International Journal of Food Science and Agriculture, 2021, 5(1), 12-18
http://www.hillpublisher.com/journals/jsfa/
ISSN Online: 2578-3475
ISSN Print: 2578-3467

Eco-Efficiency as a Modern Concept of Business Performance in Agricultural Production

Krsto Mijanović[1,*], Marko Jukić[2], Jefimija Mijanović-Jukić[3]

[1]Univerzitet Hercegovina, Bosnia and Herzegovina.
[2]Jajce Alloy Wheels Ltd., Bosnia and Herzegovina.
[3]Holdina Ltd., Bosnia and Herzegovina.

How to cite this paper: Krsto Mijanović, Marko Jukić, Jefimija Mijanović-Jukić. (2021) Eco-Efficiency as a Modern Concept of Business Performance in Agricultural Production. *International Journal of the Science of Food and Agriculture*, 5(1), 12-18.
DOI: 10.26855/ijfsa.2021.03.003

Received: November 28, 2020
Accepted: December 26, 2020
Published: January 8, 2021

***Corresponding author:** Krsto Mijanović, Univerzitet Hercegovina, Bosnia and Herzegovina.
Email: krsto.mijanovic@unmo.ba

Abstract

Soil and air pollution in the context of the environmental outcomes of economic activities in agriculture has led to greater pressure on farmers to accept the environment as a stakeholder and to internalize the harmful effects that agriculture has on natural resources. As the costs of prevention and remediation affect the total costs (cost price), manufacturers strive to simultaneously improve both economic and environmental performance and to achieve economic viability. This paper examines traditional business indicators and (re)defining modern performance indicators of agricultural enterprises through eco-efficiency analysis. A set of environmental performance indicators, as a measure of environmental responsibility, was considered in the function of improving economic performance, including indicators on the basis of which material intensity (resource intensity), and material and eco-efficiency (resource efficiency) can be calculated, followed by emissions. and the amount of waste generated in agricultural production.

Keywords

Eco-Efficiency, Agricultural Production, Pesticides, Nitrites and Nitrates, Resources, Environmental Performance

1. Introduction

During the Earth Summit, world leaders agreed that the equal use of natural resources and ecosystems ensures sustainable development and poverty reduction in the world. Most environmental problems are attributed to the overexploitation of natural resources, especially arable land. Material and eco-efficiency, as a result of a new view and concern for the state of the environment, have begun to affirm discussions on efficiency assessment.

Efficiency is the relationship between results and investment [1]. Numerous authors equate efficiency and productivity by explaining that both indicators represent the relationship between output and input and from that aspect are cooperative concepts. In modern conditions of agricultural production, one of the critical success factors in creating a positive image of the company is the protection of the environment and the achievement of a defined level of environmental performance of disruption of the balance in nature, as a result of agricultural production and economic activities based on that, has taken on significant proportions [2]. This requires a serious change in the attitude of the economy and society towards nature and the environment as a "specific stakeholder". Part of the solution to these problems lies in the greening of the agricultural production process, which according to [3] is "synchronization and harmonization of the production process" with neutral or positive consequences for the environment. The motive of the company to accept a healthy environment as a "specific stakeholder" and to improve environmental performance is their impact on the economic performance [4]. Linking economic and environmental effects, this paper will review the traditional business indicators of agricultural enterprises, as well as (re)defining eco-efficiency indicators in agricultural production, which includes the use of chemicals for intensification and protection.

2. Eco–Efficiency

The World Business Council for Sustainable Development (WBCSD) has defined the concept of eco-efficiency as a management philosophy that encourages companies to implement environmental solutions as a contribution to improving economic performance (WBCSD, 2006, p. 3). The essence of the concept of eco-efficiency is to achieve the highest possible value with less environmental impact (WBCSD, 2006, p. 27). The concept of eco-efficiency assessment is based on the analysis of expanding business opportunities that enable agricultural producers to achieve a higher degree of environmental responsibility measured through environmental performance, but also economy (reducing costs, increasing profits). The implementation of the concept of eco-efficiency is carried out with the aim of optimizing agricultural production, use of waste as a resource, development and implementation of innovative solutions that result in new products, with new functional characteristics (WBCSD, 2006, p. 4).

The concept of eco-efficiency in agriculture brings to the fore the financial benefits that result from the reduction of pollution and more efficient management of resources (primarily land) in the process of agricultural production. The response to the demand for environmental protection through the adjustment of production goals to the state and availability of natural resources, indicates the economic sustainability of business and corporate social responsibility.

