DOI: 10.2428/ecea.2014.21(1)2 ECOL CHEM ENG A. 2014;21(1):15-24

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FERTILIZERS APPLIED IN MODERN AGRICULTURE ARE NEITHER HARMFUL NOR TOXIC

NAWOZY STOSOWANE W NOWOCZESNYM ROLNICTWIE NIE SĄ ANI SZKODLIWE, ANI TOKSYCZNE

Abstract: The paper presents definition of a modern agriculture as a man activity in very broad natural and social interactions. The paper also presents critical views on modern farming and fertilization, as well as indicates that the proper use of artificial fertilizers is and should be an important factor of crop productivity. The paper gives the list of the most basic chemical fertilizers and current level of fertilizing components use in Poland. The title of the paper, which is also the main thesis of the study, fully confirms the legitimacy of a view that chemical fertilizers are neither harmful nor toxic, and it is in the opposition to the common and false opinions that present chemical fertilizers as dangerous for humans, which is of course completely groundless.

Keywords: agriculture definition, chemical fertilizers, fertilization criticism

Definitions of agriculture

Agriculture is such a large and important area of human civilization, that a concise definition of the forms and scope of activity seems to be extremely difficult. Perhaps the first and unbeatable definition of agriculture is attributed to the Roman speaker Cicero: "Agriculturae proxima sapientiae est". This is very accurate and interestingly still true definition. As it seems, the best modern definition of agriculture, that can be considered as quite close to perfection, as it is accurate and concise and actually fully correct, is "Agriculture is an activity of man primarily aimed at the production of food, fiber and other materials (as well as power and fuel) by the controlled use of (mainly terrestrial) plants and animals." by [1].

Generally, to formulate any definition in science is not an easy task, because it turns out that it is difficult to write a good scientific definition, which would not include any exceptions. Therefore, an attempt to develop a schematic, *ie* glossary, definition of modern agriculture, which is definition based on a set of terms including: firstly, the

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main particular agricultural terms, secondly, two main groups of concepts forming the complete definition of agriculture, and thirdly, indicating the share of these two groups of contained concepts as the definition of modern agriculture. Thus, it can be assumed that the overall definition of agriculture in a schematic can distinguish one group (soil, water, air, plant, fertilizer, energy, time) estimated for 10 % of its importance in agriculture, and the second group (human, knowledge, information) estimated for 90 % of importance in modern agriculture.

Modern agriculture

Modern agriculture uses a wide spectrum of different terms, that are sometimes inappropriate or incorrectly defined; the simplest example to specify is *eg* "conventional" as opposed to 'organic' farming. For further discussion, it would be necessary to add three assumptions: first, that the main product of agriculture is the primary yield, which is useful parts of plants, second, that agriculture produces only the raw agricultural materials, and third, that food is produced by the food industry, and of course there are also exceptions, for there are also products of direct consumption in agriculture, but when such products are sold, must be subject to the market rules, *ie* must keep some standards as any commodity to trade.

If common nomenclature to accept, distinguishing such terms as 'conventional' and 'organic' farming is certainly not appropriate in the sense of the notions: 'conventional' and 'organic', and if it would be accepted as a correct statement, then very accurate comparison of the major differences between 'conventional farming' and 'organic farming' was presented by what is very well illustrated on a diagram. The graph shows that the distinction between these terms is significant, however it is not an issue associated with the use of fertilizers, but pesticides, and it is truth, indeed because chemical pesticides are very dangerous for man (Fig. 1) after [2].

