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CORRELATION RHYTHMS ON THE APPLICATION OF CHEMICAL FERTILIZERS/PESTICIDES AND THE EXPENDITURE ALLOCATION FOR POLLUTION PREVENTION AND CONTROL IN THE SOIL AND GROUND WATER OF ROMANIA

Raluca NECULA[1], Marian CONSTANTIN[1], Manea DRĂGHICI[1], Mihai Daniel FRUMUȘELU[1]

Keywords: chemical fertilizers, pesticides, soil pollution, capital expenditure / current, standard deviation, coefficient of variation, dispersion, regression equation.

Cuvinte-cheie: îngrășăminte chimice, pesticide, poluare a solului, cheltuieli de investiții/curente interne, abatere standard, coeficient de variație, dispersie, ecuație de regresie, determinație.

Abstract. *The present work is the result of a pertinent analysis and highlights the results regarding both the first variational existing level of application of chemical fertilizers/pesticides, and the level of expenses made in order to prevent and fight soil and ground water pollution in Romania. The statistical results on variability were rendered by statistical indexes which were based on the data corresponding to the interval 2008-2015. The main values are the average, the standard deviation and the coefficient of variation. All this enabled us to calculate the annual growth rate. We monitored the variation results of the influence factors, which methodologically using forms of regression equations ($y = a \cdot x$) showed the influence of the use of fertilizers / pesticides (x) on the expenses made in order to combat pollution (y). The variations in amplification by means of ± 5% ± 50% x, variations enabled us to sequentially identify the presumptive levels of domestic investment expenses and current (y). The overall results were also founded upon knowing the percentage changes of the elasticity. We have found out that there is an inadequate level of expenditure allocation for fighting pollution in relation to the increased use of fertilizers/pesticides.*

Introduction

The use of chemical fertilizers and pesticides is regarded as a fundamental agrotechnical link, whose popularity suggests the necessity of knowing its implications in various areas of economy and society. A constant and important problem is the triple relationship between pollution, control expenses and human protection. The present paper analyses the necessity and rhythm of the expenses needed for controlling soil pollution by using chemical fertilizers and pesticides in agriculture.

[1]University of Agricultural Sciences and Veterinary Medicine Bucharest, 59 Marasti, District 1, 11464, Bucharest, Romania, Phone: +40213182564, Fax:+40213182888, Mobile:+40744 6474 10, marianconstantin2014@yahoo.com; raluca_nec@yahoo.com.

The use of the prospective forms resulted from regression equations led to the identification of relations between the present level of using fertilizers/pesticides and the soil protection expenses used nationwide. These were highlighted using the variation levels of the use of fertilizers/pesticides by means of regression equations regarded as specific correlative forms. The analysis has led to the conclusion that the present expenses are insufficient and they must be raised (both the investments and the current internal ones) in order to prevent and fight the pollution of Romania's soil and ground water.

Materials and Methods

The methodology employed in the present paper aims to use the most appropriate systems of highlighting the analysed problem. The initial data are the levels of using fertilizers/pesticides and the expenses made for preventing and fighting the pollution of the soil and of the ground water in Romania during the interval 2008-2016. The data processing leading to the mapping of the relations and conditions concerning the budgeting the prevention and the fighting of soil and ground water pollution as an effect of the use of fertilizers was structured two-dimensionally.

Several indexes were used in the analysis of the fertilizers quantities and of the protection expenses allocated, in order to follow the fluctuations occurring during the time interval that was investigated. These indexes were the result of the average values, standard deviation, coefficient of variation and determination, which enable us to identify the annual growth rate.

