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¹Agriculture Extension and Technology Transfer Department, College of Agriculture and Forestry,
University of Mosul, Iraq

²Department of Plant Production Technology and Commodities, University of Life Sciences
in Lublin, Akademicka 15, 20-950 Lublin, Poland
e-mail: barbara.sawicka@up.lublin.pl

TALAL SAEED HAMEED¹, BARBARA SAWICKA²

Farmers' knowledge of sustainable potato cultivation techniques in Poland

Wiedza rolników o zrównoważonych technikach uprawy ziemniaka w Polsce

Summary. The research was aimed at determining the farmers' knowledge about sustainable agricultural techniques in potato cultivation by identifying their personal, social, economic and communication characteristics. In addition, the intention of research was to find a connection between the farmer's knowledge of potato cultivation in sustainable agricultural techniques and independent variables that characterize the farmers. These studies were based on primary data collected in the years 2014–2016 on a representative sample of 152 potato producers in the Mazovian province. A standardized structure questionnaire was used to collect the field data through personal interviews. The questionnaire consisted of two parts: the first part contained independent variables (age, level of education, marital status, occupation, sex, source of income), while the second one consisted of an assessment test of potato producer knowledge on sustainable agricultural techniques. The results showed that knowledge about potato cultivation for sustainable agricultural techniques is medium with a low tendency. Among the socio-economic variables, the level of education and occupation were the most important factors influencing the knowledge of a farmer-producer of potato with sustainable agricultural techniques in the studied area. The significant differences occurred between knowledge about potato cultivation for sustainable agricultural techniques according to variables in categories (age, level of education and profession). Only three independent variables had a significant link to the adoption of innovation in agriculture: source of income, level of education and occupation.

Key words: knowledge, education, sustainable agriculture, techniques farming

INTRODUCTION

Agricultural knowledge is indispensable for the sustainability of natural resources and agroecosystems. It consists of a local component, knowledge of species and environmental

phenomena, understanding of agricultural practice, as to the ways in which farmers carry out activities related to the use of resources in ecosystems [Mazvimavi 2011, Ashok et al. 2016]. Interest in agricultural knowledge has been growing in recent years, especially as the recognition of such knowledge can potentially contribute to biodiversity and its protection, maintaining sustainable resources and strategies. Traditional agricultural knowledge and practices are of great importance; they also become a test of time and prove effective for the local population and form the basis of their connection with nature, and varying levels of sophistication of this knowledge depend on the level, at which the basis for social evolution is found. Some traditional technologies offer promising entry points for creating packages based on the local community [Junge et al. 2009, Jadalla et al. 2011, Hameed and Sawicka 2017]. This is the case with agroecosystem resource management technologies. While these changes in the strategy would result in a better implementation of these programs, the participation of local communities may also lead to the greater use of traditional practices. The rediscovery of traditional ecological knowledge as adaptive management and the need for an ecological adaptive strategy for the management of natural resources gives scientists the opportunity to solve problems that plague biologists, farmers and nature conservationists [Ashok et al. 2016, Jahnavi 2018]. It is therefore necessary to properly document such a knowledge base. There is a mounting body of evidence demonstrating that sustainable production practices in potatoes can work. Researchers from across the country have analyzed the benefits of diverse crop rotations and tillage practices on potato production, and found positive results [Gumul et al. 2011, Birch et al. 2012, Hameed and Sawicka 2017]. Hence, environmentally sustainable potato production requires reduced dependence on pesticides. Consumers are increasingly lobbying for the protection of the environment and are underscoring these requests by changing their purchasing patterns. Farmers are responding with reduced and more efficient use of pesticides by means of more environmentally friendly chemicals, superior application equipment, scouting, training and increased communication [Van der Zaag 2010, De Steur et al. 2019]. Today, there is a need for sustainable agricultural technologies and practices, because sustainability in agricultural systems incorporates concepts of both resilience (i.e. the capacity of systems to buffer shocks and stresses) and persistence (i.e. the capacity of systems to continue over long periods). This culminates in many wider economic, social and environmental outcomes [Gopalswamy and Anbarashan 2011, De Steur et al. 2019]. Therefore, the goal of agricultural extension is to satisfy knowledge, skills and needs of all types of farmers in order to help them in running their farms efficiently to become good citizens and to improve their quality of life [Farrington 1995]. It also helps to reform the management of agricultural and rural development by creating effective regulatory agencies for agriculture. Effective regulatory agencies create a good investment climate for the private sector and farmer organizations, giving priority to agriculture agendas and local government institutions [Farrington, 1995, Jadalla et al. 2011, Hamed and Sawicka 2016]. The aim of the work was to examine the factors affecting the flexibility of potato production and the adoption of new methods while analyzing some of the key issues that dominate the flexibility of adoption of production in the context of Polish soil and climatic conditions.