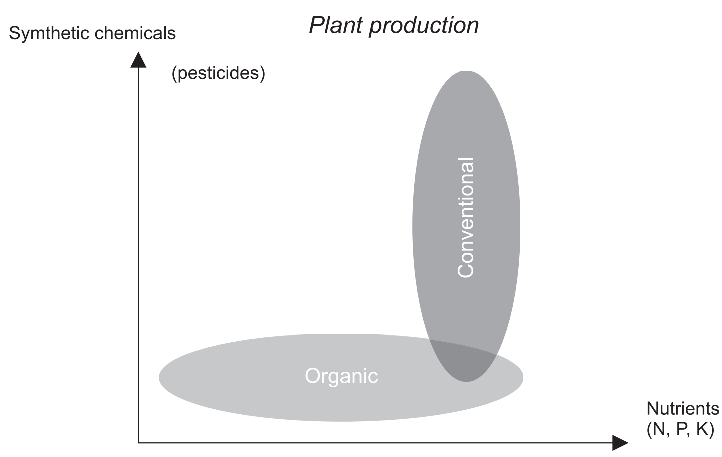

Fig. 1. Relationship between nutrient inputs and the use of synthetic compounds in organic and conventional plant production [2]

In the science, particularly in the applied sciences, and most particularly in agriculture, it had been that different soil tillage were initially made for centuries of human history, and later the theories proving the agricultural practices were developed. Theories to practical applications using modern methods of different treatments and cultivations, are proposed for now and for the future [3–5] presented a wonderful publication containing considerations of what can result from “organic farming”, with a title being some kind of a reminder and warning. Meanwhile, some views about the dangers of chemical fertilizers are still supported by suggestions that artificial fertilizers used in agriculture are agents that contaminate soils and the environment [6].

Current definitions of ‘conventional farming’ and ‘organic farming’, whatever they mean, are methods recommended in ‘organic farming’, are usually amended without any scientific evidence. Meanwhile, there is no scientific evidence for the superiority of ‘organic farming’ over ‘conventional farming’. Besides, the terminology itself is not correct, because ‘conventional’ means simply ‘traditional’, whereas the opposition to conventional is not newer, but older and organic manner of production, which is about 100 years earlier than conventional one. And perhaps it would be much more appropriate to refer to ‘conventional farming” as ‘modern farming’ and ‘organic farming’ as simply ‘medieval farming’. In addition, legal acts are also created that are to give an impression that ‘organic farming’ cares about human health. And it is commonly known that from a scientific point of view, there is no question about whether a phenomenon, view, or a method is consistent with the law, but about whether the phenomenon, view, or method is true or not.

Fertilization criticism

Based on many years of observation and research, simple and clear, and above all practically useful yet important, principles of fertilizer recommendations have been formulated indicating that high yields and the highest quality of crops can be achieved by different management ways and chemical methods of soil and plant analysis are only little precise and generalized assessment of a cropland. At the same time, the use of manure and fertilizers, taking into account the abundance of arable field and natural environment conditions are important for a good utilization of fertilizing components and reduction of environmental hazard. However, yields are often limited by climate, such as rainfall and temperature, or inappropriate physical and biological soil conditions, or increased susceptibility to plant diseases. A most interesting issue was to draw attention to the practically most important principle that before any fertilizer recommendation, a farmer should always consider which factor may actually limit the yield, because this way the disappointments can be avoided [7].

The history of fertilization taking into account the experimental fertilization schemes was concisely and interestingly described in the introduction to the considerations upon the main problem, which was to search for optimal fertilizing components ratios in a total summering rate of N, P, and K. However, it seems that in this work the most interesting was that applied mass of fertilizing nutrients are not important for plants, but amount of fertilizing nutrients affecting or taken up by crops, i.e. amount of fertilizing components expressed by amount of substance [8].

A new approach to fertilizer recommendations based on the use of the elemental composition in the entire above-ground parts of plants during the flowering stage to determine the fertilizing components ratios useful for practical fertilization, was also considered. This concept assumed that fertilization using lower rate of five fertilizing components (N, P, K, Mg, and S) and their appropriate ratios (N/P, N/K, N/Mg, and N/S) should lead to better results on the yielding than higher rates of only one or two, or even only three fertilizing components. In this fertilization, which component is the yield limiting factor should be also determined, and if the limiting fertilizing component would be, e.g. N, then the following ratios should be taken into consideration P/N, K/N, Mg/N, and S/N [9].

