the growth of the reed and the conservation of biodiversity, both in the Prespa area and in other wetlands (Kazoglou *et al.,* 2001). In addition, grazing brings other benefits to the wetland through the recycling of nutrients into the soil, while the pressed reeds allow the wetlands to flood freely. In the present study, the mean percentage of fibrous substances in all locations at the August sampling was 33,9%, a percentage which is comparable to the percentage of maize fibrous substances at the milky stage (Zaralis *et al.,* 2014). Considering also the concentration of *P. australis* in sugars (NFE), it makes it an alternative coarse feed to silage. Indeed, recent studies show that *P. australis* can be successfully silaged and administered to ruminants (El-Talty *et al.,* 2015; Monllor *et al.,* 2020). Administration of *P. australis*-based silage to lambs did not adversely affect their growth leading to the expected meat yield (El-Talty *et al.,* 2015). In a goat silage food preference study, reed silage was the least preferred of the other silage, possibly due to its higher fiber content (Volesky *et al.,* 2016).

CONCLUSION

The present study confirms the possible use of *P. australis* from the riparian areas of Lake Mikri Prespa as a high quality coarse feed, especially when direct grazing or cutting is done at an earlier stage of development. Further research on the use of lakeside vegetation for silage production and an extensive study on its effects on the diet of small and large ruminants would be in the right direction.

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FERMENTATION AND MICROBIAL DYNAMICS OF PERENNIAL GRASSES SILAGE PREPARED WITH BIOLOGICAL INOCULANT

Jurgita DAILIDAVIČIENĖ[1], Lina MERKEVIČIENĖ[1], Modestas RUŽAUSKAS[2], Sigita KERZIENĖ[3], Saulius ALIJOŠIUS[4]

[1]Lithuanian University of Health Sciences, Department of Anatomy and Physiology, Lithuania
[2]Lithuanian University of Health Sciences, Institute of Microbiology and Virology, Lithuania
[3]Lithuanian University of Health Sciences, Department of Physics, Mathematics and Biophysics, Lithuania
[4]Lithuanian University of Health Sciences, Library and Information Center, Lithuania
*Corresponding author: jurgita.dailidaviciene@lsmuni.lt

ABSTRACT

Ensilage provides an effective means of conserving green forage to supply as feed to ruminants. The fermentation process presented in the ensilage process depend on lactic acid bacteria (LAB). Silage quality is variable and the only way to effectively control the fermentation process, to improve the ensiling process and the quality of the resulting silage is to use an additive, mostly biological inoculants with LAB. The aim of this study was to evaluate the fermentation and microbial dynamics of perennial grasses silage with biological inoculant. Alfalfa and *Poaceae* mixed grasses were ensiled. Into grass silage was added biological additive, consisted of mixture of homofermentative and heterofermentative LAB and enzymes. Inoculant included strains *Lactobacillus plantarum, Pediococcus acidilactici, Pediococcus pentosaceus, Propionibacterium acidipropionici,* α-amylase, β-glucanase, cellulase and hemicellulase. The fermentative quality, chemical composition parameters and microbiological counts of silages at 7, 14, 21 and 60 days after ensilage were evaluated. Fermentation dynamics were examined using chemical analysis. The study showed higher values of dry matter, crude fat and NDF after supplementation of biological additive in all analyzed samples. Conversely, there was a reduction of the pH and water soluble carbohydrates concentration. Ensiling caused an increase of acetic acid concentrations as well ($p<0.001$). There were found significant differences ($p<0.05$) in contents of NEL between 21 and 60 days of ensiling after treatment and between the control group of fresh grass and 7 and 21 days after treatment as well. At the 7 day of fermentation process there was a significant increase in *Lactobacillus* spp. abundance ($p<0.001$) and on 60 day there was a decrease in *Clostridium* spp. abundance ($p<0.001$).

Key words: *Silage, Inoculant, Lactic acid bacteria, Enzyme, Fermentation.*

INTRODUCTION

Grass silage is an important ruminant feedstuff in dairy farms worlwide including Lithuania dairy farms. Different research studies concluded that individual elements of silage production - grass and other green plants vegetation phase, dry matter of fresh grass, used machinery, storage facilities, silage additives are the most important factors determining silage fermentation rates and impact on nutrient and energy levels and the hygienic properties of the feed (Santos et al., 2016). Silage making process can be explained very simply, it is actually very complex and dependant on many factors, such as the natural microbial population, harvesting conditions and the sugar content of the forage. Consequently, silage quality can be very variable and the only way to effectively control the fermentation process is to use an additive. Additives control or prevent certain types of fermentation, thus reducing losses and improving silage stability (Yitbarek et al., 2014). In most commercially available inoculants, homofermentative lactic acid bacteria (LAB) have been used because they are fast and efficient producers of lactic acid, improving natural silage fermentation (Weinberg et al., 1996). Heterofermentative LAB have attracted attention as an alternative additive to inhibit aerobic deterioration (Herkel et al., 2015). LAB as a biological silage additive provides stable feed value and secondary metabolic products during rapid anaerobic primary silage fermentation. They are able to ferment a large number of forage crops and also to reduce pH levels in fermented forages, which helps to suppress the growth of spoilage microorganisms. Furthermore, silage inoculants can enhance silage quality, nutritional recovery and shelf life of the inoculated product (Kim et al., 2021). The combination of different cultures of lactic acid bacterial species as a silage inoculant may be more beneficial than using a single species alone due to the differences in growth pattern and positive interaction among bacteria (Jatkauskas et al., 2013). Recently, inoculants containing homo- and hetero-fermentative LAB has become predominant additives, because the combination of both types of these LAB can reduce losses and increase the fermentation quality as well as aerobic stability of silage (Li et al., 2016). The possibilities of using enzymes help to improve nutrient digestion, utilization, and animal productivity and at the same time reduce animal fecal material and pollution. The enzyme amylase is useful for degrading starch into sugars. Cellulases or xylanases degrade cell walls into sugars. Sugars released by the enzymes increase growth of silage bacteria and, in some cases, fiber degrading enzymes also increase forage digestibility (Yitbarek et al., 2014). The aim of this study was to evaluate the fermentation and microbial dynamics of perennial grasses silage with biological inoculant containing LAB and enzymes.

MATERIAL AND METHODS

Samples collection

The silage samples were collected from one conventional (intensive) cattle farm in Lithuania, located in the central part of Lithuania (coordinates: 55.45860857021875, 23.6184147274186) during the year 2020. The

experiment was realized in practical conditions. The second-cut perennial grasses (Alfalfa and *Poaceae* mixed grasses) was harvested at initial flowering stage at July, 2020, and after 24h wilting, the silage mass was chopped on about 60 mm chop length using chopper harvester. Into grass silage was added biological additive, consisted of mixture of homofermentative and heterofermentative lactic acid bacteria (LAB) and enzymes. Inoculant was sprayed using a plant sprayer over the course of filling the silos. The inoculant was applied at recommended rate of 2 g/t of fresh forage. Inoculant included strains *Lactobacillus plantarum* CNCM I-3235 (≥ 1.00 x 1011 CFU/g), *Pediococcus pentosaceus* NCIMB 12455 (≥ 4.00 x 1010 CFU/g), *Pediococcus acidilactici* CNCM I-3237 (≥ 4.00 x 1010 CFU/g), *Propionibacterium acidipropionici* CNCM MA 26/4U (≥ 2.00 x 1010 CFU/g), Alpha-amylase (EC 3.2.1.1) from *Bacillus amyloliquefaciens* (≥ 3600 BAU), Cellulase (EC 3.2.1.4) from *Trichoderma longibrachiatum* (≥ 60 CMCU), Beta-glucanase (EC 3.2.1.6) from *Aspergillus niger* (≥ 1000 IU), Xylanase (EC 3.2.1.8) from *Trichoderma longibrachiatum* (≥ 1500 IU), organic sucrose, colloidal silica up to 250 g. Inoculant contained $5x10^{11}$ CFU per 1 g. After treatment grass was ensiled in trench silo. Laboratory analysis of control group (fresh grass) was made before ensiling. Laboratory analysis of treated silage samples was carried out at 7, 14, 21 and 60 days after treatment. The number of samples was three from each sampling at different periods. The samples were packed into plastic bags to avoid exposure to air and delivered to the laboratory. Chemical and fermentation analysis was conducted at Chemical Research Laboratory of the Lithuanian Research Centre for Agriculture and Forestry, Microbial counts analysis was made at Microbiology and Virology Institute at Lithuanian University of Health Sciences.

Chemical and fermentation analysis

Chemical analysis of examined silage samples was determined according reference methods of forage analysis. Crude fat (CF) content was determined according to Soxhlet method, crude protein (CP) according to Kjeldahl (AOAC 1990; Đorđević et al., 2016), crude fiber (CFB) according to Weende method, total nitrogen was measured as Kjeldahl nitrogen (LST EN ISO 5983-1:2005), neutral detergent fibre (NDF) and acid detergent fibre (ADF) according to Van Soest method, crude ash (CA) determined gravimetrically after biomass dry combustion at 600^{o}C. Element contents in DM (dry matter) were analyzed using near-infrared reflectance (NIR) spectroscopy (NIRS-6500). Metabolic energy (ME, MJ/kg DM), netto energy of lactation (NEL, MJ/kg DM) was calculated by a formula Nauman and Bassler (1993), organic matter digestibility evaluated according to the Hohenheim feed test (Naumann and Bassler, 1993). Fatty acid content evaluated according to gas chromatography method (Naumann and Bassler, 1993).

