



AgEcon SEARCH

RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

MARIUSZ MATYKA

Institute of Soil Science and Plant Cultivation – State Research Institute in Puławy, Poland

**THE CURRENT STATE, CHANGE TRENDS AND CROSS
RELATIONSHIP OF NPK MINERAL FERTILIZER
CONSUMPTION AND CEREAL YIELD
FROM A GLOBAL PERSPECTIVE¹**

Key words: NPK, mineral fertilizer consumption, cereal yield, global trends

ABSTRACT. Cereal grains have been a primary source of nourishment for humans for thousands of years. Agronomic inputs such as fertilizers, pesticides, water and modern seeds have a major impact on the level of cereal crops. However, yield, to a greater extent, depends on the dose of applied NPK mineral fertilization. The aim of the article is to determine the consumption level of NPK mineral fertilizers and cereal yield and their tendency to change over time, taking correlation into account. Analysis was performed on a global level. The material for analysis was statistical data from the Food and Agriculture Organization of the United Nations database for the years 2002-2017. As a result of the conducted analyzes, it was confirmed that mineral fertilization is the main factor of production that determines the food security of the world's growing human population. However, the consumption of this factor of production is greatly varied in the world. It should also be emphasized that, both on a global scale and for most continents, there are clear trends reflecting a correlation in the increase in the use of NPK mineral fertilizers, including nitrogen fertilizers, and cereal yield level.

INTRODUCTION

Cereal grains have been a primary source of nourishment for humans for thousands of years. Today, cereal grains are the single most important source of calories to the majority of the world's population. Developing countries depend more on cereal grains for their nutritional needs than the developed world. Close to 60% of calories in developing countries are directly derived from cereals, with values exceeding 80% in the poorest countries. By comparison, approximately 30% of calories in the developed world are directly derived from cereals. The type of grains produced around the world depends on various factors, the most important being environmental, cultural and economic. The three most important food crops in the world are rice, wheat and maize. The three cereal grains

¹ The scientific work was carried out as part of task 1.8 in the IUNG-PIB Multi-annual Programme for the years 2016-2020.

directly contribute more than half of all calories consumed by human beings [Ginter, Szarek 2010, Awika 2011]. Agronomic inputs such as fertilizers, pesticides, water and modern seeds, etc., have a major impact on the level of cereal crops. However, yield, to a greater extent, depends on the dose of applied NPK mineral fertilization [Sattari et al. 2014, McArthur, McCord 2017]. There is no doubt that maintaining an upward trend in grain production is necessary because the human population is growing. It is also related to the maintenance of the growth trend in the use of mineral fertilizers and the rationalization of their use [Gilland 2002, Zalewski, Piwowar 2018]. On the other hand, intensive soil fertilization with mineral fertilizers has led to several issues such as high cost, nitrate pollution and loss of soil carbon [Nkoa 2014].

The aim of the article is to determine the consumption level of NPK mineral fertilizers and cereal yield and their tendency to change over time, taking correlation into account. Analysis was performed on a global level.

MATERIAL AND METHODS

The material for analysis was statistical data from the Food and Agriculture Organization of the United Nations database for the years 2002-2017 [FAO 2020]. The following indicators were included in the analysis:

- consumption of mineral nitrogen fertilizers kg N/ha,
- consumption of mineral phosphorus fertilizers kg P₂O₅/ha,
- consumption of mineral potassium fertilizers kg K₂O/ha,
- total consumption of mineral NPK fertilizers kg NPK/ha,
- cereal yield t/ha.

Regional variation analyzes were carried out by continent with reference to average values for the world. Collected data was also processed dynamically using trend analyzes. The aim was to determine the direction and strength of changes taking place in the values of the examined features.

The strength of the relationship between the consumption of NPK mineral fertilizers and the level of cereal yield for selected geographical units was determined on the basis of the Pearson linear correlation.

RESULTS

Based on analysis, it was found that the lowest mineral NPK fertilizer (20 kg/ha) and cereal yield (1.5 t/ha) is characterized by Africa (Figure 1). On the other hand, the highest consumption of NPK mineral fertilizers, on average for the years 2002-2017, was recorded in Asia (172.6 kg/ha). It should be noted, however, that the cereal yield on this continent was similar to that obtained in Europe and in the world, which are characterized by a much lower consumption of NPK mineral fertilizers.