In theory and practice of fertilization, it was indicated that applied the initial and lower fertilizing component rate gives the greatest increased of the yield, whereas the effectiveness of higher fertilizing component rates always getting lower and lower and tending to zero. Thus, in modern crop productions, the fertilization should be on the sake of minimizing the use of fertilizing components, it means that only such fertilizing component rates should be use the only in the range of increase the yields, but never to tend to the optimizing of fertilization and maximizing of yields, and expect of the highest yields.

Chemical fertilizers in agriculture

There is large spectrum of available fertilizers for agricultural practice. It is very significant that the number of chemical compounds is the same for decades, so the assortment is formed from the same chemicals, obviously with new names, or different mixtures are produced from the same compounds, but then with variety names. In addition, producers of fertilizers do not unveil the constituent chemical compounds, and only content of fertilizing components are given. Then the problem is even worse, because the farmers often in their observations, and rarely scientists, reflect upon the influence of the fertilizer name on the yield size or crop quality.

Producers of fertilizers generally provide the content of main fertilizing component, and very rarely give the chemical compounds in fertilizers, and almost never give the elemental composition. What a pity, because natural materials recommend in the ‘organic farming’, in general in a form of crumbled or ground raw rock, may contain elements that should be not exist in fertilizers, and among these elements are sometimes unwanted radioactive elements; this is not mentioned, however, in the ‘organic farming’. Another example can be the application of manure or composted manure for ‘organic farming’, as wastes from a farm, which have no standards: neither chemical nor parasitological nor microbiological. Another example: as in the 19th century, today the phosphorus content in fertilizers is given in its oxide form. This also includes potassium and other nutrients and this cannot be changed neither by universities, nor by world fertilizer congresses, where the issue is recalled; it is the highest time to give the content of nutrients in their correct elemental forms. And the anachronism, is that phosphorus and potassium are not present in the oxide forms, neither in soils, nor in plants, nor in fertilizers.

No harmful chemical fertilizers

A background to the consideration is a compilation of basic chemical fertilizers including the four most important information about fertilizers: (1) name of fertilizer, (2) fertilizing compound, (3) content of the fertilizing component, (4) fertilizing nutrient. Distinction of these four characteristics is very useful in practice, because conscious farmer should know what forms of fertilizing nutrient will affect crops from the soil (Table 1).

Table 1

Common fertilizers and defined as approximate content of fertilizing components in Poland

Artificial and commercial fertilizers			
Fertilizer name	Fertilizing compound as chemical formula	Fertilizing component in %	Fertilizing nutrient as chemical form
Ammonium sulphate	$(NH_4)_2SO_4$	N 20 % S 24 %	NH_4^+ SO_4^{2-}
Sodium nitrate	$NaNO_3$	N 15 %	Na^+ NO_3^-
Potassium nitrate	KNO_3	N 13 % K 38 %	K^+ NO_3^-
Calcium nitrate	$Ca(NO_3)_2$	N 15 % Ca 15 %	Ca^{2+} NO_3^-
Ammonium nitrate	NH_4NO_3	N 34 %	NH_4^+ NO_3^-
Calcium ammonium nitrate	$NH_4NO_3 + CaCO_3$	N 28 %	NH_4^+ NO_3^-
Urea	$CO(NH_2)_2$	N 46 %	
Single superphosphate	$Ca(H_2PO_4)_2 + CaSO_4$	P 8 % S 12 %	Ca^{2+} $H_2PO_4^-$ SO_4^{2-}
Triple superphosphate	$Ca(H_2PO_4)_2$	P 20 %	Ca^{2+} $H_2PO_4^-$
Ground rock phosphate	$Ca_3(PO_4)_2$	P 13 %	Ca^{2+} $H_2PO_4^-$
Potassium chloride[1]	KCl	K 50 %	K^+ Cl^-
Potassium sulphate	K_2SO_4	K 41 % S 18 %	K^+ SO_4^{2-}
Magnesia kainite[2]	$KCl + K_2SO_4 + MgSO_4$	K 21% Mg 5 % S 10 %	K^+ Mg^{2+} SO_4^{2-} Cl^-
Kieserite	$MgSO_4\ H_2O$	Mg 16 % S 22 %	Mg^{2+} SO_4^{2-}
Epsom salts	$MgSO_4\ 7H_2O$	Mg 10 % S 13 %	Mg^{2+} SO_4^{2-}
MAP[3] + DAP[4]	$NH_4H_2PO_4 + (NH_4)_2HPO_4$	N 18 % P 20 %	NH_4^+ $H_2PO_4^-$ HPO_4^{2-}
MAP[3] + DAP[4] + MOP[1]	$NH_4H_2PO_4 + (NH_4)_2HPO_4 +$ $+ KCl$	N 18 % P 10 % K 20 %	NH_4^+ $H_2PO_4^-$ HPO_4^2 K^+