The Global Development Research Center states that eco-efficiency is primarily a concept of managing all stages of the process (from seed procurement, fertilization and protection, through production to distribution and sale of products and/or services) that connects economic and environmental performance agricultural activities. Therefore, it can be concluded that at each stage of the product life cycle there is an opportunity to improve eco-efficiency (WBCSD, 2006, p. 4). The goal of the implementation of the eco-efficiency strategy is to reduce environmental pollution that occurs as a result of resource depletion and related emissions [5]. The authors distinguish two basic eco-efficiency strategies:

1. strategy for reducing the consumption of planting and protection materials;
2. strategy of substitution of dangerous substances in the treatment and protection of crops.

The first strategy implies increasing eco-efficiency by reducing the use of resources per unit of produced value, while substitution implies improving eco-efficiency by replacing existing means of protection with less harmful (dangerous) substances per unit of produced value. The concept of eco-efficiency includes the main inputs of the production process (material, energy and energy, water), but also the key environmental outcomes of production (emissions to air, emissions to land, emissions to water, solid waste). The author of [13] states the definition of eco-efficiency, explaining that the prefix “eco” in the name of the concept of eco-efficiency refers to both environmental and economic resources, and the second part of the word “efficiency” indicates the need for optimal use of resources.

Manufacturers who apply the concept of eco-efficiency management are more competitive in the market and more profitable because they use fewer resources: water and energy per unit of product, cause less waste and pollution, improve production methods, develop new products and services, recycle, etc. business council for sustainable development, eco-efficiency should become an integral part of the strategy of growth and development of agricultural production. Eco-efficiency includes (WBCSD, 2006, p. 20):

- optimization of agricultural production—transition from expensive pollution remediation solutions when waste has already been generated to an approach that results in pollution prevention,
- recycling of waste—use of residues from agricultural production as raw materials for the second cycle,
- networks/virtual organizations - joint use of resources in order to increase the effectiveness and efficiency of business,
- eco-innovations—in the function of more efficient agricultural production from the aspect of resources, as well as their use.

Innovations in agriculture can achieve significant improvements in environmental performance with special emphasis on innovations that affect the eco-efficiency [7]. It is evident that agricultural producers are increasingly implementing the concept of Cleaner Production by reducing the amount of materials (raw materials) and/or energy consumed in production processes. Producers are increasingly integrating environmental strategies into the management system (strategies), establishing “closed” material flows, which eliminate waste disposal by using residues as resources, control pollution and establish the growth of eco-efficiency, see Figure 1.

The advantage of applying the concept of eco-efficiency is that in addition to reducing costs, new sources of income are opened through the sale of byproducts. Through the concept of eco-efficiency, companies focus on business opportunities arising from the improvement of environmental performance, which will at the same time bring financial benefits [8]. Eco-efficiency can be improved in several ways (WBCSD, 2006, p. 24):

1. Reengineering of agricultural production—reducing resource consumption, reducing emissions, saving natural energy resources.

2. Revaluation of byproducts—means that the exchange of byproducts establishes synergetic links with other producers, ie that the waste of one company becomes a raw material for another.

3. Redesign the production service—as a result, the production service should be simpler, with as few different materials as possible.

4. Changing market access means finding new ways to meet consumer needs.

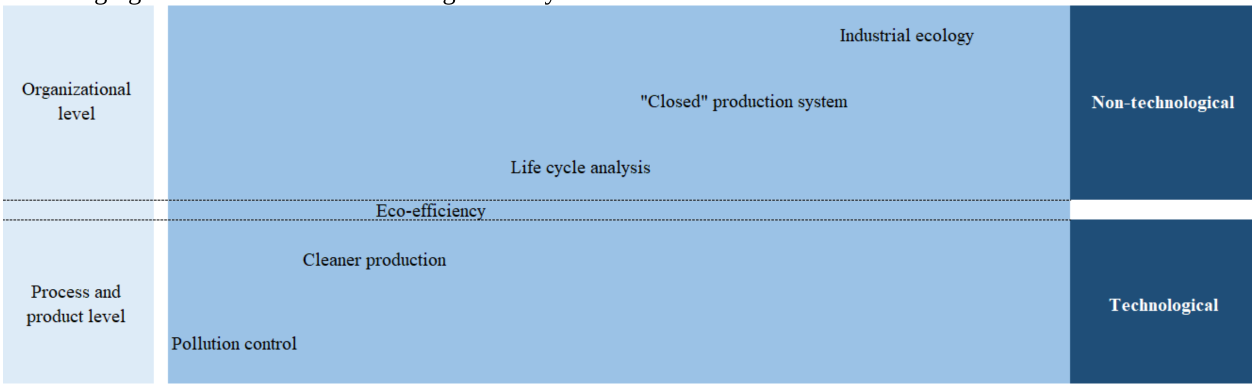

Figure 1. Sustainable production, eco-innovation and eco-efficiency [7].

