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THE INFLUENCE OF MINERAL FERTILIZATION ON YIELD IN MAIZE CROPS

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Abstract: *Our research focused on the influence of mineral fertilization on the yield and some quality indices in maize crops. Taking into consideration the variable conditions for nutrition determined by the irregular rainfall regime and the humidity deficit happening in recent years in the periods of maximum consumption, making the best of fertilizers has become a problem. In this context, we tested the influence of mineral fertilization on the nutrition of maize plants, on yield and its quality. The fertilization system was based on complex fertilizers and ammonium nitrate for obtaining the necessary quantity of nitrogen. Two thirds of the complex fertilizers were applied at sowing, and the rest of the complex and ammonium nitrate was administered in the vegetative stage of 3-4 leaves. Complex fertilizers were used in three variants NPK 0-50-100-150 kg a.s. ha^{-1} and nitrogen varied between 0 and 200 kg ha^{-1}. Over the experimental period, fertilizer bioavailability was strongly influenced by the rainfall regime, and by soil humidity. Use of fertilizers was different from one agricultural year (2010-2011) to the other (2011-2012), as a result of the unfavorable rainfall regime, in what the quantity and time distribution are concerned. Therefore, fertilization efficiency was strongly affected by soil humidity and nutrient bioavailability. Yield oscillated between 4207 kg ha $^{-1}$ and 8120 kg ha $^{-1}$ in the agricultural year 2010 - 2011 and between 2315 kg ha $^{-1}$ and 5710 kg ha^{-1} in the agricultural year 2011-2012. Due to moisture deficit, nitrogen had bigger influence on the formation of the maize yield in 2011 and a smaller influence in 2012. PK contribution was observed in the formation of the yield by increasing drought resistance in plants, as the oscillation level of the yield to nitrogen variation being lower on soils treated with PK than in soils with PK0.*

***Key words**: mineral fertilizers, fertilization, maize crop, yield, quality indices*

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important crops cultivated in very many countries around the world because of its various uses. Maize can be used as raw matter for industry as well as in animal food.

According to the structure of agricultural crops in Romania, HERA C. and KLEPS C., 2007, the area cultivated with maize covers approximately 32% of the total surface. Rational use of fertilizers in quantities and proportions suitable for each type of soil and each crop, and their application in optimal doses is recognized worldwide as the safest method for increasing agricultural yield and soil fertility, HERA C, 1996; HERA C., 2009.

For maize crops, yield is mostly determined by the application of nitrogen treatments, in close relation to the specific conditions of the year and to the vegetation state of the crop, GOIAN et al., 2004. Use of moderate quantities of nitrogen and phosphorus based fertilizers with enough soil humidity leads to high efficiency in maize, ensuring yield increase per land unit, ZAHARIA G. and COCIU A., 2009, as nitrogen is a vital element and determining factor in maize yield, ADEDIRAN and BANJOKO, 1995; SHANTI et al., 1997.

The water content of soil (soil humidity) influences the mineralization, the availability, nitrogen intake and ulterior growth of maize. The variation of climatic factors, temperature and rainfall are synchronized with releasing nutritive elements in the soil and their assimilation by plants, VANLAUWE et al., 2002, MYERS et al., 1994.

Studies on increasing maize yield in different experimenting conditions, JONES and WENDT, 1994, SMALING et al., 1992; PANDEY et al., 2000; FARRE and FACI, 2009, revealed that maize requires a lot of water and nutrients in the blossoming stage; less water leads to yield decrease, through a decrease in the number of ears and in cob weight. Drought is the second factor, after poor soil fertility, which decreases maize yield, EDMEADES et al., 1992, 1999, PANDEY et al., 2000, MOSER et al., 2006, obtaining data which showed that, with drought, the yields were smaller than the fertilizer-free variants.

Given the weight of maize crops in the crop structure in our country, given the general issues regarding fertilizer use, given the nutritive imbalance signaled by some researchers and given the climatic changes, we researched the influence of mineral fertilization on some elements of productivity, yield and some quality indices for maize crops.

MATERIAL AND METHOD

Our research evaluated the influence of fertilization on some elements of productivity in maize crops, on maize yield and its quality.

Nutriments were supplied through complex mineral fertilizer of the type NPK (S) + Zn together with ammonium nitrate (35:0:0).