Microbial count analysis

20 g of silage samples were placed into plastic bags containing 180 ml of sterile physiological solution and mixed for 3 minutes using BagMixer (Interscience,

France). Serial dilutions of suspension were prepared in tubes with 9 ml of physiological solution. The total bacterial count was quantified by Tryptone Soya Agar (CM0131R, Thermo Scientific, Oxoid, UK), molds and yeasts counts were cultured on Sabouraud Dextrose Agar (PO1166A Thermo Scientific, Oxoid, UK), *Enterobacteriaceae* were quantified using Violet Red Bile Glucose Agar (PO5043A Thermo Scientific, Oxoid), *Clostridium* spp.were quantified using *Clostridium perfringens* agar (610147 Liofilchem, Italy) and *Lactobacillus* spp. were quantified using MRS agar (4017292 Biolife Milan, Italy).
After collecting complete analyze results of experiment, it was assessed the impact to inoculant on process of fermentation and changing nutrients in silage.

Statistic analysis

Statistical analysis was performed using the IBM SPSS Statistics Version 26. Differences in the test properties of the compared groups are expressed as means and RMSE (root mean square errors). For fermentation, chemical and microbial analysis was performed 1-way ANOVA analysis. The differences between the investigated groups were evaluated using Fisher's LSD criterion (α=5%). The differences were considered to be statistically significant when $p < 0.05$.

RESULTS AND DISCUSSION

After collecting complete analyze results of experiment, it was assessed the impact to inoculant on process of fermentation and changing nutrients in silage. Data in Table 1 shows that inoculant at different examination periods had highly significant impact on content of dry matter, crude fat and NDF after supplementation of biological additive in all analyzed samples. Conversely, there was a reduction of the pH and water soluble carbohydrates concentration. The data in Table 1 showed that starting pH of the fresh forage was 5.8 and the DM was 52.90%. The pH values at all experimental periods decreased and the final pH at the 60 days of ensiling after treatment with inoculant was 4.7. The result was statistically significant compared with the control group and to silage from each experimental periods ($p<0.001$). The final pH for the purpose of this assessment is controlled by 3 parameters. Primarily the DM controls the pH, but the acid that is formed utilises sugar as substrate, and the protein content of the forage defines the buffering capacity. The low pH shows the silage is stable and can not further develop undesirable microbes too in the in-silo (Kim et al., 2021). Kung et al. (2001) data suggests a pH of 4.7 at a DM of 35% on grass, or a pH of 5.0 on 55% legume silage which has a high buffering capacity. In our study a rapid drop in pH from 5.8 to 5.0 in the first week and then slow drop in pH to 4.7. In this study pH is perfectly reasonable and corresponds for the higher DM. There simply is not the free moisture available as the DM increases to produce the lactic acid to drop the pH. The final pH is higher as the DM increases (Driehuis et al., 2018). The lower pH in inoculated silage is important for conserving of nutrients and promoting homofermentative lactic acid bacteria. Generaly, the main effect of silage inoculant

was the increased production of lactic acid with significant reduction of pH (Đorđević et al., 2016, Stoškus et al., 2017).

Santos et al. (2016) concluded that low DM content in alfalfa silage is 35%, when high dry matter content is 45% respectively. In our study the dry matter content of silage was higher. The dry matter in fresh grass was 52.90% and at the ensiling process it increased to 57.80%. This result was statistically significant comparing to control group and to silage from each experimental periods ($p<0.001$). The DM of the forage increases the relative density of the forage decreases and the amount of air ensiled increases (Borreani et al., 2018). The fermentation occur once the ensiled air is converted to CO^2. In high DM silage the lagging in fermentation where the epiphytic bacteria are active and can be producing undesirable products is greater. Typically, for a 35% dry matter grass lactic acid and total volatile acids ratio is approximately 3:1 of (Kung et al., 2018). In our study DM content was higher than that ratio in at 50% in resulting a rapid anaerobiosis and then pH fall which stops loss of digestibility, metabolic energy and protein breakdown.

The NDF and ADF are important quality parameters of silage. High contents of NDF and ADF in silage adversely affect the quality and decreased digestibility (Đorđević et al., 2016). A decrease in NDF between fresh and ensiled samples has been reported by others (Ozduven et al., 2009; Đorđević et al., 2016) but in our study, NDF and ADF was higher at the period of 60 after treatment.

Table 1. Chemical composition of the silages at different periods of experiment

Variable	Control group	Days after treatment				SEM	p-value
		7	14	21	60		
DM, %	52.90^{a}	56.05^{b}	57.74^{c,d,e}	57.40^{d}	57.80^{e}	0.179	<0.001
pH	5.80^{a}	5.00^{b,c}	4.90^{c,d}	4.80^{d,e}	4.70^{e}	0.086	<0.001
CP, % DM	21.40^{a}	19.30^{b}	18.37^{c}	20.40^{d}	19.10^{b}	0.126	<0.001
CF, % DM	2.82^{a}	3.61^{b}	3.61^{b}	3.79^{c}	3.62^{b}	0.051	<0.001
CFB, % DM	21.20^{a}	23.57^{b}	23.09^{c}	22.80^{d}	24.10^{e}	0.085	<0.001
CA, % DM	11.00^{a}	10.87^{a}	10.42^{b}	10.60^{b}	10.90^{a}	0.090	<0.001
WSC, % DM	3.98^{a}	0.39^{b}	1.64^{c}	2.16^{d}	0.81^{e}	0.041	<0.001
NDF, % DM	38.20^{a}	40.75^{b}	42.57^{c}	41.80^{d}	44.70^{e}	0.091	<0.001
ADF, % DM	23.40^{a}	26.93^{b}	28.25^{c}	27.30^{d}	29.60^{e}	0.086	<0.001

Note. DM – dry matter, CP – crude protein, CF – crude fat, CFB – crude fiber, CA – crude ash, WSC – water-soluble carbohydrate, NDF – neutral detergent fibre, ADF – acid detergent fibre, SEM – standard error meaning.

a, b, c, d, e – means in row marked different letters differed statistically significant ($p<0.05$)

Results of energy characteristics are presented in Table 2. We found significant differences in content of ME and NEL as well. Higher contents of ME was found at all silage samples with inoculant at all experimental periods comparing to the control group. The highest levels of ME was found at 21 day after treatment and was statististically significant comparing to the silage sample at 60 day after treatment ($p<0.01$). There were observed significant differences ($p<0.05$) in contents of NEL after all days after treatment. The highest levels of NEL was in silage sample at 21 day after treatment. Herkel et al. (2015) reported similar results while Đorđević et al. (2016) reported that ME and NEL were not affected by inoculation treatment.

Table 2. Energy characteristics of the silages at different periods of experiment

Variable	Control group	Days after treatment				SEM	p-value
		7	14	21	60		
ME, MJ/kg DM	9.33[a]	9.69[b,c]	9.52	9.82[b]	9.46[a,c]	0.133	<0.001
NEL, MJ/kg DM	5.39[a]	5.64[b,c]	5.52[a,c]	5.72[b]	5.48[a]	0.106	<0.05

Note. ME – metabolic energy, NEL – neto energy for lactation, SEM – standard error meaning.

a, b, c – means in row marked with different letters differed statistically significant ($p<0.05$)

Data presented in Table 3 show that silage treated with inoculant had significant effect on all fermentation parameters resulting in excellent to very good fermentation value and silage stability (Figure 1). The lactic acid increased 14 days of ensiling after treatment with inoculant, but decreased at the 60 days after treatment statistically significant between these experimental periods ($p<0.001$), conversely decreased at 14 days of experiment, but increased at all other periods statistically significant ($p<0.001$). Butyric acid was generally not found in perenial grass silage samples. In this study according to DM content there were less moisture available to convert sugar to lactic acid, so as the DM increases end up producing a lower concentration of all fermentation products (Nielsen et al., 2007). The level of total acid was consistent at 44 – 48 g/kg DM which is actually high for the ensiled DM, with lactic acid accounting for approximatelly 70% of the total fermentation product which means it has been a driven homofermentative fermentation.