By far the highest cereal yield (5.2 t/ha) in the analysed period was noted in America (North, South and Central America in total), where the consumption of NPK mineral fertilizers was close to the world average. Oceania was characterized by a slightly higher

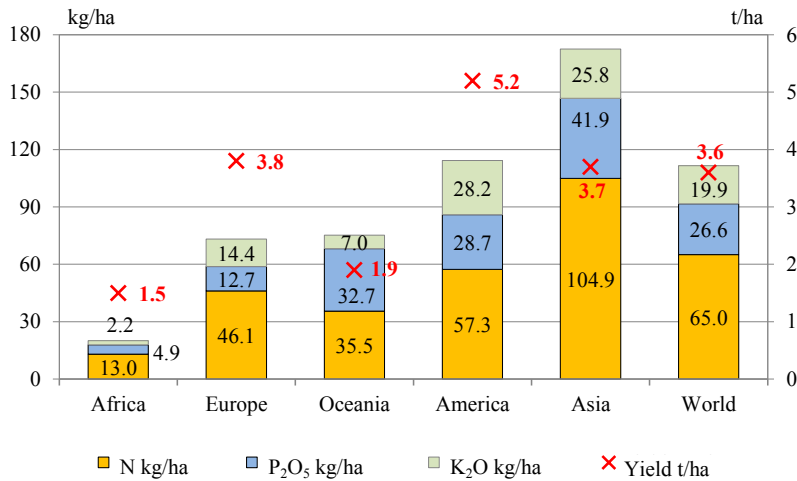


Figure 1. Consumption of NPK mineral fertilizers and cereal yield by continent, average for 2002-2017

Source: own study based on FAO data

consumption of NPK mineral fertilizers (75.2 kg/ha) than in Europe. However, the cereal yield on this continent was only slightly higher (1.9 t/ha) than that achieved in Africa.

The analysis of relations between the consumption of mineral fertilizers and cereal yield shows a very strong, positive correlation of these indicators on a global level (Table 1). Similar relationships, but slightly less strong, were found for America and Asia. On the other hand, in Africa, a strong dependence of cereal yield on the total consumption of NPK mineral fertilizers was demonstrated, which was determined to a large extent by a significant relationship with the consumption of P₂O₅. In Europe, cereal yield was strongly, directly proportionally related to the consumption of mineral nitrogen fertilizers. At the same time, no correlation was found with the consumption of mineral phosphorus and potassium fertilizers on this continent. It may result from improper fertilization, and in particular from the inability to maintain appropriate proportions of the fertilizer components N:P:K. In Oceania, a negative correlation between cereal yield and the consumption of mineral potassium fertilizers was found. The rationale for this relationship could stem from the fact that cereals are not the main group of arable crops on this continent, where permanent grasslands dominate. It is also confirmed by a low level of cereal yield (Figure 1). So, the presented relationship may be apparent.

Analysis of trends of changes in the consumption of NPK mineral fertilizers, including nitrogen fertilizers, and the level of cereal yield in 2002-2017 showed that the value of these parameters is characterized by a clear upward trend for the vast majority of the world (Figure 2). The only exception is Oceania, which, as mentioned, stems from the use of permanent grassland for agricultural development. The most discussed trends are emerging at a global level, as well as in America and Asia. In Europe, there was a strong tendency to increase the consumption of nitrogen fertilizers and increase in cereal yield,

Table 1. The correlation matrix for the consumption of NPK mineral fertilizers and cereal yield by continents (data for 2002-2017)

Specification			Cereal yield [t/ha]					
			Africa	America	Asia	Europe	Oceania	World
Fertilizers consumption [kg/ha]	Africa	N	0.464549					
		P ₂ O ₅	0.740997					
		K ₂ O	0.230182					
		NPK	0.626899					
	America	N		0.787457				
		P ₂ O ₅		0.673707				
		K ₂ O		0.697400				
		NPK		0.761454				
	Asia	N			0.869869			
		P ₂ O ₅			0.701435			
		K ₂ O			0.914848			
		NPK			0.905668			
	Europe	N				0.728890		
		P ₂ O ₅				-0.370720		
		K ₂ O				-0.461553		
		NPK				0.252154		
	Oceania	N					0.074337	
		P ₂ O ₅					-0.352481	
		K ₂ O					-0.595036	
		NPK					-0.341298	
World	N						0.917084	
	P ₂ O ₅						0.765592	
	K ₂ O						0.816351	
	NPK						0.907390	