The research was performed at Timisoara Didactic station, on slightly gleyed cambic chernozem of medium fertility.

The climate conditions in the experimenting period (2010 - 2012) were generally characterized by pronounced rainfall deficit from August to November 2011 and from June to September 2012. This reduced the use of fertilizers by plants and affected yield especially in 2012.

The hybrid cultivated was *DKC 5143*, high-productivity hybrid, recommended for cultivation in the west of Romania.

The experience was organized in randomized blocks, the surface if each experimental unit being 30 m^2. The fertilization was performed manually, by uniform application of fertilizers on the experimental plots. We complied with the crop technology, performing quality maintenance works at the right time.

The yield was harvested manually, and all determinations and biometric measurements were made in the laboratory.

Quality indices, protein, starch and fats were determined with the help of a grain analyzer, Omega Analyzer, by non-destructive method FT-NIR (Fourier transform near infrared), a fast and effective method.

The experimental data were processed statistically by variance analysis, correlations, regressions, multivariate analysis.

RESULTS AND DISCUSSIONS

Managing plant nutrition and the extent to which nutrients are used by maize crops is a process strongly influenced by climate factors, soil and rainfall regime respectively. During the experiment period 2010 - 2012, we recorded wide variations in the rainfall regime, with strong deficit in June to September 2012, which triggered different use of fertilizers by plants. This fact is reflected in the yield and in the productivity indices analyzed.

Table 1 presents the results of our research on the yield of grain maize crops from 2010 to 2012.

The analysis of the yield data and the increases related to fertilization reveals that plants made different use of fertilizers during the experimental period.

We made a comparative analysis of results against natural soil fertility expressed in the control variant and considered to be an absolute control M0. We also analyzed the results compared to a level of fertilization that is widely used in practice, for economic reasons, within variant V1, which is considered control M1.

Table 1.

Yield data for maize crop and the significance of the differences

Period and Yield / Experimental variant	2011			2012		
	Yield 2011	General differences from M0	Differences from control M1	Yield 2012	General differences from control M0	Differences from control M1
$PK0N0_{M0}$	4207±80.07	0	-2003°°°	2315±174.95	0	-1250°°°
$PK0N100_{M1}$	6210±189.09	2003^{***}	0	3565±146.99	1250^{***}	0
PK0N200	7540±177.85	3333^{***}	1330^{***}	5320±269.92	3005^{***}	1755^{***}
PK50N50	5225±246.18	1018^{**}	-985°°	3715±185.83	1400^{***}	150
PK50N100	7080±232.59	2873^{***}	870^{**}	4380±173.37	2065^{***}	815^{*}
PK50N200	8120±105.98	3913^{***}	1910^{***}	5470±295.90	3155^{***}	1905^{***}
PK100N100	5835±190.94	1628^{***}	-375	4510±264.87	2195^{***}	945^{**}
PK100N150	6910±225.02	2703^{***}	700^{*}	4965±173.85	2650^{***}	1400^{***}
PK100N200	7935±159.71	3728^{***}	1725^{***}	5580±252.50	3265^{***}	2015^{***}
PK150N150	6805±225.88	2598^{***}	595^{*}	4835±190.67	2520^{***}	1270^{***}
PK150N200	7680±163.27	3473^{***}	1470^{***}	5710±180.57	3395^{***}	2145^{***}

2011: DL 5%= 583.32; DL 1%= 792.65; DL 0.1%= 1074.54
2012: DL 5%= 659.19; DL 1%= 895.75; DL 0.1%= 1214.30

In the agricultural year 2010 – 2011, with more uniform rainfall regime, especially in the vegetative period of maize (April - September), we found better use of the fertilizers applied. The yield values ranged from 4207.00±80.07 kg ha^{-1} in the variant reflecting natural soil fertility, to 6210.00±189.09 – 8120.00±105.98 kg ha^{-1} in the fertilized variants. Yield increase is within 1018.00 – 3913.00 kg ha^{-1} if the reference is the natural soil fertility (M0), with statistical assurance of the differences, and with very distinctively significant significance degree. After comparative analysis of the results with medium fertilization variant (M1), the differences are from 595.00 to 1910.00 kg ha^{-1}, with different significance degrees and statistical assurance of the results, figure 1.