MATERIAL AND METHODS

The study was carried in Mazovian region, in Poland. The population of this study consisted of 152 farmers. Data were collected through questionnaire, which consisted of two parts. The first part included independent variables (farm size, farming experience and age) measured by number of years, and level of education including 5 following levels: graduate of an elementary education (1), graduate of a secondary (2), graduate of school of vocational education (3), graduate of college (4), highest certificate (5). Marital status had four categories: single, married, divorced and widowed; and family size by number of persons. Types of questions: true, false, single choice, multiple choice and match the answer (there may be more answers than questions). The test consisted of a set of 20 questions. Numeric answers (possibility to give the accuracy of the answer), short answer a long answer. Request to define exactly how the answers were verified: the multiple-choice question is characterized by the fact that the respondent has several answers to choose from, at least one of which is true. It is also possible that all questions are correct. Every correct answer should be given its weight (expressed as a percentage). The sum of correct grades must total 100%. Usually, each correct answer is assigned the same weight. It is possible when their number is <10.

THE SCALE ADOPTION OF SUSTAINABLE AGRICULTURE PRACTICES BY POTATO'S FARMERS

Based on available literature on the selection of adoption sustainable Agriculture practices [D'Emden et al. 2006, Ayoade 2013, Thanh and Yapwattanaphun 2015], and through field visits and discussion with some professors who their specialty in sustainable agriculture, were designed scale to measured adoption level of sustainable agriculture practices. The scale consisted of 20 items which distributed into four domains these are: fertilizers and fertility – 5 items, control harmful organism – 6 items, seed production – 5 items, management of production – 4 items, and the items were formulated as questions, a type of multiple-choice (Tab. 1). Every practice in the scale Adoption level of sustainable Agriculture practices was dichotomized the such that a value of 1 was given an adopter farmer, while 0 – was given a nonadopter farmer, and then was dichotomized the value of 1 to numeric values (1–9), depending on the number of choices for each practice an overall adoption score was computed for each of the respondent by adding the score of 20 practices. Possible range of the overall adoption score of the study respondent farmers could range from 1 to 104 numerical values, where 1 indicated minimum adoption and 104 indicated maximum adoption of sustainable agriculture practices. For comparing the extent of adoption of all selected practices of sustainable agriculture as a factor of adoption determinants it was required to compute an adoption index for each of the 20 practices (Tab. 1).

Table 1. The domains of sustainable agriculture practices

Domain	No	Sustainable agriculture practices	Range of scores
I Fertilizers and fertility	1	Consumption of natural and organic fertilizers	0–9
	2	Consumption of mineral fertilizers	0–6
	3	Dose of nitrogenous fertilizers for potatoes	0–4
	4	Micro- and macro-nutrient fertilizers	0–6
	5	Fore crop	0–7
II Control harmful organism	1	Potato tubers treatment with emoldant before planting	0–5
	2	Methods of mechanical weeding	0–4
	3	Herbicides products effectiveness against dicotyledonous weeds	0–7
	4	Herbicides products effectiveness against monocotyledonous weeds	0–6
	5	Fungicides effectiveness against light blight	0–5
	6	Chemicals effectiveness against Colorado potatoes beetle	0–5
III Seeds and tubers	1	Class of seed potatoes	0–4
	2	Usage of fractionated seed potatoes	0–3
	3	Acceleration of seed potatoes germination	0–3
	4	Usage of refining treatments of seed potatoes	0–5
	5	Implementation of chemical treatment on seminal potatoes plantation	0–5
IV Management of production	1	Potatoes production system in the farm	0–6
	2	Application of irrigation	0–6
	3	The use of plant growth bioregulators	0–5
	4	Preparation of plantation for harvest	0–3
Total range of scores for sustainable agriculture practices			0–104