Note: bolded font marked statistically significant correlations for $\alpha = 0.05$

Source: own study based on FAO data

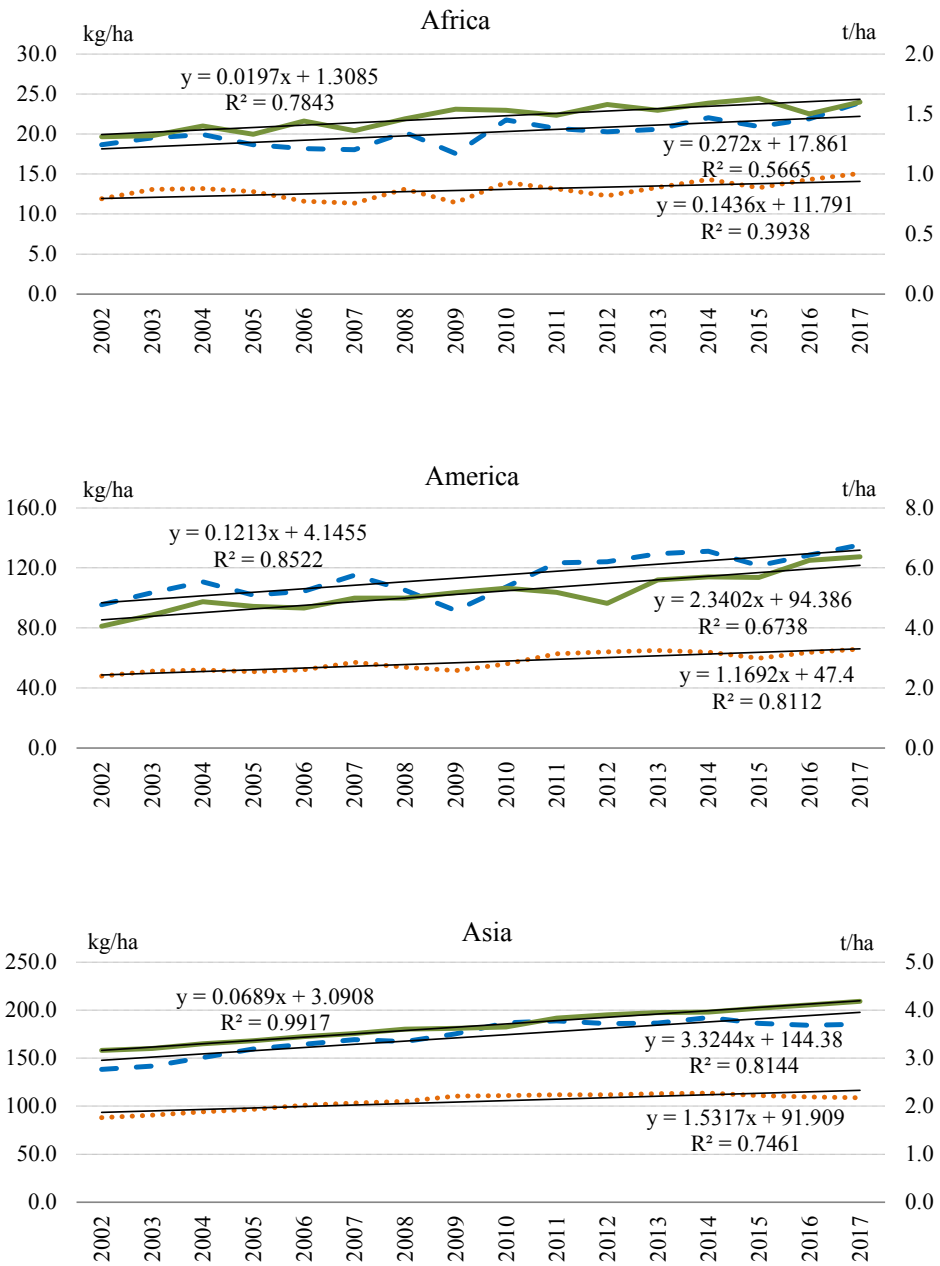


Figure 2. Trends in changes in the consumption of NPK mineral fertilizers (including N) and cereal yield according to continents in 2002-2017