Agricultural year 2011 – 2012 was different in what rainfall regime is concerned, as it was characterized by a strong rainfall deficit from June to September, with relatively low air humidity. These climate aspects, which overlapped the period of flowering and fertilization, caused a drop in the yield, mainly through poor pollination and fertilization and a decrease in the number of ears on a cob.

Yield oscillated from 2315±174.95 kg ha^{-1} for the control variant that represents the natural sol fertility, and 3565±146.99 - 5580±252.50 kg ha^{-1} for fertilized variant. This year's yield increase for this year was between 1250 kg ha^{-1} and 3395 kg ha^{-1} if we compare the results with those of the variant representing the natural soil fertility (M0); all values are assured statistically. For the case when we considered control M1 as reference, which reflects a medium fertilization variant, the differences, as yield increase, were between 150.00 – 2145.00 kg ha^{-1}, with statistical assurance for most situations, figure 2.

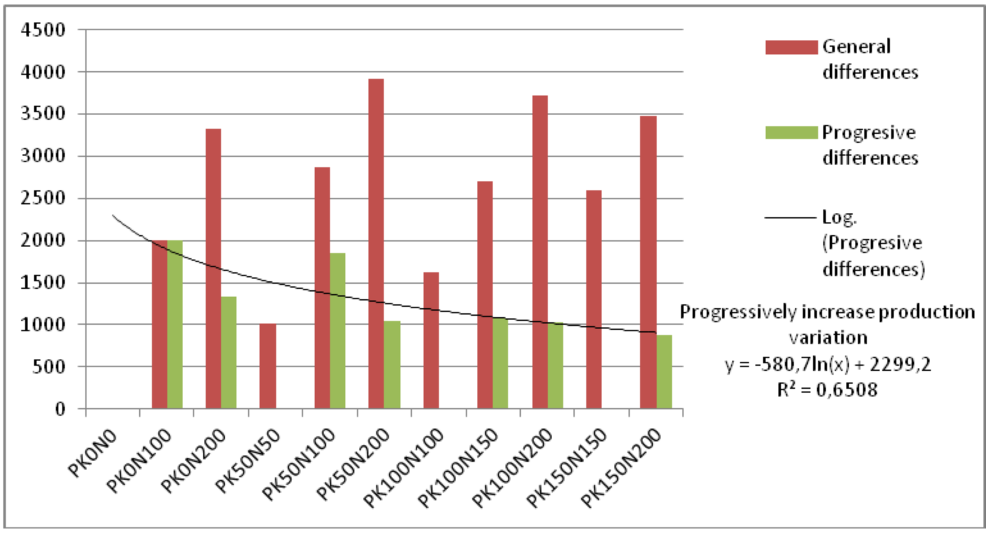

Figure 1. Yield increase and progressive yield increase for 2011 year

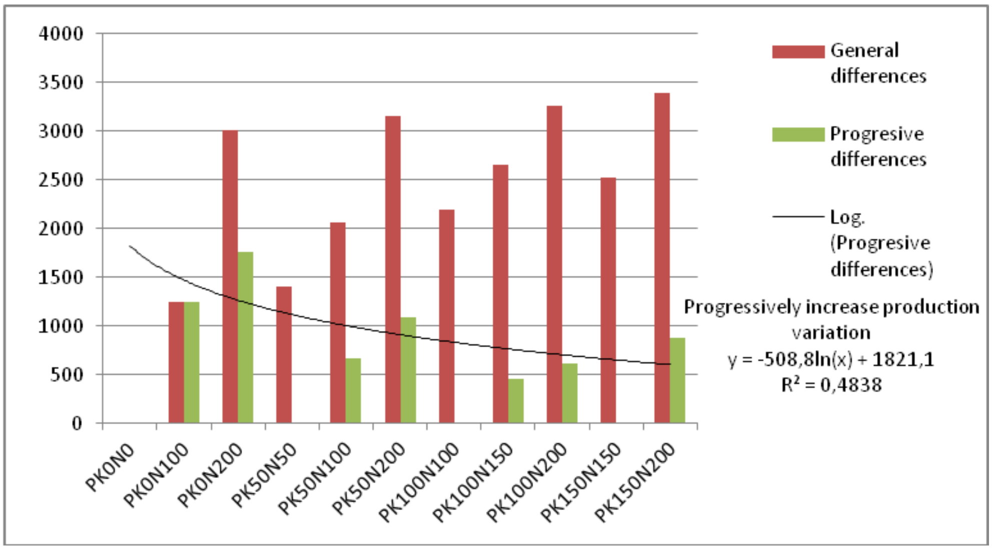

Figure 2. Yield increase and progressive yield increase for 2012 year

In the comparative analysis for the two experimental years, we noted bigger contribution of phosphorus and potassium for the yield in 2012, with rainfall deficit. The yield differences from the two variants considered to be controls are more reliable, the amplitude variation is smaller and they have a higher degree of statistical assurance.