As long as all these observations were considered to be static forms during the interval analysed, the results were known by analysing the influence factors. The methodology made use of regression equations ($y = a \cdot x$) and framed the relations between the quantities of fertilizers/pesticides used and the expenses made for them. In such cases, the determinant factor (x) was made up by the allocated quantities and the resultant factor (y) by expenses made for protecting the soil and the ground water. Starting from the annual differentiation of the fertilizers/pesticides depending on the variations of the amplification by the ±5% x and ±.50% x variations, we identified the presumptive levels of the investment expenses and of the internal expenses (y). The overall results were based on finding out the differences between Y adjusted (with +5%x and +10%x) and Y with initial/brute values (of the year 2015). All these were completed with the percentage variations of the quotient of elasticity, correlation and determination. By the way the statistical determination (R2) was interpreted, the share of the simultaneous influence of all the factorial variables (the use of fertilizers/pesticides) out of the overall variation of the resultant variable (allocating the investment expenses/current internal expenses).

Results and Discussions

The growth of the agricultural productions based on chimisation is a problem that permanently involves both the modalities and the quantitative level and the investment and current expenses caused by the quantitative amplification made for fighting the possibly occurring pollution. This aspect is analysed nationwide, covering the time interval 2008-2015, and expressed in quantitative values starting from the annual variations. Moreover, some presumptive situations are also analysed.

I. - The quantitative level and the variation system of the use of fertilizers/pesticides and of allocating expenses for preventing and fighting the pollution of soil and ground water in Romania.

The analysis of the use of fertilizers/pesticides and of allocating expenses for preventing and fighting pollution is rendered for the whole country both in their evolution and in the variation system made up starting from statistical indexes. The values displayed in Table 1 lead to the following conclusions:

Table 1. The use of fertilizers/pesticides and the budgeting of expenses for the prevention and fighting of the pollution of soil and ground waters in Romania.

Specification	Total *fertilizers used*	Total *pesticides used*	*Investment expenses* (for preventing and fighting the pollution of soil and ground water)	*Total internal expenses* (for preventing and fighting the pollution of soil and ground water)	
U. M.	thousand tons (s. a.)	thousand tons (s. a.)	thousand lei (current prices)	thousand lei (current prices)	
2008	397.965	7.193719	360468	267421	398
2009	426.207	6.548733	282997	128295	426
2010	480.586	7.249206	333749	90845	481
2011	486.944	6.582935	192899	159410	487
2012	437.972	6.418796	257166	66552	438
2013	491.831	6.947877	250018	69313	492
2014	452.239	6.723793	220678	62820	452
2015	532.702	6.608037	366781	109987	522

Indexes concerning the level of the variational system for the interval 2008-2015

average	463.3	6.8	283094.5	119330.4
standard deviation	42.9	0.3	64756.0	68657.5
Coefficient of variation (%)	9.26	4.58	22.87	57.54
annual growth rate (%)	4.25	-1.21	0.25	-11.92

- the use of fertilizers and pesticides is different as to its annual rhythm but has different trends. One may remark that fertilizers have a growing trend whereas pesticides have a regressive one.

- the expenses allocated, both the invested ones and the current internal ones, have also annual variations, but also with differentiated trends. Thus, the investment expenses are much higher than the current ones, which have a regressive trend up to the year 2014; the current internal expenses have a definite regressive trend with a minimum identified for the year 2014.

- the results of the statistical indexes for the annual differentiation of the quantities of fertilizers/pesticides and the respective expenses are compared to their average values on the analysed time interval. They led to the following conclusions: the standard deviation has values which are very different from the average; the variation quotient, calculated as the difference between the standard deviation and the average value, shows that the percentage values are not favourably grouped around the average values; the growth rate is the result of the influence made by all the causes and conditions that cause the growth of the quantities of fertilizers/pesticides used, which leads to a growth (that can be described as slightly significant) of the use of fertilizers only, an insignificant growth of the investment expenses, as well as decreases of the current internal expenses for using pesticides.

The analysis done synthetically suggests a differentiation of the growth, which means that an increase of 4.24% in the use of fertilizers corresponds to an increase of 0.25% of the investment expenses and a decrease of -11.92% in the current internal expenses.

2. - ***The variations of the quantities of fertilizers/pesticides according to the sequential forms of design***.