Table 3. Fermentation parameters of the silages at different periods of experiment

Variable	Days after treatment				SEM	p-value
	7	14	21	60		
Protein breakdown, %	62.0^{a}	64.2^{b}	64.9^{c}	66.1^{d}	1.473	<0.001
Digestibility of OM, %	71.0^{a,c,d}	75.0^{b}	73.0^{b,c}	70.0^{d}	1.132	<0.01
NH_3-N/TN,%	4.0^{a}	4.0^{a}	5.0^{b}	6.0^{c}	0.065	<0.001
TA, g/kg DM	44.0^{a}	45.0^{a}	46.0	48.0^{b}	1.080	<0.05
LA, g/kg DM	70.7^{a}	72.3^{b}	69.8^{c}	65.3^{d}	0.141	<0.001
AA, g/kg DM	11.0^{a}	10.0^{b}	13.0^{c}	14.0^{d}	0.094	<0.001
BA, g/kg DM	< 1	< 1	< 1	< 1		

Note. TN – total nitrogen, TA – total acids, LA – lactic acid, AA – acetic acid, BA – butyric acid, DM – dry matter, SEM – standard error meaning.
a, b, c, d, – means in row marked with different letters differed statistically significant ($p<0.05$)

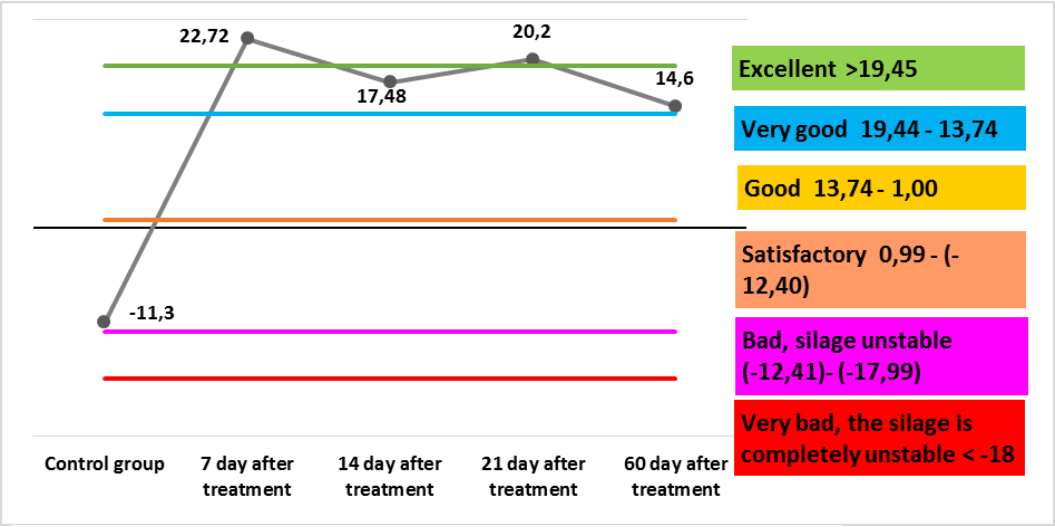

Figure 1. Relationship between fermentation value and silage stability at different periods of experiment

Microbiological composition of silage reveals counts of *Enterobacteriaceae*, *Lactobacillus* spp. *Clostridium* spp., yeast and molds. These indicators indicates to various silage failure processes. They are important because the results of the study can be used to determine whether the silage is safe to store and feed, whether it is overgrown or even spoiled, whether it contains a large number of dangerous microorganisms and is unsuitable for animal feed. Silage microflora can be categorized into two main groups, desirable and undesirable organisms. LAB are desirable microbes, while undesirable microorganisms (*Enterococcus*, yeast and molds) can cause anaerobic or aerobic spoilage during silage fermentation (Kim et

al., 2021). Clostridium species are gram-positive, obligate anaerobic spore-forming bacteria. Clostridia require relative high pH values (>4.5), high forage moisture concentration (>70%), and high water activity (from 0.952 to 0.971) for growth; hence, they are inhibited in silages if rapid acidification reduces the pH to 4 or below within 3 (Muck et al., 2003). The critical pH that inhibits clostridial growth varies with the plant moisture content (Driehuis et al., 2018). The microbiological composition of the corn silages is given in Table 4. Lactobacilli numbers of grass silages increased during the 14 day of fermentation. At the 7 day of fermentation process there was a significant increase in *Lactobacillus* spp. abundance ($p<0.001$) and on 60 day there was a decrease in *Clostridium* spp. abundance ($p<0.001$).

Table 4. Microbial composition of the silages at different periods of experiment

Variable	Days after treatment				SEM	p-value
	7	14	21	60		
TBC, log10 CFU/g	1.00^{a}	6.91^{b}	6.12^{b}	6.20^{b}	0.713	p<0.001
Lactobacillus spp. log10 CFU/g	7.43^{a}	7.64^{a}	6.19^{b}	4.39^{c}	0.162	p<0.001
Enterobacteriaceae log10 CFU/g	0.00	1.00	0.00	1.00	1.000	p=0.347
Clostridium spp. log10 CFU/g	4.86^{a}	7.17^{b}	5.78^{c}	0.00^{d}	0.117	p<0.001
Molds log10 CFU/g	0.00	0.00	0.00	0.00	0.00	p=1
Yeast log10 CFU/g	0.00^{a}	0.00^{a}	1.10	2.62^{b}	0.781	p<0.01

Note. TBC – total bacteria count, CFU – colony forming units, SEM – standard error meaning.
a, b, c, d – means in row marked with different letters differed statistically significant ($p<0.05$)

Our study results showed rapid decreasing of pH in resulting high levels of *Lactobacillus* spp. and the lowest levels of *Clostridium* spp. at the 60 days after treatment with inoculant. Before and during ensiling, management practices that favor rapid homolactic fermentations should be ensured because a rapid pH drop is critical to inhibiting *Clostridium* spp. and enterobacteria, which cause proteolysis and secondary butyric fermentation (Queiroz et al., 2018).

CONCLUSIONS

The study showed higher values of dry matter, crude fat and NDF after supplementation of biological additive in all analyzed samples. Conversely, there was a reduction of the pH and water soluble carbohydrates concentration. Biological inoculant with enzymes increased acetic acid concentration which had a significant impact on higher levels of *Lactobacillus* spp. abundance and decreased in *Clostridium* spp. abundance.

Our study showed that LAB and enzyme inoculation of perennial grass improved silage fermentation by increasing lactic acid and reducing pH value at the same time increasing ME and NEL.

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PARENT MATERIAL AS A KEY DETERMINANT OF SOIL PROPERTIES IN SOUTHERN PART OF NATIONAL PARK KRKA, CROATIA

Aleksandra BENSA[1]*, Mirna ŠVOB[1], David DOMÍNGUEZ-VILLAR[2], Dražen PERICA[3], Kristina KRKLEC[1]

[1]University of Zagreb, Faculty of Agriculture, Svetošimunska 25, 10000 Zagreb, Croatia
[2]University of Salamanca, Faculty of Sciences, Plaza de los Caídos s/n. 37008 Salamanca, Spain
[3]University of Zadar, Department of Geography, P. Svačića 9, 23000 Zadar, Croatia
*Corresponding author: abensa@agr.hr

ABSTRACT

Parent material is an important factor in soil formation, especially in soils formed in Mediterranean region dominated by calcareous sedimentary rocks. Their basic properties (mineralogical composition, coherence, and permeability for water) influence the resistance to weathering and type of weathering products, its amount, particle size distribution, as well as the intensity of physicochemical transformations within the original rock residue. Thus, the aim of this study was to investigate the impact of parent material on soil properties in southern part of Krka National Park, Croatia. Weathering of carbonate parent material (limestones, dolomites, conglomerates, marls) along with other soil forming factors was the base for soil development in this area. Thus, Calcocambisols and Terra rossa, typical and ilimerized are the most widespread soil types, while Calcomelanosols, Colluvium and Rendzinas are as well represented, but in much lesser extent. Soil depth, presence of coarse fragments and carbonate content in these soils vary considerably depending on parent material, although factors such as relief, vegetation and anthropogenic impact cannot be neglected. In general, shallow soils (< 35 cm) were formed on limestones and conglomerates, while medium deep soils (35-70 cm) were formed on marly substrates. The content of coarse fragments of variable size in soils (fine gravel 2-6 mm to boulders 60-200 cm) is related to different weathering processes of parent material. The presence of carbonate nodules on soil surface and within soil profile also indicates pedogenetic processes related to different types of carbonate parent material.

Key words*: Cambisols, carbonate rocks, soil depth, rock weathering.*

INTRODUCTION

Parent material is one of the crucial pedogenetic factors governing soil genesis (Badia *et al.*, 2013) and affecting soil properties (Burke, 2002; Koojiman *et al.*, 2005; Rodrigo-Comino *et al.*, 2018) especially at the regional scale (Bockheim *et*

al., 2005). Mediterranean region is dominated by calcareous sedimentary rocks (limestone, dolomite, marl, etc.) having different characteristics affecting soil formation (Verheye and de la Rosa, 2006). Its mineral composition, rock structure and texture play important role in rock weathering (Pope, 2013), controlling the type of weathering products, its amount, particle size distribution, as well as the intensity of physicochemical transformations within the original rock residue (Verheye and de la Rosa, 2006). Soils formed on carbonate rocks, especially in karst areas, are frequently shallow and highly susceptible to degradation (Moore *et al.*, 2017).

Southern part of Krka National Park is mostly built up from Mesozoic carbonate rocks (CGS, 2009) characterized by high degree of karstification (Perica *et al.*, 2005). Carbonate rocks weathering processes lead to dissolution, disintegration, and accumulation of insoluble residue and organic matter, resulting in formation of reddish soils with high spatial variability (Vrbek and Pilaš, 2007). Thus, the aim of this study was to investigate the impact of parent material on soil depth and selected physical and chemical properties in southern part of Krka National Park, Croatia.

MATERIAL AND METHODS

Situated in the southern part of Krka National Park, study location (Figure 1) is built up from Eocene limestones and carbonate conglomerates ("Promina beds") (CGS, 2009). This area has been intensively faulted and folded forming structures having Dinaric orientation (i.e., NW–SE) and later levelled over a long period of denudation by corrosion planation in the level of the karst water. Karstification of carbonate bedrock resulted in development of karst relief forms (Perica *et al.*, 2005).