Analysis of productivity elements and of some quality indices also revealed the influence of experimental variants in the quantitative and qualitative crop formation, as presented in Table 2.

The influence of fertilizers on productivity indices was different depending on the nature of the index, their variation having different limits, Figure 3.

Table 2

Mean values of productivity indices

	Ear weight*	Cob weight*	Grain weight*	Average productivity / cob*	Protein (%)	Fats (%)	Starch (%)
PK0N0	1461.1	166.3	1294.8	88.62	7.8	4.0	71.4
PK0N100	1956.1	229.7	1726.4	88.26	9.4	4.3	71.3
PK0N200	1997.6	232.5	1765.1	88.36	9.7	4.4	71.0
PK50N50	1625.2	204.4	1420.8	87.42	8.6	4.1	72.5
PK50N100	2003.2	235.2	1768.0	88.26	9.5	4.3	71.8
PK50N200	1713.7	218.7	1495.0	87.24	9.7	4.2	71.3
PK100N100	1978.6	240.1	1738.5	87.87	9.4	4.2	71.9
PK100N150	1790.1	220.9	1569.2	87.66	9.9	4.2	71.5
PK100N200	1940.3	234.2	1706.1	87.93	10.5	4.1	70.4
PK150N150	1691.9	212.2	1479.7	87.46	9.8	4.2	71.4
PK150N200	1739.8	221.7	1518.1	87.26	10.6	4.1	70.5

*mean values for 10 cobs

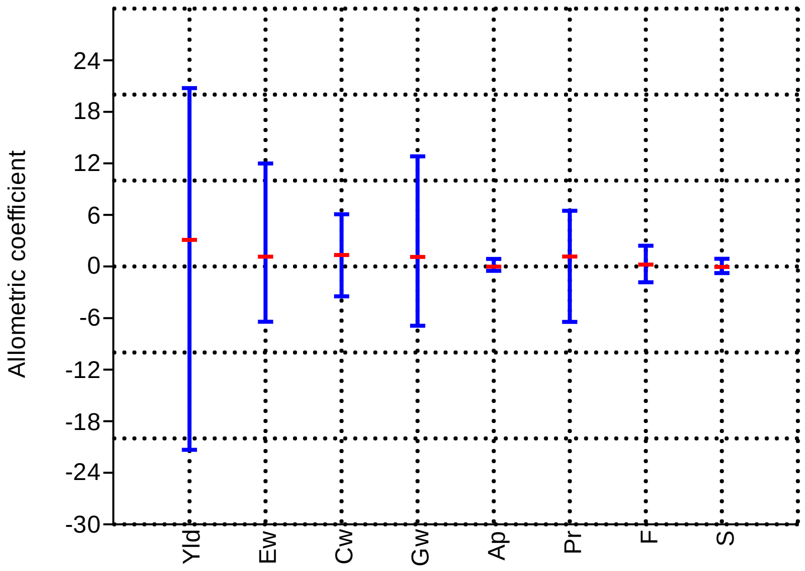

Figure 3. Multivariate allometry, 95% confidence;
(Yld – Yield, Ew - Ear weight, Cw - Cob weight, Gw - Grain weight, Ap - Average productivity / cob, Pr – Protein, F – Fats, S - Starch)

In general, it was for the yield that we recorded the widest range of variation. Ear weight and grain weight had average values. Lower values were recorded for cob weight, protein content and fat content. Limited variation appeared for average productivity and starch content. Overall, for the indices we analyzed, the percentage of variation in PC1 was 81.76%.

Comparative analysis regarding the correlations between the productivity elements under study and the yield or some quality elements reveals different use of fertilizers under water and temperature stress, Table 3.