They define the concept of eco-efficiency as a practical approach that enables the establishment of a balance of economic and environmental benefits with the aim of reducing the consumption of resources (raw materials, energy, water) while increasing the value of production [9].

The necessity of developing and introducing a new concept (eco-efficiency) is explained by the view that for defining and implementing laws and regulations in the field of natural resources protection on the one hand, as well as a positive response from producers, on the other hand, an integrated approach translated into clearly defined methods and procedures is needed, that simultaneously measure both the economic and environmental aspects of business [10]. A different combination of variables, which is the subject of user choice of eco-efficiency indicators, resulted in the definition of a basic model for measuring eco-efficiency:

$$e_{ef} = D_{profit} + D_{benefit} / T_{costs} + O_{load} \quad (1)$$

Measuring eco-efficiency, with the help of appropriate indicators, is important in order to determine the success of the application of certain business improvement measures from the economic (financial) and environmental aspects. Authors Verfaillie and Bidwell (2000) have defined a methodological framework that will make it easier for farmers to monitor their performance and for stakeholders to assess the progress that producers are making in terms of eco-efficiency.

Companies strive to achieve continuous growth of eco-efficiency and development, while reducing the negative impact on the environment, but measure and interpret performance differently. Indicators that have this characteristic are called general indicators [11].

The second group of indicators is used by agricultural producers in accordance with the relevant business context and is called special indicators, which means that they differ from producer to producer. The decision on which indicators to use is made by the management, individually. General indicators for measuring eco-efficiency are divided into two groups.

General indicators for product/service value:

- quantity of products (volume of production) or services provided,
- net sales revenue.

General indicators for environmental impact are:

- energy consumption,
- consumption of materials for planting, tillage, fertilization and protection,
- water usage,
- greenhouse gas emissions,
- emission of ozone depleting substances.

The following indicators may become generally applicable in the coming period, if the agreement of the interested parties is reached:

- additional financial indicators,
- air emissions leading to acidification,
- total amount of waste.

Product value and environmental impact can be measured for different entities, such as a particular production line, plant, at the company level, corporations as well as for individual products, market segments and even individual regions, countries, etc. [11].

3. Assessment of Eco Efficiency in Intensive Agricultural Production

Land, as arable land, has its capacity that must match the MPC (Maximum Permissible Concentrations) of the pesticide used per unit of cultivated area. n Form (1) for calculating eco-efficiency, the significance of individual quotient factors is as follows:

Profit is an economic category and depends primarily on:

- marketing activities (market processing, selection of suppliers, product placement);
- land quality;
- processing technology;
- soil treatment (with a good choice and use of the recommended means and their doses, it is possible to choose the optimal solution, which will cause the expected yield).

The benefit of cultivating agricultural land is generally of an unknown magnitude, which is estimated differently by each management. Parameters for assessment/evaluation of Benefit can be systematized as follows:

- Degree of maintaining the vitality of the pedosphere for long-term use by fertilizer dosing, fertilization and protection;
- Degree of impact on groundwater;
- Impact of agricultural production on flora;
- Impact of agricultural production on fauna, especially bees and other pollinators;
- Use of groundwater for irrigation;
- Use of bio-fuels to start cultivation machines;
- Collection of selections and shipment of waste (packaging of fertilizers and protective agents, and other auxiliary materials and spare parts).

Costs, which occur in this type of production arise from:

- Costs of concession relations with the land owner;
- Costs of cultivation and land preparation;
- Seed costs;
- Costs of auxiliary materials;
- Processing and planting costs;
- Savings costs;
- Costs of seedling protection.

Environmental load is also an economic category in the form and consists of:

- Costs of eco-taxes, which relate to land pollution;
- Costs of eco-taxes related to water pollution;
- Costs of eco-fees for registration of motor vehicles for cultivation, processing and planting;
- Costs arising from sectoral regulations, which may relate to the protection of bees, birds, etc.
- Costs incurred in compliance with the “olluter pays” principle;
- Costs related to air pollution in the working environment.