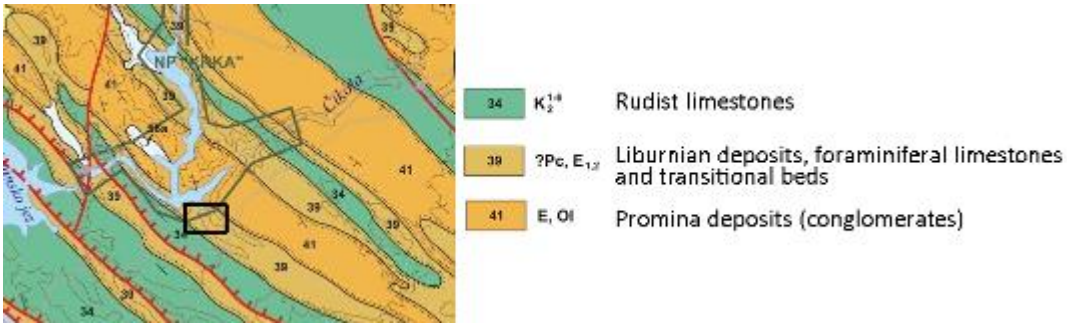

Figure 1 Geological map of study area. Black square indicates location of profiles (CGS, 2009).

The region is characterized by Mediterranean climate (Csa) with dry and hot summers and mild rainy winters (Filipčić, 1998). The mean annual temperature measured at meteorological stations Drniš and Šibenik during 1961-1990 period was 12.9 °C and 15.1 °C, while average annual amount of precipitation was 1063.2 and 808.1 mm respectively (Milković and Trninić, 2007). Accordingly, typical

Mediterranean vegetation dominates the region, characterized by heavily fragmented and degraded downy oak and oriental hornbeam forest (*Querco-Carpinetum orientalis H-ić 1939*) (Medak and Perić, 2005). On sparse agricultural plots grape vine (*Vitis vinifera*), olives (*Olea europaea*), figs (*Ficus carica*) and almonds (*Prunus dulcis*) are cultivated. According to the Basic pedological map of Croatia 1:50 000, section Šibenik 1 (Čolak and Martinović, 1975) dominant soil types on study area are: Calcocambisols, and Terra rossa, with less represented Calcomelanosols, Colluvium and Rendzinas.

Four study sites were selected to exemplify the most common parent material and soil types of the study area. Profile P-1 is developed on conglomerates; P-2 and P-3 on limestones, while P-4 on marly limestones. Field description of soil morphology and coarse surface fragment content followed FAO guidelines (FAO, 2006). Laboratory analyses were carried out by following methods: particle size distribution (ISO 11277:2009), pH (ISO 10390:2005), humus content (Tjurin method, JDPZ, 1966) and total carbonate content (ISO 10693:2004).

RESULTS AND DISCUSSION

Parent material at the study site is build up from Eocene conglomerates and limestones. Conglomerates are poorly sorted, clast supported with pebbles up to 2 cm in diameter, having variable sphericity. These are composed of Cretaceous and Paleogene limestones, granular dolomites, dolomitized radiolarian cherts and fossil fragments. Although outcrops mostly have massive appearance, weathering propagates along grain edges, causing disintegration of rock (while grains remain mostly intact). Limestones on the other hand are mostly detrital, fine-grained, and often alternate with marls or marly limestones with microcrystalline to cryptocrystalline structure. These rocks are subject to intense karstification process, causing rock weathering.

Figure 2. Typical appearance of rock outcrops a) conglomerates, b) limestones.

Described differences of parent material reflect in style of rock weathering, resulting in distinct properties of the soils develop on top (rockiness, soil depth, physical and chemical properties).

Surface of P-1 profile developed on conglomerates is characterized by having few rock outcrops (2-5-% with distance between rock outcrops 20-50 m), while surfaces of profiles developed on limestones (P-2 and P-3) and marly limestones (P-4) have many rock outcrops (15-40% with distance between rock outcrops 2-5 m; FAO, 2006). Furthermore, abundance and size of coarse surface fragments of analysed profiles as well depends on parent material (Figure 2). Conglomerates (profile P-1) have abounded amount (40-80%) of surface fragments, which size is mostly fine gravel (0.2-0.6 cm) and medium gravel (0.6-2 cm), while coarse gravel (2-6 cm) and stones (6-20 cm) are as well present. Profiles P-2 and P-3 developed on limestones have many (15-40%) coarse surface fragments, both being dominated by coarse gravel fraction, where medium gravel and fine gravel are present in P-2 profile, while P-3 profile contains stones and boulders (20-60 cm) fraction. Surface of P-4 profile developed on marly limestones has common (5-15%) surface fragments of larger size classes (boulders and large boulders; 60-200 cm). Determined surface rockiness and abundance and size of coarse fragments are in agreement with studies done in the region (Čolak and Martinović, 1975; Vrbek and Pilaš, 2007).

Soil depth is closely related to weathering processes of parent material (Koojiman *et al.,* 2005; Vrbek and Pilaš, 2007; Badia *et al.,* 2013; Perković *et al.,* 2017), thus studied soils vary from shallow (<35 cm) to medium deep (35-70 cm). Thickness of soil cover varies from 11 cm (P-1, conglomerates), over 17 cm (P-2, limestones), and 38 cm (P-3, limestones), to 66 cm (P-4, marly limestones). This can be attributed to weathering style of parent material and erosion. Thus, weathering of conglomerate rocks propagates along grain boundaries, causing detachment of clasts of different sizes which are accumulated on the surface, while fine fraction is probably eroded by water or blown away. Weathering of the limestones and marly limestones results in accumulation of insoluble residue which is a basis for soil development. These particles as well can be blown away, but rough morphology of limestone outcrops can act as a trap for sediments, where deeper soil outcrops are often found in fissures formed by karstification process (Bogunović *et al.,* 2009). Thus, profiles P-1 and P-2 have only one horizon A/B developed, profile P-3 has A and Bw horizons, profile P-4 has horizons A, Bw, Bt and Bk (FAO, 2006; Figure 3 a-d).

Analysed soil profiles mostly have clayey texture (Table 1) typical for these soil types (Durn 1999, Bogunović *et al.,* 2009, Vrbek and Pilaš, 2007, Vingiani *et al.,* 2018) having clear increase of clay content with depth.

Figure 3. Soil profiles on different parent material a) P-1 Terra rossa on conglomerates b) P-2 Terra rossa on limestone c) P-3 Calcocambisol on limestone d) P-4 Calcocambisol on marly limestones.

Table 1. Particle size distribution and texture classes of analysed soil profiles

Soil profile/horizon	2-0.2 mm	0.2-0.063 mm	0.063-0.02 mm	0.02-0.002 mm	<0.002 mm	Texture class
P-1/ A/B	2.9	2.7	36.5	26.3	31.6	Silty clayey loam
P-2/A/B	2.3	3.3	65.2	10.9	18.3	Silty loam
P-3/ A	1.8	3.6	34.9	37.0	22.7	Silty loam
P-3/ Bw	2.0	3.7	31.0	18.5	44.8	Silty clay
P-4/ A	4.5	6.1	18.0	24.1	47.3	Clay
P-4/ Bw	2.8	5.6	14.1	19.1	58.4	Clay
P-4/Bt	1.7	4.7	10.2	12.2	71.1	Clay
P-4/Bk	10.7	7.2	17.1	14.2	50.7	Clay

The soil reaction of analysed soils is weakly acid to alkaline (Table 2) depending on the presence of carbonates. Profiles P-1, P-2 and P-3 are non-calcareous throughout entire depth, indicating dominant chemical weathering of parent material, dissolution of carbonate sedimentary rocks and accumulation of insoluble residue, Table 2. Weakly acid reaction and absence of carbonates in soil profile is reported in many studies of Terra rossa (Škorić *et al.*, 1987; Miloš and Maleš, 1987; Temur *et al.*, 2009; Vingiani *et al.*, 2018) and Calcocambisols (Bogunović *et al.*, 2009; Vrbek and Pilaš, 2007).

Table 2. Soil reaction, carbonate and humus content of analysed soil profiles

Soil profile/horizon	pH		$CaCO_3$ %	Humus %
	H_2O	KCl		
P-1/ A/B	6.9	6.5	0.0	6.4
P-2/A/B	7.0	6.5	0.0	8.1

P-3/ A	6.9	6.5	0.0	7.4
P-3/ Bw	6.9	6.5	0.0	6.9
P-4/ A	7.0	6.6	3.9	9.1
P-4/ Bw	6.1	5.1	0.0	5.8
P-4/Bt	6.5	5.3	0.0	3.0
P-4/Bk	8.0	7.2	20.3	1.4

The carbonates present in profile P-4 in A horizon could be attributed to calcareous wind –blown particles. Carbonates are as well presented in the lowermost part of this profile (20.3% in Bk horizon) in a form of spheroidal nodules, few millimetres in size, that can be result of re-precipitation of dissolved $CaCO_3$ from underlying carbonate parent material. Furthermore, presence of carbonate rock fragments in this horizon indicates physical weathering of marly limestones.

Analysed soils have low to medium humus content (Table 2) depending on vegetation (amount of biomass) that is indirectly related to soil depth. The highest humus content was measured in the thickest soil profile (P-4), where values decrease with depth. Similar results were obtained in studies of cambic soils on carbonate parent material in Mediterranean area (Miloš and Maleš, 1998; Bogunović *et al.,* 2009; Vrbek and Pilaš, 2007; Vingiani *et al.,* 2018).