Table 3

Table of correlations between productivity indices under study

	Ear weight	*Cob weight*	*Grain weight*	*Average productivity / ear*	*Protein (%)*	*Fats (%)*	*Starch (%)*
Ear weight	1						
Cob weight	**0.926**	1					
Grain weight	**0.999**	**0.907**	1				
Average productivity/ ear	0.243	-0.141	0.289	1			
Protein (%)	0.532	0.727	0.501	-0.463	1		
Fats (%)	0.751	0.666	0.754	0.228	0.282	1	
Starch (%)	-0.177	-0.182	-0.174	-0.017	-0.646	0.039	1

Very significantly positive correlations were recorded between ear weight and grain weight (r = 0.999), ear weight and cob weight (r = 0.926), cob weight and grain weight (r = 0.907).

The correlation of yield with the productivity elements under analysis presents lower degree of significance, as a result of the fact that in 2012 the fertilization percentage was negatively affected by climate conditions (drought and low relative air humidity).

Multivariate analyses regarding the association of variants based on similarity gave an orientation and grouping of variants in two distinct groups (one with two subgroups) together with the control, fertilizer-free variant, as shown in Figure 4. As for the fertilized variants, we notice their grouping especially based on the doses of nitrogen applied on various PK variants.

The value of the cophenetic coefficient is 0.855, which indicates that the graphical representation of variant grouping has a high degree of confidence.

CONCLUSIONS

Yield, productivity elements and quality indices for maize crops had specific variation under the influence of mineral fertilization. The climatic conditions, especially rainfall regime together with air humidity and temperature influenced the plants, diminishing the manifestation level of the parameters we analyzed.

Yield increase was analyzed by comparison to a given control variant, to natural soil fertility and to medium fertilization. In a year with normal rainfall regime, with a generally even distribution, the contribution of nitrogen-based fertilizers is higher than in the years with rainfall deficit. In such years with yield deficit, potassium and phosphorus play a more important role in assuring yield stability.

The elements of productivity did not have high correlation with the yield, because of lack of uniformity of the ears due to deficit pollination.

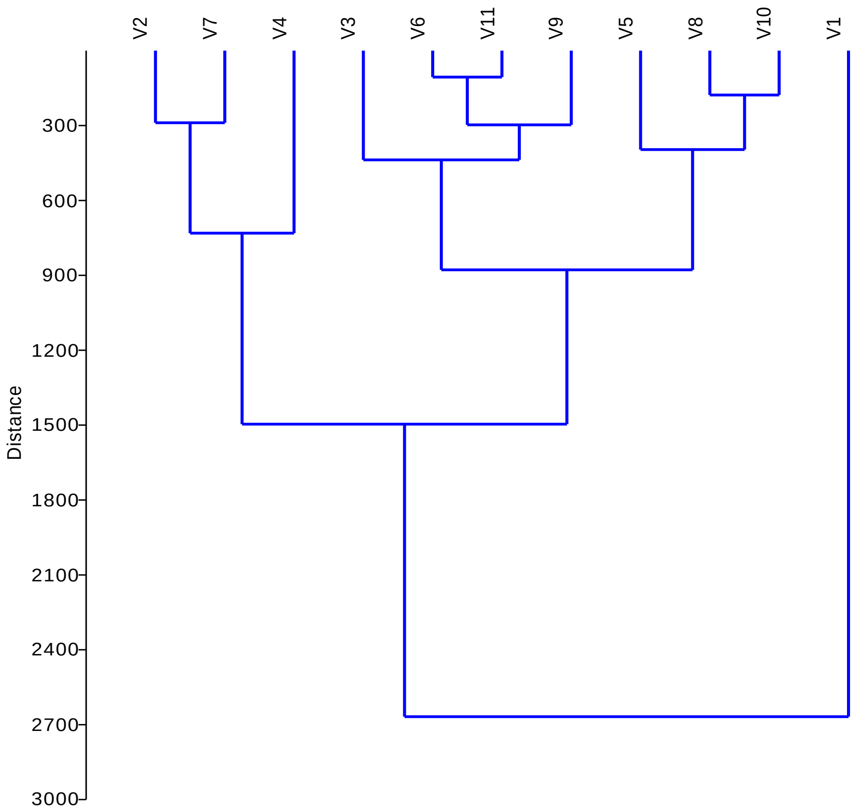

Figure 4. Euclidean distribution of variants.