Maximum permissible concentrations of substances in the air, to which workers can be exposed continuously without the harmful effects of TLV, and the Average concentration for eight (8) hours weighted by TWA time are used for air pollution in the workplace.

4. Hazardous Chemicals in Agricultural Production

4.1 Pesticides

Pesticides are organic (rarely inorganic) synthesized compounds, lower molecular weight, good soluble in oils, waxes, fats, and sparingly soluble in water. They are most commonly used in agriculture (90%), forestry (3%), veterinary and livestock (3%), communal hygiene (3%) and in the food industry (1%) [12].

After synthesis, the compound received the first coded label, which is different for different manufacturers. After that, it got a chemical name that talks about the chemical structure of an organic compound with pesticidal properties. As chemical names are very long and impractical, the compound is also given a popular name (which can often be an abbreviation derived from a chemical formula) which is more suitable for everyday communication. When the pesticide is formulated into a preparation, it gets a new commercial name which is protected and under that name the pesticide is marketed. The formulated preparation also contains other excipients which ensure the effectiveness of the pesticidal compound which is called the active substance in the formulated preparation.

4.1.1 Pesticide properties and their impact on the environment

In addition to their useful properties to protect crops from pests, pesticides also have a number of negative properties. Each compound has its dark and light side. The assessment of how much harm, and how much benefit can be from the use of a compound, takes place continuously. Some negative properties are discovered only after the compound is placed on the plant protection market. Extensive research that each chemical the company conducts before the official acceptance of the compound for use, just examine all the consequences that the new compound may have on the environment and the living world with which it comes contact. Pesticides can be very persistent in the environment. The decay time speaks of how much the substance in the environment remains in the unchanged side. Compounds that are stable and remain in some part of the environment for a long time are gradually phased out or their dose is limited.

Pesticides also have a negative effect, destroying beneficial species and exhibiting phytotoxicity.

This is the appearance of side effects on plants after the application of pesticides. Plants develop slowly, are damaged and dry out. Pesticides enter the food chain. As a result of the treatment of orchards, vegetable gardens, fodder crops, pesticide residues can also appear in food as a result of food contact with pesticides through air, water or soil. Pesticides reach animals when they introduce animal feed with pesticide residues present. The amount of pesticide residues in food depends on many factors: dose of pesticide during treatment, extent of contact, physicochemical properties of pesticides, time elapsed from treatment to crop removal, food processing before use in food, degradation of basic compound to one or more metabolites [12]. Pesticides endanger human health. The organisms that pesticides destroy have a lot in common biochemical processes with non-target organisms in the agroecosystem, domestic animals and humans. Biological similarities make it difficult to develop a pesticide that will act strictly specifically on some harmful organism.

Occupational exposure most often leads to dermal and inhalation exposure. In the workplace, workers are exposed to a specific pesticide during production, packaging, distribution or application. Exposure at work is more common in underdeveloped countries due to inadequate technology transfer.

With exposure during production, the risk is minimal because workers are supervised and exist threshold limits—TLV (threshold limit value) that are monitored. When concentration of pesticides in the workplace is larger than TLV, worker exposure is interrupted. During the production of pesticides, workers can be exposed to pesticides, but also byproducts syntheses that may have more adverse health effects than the basic compounds. During synthesis of 2,4,5-T byproduct is dioxin 2,3,7,8-TCDD. Dioxins cause chloracne, damage the liver, cause porphyria (caused by gene mutations), are carcinogenic to mice. 2,4,5-T is due to dioxins thrown out of use. Under normal conditions of use, the greatest exposure of workers occurs during the preparation of the spray solution and the spraying itself. The greatest exposure is when treating from the ground targeted crops that are taller than man (fruit).

Pesticides are absorbed:

- by inhalation;
- ingestion;
- dermal.

It is necessary to know the toxicity of the pesticide being treated. The rate of dermal absorption depends on the size of the molecules and liposolubility. Pesticide residues in packaging can also be a source of poisoning when packaging is used for other purposes (to hold water or beverages). The new direction of development of plant protection has led to the third (III) generation of pesticides in which their impact on the environment is brought to the fore and becomes a decisive factor in the implementation. New generation pesticides are compounds that are easily biodegradable. These include pheromone preparations as a result of knowledge of insect physiology as well as specific compounds that act on a certain part in insect metabolism.