CONCLUSIONS

Parent material is an important factor in soil formation, impacting rock weathering style, type and amount of weathered material and consequently properties of the soils developed on top. Study area is built of conglomerates, limestones and marly limestones of Eocene age, characterized by high degree of karstification. Soils developed on conglomerates are shallow, having few rock outcrops and abundant coarse fragments (having fine and medium gravel size). Limestones have many rock outcrops and coarse fragments of coarse gravel size. Finally, soils on marly limestones are medium deep and have many rock outcrops, where coarse fragments are common and of larger size. Analysed soils have uniform clayey texture and variable chemical properties (pH, $CaCO_3$ and humus content) indirectly related to different weathering processes of carbonate parent material.

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IMPACT OF PRUNING LEVEL ON THE PRODUCTIVITY AND QUALITY PARAMETERS OFCARIGNAN WINE GRAPE CULTIVAR UNDER AS-SWEIDA GOVERNORATE CONDITIONS

Bayan M. MUZHER*, Ola T. ALHALABI, Samer ABOU-HAMDAN

General Commission for Scientific Agricultural Research (GCSAR), Sweida, Syria
*Corresponding author: bmuzher@hotmail.com

ABSTRACT

This research was carried out in the fields and laboratories of Apple and grapevine Research Department in Sweida Governorate- Syria during the period 2016-2018 on 20 years old Carignan wine grape cultivar grafted on Paulsen 1103 rootstock, in order to study the impact of the pruning level on productivity, and quantitative and qualitative characters of bunches and berries. The vines were pruned with three levels 4, 6 and 8 nodes/cane, with a total of 48 fruitful buds/vine. The results showed that the highest average of fertility rate was at 8 nodes/cane (76%). Productivity varied by the applied Pruning treatments as the pruning treatment 4 buds/cane significantly revealed the highest production (15 Kg/vine). Concerning the average of bunch weight, there were no significant variance among all pruning levels, and the highest bunch average weight was in 8 buds/cane treatment (163g), which also significantly revealed the highest weight of 100 berries (195.6 g), as well as the average ratio of juice (66.2 ml/100g). However, the effect of pruning levels varied in the average of total soluble solids (TSS), total sugar (TS), and titratable acidity (TA). Consequently, the results indicate the effective role of determining the level of pruning in Carignan wine grape cultivar and its impact on fertility, production characteristics and quality characters of this wine grape cultivar.

Keywords: *Grape, pruning, wine cultivar, fertility, productivity*.

INTRODUCTION

Grape is considered as one of the most important fruit crops in the world and in Syria. However, Grape cultivation in Syria has been taken up under different soils and climate conditions, the total cultivated area 44802 Ha produced 223383m ton (Annual statistics abstract, 2019). Grape production with high quality especially in the steady trend of climate changes and the variation of environmental regions required special treatments lead to the optimal size of canopy that effects on the production and bunch and berry traits through the correct practices of pruning and fertilization, in addition to suitable rootstocks (Bates, 2008). Wine grapes revealed distinct success under rainfed conditions in Sweida governorate at the south of

Syria (Al-Halabi *et al*., 2017). Pruning and the precision of grape yield is an important culture treatment to get the balance between different growth and fruitage and lead to high qualitative and quantitative characters of bunches and berries. Hence, the incorrect management of farms will reduce the productivity and the quality of fruits (Bem *et al*., 2016). Fruitfulness of any variety is of considerable importance in viticulture as it has direct impact on productivity of vines. An increase in the severity of pruning will increase the vigor of individual shoot at the expense of total growth and crop (Winkler *et al*., 1974). Pruning is one of the important cultural operations in grape production and standardized the pruning severity for any grape varieties is of utmost meaning for obtaining optimum yield and quality, and the vine should carry a sufficient number of canes, in order to maintain the uniform vigor throughout its life span (Kumar *et al*., 2017). Canopy vigor and productivity can be balanced through pruning levels which related to the variety and fruiting buds (Almanza *et al*., 2012; Allebrandt *et al.*, 2017). The application of three pruning levels (2,4,6 buds/cane) with a total number 12 canes/vine on Pusa Navrang grape cultivar showed that the 6 buds/cane treatment revealed the highest bunch numbers and weight (Palanichamy *et al*., 2004). However, production technology is yet to be standardized in Syria for wine grapes, as well the introduced wine grape cultivars have an essential importance due to their adaptation with environmental conditions and their benefits in wine making field, which require to standardize cultural practices especially pruning which is of immense importance. Carignan is an important wine grape cultivar requires enough labor for canopy management. Since, the present investigation was carried out to study the influence of different pruning levels on yield and qualitative traits of bunches and berries of Carignan wine grape cultivar.

MATERIAL AND METHODS

The present research was carried out during 2016-2018 in grapevine orchards at Pome and grapevine Division- GCSAR in Sweida Governorate, which located in the south of Syria at 1200-1500 m altitude. The mean rainfall 525mm.

Plant materials

-Carignan: is an introduced wine grape cultivar from Spain, the bunch is broad conical, the berry is short oval, with dark purple- black skin (Dokoozlian, 2003). The vines 20 years old, grafted on the rootstock Polsen 1103, the training system is cordon, the distance between vineyards and between the rows is 2.5 x 3 m under rainfed system agriculture.

Methods

Three winter pruning levels were applied with a total number 48 buds per vine. The three treatments were:

- Short pruning 4 buds/cane with 12canes per vine
- Moderate pruning 6 buds/cane with 8 canes per vine
- Long pruning 8 buds/cane with 6 canes per vine

Studied indicators

- Buds behavior: Bud burst ratio, fertility buds ratio, fertility coefficient according to (Bessis, 1960)
- Vine yield through calculation of the mean average of bunch weight (kg/vine) at maturity time (when total soluble solids range between 18-20° Brix.
- Physical characters of bunches: Mean number of bunches per vine, mean bunch weight (g), mean bunch length (cm), mean number of berries per bunch(10 bunches per vine were used for each pruning level)
- Physical characters of berries: Mean weight of 100 berries (g), mean number of berries in 100g, berry firmness, must yield per 100g.
- Chemical characters of berries: % Total soluble solids according to (Schwallier, 2005), % total sugar (Lane and Eynon 1923), % titratabe acidity(Graham,2004). pH.

Data analysis

experiment was designed in complete randomized blocks, using 3 treatments in three replicates. The variance among varieties was analyzed for each trait by one way ANOVA analysis, LSD5% was calculated to compare means.

RESULTS AND DISCUSSION

Buds behavior

The results showed that the highest bud burst percentage was (71.5%) in 4 buds/cane treatment, without significant variance among treatments and years. While as, the highest fertility buds percentage was (76.0%) in 8 buds/ cane treatment with significant variance with 6 buds/cane treatment (Table 1), the first year of study showed also significant variance in fertility percentage (86.9%) with the second and third year (60.3% and 65.6% respectively). Fertility coefficient was insignificantly the highest in 4 buds/cane treatment (170.8) among treatments, however the first year of study showed significant variance in fertility coefficient (221.8) with the second and third year (118.7 and 72.2 respectively). This result was in accordance with (Al-Halbai *et al*.,2017), they demonstrated that the highest fertility buds laid in the fifth based buds in wine grape cultivars like Cabrenet Sauvignon and Quartz treminer. Varieties responded differently for different levels of pruning, Grenache variety revealed the highest fertility buds in 8 buds/cane pruning treatment, while it was minimum (60%) in the variety Cabernet Sauvignon in 4 buds/cane pruning treatment (Chalak *et al*., 2011)

Table 1. Effect of different pruning levels on the mean of Bunch physical traits Caringnan cultivar

treatment	of Bud burst (%)	Fertility buds (%)	Fertility coefficient
4 buds / cane	71.5	70.6 ab	170.8
6 buds / cane	63.6	66.4 b	109.7
8 buds / cane	64.6	76.0 a	132.2
LSD5%	-	**9.5**	-

Different letters (a,b)in the same column indicate to significant variance

Yield

The data presented in Figure 1 revealed that the 4 and 8 buds/ cane treatments were significantly higher than 6 buds / cane treatment during the years of study, the mean yield was 15.0, 9.2 and 14.0 kg/vine in 4 buds, 6 buds and 8 buds/cane respectively. It is clear from Figure 1 the differences in yield between years but without significant variance, The effect of pruning levels on yield parameters is not always consistent from year to year as shown in a four years study conducted by Freeman *et al*. (1979). This result was in accordance with (Chalak *et al*., 2008), they found that the maximum yield (3.80 kg/vine) was recorded in the variety Pinot Noir in 4 buds/cane pruning treatment. Also, long pruning treatment gave the chance to more fertility buds which contributed to increase the yield (Almanza-Merchán *et al*., 2014). Hence, the effect of pruning treatment on yield differed due to the studied cultivar and pruning level (Chalak et al., 2011).