An intermediate stage consists of the time grading of the structure, which can be rendered sequentially for the levels of fertilizers/pesticides. The variations of +5% *x* and +10% *x* reveal an increase of the initial level for each type of fertilizer. Table 2 displays these levels for each variational form. The quantitative values (thousand of tons, etc.) are thus expressed by successively amplifying these alterations, whereas the variational forms are needed in order to estimate the presumptive expenses. By modifying the *x* factor while keeping the other factors constant, structural modifications result. These modifications are summed up in the regression equation and will influence the presumptive variations of all the protection expenses. These expenses were taken into account both as investment expenses and as current internal expenses.

Table 2. Sequences of the quantitative differentiations for fertilizers/pesticides (in relation to the variations of the amplifications +5%*x* and +10%*x*)

Variational amplification of the *x* factor (+5%x and +10%*x*)	The structure of the quantities of fertilizers/pesticides in relation to the designed variations (thousand tons s.a.)					
	Nitrous x_1	Phosphatic x_2	Potash x_3	Insecticide x_4	Fungicide x_5	Herbicide x_6
X_1+5%	**375.220**	132.657	42.693	0.716	2.246	3.646
X_2+10%	**393.087**	132.657	42.693	0.716	2.246	3.646
X_1+5%	357.352	**139.290**	42.693	0.716	2.246	3.646
X_2+10%	357.352	**145.923**	42.693	0.716	2.246	3.646
X_1+5%	357.352	132.657	**44.828**	0.716	2.246	3.646
X_2+10%	357.352	132.657	**46.962**	0.716	2.246	3.646
X_1+5%	357.352	132.657	42.693	**0.752**	2.246	3.646
X_2+10%	357.352	132.657	42.693	**0.788**	2.246	3.646
X_1+5%	357.352	132.657	42.693	0.716	**2.358**	3.646
X_2+10%	357.352	132.657	42.693	0.716	**2.471**	3.646
X_1+5%	357.352	132.657	42.693	0.716	2.246	**3.828**
X_2+10%	357.352	132.657	42.693	0.716	2.246	**4.010**

The amplification was calculated for the last year – 2015.

3. - Presumptive variations of the investment expenses made for preventing and fighting the pollution of soil and ground water

For the investment expenses, a delimitation was possible by using the most adequate regression equation. These expenses were rendered in an adjusted form, their presumptive levels being filled up with the difference to the real (initial) data and the form of elasticity. This structural set led to the conclusions summed up in Table 3.

Table 3. Sequential differentiations of the **investment expenses** caused by the variations of the amplification level (+5% and +10%) by using fertilizers/pesticides [using the regression function: *Y*(invest. expenses, thousand lei) = -725144+ 1077,173 x_1+ 11654,45 x_2 -16327,9 x_3 + 483800,7 x_4 + 12177,96 x_5 - 152501 x_6 (R^2 = 0,5829; r = 0,76)]

Type of fertilizer/ pesticide	Name of the fertilizer type (in the regression equation)	Variational levels of the fertilizer/pesticide type	Levels of the variable amplification (thousand tons)	*Y adjust.* investment expenses (data entered in the calculation with +5%/....+10%) thousand lei	Difference (from Y adjusted with +5%/....+10%) and Y adjusted with initial/brutto data)	Elasticity (%)
Nitrous	X_1	+5% x_1	375.220	345944	19246	5.9
		+10% x_1	393.087	365191	38493	11.8
Phosphatic	X_2	+5% x_2	139.290	404000	77302	23.7
		+10% x_2	145.923	481302	154604	47.3
Potash	X_3	+5% x_3	44.828	3.646	-34854	-10.7
		+10% x_3	46.962	3.646	-69709	-21.3
Insecticide	X_4	+5% x_4	0.752	344025	17328	5.3
		+10% x_4	0.788	361353	34655	10.6
Fungicide	X_5	+5% x_5	2.358	328065	1368	0.4
		+10% x_5	2.471	329433	2735	0.8
Herbicide	X_6	+5% x_6	3.828	298900	-27797	-8.5
		+10% x_6	4.010	271103	-55595	-17.0