The new pesticides are non-chemical in nature and are microbial pathogens (Bacillus thurigensis). Genetic engineering methods are used for new compounds, where pesticides are produced in cell culture. Transgenic plants (with a built-in disease resistance gene) are being developed that have other methods of defending against pests. New third-generation molecules are being developed that have a new mode of action, structure, specificity and origin. New pesticides are easily degradable, less bioaccumulative and have lower doses of application. This does not guarantee a lower risk, but with the right control it largely ensures the safe and adequate application of pesticides. Pesticides move in soil, water and air. The processes that lead to movement and that affect the spread of pesticides are:

1. Convection—water-borne pesticides travel through the environment;
2. Dispersion—spreading from the place of contamination by molecular diffusion;
3. Transfer between phases—liquid/liquid distribution, sorption and evaporation;
4. Transformation reactions—hydrolysis, photolysis, biotransformation.

4.2 Nitrites and nitrates

Nitrogen is 80% the most abundant chemical element in the atmosphere. It is also a key component of essential biomolecules, such as amino acids, vitamins, hormones, enzymes and nucleotides. In living tissues, nitrogen ranks quantitatively as the fourth most common element after carbon, oxygen, and hydrogen, and is an integral part of the nitrogen cycle. In nature it occurs in the form of two isotopes, ^{14}N—99.62% and ^{15}N—0.38%, while its largest amount occurs in the atmosphere in the form:

- elemental gas N_2;
- nitrogen oxides (NO_x);
- in a very small amount in the form of ammonia.

Nitrates and nitrites occur naturally as products of the nitrogen cycle. They are usually found in the environment in highly water-soluble forms, along with other ionic species such as sodium and potassium. The salts of nitrate and nitrite completely dissociate in the aqueous medium. Nitrite is easily oxidized (combines with oxygen) to form nitrate. Nitrates are generally stable in the environment; however, they can be reduced to nitrites through biological processes involving plants, microorganisms, etc. Nitrates are the most important nutrients used for plant nutrition and are generally compounds that enter into inorganic fertilizers and are added to the soil in large quantities. They occur naturally in soil and in groundwater and surface water as part of the nitrogen cycle. This process is known as nitrification. Nitrates and nitrites were detected in surface waters and in groundwater. Most of the total available nitrogen in surface waters is nitrates. Water contamination is the result of agricultural activities (use of chemical fertilizers or manure) and discharges from septic systems and communal wastewater treatment plants.

4.3 Biological exposure indicators

Exposure to chemicals can also be obtained by determining their concentrations in the breath, the body tissues and fluids (urine, blood, hair, nails, etc.). The advantage of these measurements is that they provide data on the actual absorption of chemicals in the body. Biological indicators of exposure to certain chemicals represent the most likely level of concentrations in the tissues of workers exposed to TLV concentrations in air. Biological indicators of exposure are checked after a working week of 5 days by 8 hours.

4.4 Calculating exposure to chemicals in the workplace

Hygiene standards are used as risk indicators in order to define the conditions under which workers can be exposed to toxic substances in the workplace. The hygiene standards in America defined by the "American Conference of Govermental Industrial Hygienists (ACGIH)" are labeled "Threshold Limit Values" (TLV).

TLV—"threshold limit value"—is the maximum allowable concentration of substances in the air to which workers can be exposed day after day without harmful effects on health.

There are three categories of TLV:

1. Time-weighted average —TWA—average for an 8-hour working day and a 40-hour working week. This value averages more extreme situations.
2. TLV for short-term exposure limit STEL—concentration during the day so that the time interval is 1 hour between the maximum exposure.
3. Upper TLV—concentration which must not be exceeded during worker exposure. Exposure during the working day of 8 hours can be calculated if concentrations are known substances in the air of the working space, Table 1, and on the basis of forms (2) and (3).

Table 1. Concentrations during the working day

Working day (h)	8.00-10.30	10.30-10.45	10.45-12.45	12.45-13.30	13.30-15.30	15.30-15.45	15.45-17.15
Air concentration (mg/m^3)	0.16	0.00	0.07	0.00	0.42	0.00	0.21

$$TWA = 0.16 \text{ x } 2.5 + 0.07\text{x}2 + 0.21 \text{ x } 1.5/8\ 0.21 \text{ mg/m}^2 \ldots\ldots\ldots\ldots \quad (2)$$

If more than one substance is present in the air of the work area, each individual substance in air affects the organism: independently, additively, synergistically or antagonistically.