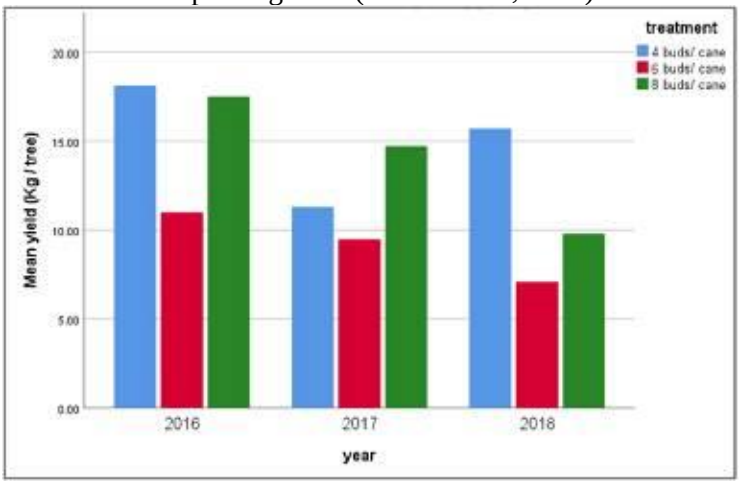

Figure (1): Effect of different pruning levels on yield of Caringnan cultivar. LSD5% between pruning levels = 4.82

Bunch physical traits

The highest mean number of bunches was in 4 buds/cane treatment (109.0 bunches), followed by treatment 8 buds/cane (99.7 bunch). While the lowest mean bunch weight was in treatment 4 buds/cane (133.8 g), and the highest mean bunch weight was (163.0 g) in treatment 8 buds/cane. This result was in line with (Chalak et al., 2011) in Cabernet Franc cultivar, it was the maximum (121.87 g) in 8 buds/cane pruning treatment. On the other hand, the 6 buds/cane treatment revealed the highest mean bunch length (17.0 cm) and berries number/ bunch (132.8 berries). The results in Table 2 showed that the differences between pruning levels were insignificant in all studied bunch physical traits, as well as between studied years in mean bunch number, while in mean bunch weight the second year was significantly higher (167.3 g) than first year (134.5 g), and also showed significant variances with third year in bunch length and berries number / bunch. Chalak *et*

al. (2011) found that the two pruning levels 4 and 8 buds/cane recorded the maximum number of bunches in Cabernet Franc cultivar (69.7 and 76.16 bunches/vine). Light pruning treatments lead to produce more number of sprouted buds than in severe pruning treatments. This increased total number of sprouted buds in light pruning treatments ultimately reflected into more number of bunches (Main and Morris, 2008).

Table 2. Effect of different pruning levels on bunch physical traits of Caringnan cultivar.

treatment	**Mean No. of Bunches/vine**	**Mean Bunch Weight (g)**	**Mean Bunch Length (cm)**	**Mean No. of Berries/Bunch**
4 buds / cane	109.0	133.8	14.9	107.7
6 buds / cane	78.7	144.4	17.0	132.8
8 buds / cane	99.7	163.0	16.7	119.0
LSD5% between pruning levels	-	-	-	-

Berry physical traits

The data presented in Table 3 showed that the mean weight of 100 berries was the highest in 8 and 4 buds/cane treatments (195.6 and 189.4g, respectively) with significant variance with 6 buds /cane treatment. The 6 buds/ cane pruning treatment revealed the highest mean berries number/100g (66.0 berries) with significant variance in the comparison with the two other treatments. However, mean berry firmness and must yield showed insignificant variance among all studied treatments which is in line with (Souzaleao and Lima, 2016). When we compared between the years of study, the second year showed significant differences with the two other years for all studied berry physical traits .Sabbatini *et al*. (2015) stated that the increase of bunches number negatively reflected on bunches and berries weight. However, the number of berries in 100g affected by the nutrition status of vine and pruning level (Zheng Song *et al*.,2015).

Table 3. Effect of pruning levels on berry physical traits of Caringnan cultivar.

treatment	**Mean 100 berries weight (g)**	**Mean berries number/100 g**	**Mean berry firmness (kg/cm^2)**	**Mean must yield (ml/100 g)**
4 buds / cane	189.4 a	56.0 b	0.7	58.8
6 buds / cane	170 b	66.0 a	0.5	59.3
8 buds / cane	195.6 a	55.7 b	0.6	66.2
LSD5% between pruning levels	**18.2**	**3.82**	**-**	**-**

Different letters (a,b) in the same column indicate to significant varianceBerry chemical traits

The 4 buds/ cane pruning treatment significantly showed the highest values of TSS, total sugar and pH (23.1 %, 20.5 % and 3.90, respectively), followed by 6 buds / cane treatment (21.2 %, 18.8 % and 3.72 respectively) which in turn differed significantly than 8 buds / cane except in pH (Table 4). While as, the 6 buds/ cane treatment significantly showed the highest total acidity (0.71 %). When we compared between the years of study, the difference were significant in TSS, total sugar and total acidity, while in pH the third year significantly revealed the maximum value. Kilby *et al*. (1999) found that the total soluble solids decreased with the increase of buds/cane.

Table 4. Effect different pruning levels on berry chemical traits of Caringnan cultivar

Treatment	**TSS (%)**	**Total sugar (%)**	**Total acidity(%)**	**pH**
4 buds / cane	23.1 a	20.5 a	0.50 c	3.90 a
6 buds / cane	21.2 b	18.8 b	0.71 a	3.72 b
8 buds / cane	19.3 c	18.0 c	0.60 b	3.75 b
LSD5% between pruning levels	**0.9**	**0.79**	**0.02**	**0.09**

Different letters (a,b,c) in the same column indicate to significant variance

CONCLUSION

It is evident from the results the effective role of determining the level of pruning treatments in Carignan wine grape cultivar and its impact on fertility, production characteristics and quality characters of this wine grape cultivar.

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THE COMPARISON ANALYSIS OF SOFTWARE FOR MANTEL TEST BETWEEN DNA MARKERS AND MORPHOLOGICAL TRAITS OF PLANT VARIETIES

Larysa PRYSIAZHNIUK[1*], Yevhenii STARYCHENKO[1], Svitlana HRYNIV[1], Yuliia SHYTIKOVA[1], Nadiia LESHCHUK[1], Serhii MELNYK[1], Oksana KLIACHENKO[2]

[1] Ukrainian Institute for Plant Variety Examination, Ukraine
[2] National University of Life and Environmental Sciences of Ukraine
*Corresponding author: prysiazhniuk_l@ukr.net

ABSTRACT

An advanced approach to the assessment of varieties for the determination of their differences both within the DUS test and breeding is a combination of morphological traits and DNA markers. An implementation of this approach includes a correlation assessment between genetic distances matrices. To this end, the Mantel test is applied. The purpose of the study was to identify the main advantages and disadvantages of different software products for the Mantel test based on correlation investigation between DNA markers and morphological traits of lettuce varieties and maize lines. As a result of correlation calculation between 8 SSR markers and 36 morphological traits of 100 maize lines by XLSTAT (software for Microsoft Excel) p-value (probability of obtaining test results) was 0.0005. The value of this indicator obtained by PASSaGE software was 0.034. There was a p-value of 0.045, which was calculated by GenAlEx 6.5 in Microsoft Excel (MS Excel). A similar result (0.036) was obtained by software environment R. The p-values, which were calculated between 7 EST-SSR markers and 32 morphological traits for four lettuce varieties by XLSTAT, PASSaGE, GenAlEx, and R, were 0.033, 0.039, 0.038, and 0.035, respectively. In the study, the upper-tailed test served an alternative hypothesis type, the level of significance α was 0.05, the type of correlation was Pearson correlation, and the Monte Carlo method was used for p-value computation. Thus, the obtained p-values allow to reject the null hypothesis (H0) and adopt the alternative hypothesis Ha of correlation ($p < \alpha$). The correlation coefficient for maize lines was 0.05 and for lettuce varieties 0.65. Therefore, XLSTAT and software environment R are the most suitable instruments for correlation assessment between genetic distances.

Keywords: *correlation coefficient, maize, lettuce, Mantel, p-value.*

INTRODUCTION

In molecular genetic analysis, it is often necessary to compare two sets of distance measures. These measures can be based on genetic markers, morphological traits, geographic separation, ecological divergence, etc. (Smouse *et al.*, 1986). Following UPOV (International Union for the protection of new varieties of plants) principles, the description of plant lines and varieties that are subject to the DUS (distinctness, uniformity, and stability) examination is based on marker morphological characteristics. However, since the beginning of the 2000s, some countries have begun to use additional methods for assessing variety differences at the national level (Prysiazhniuk *et al*., 2020) and test them at the international level. SSR (Simple Sequence Repeats) is a commonly used technique. The main advantages of SSR markers are a high level of polymorphism, widespread genome distribution, codominant type of inheritance, and the presence of validated methods for their use. Among DNA markers, EST-SSR (Expressed Sequence Tag Single Sequence Repeats), which are related to the expression regions, are widely used for the analysis of the genetic diversity of common species and the study of intraspecific diversity (Leshchuk *et al*., 2021). According to UPOV's core principles for the comprehensive analysis of new varieties, there are several approaches to the involvement of DNA markers: the management of a reference collection of varieties, the study of links between DNA markers and economically important traits, and a combination of varieties assessment by morphological and DNA markers. The combination of DNA markers and morphological characteristics includes the study of the correlation between DNA markers and morphological traits. Mantel test is a commonly recognised method for assessing this correlation (Karuri *et al*., 2010; Riday *et al*., 2003; Hong *et al*., 2015; Huseynova *et al*., 2018; Ho *et al*., 2020).

Today many software products may be used for analysing molecular data by Mantel test (Omelka & Hudecova, 2013; Huseynova *et al*., 2018). The most commonly used software for molecular data and population genetic data analysis are add-on XLSTAT MS Excel, PaSSaGE, GenAlex, and software environment R, which differ from each other with particular features such as type input data, methods of results interpretation, type of indexes calculation, etc. Thus, the purpose of this study was to apply XLSTAT, PaSSaGE, GenAlex, and software environment R for correlation determination between DNA markers and morphological traits of different data types by Mantel test.

