INFLUENCE OF FERTILIZER APPLICATION AND CROP ROTATION ON IRRIGATED WHEAT AND MAIZE

CORNELIU NEDELCIUC[1)], MARIANA NEDELCIUC[1)], GHEORGHE IAGĂRU[1)] AND NICOLAE GROZA[1)]

ABSTRACT

The authors develop an analysis, based on several criteria,regarding the results obtained by cultivating wheat and maize in different crop rotations, by using various fertilization formulae. A method was introduced in order to establish a hierarchy of experimental variants according to criteria in which agrochemical (pH, P mobile) as well as physical indicators (apparent density and resistance to penetration) of irrigated chernozem in the Caracal Plain are prevailing, as compared to indicators referring to yield and energy quantity obtained in seven years of experimentation. This method reveals another classification of these variants. Thus, the fact is pointed out that both continuous cropping of wheat as well as wheat-maize crop rotation contribute to preserving soil productive capacity, by diminishing export of nutritive elements and reducing soil tillage that can be carried out in optimum moments. On the other hand, maize crop, under irrigation, with hybrids of high productivity requires large quantities of fertilizers and adequate soil treatments if a high state of native fertility of the soil is to be maintained.

Key words: fertilizer application, crop rotation, wheat, maize.

INTRODUCTION

Researches aimed at classifying variants according to several criteria considered simultaneously are of relatively recent date (Schimek, 1992).

In our country they were explained as being possible by Baghinschi (1979) and tested by Sin et al. (1979), Nica et al. (1983) and Nedelciuc et al. (1996). In other countries such studies were also approached in a rather restricted form (Gantzer and Blacke, 1978; Le Floch, 1986; Gachon, 1988; Cabelguenne et al., 1988; Fardeau, 1983).

The method has the advantage that it offers the possibility of classifying some variants according to several indicators (variables). After having established this classification, its causes can also be identified which sometimes may lead to revealing some new aspects in studying the respective variants.

MATERIALS AND METHODS

The paper presents certain results obtained in a trial with several agricultural crops included in different rotations and with a different fertilization for each crop, under irrigation conditions.

The experiment was carried out on typical clayey-illuvial chernozem on the third terrace of the Olt river in the Caracal Plain, starting by the autumn of 1986 and having a long term character.

The results regarding yield and total energy quantity are presented in a cumulative way fort the period 1987-1993, and laboratory determinations were developed after harvesting the respective crops in the autumn of the year 1983.

From among the crops experimented wheat and maize have a great share in the crop structure of the zone of influence, around the Agricultural Research Station Caracal.

The fertilization variants were the following: No, N minimum (N60 – wheat, N80 – maize), N optimum (N120 – wheat, N 180 maize), N maximum (N180 – wheat, N 250 – maize), N complex, (N 120 + 10 t manure /ha/year – wheat, N 180 + 10 t manure /ha/year – maize).

Rates of nitrogen fertilizers were annually applied on a basal dressing of 80 kg P_2O_5/ha/year.

The cropping systems in which wheat and maize were included were the following: continuous cultivation, two-years crop roration (wheat-maize), three-years crop rotation (wheat maize-soybean) and four years crop rotation (wheat-sugar beet-maize-sunflower).

The multi-criteria analysis (Schimek, 1992) permits the establishment of a hierarchy of variants considered in the study by means of the following methods: simple additive balance, TOPSIS, Onicescu and diameter procedure. This programme permits the studying of

[1)] Agricultural Research Station, 0810 Caracal, Olt County, Romania

30 variants whereby 35 criteria can be simultaneously considered.

The fact has to be mentioned that by its way of being processed, the programme grants an equal weight to all criteria, which requires that users carefully select them. Furthermore, differentiation between variants must not be necessarily significant according to statistical assessment of the results by means of other methods.

Due to this reason the conclusions that can be drawn from such a way of data processing cannot constitute at the same time recommendations for agricultural practice, except only to the extent to which criteria selection was done with a well determined aim in view.

At the same time, results achieved by such a method can be a starting point in initiating research meant to go deeper into studying the causes determining the hierarchy of variants according to a certain category of criteria.

In the present study, two types of classifications of the respective variants have been made:

A. According to six criteria: - total yield (q) of cereal units (c.u.);
- total energy quantity (MkWh);
- P mobile quantity (AL) in the soil (0-20 cm);
- pH value (water) in the soil (1:2.5);
- apparent density (g/cm^3) of the soil;
- penetration resistance (kgf/cm^2) of the soil.

B. According to four criteria: agrochemical and physical soil indices.

As there can be observed in the first case, criteria that refer to variety are more numerous than those which refer to yield, while in the second case only indicators referring to soil have been selected.

The programme demanded that the hierarchy of variants should be established by taking into account maximization of the first three indicators, a higher pH value and more reduced values regarding apparent density and penetration resistance.

In this way information could be obtained regarding indications of high yields, the keeping of productive capacity of the soil and eventually indications regarding the necessary correction steps, by considering the equal importance of vegetation factors.