Source: own study based on FAO data

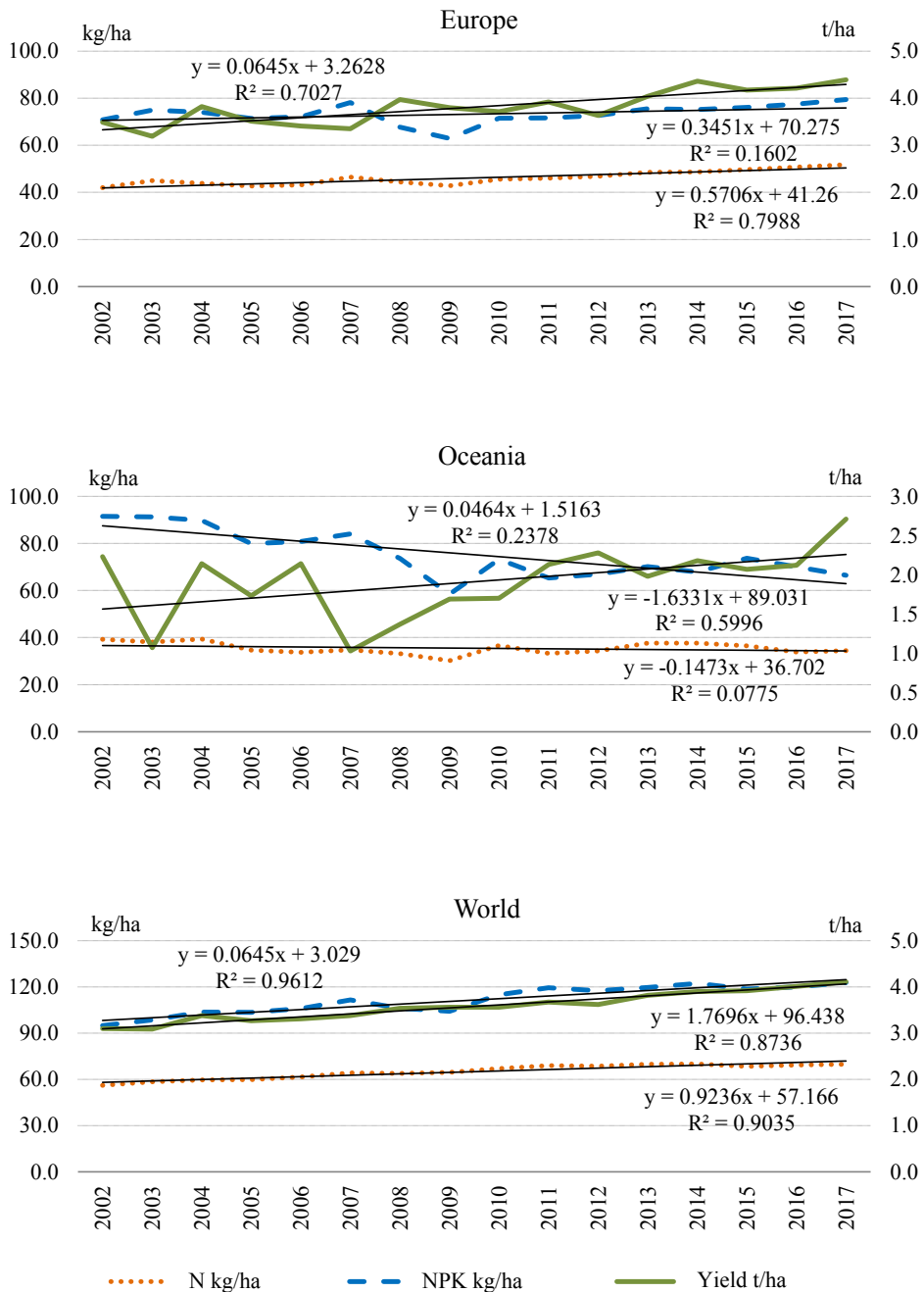


Figure 2. Count.

Source: own study based on FAO data

with no clear trend in the consumption of NPK mineral fertilizers in total. On the other hand, in Africa, the consumption of mineral nitrogen fertilizers is increasing strongly, with a moderate upward trend in the overall use of NPK fertilizers and a weak trend in yield growth.

CONCLUSIONS

The obtained results confirm that mineral fertilization is the main yield factor and that the increase in yield, which determines food security for the world's growing population, is largely dependent on this production factor. In this context, the question arises concerning the legitimacy and scale of impact of solutions proposed under the "New Green Deal" aimed at reducing the consumption of mineral fertilizers by 20% in EU. Obviously, the consumption of mineral fertilizers varies considerably both on a global and national scale. Europe, as a continent, is characterized by a relatively low value of this indicator with cereal yield close to the world average. It should also be noted that both globally and for most continents, there is a clear growth tendency of mineral NPK fertilizer consumption, including nitrogen, and the level of cereal yield. These indicators show a strong, directly proportional relationship.