[1] MOP Muriate of potash; [2] Content of chemical components is very changing; [3] MAP Monoammonium phosphate; [4] DAP Diammonium phosphate.

Extensive studies upon the use of fertilizing component in Poland were carried out for a longer time with 5 years increment. However, it should be clearly stated that these results do not show a direct cause-effect relationship between use of fertilizing component and yields of these crops, because results are of global nature and nothing is known about it: where, when, and how these fertilizing components of fertilizers were applied. This study had been show in three parts: the first, use of fertilizing components and substances for soil de-acidification, the second as trends in the use of fertilizing components and alkali for soil de-acidification in subsequent periods. Calculated regression coefficients b_{yx} for the equation y = b + c in the adequate periods when was linear depending between of the features. And calculated values were marked with sign as (+) or (–), which is easy visible on graph (Fig. 2), and the third, yields was gives for the only four crops, because data of yields in the statistical source referring only to these crops yields were presented throughout the overall examined period. Finally, which was the most important in the presentation of this study that presented results can also easily indicate what were the yields without the use of chemical fertilizers, the good example of which was year 1946 (Table 2).

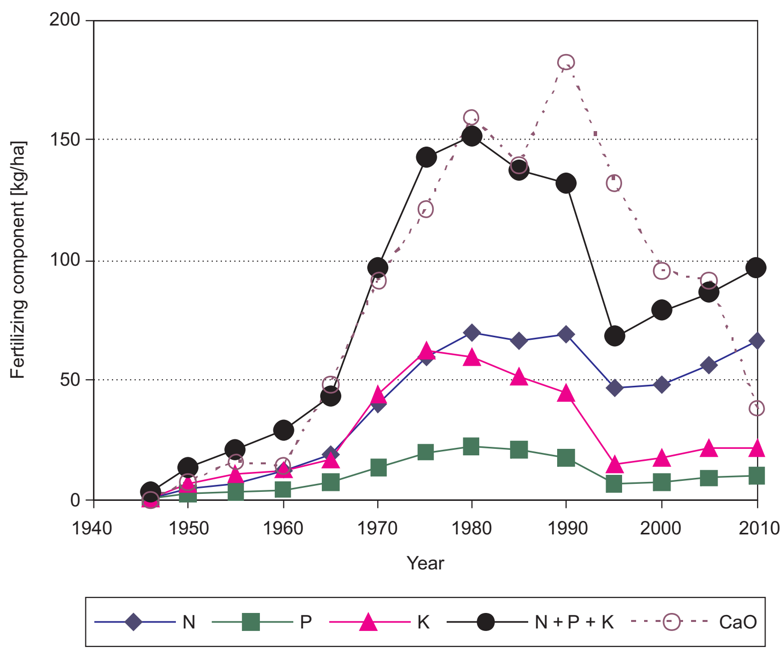

Fig. 2. Fertilizing components and liming use in Poland in the years 1946–2010

The evidence confirming the thesis in the paper title is a summary of the main compounds in chemical fertilizer (Table 1) along with chemical compounds that are widely use as food preservatives (Table 3). And the proof is easy and simple. The same chemical compounds that are chemical fertilizing compounds are also chemical food preservatives. Thus, the title of the work, which is also the main thesis of the study, fully confirms the validity of a view that chemical fertilizers are neither harmful nor toxic, which is opposite to the common and false opinions that chemical fertilizers as