The adoption index for a certain practices was measured by use means of an adoption index developed by [Karthikeyan 1994] and was used it also by Poyyamoli and Padmavathy [2011], Koirala et al. [2015] using the following formula:

$$Adoption\ index = 100 \frac{Respondent\ total\ score}{Total\ possible\ score}$$

where:

Respondents total score – total number of practices adopted by a farmer / multiplied by the respective practice weight age and summated.

Total possible score – total number of practices recommended, multiplied by the respective practice weight age and summated. Using the cumulative frequency method, the rate of adoption by respondents were classified into low, medium and high based on adoption index value.

STATISTICAL METHODS

Percentages: it has been used to describe the characteristics of respondents for each category in the variables included in the study. Range: it has been used to divide independent variables into categories. Frequencies: it has been used to describe the characteristics of respondents for each category in the variables included in the study. Means: it has been used to describe the variables in the study and in ranking the domains and their items in the scale adoption of sustainable agriculture practices. Cronbach's alpha coefficient: it has been used to find reliability of the adoption's scale [Gwet 2012]:

$$\alpha = \frac{n}{n-1} \left[1 - \frac{\sum S_i^2}{S_x^2} \right]$$

where:

n – number of questions,

S_i^2 – variance of scores on each question,

S_x^2 – total variance of overall scores (not's) on the entire test.

Standard deviation: it has been used to describe the deviations of values; it collects their arithmetic averages to some of the independent variables included in the study [Pripp 2013].

Pearson's correlation coefficient: it has been used to identify the correlation between farmer's adoption and each of the quantitative variables. One-way analysis of variance: it has been used to identify the significance of differences between averages of the variables that were divided into three categories or more [Rushing et al. 2013].

Multiple step-wise regression analysis: was another statistical technique used to analyze the influence among variables (i.e. single dependent variable and several independent variables) with the object of using the independent variables, the values of which are known to predict the single dependent value. According to Pripp [2013], the regression equation takes the form:

$$y = a + b_1x_1 + b_2x_2 + b_3x_3 + \dots + b_px_p$$

where:

y – dependent variable,

x – independent variable (of there are p),

a – y intercept,

b – the slope of the line [Seltman 2018].

DESCRIPTION OF THE STUDY AREA

The Mazovian province is the unit of the administrative division of Poland, the largest in terms of area and population of the province, located in the central and eastern part of Poland, both in terms of area (35.6 thousand km²), and in terms of population (5.2 million) [Rocznik Statystyczny Województwa Mazowieckiego 2017]. According to data from 30 June 2017, it had an area of 35 558.47 km² and 5.39 million inhabitants [GUS 2017].

In 2016, a number of agricultural holdings with sown area reached 175.3 thousand, which represented 83.7% of total agricultural holdings. Total sown area in 2014 amounted to 1193.5 thousand ha and it was by 24.8 thousand ha (2.1%) larger than in 2013. Sown area on private farms represented over 98% of sown area in agricultural holdings in total. In the total sown area, the largest area – 879.6 thousand ha, i.e. 73.7%, was covered with cereals. Compared with the previous year, sown area of edible pulses and sugar beets increased by 39.9% and 21.8% respectively, whereas potatoes as well as rape and turnip rape decreased by 27.1% and 12.9%, respectively [GUS 2017b]. The province is mostly located in the Central European Lowland, only its small eastern fragments lie in the area of the Eastern-Baltic-Belarusian Lowland and the southern ones in the Polish Uplands. The area of the province is contained in 11 physical and geographical macro-regions and 34 meso-regions. In the administrative division of the country, the Mazovian province consists of 37 counties and 5 cities with counties rights. The counties are divided into 314 communes – 35 urban, 53 urban-rural and 226 rural [GUS 2017, Rocznik Statystyczny Województwa Mazowieckiego 2017].