BIBLIOGRAPHY

- Awika Joseph. 2011. Major cereals grains productions and use around the world. [In] *Advances in cereal science: Implications to food processing and health promotion*, ed. Joseph Awika, Vieno Piironen, Scott Bean, 1-13. Washington: American Chemical Society.
- FAO. 2020. *FAOSTAT data*, <http://www.fao.org/faostat/en/#data>, access: 02.07.2020.
- Gilland Bernard. 2002. World population and food supply: can food production keep pace with population growth in the next half-century? *Food Policy* 27 (1): 47-63. DOI: 10.1016/S0306-9192(02)00002-7.
- Ginter Agnieszka, Stanisław Szarek. 2010. Sytuacja dochodowa producentów zbóż na przykładzie uprawy pszenicy (Income situation of cereal producers on the example of wheat producers). *Journal of Agribusiness and Rural Development* 4 (18): 29-39.
- McArthur John, Gordon McCord. 2017. Fertilizing growth: Agricultural inputs and their effects in economic development. *Journal of Development Economics* 127: 133-152. DOI: 10.1016/j.jdeveco.2017.02.007.
- Nkoa Roger. 2014. Agricultural benefits and environmental risks of soil fertilization with anaerobic digestates: a review. *Agronomy for Sustainable Development* 34: 473-492. DOI: 10.1007/s13593-013-0196-z.
- Sattari Sheida, Martin Van Ittersum, Alexander Bouwman, Andre Smit, Bert Janssen. 2014. Crop yield response to soil fertility and N, P, K inputs in different environments: Testing and improving the QUEFTS model. *Field Crops Research* 157: 35-46. DOI: 10.1016/j.fcr.2013.12.005.

Zalewski Arkadiusz, Arkadiusz Piwowar. 2018. *Światowy rynek nawozów mineralnych z uwzględnieniem zmian cen surowca i bezpośrednich nośników energii* (The global market of mineral fertilizers, taking into account changes in the prices of raw materials and direct energy carriers). Warszawa: IERiGŻ-PIB.

STAN AKTUALNY I TENDENCJE ZMIAN ORAZ WZAJEMNE POWIĄZANIA ZUŻYCIA NAWOZÓW MINERALNYCH NPK I PLONOWANIA ZBÓŻ W UJĘCIU GLOBALNYM

Słowa kluczowe: NPK, zużycie nawozów mineralnych, plonowanie zbóż, tendencje globalne

ABSTRAKT

Ziarno zbóż jest od tysięcy lat głównym źródłem pożywienia dla ludzi. Duży wpływ na poziom upraw zbóż ma wykorzystanie środków produkcji, takich jak: nawozy, środki ochrony roślin, woda, nowoczesne nasiona. Jednak plon w największym stopniu zależy od dawki zastosowanego nawozu mineralnego NPK. Celem pracy jest określenie poziomu zużycia nawozów mineralnych NPK oraz plonowania zbóż i tendencji ich zmian w czasie, przy uwzględnieniu wzajemnych powiązań. Analizy problemu dokonano na poziomie globalnym. Materiał źródłowy do analizy stanowiły dane statystyczne z bazy Organizacji Narodów Zjednoczonych ds. Wyżywienia i Rolnictwa za lata 2002-2017. W wyniku przeprowadzonych analiz potwierdzono, że nawożenie mineralne jest głównym czynnikiem produkcji, warunkującym zapewnienie bezpieczeństwa żywnościowego rosnącej w skali świata populacji ludzkiej. Jednak zużycie tego czynnika produkcji jest znacznie zróżnicowane w skali świata. Należy również podkreślić, że zarówno w skali globalnej, jak i dla większości kontynentów, zarysowały się wyraźne tendencje wzrostu zużycia nawozów mineralnych NPK, w tym azotowych, a także poziomu plonowania zbóż.

AUTHOR

MARIUSZ MATYKA, PROF.

ORCID: 0000-0001-6269-1175

Institute of Soil Science and Plant Cultivation

– State Research Institute in Puławy

8 Czarторыskich St., 24-100 Puławy, Poland