When the substances behave additively, the concentration of C1, C2, C3, TLV mixture in the air is given equation:

$$C_1/\ TLV_1 + C_2/TLV_2 + C_3/TLV_3 = 1 \ldots\ldots\ldots\ldots \quad (3)$$

Example:

The air contains:

200 ppm acetone (TLV = 750),

300 ppm sec-butyl acetone (TLV = 200) i

200 ppm methyl ethyl ketone (TLV = 200):
TLVof mixture = 200/750 + 300/200 + 200/200 = 0.26 + 1.5 + 1 = 2.76
When substances behave independently, TLV of mixture is calculated for each substance:
C1 /TLV1 = 1; C2 /TLV2 = 1; C3/TLV3 = 1
Example:
The air contains:
0.10 mg/m^3 lead (TLV 0.15 mg/m^3) i
0.9 mg/m^3 sulfuric acid (TLV 1 mg/m^3):
0.10 / 0.15 = 0.7 for lead and 0.9 / 1.0 = 0.9 for sulfuric acid
TLV is not exceeded because it is 0.7 + 0.9 <2.76

5. Conclusion

The precondition for the sustainable development of agricultural production is the acceptance (respect) of the environment as a “specific stakeholder” and the achievement of a defined level of environmental performance. The assumption of economic viability of business is the positive impact of environmental performance on economic performance. Linking economic and environmental effects (performance), results in a review of traditional business performance indicators and the definition of new efficiency indicators: resource efficiency and eco-efficiency. The growing importance attached to resource efficiency is the fact that in manufacturing companies, about 50% of the cost price is made up of material and energy costs. By applying the concept of eco-efficiency assessment, companies focus on business opportunities that will also bring financial benefits.

Management can manage agricultural production by assessing eco-efficiency, building its Environmental Matrix, Impact Assessment, and environmental indicators to evaluate products/services.

References

[1] Daraio, S., & Simar, L. (2007). Advanced Robust and Nonparametric Methods in Efficiency Analysis. Boston, MA: Springer.

[2] Knežević, G., Pavlović, V., & Stevanović, S. (2017). Izveštavanje o održivom razvoju—karakteristike, ograničenja i perspektiva u Republici Srbiji. Poslovna ekonomija, XX (1), 83-102.

[3] Ivanović, M. O., Mitić, P., & Popović, S. (2015). Globalizacija i tehničkotehnološke promene—savremenije društvo i/ili globalna ekološka propast. Poslovna ekonomija, IX (1), 263-276.

[4] Krstić, B., & Sekulić, V. (2007). Upravljanje performansama preduzeća. Niš: Ekonomski fakultet.

[5] Figge, F., Young, W., & Barkemeyer, R. (2014). Sufficiency or efficiency to achieve lower resource consumption and emission? The role of rebound effect. Journal of Cleaner Production, 69, 216-224.

[6] Koskela, M. (2015). Measuring eco-efficiency in the Finnish forest industry with public data. Journal of Cleaner Production, 98, 316-327.

[7] Machiba, T. (2010). Eco-innovation for enabling resource efficiency and green growth: development of an analytical framework and preliminary analysis of industry and policy practices. International Economics and Economic Policy, 7 (2-3), 357-370.

[8] Passetti, E., & Tenucci, A. (2016). Eco-efficiency measurement and the influence of organisational factors: evidence from large Italian companies. Journal of Cleaner Production, 122, 228-239.

[9] Maxime, D., Marcotte, M., & Arcand, Y. (2006). Development of ecoefficiency indicators for the Canadian food and beverage industry. Journal of Cleaner Production, 14, 636-648.

[10] Huppes, G., & Ishikawa, M. (2005). Why Eco-efficiency? Journal of Industrial Ecology, 9(4), 2-5.

[11] Verfaillie, H. A., & Bidwell, R. (2000). Measuring Eco-efficiency—a Guide to Reporting Company Performance. Geneva. World Business Council for Sustainable Development.

[12] Stojić, N., & Pucarević, M. (2019). Opasne i štetne supstance u poljoprivredi, RVB Studio, Bačka Palanka, 2019.

[13] Tomić, S., Delić, D., & Stoiljković. (2018). Produktivnost i eko-efikasnost—savremeni koncepti poslovne uspješnosti. Business Economics, Godina XII broj 2. Subotica 2018.