RESULTS

Identification of personal, social, economic and communicative characteristics of the farmers in the Mazovian region.

Age. The age of respondents, who participated in the study ranged from 18 to 65 years. The mean age of respondents was 31.33 years with the standard deviation of 4.90. Respondents were placed under four age categories. The respondents aged 42–53 and 54–65 were in the majority (81.59%), followed by the age group 30–41 (15.13%), next by the age group 18–29 years (3.28%), as shown in Table 2.

Table 2. Distribution of respondents according to age

Categories	Frequency	%
18–29 years	5	3.28
30–41 years	23	15.13
42–53 years	77	50.68
54–65 years	47	30.91
Total	152	100.00
x = 31.33		SD = 4.90

Education level, as evident from Table 3, makes the distribution of respondents into categories based on their education level. The percentage of farmers with primary education was 3.28%. About 15.13%, 11.84% of respondents had vocational education in agriculture, and other vocational education, respectively. Meanwhile, 34.21% of the farmers attained secondary education in agriculture and 13.15% received other secondary education. 17.13% of the farmers had higher education in agriculture and 5.26% of the farmers had other higher education.

Table 3. Distribution of respondents according to education level

Categories	Frequency	%
Primary	5	3.28
Vocational in agriculture	23	15.13
Vocational other	18	11.84
Secondary in agriculture	52	34.21
Secondary other	20	13.15
Higher in agriculture	26	17.13
Higher other	8	5.26
Total	152	100.00

Marital status. The marital status of respondents in the study was placed under four categories. The results indicate that the percentage of respondents, who were married was 60.52%, followed by 25% of respondents who were single. While, the percentage of respondents, who were widowed was 9.88%. Only 4.60% of respondents were divorced, as shown in Table 4.

Table 4. Distribution of respondents according to marital status

Categories	Frequency	%
Married	92	60.52
Single	38	25.00
Widowed	15	9.88
Divorced	7	4.60
Total	152	100.00

Occupation. The results show that majority (96.71%) of respondents were fully engaged in farming as their primary occupation, while 3.29% of the respondents were working in other occupations (Tab. 5).

Table 5. Distribution of respondents according to occupation

Categories	Frequency	%
Farmers	147	96.71
Other	5	3.29
Total	152	100.00

This means that farmers, who regard farming as their main occupation are likely to invest more time, energy and money into farming as a key source of their livelihood.

Gender. Results from Table 5 show that 93.42% of farmers were males, while 6.58% were females. It is obvious that majority of respondents are males (Tab. 6).

As Table 6 suggests, most of the farm work is undertaken by men in the study area, because work on the farm is generally perceived to be too physically strenuous, and this is suitable for men more than women because of the man's physical strength.

Source of income. Farmers keep on a farm, including both agricultural and non-agricultural resources. Table 7 shows the distribution of respondents into four categories based on their source of income: most of respondents (74.34%) in the study region work in agriculture and treat farm as a major source of income; 23.04% of respondents working on a farm also have additional source of income besides the farm. While, the proportion of respondents, who depend on their income from farm and disabled pension and farm as well as retired pension was 1.31%.

Type of tenure. The results in Table 8 indicate that the percentage of respondents, who own the land was 50.00% and those, who rent the land reached 16.44%, while the participation was 20.41%. The percentage of respondents with a contract type of possession of the land constituted 13.15% (Tab. 8).

Determining the knowledge of potato farmers on sustainable farming techniques in the Mazovian region.