RESULTS AND DISCUSSIONS

The experimental data concerning the cummulative multi-criteria analysis are presented in table 1.

A. Interpretation according to the six criteria

Unfertilized variant. The results obtained prove the following order of classification: 1. maize in two-years crop rotation; 2. maize in three-year crop rotation; 3. maize in continuous cultivation; 4. wheat in continuous cultivation; 5. wheat in two-years crop rotation; 6. Wheat in four-years crop rotation; 7. wheat in three-years crop rotation; 8. maize in four years crop rotation.

Even if the total yield and the energetic value were not at the highest level, the ranking of maize on the first place in a two-years crop rotation is due to the fact that the most convenient values have been covered for the other four criteria.

The second place was held by maize in a three-years crop rotation due to a decrease of the quantity of P mobile in the soil, determined by the export through a higher yield, the low pH value, the apparent density increase and resistance to penetration.

The third place was held by continuous cultivation of maize, due to the reduction of total c.u. yield as well as of energetic value, but by increasing the quantity of P mobile in the soil as a consequence of a more reduced export by harvesting.

Places 4, 5 and 7 were held by wheat crop in the following order: continuous cultivation, two-years and three-years crop rotation. This delimitation was determined by the level at which P mobile in the soil was assimilated with the yield, by soil density and more especially by its resistance to penetration.

On the last place ranked maize in a four-years crop rotation, although the yield achieved and the energetic value was high, which nevertheless determined a consumption of P mobile in the soil. At the same time the pH value in the soil decreased, while apparent density and resistance to penetration increased.

Table 1. Cumulated multicriteria analysis in wheat and maize (1987 – 1993)

Crop	Total yield u.c. (q)	Energetic value (MkWh)	P mobile soil ppm	pH water	Apparent density (g/cm_3)	Penetration resistance (kgf/cm_2)	Ranking	
							A	B
Unfertilized								
C. W	197.4	153.3	90.1	6.03	1.33	33.8	4	1
C. M	423.5	431.2	85.0	6.01	1.36	43.3	3	6
W. R 2	193.2	149.8	89.5	6.08	1.34	36.7	5	2
M. R 2	420.0	427.7	89.0	6.20	1.35	40.8	1	4
W. R.3	251.3	181.3	76.3	6.15	1.34	40.8	7	5
M. R 3	469.0	465.5	73.8	5.90	1.36	43.9	2	7
W. R.4	235.9	177.1	87.9	6.12	1.34	40.8	6	3
M. R.4	427.0	429.1	72.9	5.98	1.37	44.3	8	8
N minimum								
C. W	296.1	205.8	75.4	5.86	1.33	33.2	2	1
C. M	586.2	569.1	69.2	5.75	1.35	43.0	5	6
W. R 2	308.7	214.9	80.2	5.83	1.34	35.1	1	2
M. R 2	616.7	598.5	74.8	5.69	1.38	42.4	3	5
W. R.3	353.5	235.2	79.5	5.85	1.35	42.4	4	3
M. R 3	641.9	623.0	62.8	5.57	1.37	44.3	6	8
W. R.4	331.1	228.9	75.3	5.66	1.35	42.1	7	4
M. R.4	609.0	591.5	64.7	5.55	1.37	44.3	8	7
N optimum								
C. W	347.9	234.5	76.3	5.56	1.32	34.5	1	1
C. M	688.8	668.5	67.5	5.52	1.35	43.4	6	6
W. R 2	366.8	241.5	73.5	5.51	1.34	39.8	4	2
M. R 2	707.7	686.7	70.7	5.40	1.37	42.1	5	5
W. R.3	415.1	276.5	72.8	5.66	1.34	41.1	2	3
M. R 3	740.6	703.5	62.9	5.62	1.38	44.3	7	8
W. R.4	382.9	260.4	76.1	5.56	1.35	42.3	3	4
M. R.4	720.3	697.2	68.0	5.50	1.37	44.0	8	7
N maximum								
C. W	378.0	253.4	83.3	5.47	1.32	31.6	1	1
C. M	733.6	680.9	77.7	5.39	1.34	40.8	5	5
W. R 2	394.8	263.2	78.9	5.39	1.33	37.0	7	2
M. R 2	800.8	738.5	75.5	5.30	1.33	39.9	4	6
W. R.3	426.3	285.6	78.2	5.44	1.33	39.2	2	3
M. R 3	800.8	738.5	76.9	5.40	1.36	43.0	3	7
W. R.4	409.5	274.9	79.1	5.46	1.36	40.2	6	4
M. R.4	781.2	718.1	71.3	5.40	1.39	43.0	8	8
N optimum + 10 manure t/ha/year of								
C. W	365.4	245.0	85.1	5.90	1.32	31.0	2	1
C. M	711.2	688.1	83.5	5.73	1.36	41.1	5	5
W. R 2	388.5	259.0	87.0	5.82	1.33	34.7	1	2
M. R 2	725.9	702.1	86.3	5.68	1.38	39.5	3	6
W. R.3	416.5	275.8	83.1	5.80	1.33	35.1	6	3
M. R 3	756.7	732.2	80.6	5.73	1.36	42.4	4	8
W. R.4	394.1	264.6	80.8	5.92	1.34	38.6	7	4
M. R.4	738.5	702.8	77.9	5.73	1.39	42.1	8	7

C.W – continuous cultivation wheat; C.M - continuous cultivation maize; W.R 2 – wheat two-years crop rotation; M.R 2 - maize two-years crop rotation; W.R. 3 - wheat three-years crop rotation; M.R 3 - maize three-years crop rotation; W.R. 4 - wheat four-years crop rotation; M. R. 4 – maize four years-crop rotation.