MATERIAL AND METHODS

To determine the correlations between DNA markers and morphological traits we used 100 lines of maize (Ukrainian and foreign breeding) and 4 varieties of lettuce (Ukrainian breeding).

Maize lines were examined by 8 SSR markers and 36 morphological traits in the years 2018−2019 within the framework of qualification examination (Prysiazhniuk *et al*., 2019). Lettuce varieties were examined by 7 EST-SSR markers and 32 morphological traits. The description of morphological traits of lettuce was

performed during its qualification examination in the years 2010-2015 (Leshchuk *et al.*, 2021).

Genetic distances by SSR markers and morphological traits of maize lines were calculated by the MS Excel add-on XLSTAT product using the unweighted pair-group average method. Jaccard distances of lettuce varieties were obtained by IBM® SPSS® Statistics for EST-SSR markers and by add-on XLSTAT for morphological traits (Leshchuk *et al.*, 2021).

The correlation between DNA markers and morphological traits of maize lines and lettuce varieties was determined using XLSTAT, PaSSaGE, GenAlex, and software environment R. For all software products, the following parameters were selected: type of alternative hypotheses: upper one-tailed; significance level α: 5%; p-values computation: Monte Carlo method; type of correlation: Pearson. The number of permutations was chosen according to the capabilities of the software and the number of test samples (Oden & Sokal, 1992; Dutilleul *et al*., 2000). To rank software products for the Mantel test we used the analytical hierarchy process (Saaty, 1980).

RESULTS AND DISCUSSION

Since the Mantel test allows detecting correlations between distance matrices, the first step was to obtain distance matrices by DNA markers and morphological traits.

Mantel test using the add-on XLSTAT MS Excel

The add-on XLSTAT is a flexible data analysis tool based on MS Excel. The add-on XLSTAT allows calculating genetic distances by binary code and digital codes of marker traits using the Agglomerative Hierarchical Clustering (AHC) tool, with the default number of permutations being 10000.

According to the obtained genetic distances of maize lines by SSR markers, 88 out of 100 distinct lines were selected by 8 SSR markers. Four pairs of maize lines (fertile lines and their sterile analogues) were found identical by 36 morphological traits (Prysiazhniuk *et al*., 2020).

Four lettuce varieties were found distinct by 7 EST-SSR markers and 32 morphological traits.

In order to verify the presence of correlations among the studied maize lines pairs and lettuce varieties by morphological traits and DNA markers, the Mantel test (linear Pearson correlation) was performed using the Correlation/Association test. As a result of the analysis of the genetic distances matrices of maize lines and lettuce varieties by DNA markers and morphological traits using the add-on XLSTAT, a scatter plot, histogram and correlation coefficient were obtained. Shown in Fig. 1 is a scatter plot of maize Mantel test results by SSR markers and morphological traits.

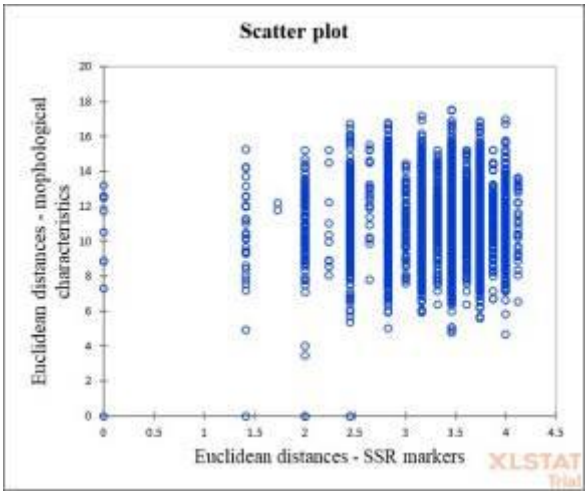

Fig. 1. Relationship between genetic distances of maize lines by SSR markers and morphological traits obtained with XLSTAT

As a result of the Mantel test performed for 100 maize lines, the p-value made up 0.0005 at α=0.05. Therefore, according to the interpretation of the test, an alternative hypothesis Ha about the presence of a positive correlation is accepted. The correlation coefficient r = 0.051.

In the analysis of four lettuce varieties, an alternative hypothesis about the presence of a positive correlation between the genetic distances matrices by EST-SSR markers and morphological traits was also accepted. In this case, the p-value was 0.033 at α=0.05. The correlation coefficient was r = 0.646.

Thus, the add-on XLSTAT is a simple and convenient tool for determining the correlation between the genetic distances matrices by DNA markers and morphological traits. A significant advantage is the convenient data entry, the ability to calculate genetic distances directly in the software environment, which eliminates conflicts with the format of data obtained with other programs, a wide range of test options (correlation type, type of alternative hypothesis, etc.), test interpretation explanation and graphical display of results. However, after the expiration of the trial version, the add-on functions of XLSTAT become significantly limited; therefore, it is necessary to purchase the full version for permanent use.

Mantel test using GenAlex

GenAlex (Genetic Analysis in Excel) is designed as a package with an intuitive and consistent interface that allows user to analyse a wide range of population genetic data within a software environment MS Excel (Peakall & Smouse, 2012). The focus of the program on the analysis of population genetics data imposes certain restrictions on the type of data and algorithms for analysis.

In GenAlex, the calculation of genetic distances by binary codes of DNA markers and codes of morphological traits is performed using the tool Distance-Based (Genetic). However, there is only Nei's genetic identity and distance measures

using GenAlex. However, the Mantel test can also be performed on ready-made both triangular and symmetric matrices which must be placed on separate MS Excel worksheets with certain input data on the number of populations, their size, etc. according to the instructions. The Mantel test was performed using the tool Distance-Based (Mantel - Paired). The maximum number of permutations (9999) was chosen for the analysis. As a result of the Mantel test, depending on the selected options for result display (Tri distance matrix), a scatter plot with a regression equation was obtained, which illustrates the relationship between the matrices. In addition, p-value (P (rxy-rand> = rxy-data)) and correlation coefficient (Rxy) are specified.

As a result of the analysis, the calculated p-value was 0.038, which does not exceed α (0.05) and allowed to accept the alternative hypothesis Ha about the presence of correlation, the correlation coefficient is 0.646 and does not differ from the value obtained with other software products. For the studied maize lines, the p-value obtained with GenAlex was 0.045 at α=0.05, which indicated the need to reject the null hypothesis H0 and proves the presence of correlation between the genetic distances matrices by SSR markers and morphological traits. The correlation coefficient value (r=0.051) coincides with those calculated using the other software products.

Thus, GenAlex software allows determining correlations between distance matrices by DNA markers and morphological traits. However, its focus on processing population genetics data requires additional preparation of the source data. GenAlex capabilities impose some restrictions on the data format (the ability to calculate genetic distances, a certain order of matrices, and field labels). Besides, the interpretation of the Mantel test is described only in the program manual and there is no choice of the alternative hypothesis. The advantages of using GenAlex for the Mantel test include its implementation based on MS Excel, the availability of detailed step-by-step instructions and demonstration files with examples of calculation, the ability to select the number of permutations, and graphical presentation of results.

Mantel test using PASSaG 2

PASSaGE 2 (Pattern Analysis, Spatial Statistics, and Geographic Exegesis) is a free software package which implements a significant number of statistical methods for biological and other data types, including cluster and correlation analysis. Since PASSaGE 2 does not provide the possibility to calculate genetic distances from binary or digital data, separate MS Excel workbooks for EST-SSR and SSR markers and morphological traits are developed to import the distance matrix. These workbooks contain symmetric matrices with the results of cluster analysis. Mantel test was performed by selecting this type of analysis in the menu for the following parameters: number of permutations 999 for lettuce varieties and 9999 for maize lines. It should be noted that in PASSaGE 2, the correlation is calculated for three types of alternative hypotheses: two-tailed, left-tailed, and right-tailed.

As a result of the analysis, a significant correlation was found between the genetic distances matrices by EST-SSR markers and morphological traits of lettuce varieties (correlation coefficient r = 0.64587). The need to reject the null hypothesis H0 is evidenced by the result of calculating p-value by the upper one-tailed test (p-value is 0.03900 at $\alpha = 0.05$).

For maize lines, the upper one-tailed test result indicates the need to accept an alternative hypothesis about the presence of correlation between genetic distances matrices by SSR markers and morphological traits (p-value is 0.03400 at $\alpha = 0.05$), with the correlation coefficient being 0.0512. Thus, as a result of the evaluation of the correlation between the genetic distances matrices by DNA markers and morphological traits of maize lines and lettuce varieties using PASSaGE 2, it was found that there is a direct positive correlation between the studied matrices, and the obtained correlation coefficients that coincide with the values calculated with the use of the other software products.

One of the significant disadvantages of work in PASSaGE 2 for the Mantel test is that all data, including input, must have a matrix format, which causes some difficulties in formatting the results obtained from other statistical software. In general, PASSaGE 2 can be assessed as easy-to-use software, if we do not consider the input procedure. There are parameters of randomization (permutation test) and the possibility of partial correlation, but there is no flexibility in the settings of the analysis, the output of graphical information, and the indication of the type of correlation. Among positives is a good help system with an explanation of the methods used.

Mantel test using software environment R+EcoGenetics

Software environment R is a cross-platform open-source software environment for statistical calculations. The EcoGenetics package has the most opportunities for analysis. It is designed to simplify and speed up data analysis procedures in the fields of ecology and genetics. Also, it has functions for the analysis of spatial autocorrelation and interactive visual data environment.