- the presumptive level of the investment expenses analysed by the structural level of the output of the regression equation has different values, which, compared to the effective (initial) values can be delimited as follows: adjusted values that reveal a level which is superior to the initial expenses — this is the case of most types of fertilizers/pesticides; for the case of phosphatic and herbicide fertilizers the amplification of the expenses leads to an adjusted level of expenses that is smaller than the initial one;

- the elasticity, which signals the limits of the ratio between the modification of the expense level and the modification of the quantities of the fertilizers used, has structures that are similar (positive/negative) to the level of the fertilizers/pesticides used;

- The value of the **index of determination** expresses the intensity of the direction of simultaneous influence between the quantities of fertilizers/pesticides used and the investment expenses made for protecting the soil. The determination (R^2=0,5829) expresses an average causal relation, **because the share of the influence of the factorial variables in the total variation of the resultant variable is an average value, respectively a form of an average correlation, which is also rendered by the value of the correlation index.**

The analysis of the variations of the presumptive levels of the investment expenses made for the protection of the soil enables the inference of the variational correlative directions of the amounts, but also incongruities related to the use of phosphatic and herbicide fertilizers.

4. - Presumptive variations of the current internal expenses made for preventing and fighting the pollution of soil and ground water in Romania.
The current internal expenses made for fighting the pollution of soil express the allocation of annual funds which are lower than the investment expenses, but which show a similar behaviour of the annual differentiations. The strong influence is expressed by the same variables that express the use of fertilizers/pesticides and for which the regression functions delimit the adequate sequences. The variational levels +5% and +10% of each type of fertilizers determine the adjusted current values of the current internal expenses. These results are shown in Table 4 and lead to the following conclusions:

Table 4.- The sequential differentiations of the **current internal expenses** determined by the variations of the level of amplifications (+5% and +10%) by using fertilizers/pesticides [using the regression function: *Y*(current internal expenses, thousand lei) = *Y*(current expenses, thousand lei) = -1366448+739,63 x_1 + 27515,9 x_2 - 37953,8 x_3 + 989561,3 x_4 - 442049 x_5 - 142357 x_6 (R^2 = 0,951; r = 0,975)]

Type of fertilizer/ pesticide	Name of the fertilizer type (in the regression equation)	Variational levels of the fertilizer/pesticide type	Levels of the variable amplification (thousand tons)	*Y adjust.* investment expenses (data entered in the calculation with +5%/....+10%) thousand lei	Difference (from *Y* adjusted with +5%/...+10%) and Y adjusted with initial/ brutto data)	Elasticity (%)
Nitrous	X_1	+5% x_1	375.220	137830	13215	10.6
		+10% x_1	393.087	151045	26431	21.2
Phosphatic	X_2	+5% x_2	139.290	307123	182509	146.5
		+10% x_2	145.923	489632	365018	292.9
Potash	X_3	+5% x_3	44.828	43596	-81018	-65.0
		+10% x_3	46.962	-37422	-162036	-130.0
Insecticide	X_4	+5% x_4	0.752	160056	35442	28.4
		+10% x_4	0.788	195498	70883	56.9
Fungicide	X_5	+5% x_5	2.358	74968	-49646	-39.8
		+10% x_5	2.471	25322	-99293	-79.7
Herbicide	X_6	+5% x_6	3.828	98666	-25948	-20.8
		+10% x_6	4.010	72718	-51897	-41.6

- the adjusted level of the current internal expenses has positive values in most of the sequences analysed. Only the use of potash fertilizers (+10% *X*3) leads to a negative value. The differences form the initial values (the actual expenses) lead to negative values for the use of fertilizers of the potash, fungicide and herbicide types.