Table 6. Distribution of respondents according to gender

Categories	Frequency	%
Male	142	93.42
Female	10	6.58
Total	152	100.00

Table 7. Distribution of respondents according to source of income

Categories	Frequency	%
Farm	113	74.34
Farm + employment outside the farm	35	23.04
Farm + disabled pension	2	1.31
Farm + retired pension	2	1.31
Total	152	100.00

Table 8. Distribution of respondents according to type of tenure

Categories	Frequency	%
Owned	76	50.00
Rented	25	16.44
Contract	20	13.15
Participation	31	20.41
Total	152	100.00

Results showed that the highest value of the knowledge of potato farmers for sustainable farming techniques in the Mazovian region was 189 (numeric value) and the lowest value was 100 (numeric value) with a mean of 89.77 with a standard deviation of 11.88 (Tab. 9).

Adoption of agricultural practices. The work includes only a few examples of adoption for agricultural practice (Tabs 10 and 11).

Fertility. Based on the results in Table 10, it has been shown that the highest mean of adoption was (72.3) for farmers with medium soil fertility on their farm, while the lowest mean of adoption was (70.4) for farmers with high soil fertility on their farm.

For determining whether there is a significant difference between the average adoption of sustainable agriculture principles according to soil fertility, the analysis of variance (ANOVA) was used and the results were shown in Table 11.

Table 9. Distribution of respondents according to the knowledge of potato farmers for sustainable farming techniques

Categories	Frequency	%
Low (100–129)	42	27.64
Medium (130–159)	79	51.97
High (160–189)	31	20.39
Total	152	100.00
x = 89.77 SD = 11.8		

Table 10. The distribution of respondents according to soil fertility and mean of adoption

Categories	Frequency	%	Mean of the adoption
Low fertility	41	27.0	71.9
Medium fertility	51	33.6	72.3
High fertility	60	39.5	70.4
Total	152	100.0	–

Table 11. The results of the variation of differences between the mean of adoption of sustainable agriculture principles according to soil fertility

Source	DF	Sum of squares	Mean square	F value	Pr > F
Model	6	6757.408	1126.235	3.67	0.87
Error	145	69462.479	479.0516		
Corrected Total	151	76219.888			

Significant at p 0.05

The results in Table 11 showed that the F value is greater than the P value at (0.05 probability). Thus, it rejects statistical hypothesis. This means there are no significant differences between the level of adoption of farmers, according to soil fertility.

Tukey test has been used to know the significant difference between the means of adoption of sustainable agriculture principles for soil fertility and the results were shown in Table 12.

Table 12. The significant differences between the average adoption of sustainable agriculture principles according to soil fertility

Categories	Difference between means	Simultaneous 95% confidence limits	
Low fertility – Medium fertility	9.336	-6.090	24.763
Low fertility – High fertility	5.911	-4.786	16.609
Medium fertility – High fertility	10.789*	9.898	11.681

Significant at $p_{0.05}$

Table 13. Stepwise Multiple Regression Analysis of the influence of socio-economic characteristics on the knowledge of potato farmers about sustainable farming techniques

Step. No	Independent Variables	R	R ²	R square change	Regression coefficient	F
1	Source of income	0.661	0.436	0.206	0.419	24.520**
2	Education level	0.712	0.506	0.124	0.870	19.633**
3	Occupation	0.786	0.617	0.056	1.990	11.956*
4	Age	0.855	0.731	0.022	1.346	0.119
5	Type of tenure	0.811	0.657	0.039	0.344	0.798
6	Gender	0.846	0.715	0.034	-0.219	0.255
7	Marital status	0.878	0.770	0.012	0.589	0.568

*Significant $p \leq 0.05$ level of probability. **Significant $p \leq 0.01$ level of probability. $R^2 = 0.446$, F value = 36.43
 $Y^{\wedge} = 21.330 + 0.419x_3 - 0.219x_2 + 0.870x_1$

Table 12 shows that there are no statistically significant differences between the average adoption of the principles of sustainable agriculture for farmers in category (low fertility) on the one hand with category (medium fertility) on the other hand. There are no statistically significant differences between the average adoption of the principles of sustainable agriculture for farmers in category (low fertility) on the one hand with category (high fertility) on the other hand. There are statistically significant differences at (0.05) between the average adoption of the principles of sustainable agriculture for farmers in category (medium fertility) on the one hand with category (high fertility) on the other hand.