Table 2

Fertilizing components use and crop yields estimated in the years 1946–2010 in Poland

Component	Year													
	1946	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
	Fertilizing component N P K and CaO equivalent in kg/ha*													
N	1.1	4.6	6.7	12.3	19.4	40.2	60.1	69.6	66.1	68.9	46.6	48.4	56.3	66.3
P	0.8	2.2	3.1	3.9	7.1	13.3	20.3	22.4	20.6	17.8	6.8	7.3	8.9	9.9
K	1.2	6.7	10.6	12.7	16.5	44.0	62.4	59.7	51.3	45.1	14.6	17.2	21.3	21.2
N + P + K	3.1	13.5	20.4	28.9	43.0	97.5	142.8	151.7	138.0	131.8	68.0	79.2	86.5	97.4
CaO equiv.	0.4	7.1	15.9	14.1	48.3	90.9	120.8	159.7	139.4	182.4	131.9	95.1	91.5	38.1
Component	Component in kg/ha for respectively determined period with sign + as increase or sign – as decrease**													
N	+1.9										+1.3			
P	+0.7								–1.4			+0.3		
K	+0.8					+3.7		–1.2			+0.5			
N + P + K	+4.7								–7.0			+2.5		
CaO equiv.	+4.5										–5.7			
Crop	Yield in tons/ha*													
Wheat	0.88	1.28	1.49	1.69	2.60	2.32	2.83	2.60	3.43	3.96	3.60	3.23	3.95	4.39
Rye	0.90	1.28	1.41	1.54	1.84	1.56	2.25	2.16	2.47	2.61	2.56	1.88	2.41	2.68
Potato	11.2	13.8	10.0	13.2	15.4	18.4	18.0	11.3	17.4	19.8	16.4	19.4	17.6	21.1
Sugar beet	17.6	22.2	18.6	25.6	25.9	31.2	31.7	22.1	33.6	38.0	34.6	39.4	41.6	48.3

* The study based on Statistical Yearbook of the Republic of Poland, Central Statistic Office, Warszawa of 1946–2011; ** Calculated trend of increase or decrease fertilizing component use what easily see on Fig. 2.

Table 3

Chemical fertilizing compounds as well as chemical food preservatives

Chemical name	Chemical compound	Approximate element content						Food preservative
		N	P	K	Ca	Mg	S	
		[%]						
Ammonium sulphate	$(NH_4)_2SO_4$	21					24	E 517
Sodium nitrate	$NaNO_3$	16						E 251
Potassium nitrate	KNO_3	14		38				E 252
Calcium nitrate	$Ca(NO_3)_2\ 4H_2O$	12			17			
Ammonium nitrate	NH_4NO_3	35						
Urea	$CO(NH_2)_2$	46						E 927
Monocalcium phosphate	$Ca(H_2PO_4)_2\ H_2O$		24		16			E 341 (i)
Tricalcium phosphate	$Ca_3(PO_4)_2$		20		38			E 341 (iii)
Monoammonium phosphate	$NH_4H_2PO_4$	12	27					E 342
Diammonium phosphate	$(NH_4)_2HPO_4$	21	23					E 342
Potassium chloride	KCl			52				E 508
Potassium sulphate	K_2SO_4			45			18	E 515 (i)
Magnesium sulphate	$MgSO_4\ H_2O$					17	23	
Magnesium sulphate	$MgSO_4\ 7H_2O$					10	13	Medication
Deacidifying compound		[%]						
Calcium oxide	CaO				71			E 529
Calcium carbonate	$CaCO_3$				40			E 170 (i)
Magnesium oxide	MgO					60		E 530
Magnesium carbonate	$MgCO_3$					28		E 504 (i)
Acidifying compound		[%]						
Sulphur	S						100	
Calcium sulphate	$CaSO_4\ 2H_2O$				23		18	E 516