- concerning elasticity, the amplitudes are very large. The positive variations include positive percentage levels (between 10.6% and 292.9%) for nitrous, fungicide and herbicide fertilizers. The analysis of the mentioned levels reveals a typological variety that includes the modification of the economic variable (current expenses made for soil protection) for the simultaneous or anterior use of fertilizers/pesticides. Despite the fact that the values resulted from the analytic calculus, explaining the analysed structure, should be in a natural relationship, there

is both elasticity (for nitrous, phosphatic and insecticide) and inelasticity (for potash, fungicide and herbicide).

- concerning the correlative trends expressed by the index of determination (R^2 = 0,951) and correlation (r = 975) there is a significant intensity of the relation between the use of fertilizers/pesticides and the allocation of current operational expenses for soil protection. This is due to the fact that the share of the influence of the factorial variables (the use of fertilizers/pesticides) in the total variation of the resultant variable (the allocation of current internal expenses) is large, which proves the existence of a strong multiple correlation.

The levels displayed by the sequential evaluations reveal the disorder that may occur in the relation between the use of fertilizers/pesticides and the allocation of expenses. All these are analysed using the variation levels and the amplitudes resulted from the calculi.

Conclusions

The analytic elements served to monitor the relations and the conditioning existing between the necessity of allocating funds for the prevention and fight of the pollution of soil and ground water caused by the use of fertilizers/pesticides in the whole country. The level of the indexes revealed the correlative rates and led to the following conclusions:

1- The growth rate of the agricultural production has a general trend, but one has to take into account the influences exerted by the increased use of fertilizers/pesticides upon the necessity of allocating expenses for protecting the soil and the ground water. The dynamic processes analysed revealed the existence of different growth rates. Thus, the quantitative use of fertilizers/pesticides has a growth of 4.24% while the investment expenses made for protecting the soil and the ground water have a growth of 0.25% and the current internal expenses go down to a level of -11.92%.

2- Concerning the quantitative evolution described using statistical indexes, one may see an ascending trend for the use of fertilizes, whereas the pesticides have a descending trend. The investment expenses are much higher than the current internal ones. The annual differences for the quantities of fertilizers/pesticides and for the expenses, using the average values of the analysed time interval, show standard deviations very different from the corresponding average values, which means that the growth rates are very different.

3- The variational influence of amplifying the use of fertilizers/pesticides (+5%x and +10%x) upon the investment expenses leads to a level of expenses that is higher than the initial expenses. The variations of the structures of the quantities of fertilizers/pesticides according to the presumptive sequential forms (+5% x and +10%

x) expressed by the results of the regression equation reveal an increase of the initial level of expenses for each type of fertilizer. The values of the correlation ratio reveal an influence exerted by the quantities of fertilizers/pesticides used and the investment expenses made for soil protection. Concerning the causal relation (according to the correlation ratio) one may notice the existence of a weak influence of the quantities of fertilizers/pesticides used upon the investment expenses made for soil protection. There are correlative variational directions of the values, but there are also incongruities in the cases of the potash fertilizers and herbicides.

4- The presumptive variations of the use of fertilizers/pesticides and of the allocation of internal expenses for preventing and fighting the pollution of soil and ground water have the same annual variational form, but at a level which is lower than the investment expenses. The adjusted values of the current internal expenses were identified within adequate sequential limits, according to the variational levels of +5% and +10% of each type of fertilizer/pesticide. The current internal expenses have an adjusted level rendered by positive values and present in most sequences, but also by negative values for the potash fertilizers, fungicides and herbicides. Concerning elasticity, the amplitudes are very large and a typological variety that includes the modification of the economic variable (current expenses made for soil protection) for the simultaneous or anterior use of fertilizers/pesticides — elasticity for nitrous and phosphatic fertilizers and for insecticides, but inelasticity for potash fertilizers, fungicides and herbicides).

The analysis of the levels of the determination index reveals the existence of a different intensity for the link between the use of fertilizers/pesticides and the allocation of expenses. For the investment expenses (as a resultant variable) the share of the influence of the factorial variables in the total variation of the resultant variable has a medium value (R^2=0.5829). For the current internal expenses, by the influence of the variables, this relation is significant (R^2 =0.951) and has a strong multiple correlation. The levels, variations and amplitudes resulted from the calculi express the correlative trends which reveal an intensity direction of the relation between the use of fertilizers/pesticides and the allocation of funds for soil protection.