Determining the relationship between the knowledge of potato farmers for sustainable farming techniques in the Mazovian region and a set of independent variables.

In order to find out the contribution of predict variables to the knowledge of potato farmers about sustainable farming techniques, stepwise regression analysis was conducted. Of the 7 variables selected based on the simple correlation account, only 3 having significant relationship with response variable based on the correlation results were selected for stepwise multiple regression analysis. They were: source of income, the education level and the occupation. Source of income explained 43.7 percent of the total variation (Tab. 13).

DISCUSSION

The results indicated that most of young people are not engaged in potato growing. Due to their migration from the countryside to the city to work, they do not rely on the agriculture for their livelihood. On other hand, findings revealed that a significant proportion of the farmers were between 30 and 50 years indicating that farmers were mainly middle aged and being in their economically active stage they can undergo some stress. This has implication for productivity of the farmers. Results show that more than half of respondents are married. The assumption here is that the married respondents are more willing to receive or accept new farming techniques than unmarried respondents, because they have a larger family labor force, high capital base and the demand for socio-cultural and economic needs for their families [Gedikoglu and Parcell 2013, Nowacki 2018].

Most of the farm work is undertaken by men in the study area, because work on the farm is generally perceived to be too physically strenuous, and this is suitable for men more than women because of the man's physical strength. This agrees with opinion of Ojo and Jibowa [2008]; Mazvimavi [2011], who claim in their study, that leadership and decision making roles are dominated by men. Women, on the other hand, have rights to the land and bear the bulk of domestic work and are less devoted to the agricultural work [Farrington 1995].

Almost three-quarters of the respondents were depending on agriculture for their income, because in fact, agriculture plays a strategic role in the process of economic development by increasing the income of farmers and providing more jobs to unemployed people. This shows that farmers would like to improve their standard of living. The half of tested farmers own the land, and owning land has many advantages. It eliminates the uncertainty of losing a lease and the impact that would have on the overall activity. Accumulating of equity in land provides an excellent source of collateral for borrowing money. Decisions about management of land including enterprise selection, conservation practices and the use of soil amendments are solely the choice of the owner [Gedikoglu and Parcell 2013, Manda et al. 2016, Nowacki 2018].

The farmers were divided into three categories according to the knowledge of potato farmers about sustainable farming techniques. As it has been shown, only 27.6% of the respondents were ranked in the low category of knowledge of potato farmer (100–129), whereas most respondents were placed in the medium category (130–159), which was 52.0%, and high category (160–189), which was 20.4%. This shows that the knowledge

of potato farmers on sustainable farming techniques is medium with a tendency to low. The low popularity of association of Polish producers into producer groups and marketing groups may contribute to this state, which limits the impact on wholesale market recipients [Hameed and Sawicka 2016, 2017, Nowacki 2018].

The adoption of agricultural practices in own research, in the case of fertilization is high (70.4–72.3%). In own research there are statistically significant differences at between the average adoption of the principles of sustainable agriculture for farmers in category (medium fertility) on the one hand with category (high fertility) on the other hand. This agrees with Koirala et al. [2015], Mugwe et al. [2009], Bonny and Vijayaragavan [2001], wherein the sustainable agriculture seeks to promote crop growing and minimizing tillage. There is no Polish research on the adoption of agricultural practices in this area. These are mainly sociological considerations [Kujawiński 2009, 2012, Wiatrak 2015, Struś and Kalinowski 2015]. Farmers, who perceive low soil fertility as an impediment to land productivity and food security, are likely to adopt these technologies that have the potential to improve soil fertility [ICRAF 2012]. This implies that when farmers perceive soil fertility to be a current problem, they are more likely to adopt technology than those farmers, who do not perceive soil fertility to be a problem and, therefore, sensitizing farmers about their soil fertility status would promote adoption [Mugwe et al. 2009].