dangerous for humans, which is obviously completely groundless. A simple example of calculation that only shows the scale of the problem can be represented in following way. Let a chemical fertilizer was applied in the amount of 300 kg/ha to the field of 1 hectare. Assuming the area of 1 ha is 10000 m^2, tillage layer is 0.2 m deep, and soil bulk density is 1.5 Mg/m^3, then concentration this applied fertilizer in the soil would reach only concentration will be 0.01 %, and this is in soil, not in food. Although the ranges of different food preservative compounds are very broad, it can be assumed, with some stipulations, that the mean concentration of chemical food preservatives is about 0.01 %, and this is in food, not in soil.

Conclusions

The use of very high rate of fertilizing components applied in the crop fertilization, which based on the concept of nutrient requirements of crops and expected of forecast yields was the cause of the harmful effects applied of fertilizers in the field as well as in the natural environment.

However the fertilizer recommendations from the science point of view seemed to be proper and correct, nevertheless it led to the common views, that application of chemical compounds in agriculture began to be perceived as improper way in the present agriculture development.

In the modern agriculture can be use chemical fertilizers because fertilizing compound applied in the crop production are neither harmful nor toxic, however, the crop fertilization should be take into consideration the fertilizer recommendation as rational, reasonable, prudent, cautious, poise or balanced.

It is sure, that just chemistry is the science which has the biggest positive effect on development of agriculture *eg* discovery of nitrogen compounds synthesis, development of fertilizers production technology, development of soil and plant analysis, and many other discoveries, which gave the possibility of common use of chemical fertilizers and very significantly increased the crop productivity. Chemistry is in fact the boon of agriculture.

References

[1] Spedding CRW, Walsingham JM, Hoxey AM. Biological Efficiency in Agriculture. London: Academic Press Inc; 1981.
[2] Brandt K, Molgaard JP. Food quality. In: Organic Agriculture: A Global Perspective. Editors: Paul Kristiansen, Acram Taji and John Reganold. Collingwood: CSIRO Publishing; 2006.
[3] Kirchmann H, Thorvaldsson G. Challenging targets for future agriculture. Europ J Agron. 2000;12:145-161.
[4] Miller FP. After 10,000 years of agriculture, whither agronomy? Agron J. 2008;100:1-3.
[5] Connor DJ. Organic agriculture cannot feed the world. Field Crops Res. 2008;106:187-190.
[6] Savci S. An agricultural pollutant: chemical fertilizer. Internat J Environ Sci Develop. 2012;3:77-80.
[7] Amberger A. Grenzen der Düngung für Ertrag und Qualität. Die Bodenkultur, 1980;31:246-256.
[8] Labuda SZ. An essay on the fertilization. Annales Universitatis Mariae Curie-Sklodowska, Sectio E Agricultura. 2006;61:1-8.

NAWOZY STOSOWANE W NOWOCZESNYM ROLNICTWIE NIE SĄ ANI SZKODLIWE, ANI TOKSYCZNE

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Abstrakt: Praca przedstawia definicję nowoczesnego rolnictwa jako działalności człowieka w bardzo szerokich przyrodniczych i społecznych interakcjach. W pracy przedstawiono również krytyczne poglądy na współczesne rolnictwo i nawożenie, a także wskazano, że właściwe stosowanie nawozów sztucznych jest i powinno być ważnym czynnikiem produktywności roślin uprawnych. W pracy przedstawiono także najbardziej podstawowe nawozy sztuczne i współczesny poziom zużycia składników nawozowych w Polsce. Tytuł pracy, który jest również główną tezą opracowania, w pełni potwierdza prawdziwość tego poglądu, że nawozy sztuczne nie są, ani szkodliwe, ani toksyczne i to jest przeciwieństwem do powszechnych i fałszywych opinii, które straszą nawozami jako niebezpiecznymi dla ludzi co jest oczywiście w pełni bezpodstawne.

Słowa kluczowe: definicja rolnictwa, nawozy sztuczne, krytyka nawożenia