Software environment R allows calculating genetic distances both by the binary code of DNA markers and digital codes of morphological traits. In addition, this software environment allows importing data from many possible formats, including MS Excel worksheets.

To assess the correlations between DNA markers and morphological traits of lettuce varieties and maize lines using software environment R as a source data we used symmetric genetic distances matrices. In the Mantel test, we used an *eco.mantel function.* Before using the function we connected the EcoGenetics library. The following *eco.mantel* function arguments were used to calculate the correlation: **method =«pearson», nsim = 9999, alternative = «greater»**. The displayed results are shown in Listing 1.

Listing 1. Mantel test results by SSR markers and morphological traits of maize lines

```
############################
   Mantel test
 ############################

  > Correlation coefficient used -->
Pearson
  > Number of simulations -->  9999
  > Alternative -->  greater
  > P-value -->  0.036
  > Observed value -->  0.0512
  > Expected value -->  -0.117
```

As a result of the calculations, the correlation coefficient (r) is equal to 0.0512 and does not differ from the value obtained by using other software products, and p-value of 0.036 at $\alpha = 0.05$ indicates the need to accept an alternative hypothesis Ha about the positive correlation between matrices and morphological traits of maize lines.

For lettuce varieties, a direct positive correlation was found between genetic distances matrices by EST-SSR markers and morphological traits. The correlation coefficient (r) is 0.646. The obtained p-value of 0.035 at $\alpha = 0.05$ indicates the rejection of the null hypothesis H0 and the adoption of an alternative hypothesis about the presence of the correlation Ha.

Even though the use of software environment R together with EcoGenetics package provides the widest possibilities and variability of analysis, the statistical environment is difficult to use. In particular, because of the use of commands rather than a graphical environment and the need to convert data into different formats for the relevant statistical analysis methods. The advantages of using R include cross-platform, the ability to integrate into Excel (RExcel,) and creating software scripts for analysis, which can be used in similar research. The advantages also include a built-in help and tips system, a lot of free literature on the implementation of statistical methods in the software environment R, graphical capacity for displaying research results, and the installation of support packages (libraries) with the necessary functions.

Thus, the obtained correlation coefficients for maize lines and lettuce varieties turned out to be the same with the use of different software products, which was achieved by setting the same parameters for calculation. It should be noted that the p-value calculated in the studied programs varied. This can be explained by the peculiarity of the Mantel test, which is to calculate the coefficients of significance using random permutations of the columns or rows of the studied matrices. Thus, even when performing calculations using the same program, obtained p-values are slightly different (Dutilleul *et al.*, 2000).

Thus, for both a quite large and a small number of samples, a direct positive correlation was found. Although a large sampling was studied for maize, the correlation coefficient between SSR markers and morphological traits was lower than the correlation obtained for lettuce. This can be explained by the fact that the EST-SSRs used to analyse lettuce varieties are located in the coding region of the

gene and may be closely related to genes that are responsible for a particular morphological trait. Importantly, the studied varieties of lettuce belong to the same species. As a result, they have a sufficient number of the same manifestation degrees of morphological traits, even though varieties were found different by EST-SSR markers (Leshchuk *et al*., 2021).

To evaluate the studied software products, the analytical hierarchy process was used, which allows to structure the problem of choosing alternatives and criteria for their selection, to rank alternatives, and to mathematically substantiate the obtained results.

In the analytical hierarchy process, a decision-making hierarchy is developed: the comparison hierarchy contains one hierarchical level with four criteria and four software alternatives (XLSTAT, GenAlex, PaSSaGE, and R + EcoGenetics) (Fig. 2). The criteria chosen are: the cost of the software package, the possibilities of statistical analysis, the complexity of working with the package («entry threshold» and help service), and data processing, which includes the complexity of data preparation and information processing speed.

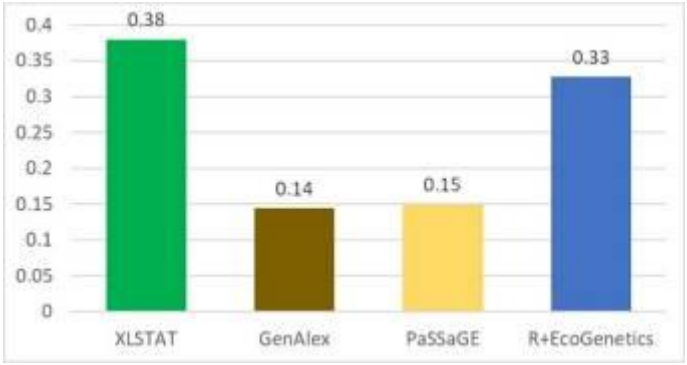

Fig. 2. Ranking of the software obtained with the analytical hierarchy process

As a result of the calculation, the add-on XLSTAT package was found to have the highest rate (0.38) among the studied programs. R + EcoGenetics is ranked in second place (0.33). GenAlex and PaSSaGE have almost the same rating (0.14 and 0.15, respectively). According to the obtained data, the most convenient and suitable for the Mantel test is the add-on XLSTAT. R + EcoGenetics is somewhat inferior to XLSTAT in terms of ease of use, but has more features and is free. Although GenAlex and PaSSaGE allow determining the correlation using the Mantel test, they have limitations on data entry and flexibility of adjusting test parameters.

It should be noted that the use of the add-on XLSTAT is quite common in determining the correlations of microbial communities of plant and soil, as well as for DNA markers. Thus, Kumar *et al*. (2014) studied the correlation between ISSR and RAPD markers in the analysis of genetic divergence of *Justicia adhatoda* L. The study of Ding *et al.* (2015) is dedicated to the determination of the correlation between EST-SSR markers and the geographical distribution of *Phoebe*

chekiangensis. Add-on XLSTAT was also applied for determination of the correlation between sampling points belonging to the same plant within the study of the vertical distribution of the ectomycorrhizal community in the topsoil of Norway spruce stands (Scattolin *et al*., 2008).

The use of GenAlex to determine the correlations between the genetic distance matrices of DNA markers and geographical coordinates is also common. In the study of Huang *et al*. (2019), the Mantel tests implemented in GenAlEx were performed to analyse the effects of geographical distance on genetic structure. Similar studies have been conducted by Nantoume *et al*. (2013). They studied the correlation between the geographical distances matrix and the genetic distance matrix using the Mantel test in GenAlex. Gupta *et al*. (2018) used the Mantel test to test the goodness of fit between RAPD and ISSR markers by GenAlEx within accessions of Cymbopogons studing. Rebaa *et al*. (2017) studied variability in Tunisian populations of faba bean. They conducted the Mantel test using the GenAlEx program for correlation between genetic, geographical, and morphological distances.

Ghalmi *et al*. (2010) used PASSaGE for morphological and molecular diversity within Algerian cowpea by Mantel test. Mushtaq *et al*. (2016) compared agro-morphological and SSR data of maize inbred lines. The analysis was performed by calculating the correlation between the agro-morphological and SSR similarity matrices through the Mantel test using PASSaGE software. The PASSaGE was used by Yadav *et al*. (2013) for the Mantel test to assess genetic diversity in Indian rice germplasm.

Extensive capabilities of the software environment R in combination with various packages involve its use for processing molecular genetic data. Thus, Nagamatsu *et al*. (2021) studied strawberry fruit shape and QTL detection by genome-wide association. They used software environment R with EcoGenetics package for significant associations determination between genotype and phenotype of strawberry. Hoppe *et al*. (2016) studied the species assemblages and their geographical distribution correlation by distances matrices comparison using R + EcoGenetics. The EcoGenetics package was also used by Bessega *et al*. (2017) in the study of semi-arid *Prosopis flexuosa* (Leguminosae) species.

Thus, it is shown that the studied software products have a wide range of possibilities for determining the correlation between distance matrices, and they are used in various fields of ecology, biology, and genetics. Our research shows the possibility of using these products to assess the correlations between DNA markers and morphological traits of plant varieties, describes the main stages in the calculation of genetic distances and conducting the Mantel test, identifies the main advantages and disadvantages of the products using the analytical hierarchy process.

CONCLUSIONS

In the study of 4 lettuce varieties by 7 EST-SSR markers and morphological traits and 100 maize lines by 8 SSR markers and morphological traits, correlations

between the genetic distances matrices of traits were determined with the aid of the Mantel test. In the course of the research, we studied four different statistical data processing software products that allow calculating the correlation coefficient and the level of significance based on random permutations of distance matrices: XLSTAT, PaSSaGE, GenAlex, and software environment R. It was found that there is a direct positive correlation between genetic distances matrices of lettuce by EST-SSR markers and maize by SSR markers and morphological traits.

The ranking of the software products with the use of analytical hierarchy process shows that the most suitable for determining the correlation between DNA markers and morphological traits based on the selected evaluation criteria is XLSTAT (0.38). R + EcoGenetics (0.33) is ranked in second place in terms of ability to perform tasks. Such an approach allowed evaluate the software products in the form of mathematical information, which minimizes subjective judgments. Thus, the possibilities of different software products for determining the relationship between DNA markers and morphological traits shown in the work open up prospects for studying links between DNA markers and economically valuable traits, and a combination of varieties assessment by morphological and DNA markers.

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INDEX OF AUTHORS

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Results and Discussion should be combined into a single section.

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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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