Data of regression analysis indicated that out of 7 variables, only 3 variables, namely source of income, education level and occupation, could finally enter to the stepwise multiple regression equation. These three predict variables were important and explained 43.7 percent of the total variation in predicting the knowledge of potato farmers. But out of them, source of income, which is the first stage contributed to the explained 20.6 percent of variation at 10% probability level, because it played the most vital role in the whole process. Higher income farmers may be less risk averse, have more access to information, have longer-term planning horizon, and have greater capacity to mobilize resources and, hence, increased likelihood of adopting new technologies, such as sustainable agriculture practices compared with those with a low income. This may be due to that agricultural information, which respondents gets that led to increase their agricultural knowledge, which could contribute to the edification and raising of the consciousness in different agricultural topics generally, and in the subject of the sustainable agriculture especially because information sources play an important role in decision-making process to reduce risks and uncertainties to enable farm households to make right decision on the adoption of SAPs [Willson and Lindoo 2011, Hameed and Sawicka 2017]. Manda et al. [2016], Hailu et al. [2014], Gedikoglu and Parcell [2013] agree with this idea, but it disagrees with Ayoade [2013]. Total household income includes income from crops and livestock products, and off-farm income (e.g. salaries, remittances, farm labor wage income, pension income and income from business). Availability of off-farm income and income received by the household as in-kind may affect the decision to adopt agricultural technologies [Tadesse and Belay 2004, Marenya and Barrett 2007], because this provides a reliable indicator of economic well-being among smallholder farmers [Kujawiński 2009, Smale and Mason 2014, Nowacki 2018]. Also, the education level, which is the second stage, contributed to the explained 12.4% of variation at 10% probability level. The more education a farmer receives the more likely to implementation of agricultural technologies. This might be due the fact that educated person has greater chances to access information about the technology and where and how he or she can be supported. This result agrees with that

by Thanh and Yapwattanaphun [2015], Omani and Chizari [2011], Razzaghi-Borkhani et al. [2010] and disagrees with Ogunlana [2004] and Emden et al. [2006]. We can observe that as far as the adoption of new farming techniques was concerned, education served a vital role, because farmers that are educated, easily adopted new farming techniques such as the sustainable agriculture if institutional factors are available [Genius et al. 2006, Ashok et al. 2016]. This position was also in agreement with Singh et al. [2012] that the level of education is a major determinant of the adoption of new farming technologies. This implies that education is a necessity for any technological change [Kujawiński 2012, Ibrahim et al. 2013, Hameed and Sawicka 2017]. The occupation is the third stage and contributed to the explained 5.6 percent of variation at 5% probability level [Immanuel et al. 2010].

Commercialization of genetically modified crops (GM) is highly questioned in the all of European Union (EU) [Wróbel and Wąsik 2015, Nowacki 2018]. Research of De Steur et al. [2019] based on a high sample ($n = 384$) assessed the readiness of farmers in Flanders and Belgium to adopt the GM varieties resistant to late blight (LBR) (Bintje). They show that more than half (54.7%) of farmers are going to accept this genetically modified potato, if it becomes available. The ethical concerns about genetically modified organisms (GMOs) (negative) and the perceived economic benefits of LBR potato (positive) GMOs have a bearing on farmers' willingness to adopt genetically modified varieties. It should be assumed that knowledge about GM technology reduces the likelihood of being indifferent, compared to the desire for adoption or opposition, as is the case in Poland [Wróbel and Wąsik 2014]. Therefore, efforts to improve knowledge alone will not be considered as an effective strategy for improving adoption rates among farmers. Socio-economic concerns about GMOs, perception of environmental benefits from LBR potatoes and socio-demographic and agricultural variables were not significant as potential determinants of the probability of farmers adopting this genetically modified potato. Such studies support a potentially favorable climate for the introduction of genetically modified potato not only in Flanders or Belgium, but in an EU region where no exclusion measures have been taken to limit the cultivation of authorized GM crops, and socio-demographic and agricultural variables were not significant as potential determinants of the probability of farmers taking this genetically modified potato [De Steur et al. 2019].