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REFERENCES

1.M. KALEEM ABBASI, MAJID MAHMOOD TAHIR, NASIR RAHIM, 2012, Effect of N fertilizer source and timing on yield and N use efficiency of rainfed maize (*Zea mays* L.) in Kashmir–Pakistan, , Geoderma., http://dx.doi.org/10.1016/j.geoderma.2012.11.013.

2.ADEDIRAN JA, BANJOKO VA (1995). Response of maize to N, P, and K fertilizers in the savanna zone of Nigeria. Commun. Soil Sci. Plant Anal. 26: 593-606.

3.EDMEADES G.O, BALANOS J., HEMANDEZ M., CHAPMAN S.C., LAFITTE H.R., BANZINGER M., 1999, Selection improves tolerance to mild/late season drougth in tropical maize population, Crop Sci., 39:1306-1315.

4.FARRE I., FACI J.M., 2009, Deficit irrigation in maize for reducing agricultural water use in Mediteranean environment, Agric..water Management, 96:383-394.

5.GOIAN M., MANEA, D., LĂZUREANU A., CÂRCIU, Gh., ALDA S., 2004 – Fertilizarea raţională a culturilor de grâu de toamnă, porumb şi soia în zona Banatului. Edit. Mirton, Timişoara: 13-20,

6.HERA, CR., 1996 – *The role of inorganic fertilizers and their management practices.* Fertilizers and Environment. C. Radriquez – Burrneco (ed.), Kluwer Academy Publishers.

7.HERA C.,Solul-temelia dezvoltării durabile a agriculturii şi economiei nationale, 2009, www.enciclopedia-economică.ro.

8.HERA C., KLEPS C., 2007,Main issue environment protection in Romania agrosystems in context of global climatic protection changes, Environment protection in agrosystems, Agraria Nauka, Kiev, 69-83.

9.JONES R.B., WENDT J.W., 1994, Contribution of soil fertility research to improved maize production by smallholders in Eastern and South Africa Regional Maize Conference, 2-14.

10.KOGBE J. O. S. and ADEDIRAN J. A.*,2003, Influence of nitrogen, phosphorus and potassium application on the yield of maize in the savanna zone of Nigeria.

11.MOSER S.B., TEIL B., JAMPATONG, STAMP P., 2006, Effect of pre-anthesis drought, nitrogen fertilizer rate and variety on grain yield, yield components and harvest index of tropical maize, Agric.water Manag, 81:41-58.

12.MYERS, R.J.K., PALM, C.A., CUEVAS, E., GUNATILLEKE, I.U. N. and BROSSARD, M. (1994) The synchronization of nutrient mineralization and plant nutrient demand. In: Woo- mer P.L. and Swift, M.J. Eds., *The Biological Management of Soil Fertility*, John Wiley and Sons, Chichester.

13.PANDEY R.k., MARANVILLE J.W., ADMON A., 2000, deficit irrigation and nitrogen effects on maize in Sahelian environment: Grain yield and yield components Agric. Water Manage, 46: 1-13.

14.SHANTI KVP, RAO MR, REDDY MS, SARMA RS (1997). Response of maize (Zea mays) hybrid and composite to different levels of nitrogen. Indian J. Agric. Sci. 67: 424-425.

15.SMALINGE.M..A, NANDA S.M., PRESTELE H., ROETTER r, MUCHENA F.N., 1992, Yield response of maize to fertilizers and manure under different agroecological condition in Kenya, Agriculture, Ecosystems and Environment, 41:241-252.

16.VANLAUWE, B., DIELS, J., AIHOU, K., IWUAFOR, E.N., LYASSE, O., SANGINGA, N. and MERCKX, R. (2002) Direct interactions between N fertilizer and organic matter: Evidence from trials with 15N-labeled fertilizer. In: Vanlauwe, B., Diels, J., Sanginga, N. and Merckx, R. Eds., *Integrated Plant Nutrient Management in Sub-Saharan Africa*: *From Concepts to Practice*, CAB International, Wallingford.

17.ZAHARIA G., COCIU A., 2009, Influenţa fertilizării organo-minerale de lungă durată asupra producţiilor de porumb obţinute în condiţiile de irigare, AN. I.N.C.D.A. FUNDULEA, VOL. LXXVII, Agrotehnica culturilor.