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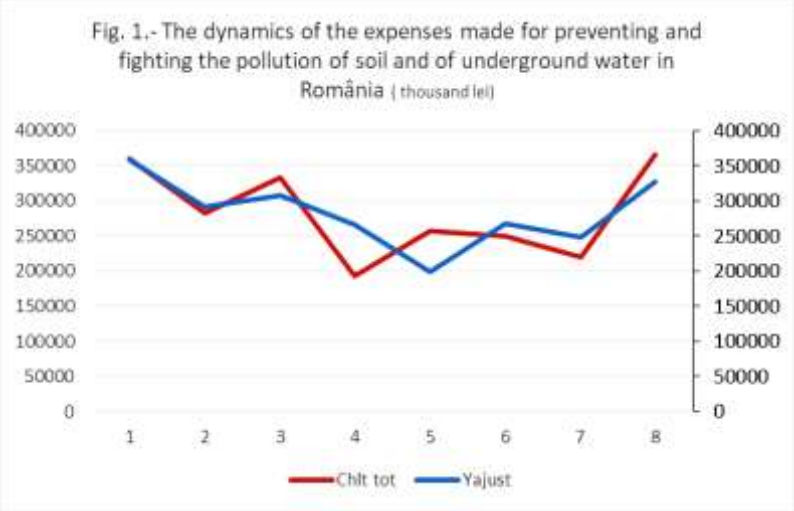

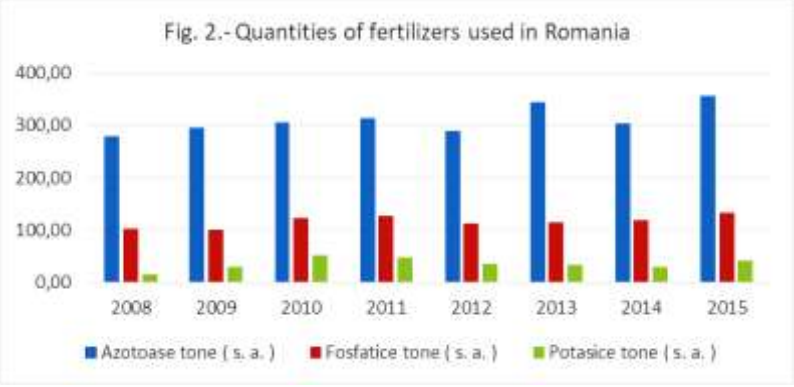

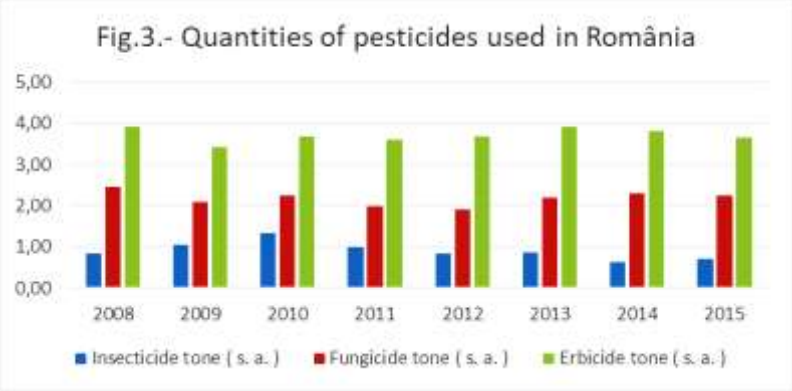
Fig.3.- Quantities of pesticides used in România
5,00
4,00
3,00
2,00
1,00
0,00
2008
2009
2010
2011
2012
2013
2014
2015
Insecticide tone (s. a.)
Fungicide tone (s. a.)
Erbicide tone (s. a.)