Insufficient level of introducing the innovations in agriculture, especially in traditional regions of potato production, polarization of potato cultivation in Poland, as well as professional and social sphere of potato production, can be considered the most important reasons for poor development of the potato industry. Nowacki [2018] believes that these reasons are also: decline in potato consumption; disappearance of Polish potato export due to legal procedures related to phytosanitary security (Cms, *R. solanacearum*); deficit of storage capacity, positive impact of area subsidies for the production of starch potatoes to stimulate starching, or low use of certified seed potato material [Wróbel and Wąsik 2014]; small scale of potato seeding and a wide range of cultivars from the catalog of CCA [Meena and Singh 2012].

Innovations in agriculture are of various nature – from technical, technological (process and product) innovations, through organizational innovations and ending with social innovations [Meena and Singh 2012, Wiatrak 2015]. Therefore, the most important binder of individual innovation activities is the sustainable and economical use of resources combined with environmental and food safety requirements [Deshmukh et al.

2007]. However, these activities usually go beyond the capabilities of individual farms, therefore, for their implementation, the cooperation of various entities in and outside of agribusiness is needed.

CONCLUSIONS

Polarization of potato cultivation in Poland concerns not only the professional but also the social sphere. It was also observed that the knowledge of potato farmers about sustainable farming techniques was generally medium with tendency to low. The step-wise regression analysis postulates knowledge as a function of some socio-economic variables. The results reveal that among the socio-economic variables considered, only the source of income, education level and occupation were the most significant factors that influence the knowledge of potato farmers on sustainable farming techniques in the study area. It is necessary to hold training meetings for farmers so that agricultural innovations can be adopted. It can be stated that introducing the innovations and explaining the benefits will clearly provide the effectiveness on the adoption of the innovation. Also, the studies have shown that farmers generally have an average level of education. The higher education the farmer receives, the more likely the adoption of agricultural technologies is. This might be due to the fact that educated person has greater chances to access information about the technology and knows where and how he or she can be supported, especially if those technologies require education to understand and implement. Traditional knowledge documentation provides tools for creating networks, storing, visualizing and analyzing the information, as well as designing the long-term trends so that complex problems can be solved effectively.

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Streszczenie. Badania miały na celu ocenę wiedzy rolników na temat zrównoważonych technik rolniczych w uprawie ziemniaka poprzez określenie ich cech osobowych, społecznych, ekonomicznych i komunikacyjnych. Ponadto celem badań było znalezienie zależności między wiedzą rolnika na temat uprawy ziemniaka w zrównoważonych technikach rolniczych a zmiennymi niezależnymi, które charakteryzują rolników. Badania te oparto na danych pierwotnych zebranych w latach 2014–2016 na reprezentatywnej próbie 152 producentów ziemniaka w województwie mazowieckim. Do zbierania danych terenowych za pomocą wywiadów osobistych wykorzystano standardowy kwestionariusz, złożony z dwóch części. Pierwsza część zawierała zmienne niezależne (wiek, poziom wykształcenia, stan cywilny, zawód, płeć, źródło dochodu), druga składała się z testu oceny wiedzy producenta ziemniaka na temat zrównoważonych technik rolniczych. Badania wykazały, że wiedza na temat uprawy ziemniaka w zrównoważonych technikach rolniczych jest średnia z tendencją do niskiej. Wśród zmiennych społeczno-ekonomicznych poziom wykształcenia i zawód były najważniejszymi czynnikami, które na nią wpływały. Istotne różnice wystąpiły między wiedzą na temat uprawy ziemniaka w zakresie zrównoważonych technik rolniczych według różnych kategorii (wiek, poziom wykształcenia i zawód). Tylko trzy zmienne niezależne miały istotny związek z przyjęciem innowacji w rolnictwie: źródło dochodu, poziom wykształcenia i zawód.

Słowa kluczowe: wiedza, edukacja, rolnictwo zrównoważone, techniki rolnicze

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