These data reflect the reduced possibilities of wheat crop of rendering high yields in the absence of mineral fertilization.

Variant of N minimum fertilization

The classification order was the following: 1. wheat in two-years crop rotation; 2. wheat in continuous cultivation; 3. maize in two-years crop rotation; 4. wheat in three-years crop rotations; 5. maize in continuous cultivation; 6. maize in three-years crop rotation; 7. wheat in four-years crop rotation; 8. maize in four-years crop rotation.

Therefore, even a minimum fertilization is sufficient in order to rank wheat ahead of maize.

As there can be seen from this classification, the first four places are held by three of the wheat crop rotations and this is due to a reduced export of P mobile in the soil, by more reduced yields than those of maize as well as by the decreased value of the two physical soil indices, as a result of the possibility of soil treatment under better conditions.

Another observation is the fact that maize cultivated in simple rotation with wheat ranks ahead of wheat in three-years crop rotation. This is explained by the fact that physical indicators show values close to each other because of the presence of wheat in crop rotation with maize once in two years. On the other hand, total yield of c.u. and energy is much higher in maize (75%, respectively 154%). The order cannot be changed by the two agrochemical indicators where the values are indeed to the advantage of wheat, but with more reduced differences (7% in P mobile and 3% pH).

The classification order of the other variants in maize show a superior place for continuous cultivation as compared to three-years crop rotation, which has a higher consumption of P mobile in the soil by the harvest achieved, a reduced pH value and physical indicators of a higher value. Therefore, maize in three-years crop rotation which includes also soybean, requires a better phosphate treatment of the soil as compared to continuous cultivation.

Wheat cultivated in four-years crop rotation ranks on the penultimate place because of the yield and the lower energetic value as a result of being cultivated after sunflower, which is a great consumer of nutritive elements and the rate of N minimum proves to be insufficient. Furthermore the P mobile quantity in the soil is more reduced because of the same reason.

Maize in four-years crop rotation ranked on the last place due to the great export of phosphorus in the soil because of the high yield, as well as the high values of apparent density and of penetration resistance. This is due to its cultivation after sugar beet, after which soil treatment is not done under optimum conditions.

Variant of N optimum fertilization

In this variant, classification is as follows:1. wheat in continuous cultivation; 2. wheat in three-years crop rotation; 3. wheat in two-years crop rotation; 4. wheat in four-years crop rotation; 5. maize in two-years crop rotation; 6. maize in continuous cultivation; 7. maize in three-years crop rotation; 8. maize in four-years crop rotation.

There may be observed that on the first four places there are the variants cultivated with wheat, which means that in such rates of nitrogen fertilizers, maize has an emphasized phosphorus export by its much higher yields. Furthermore, the physical state of the soil is much better due to the fact that in this case it gives rise to a fascicular root system in wheat which improves the physical characteristics of the soil.

Clasification on the first place of wheat in continuous cultivation is due to the decrease of the energetic value by reducing the yield which also determined a lower export of phosphorus in the soil and an increase of the pH value. The physical soil indices determined are improved due to continuity in forming a well developed fascicular root system in the arable horizon.

Wheat in three-years crop rotation held the second place, ahead of the variant of four-years crop rotation because of a superior yield and energetic value, as a result of its cultivation after soybean. Furthermore, the two indices of the physical state of the soil are better.

The fact has to be observed that in this fertilization variant, wheat in four-years crop rotation holds a higher place than the one having an N minimum rate which shows that the best response to fertilization is N_{120} rate.

Maize crop has ranked after wheat due to its great export of phosphorus in the soil because of its high yields, a lower pH value and an increase of apparent density and penetration resistance. There results that in this rate of nitrogen fertilization greater attention has to be payed to phosphatic fertilization and soil tillage.

In maize for grain, the classification order is as follows: two-years rotation, continuous cultivation, three-years rotation and four-years rotation.

In fact a delimitation between two-years crop rotation and continuous cultivation is not peremptory because there is no clear differentiation between the six criteria considered. This means that the rate of nitrogen fertilizer considered to be optimum is applied to the same extent in both systems of maize cultivation.

On the other hand, as a result of the high yields of maize in three-years crop rotation, an increased phosphorus consumption in the soil may be observed, which associated with a bad physical state of the soil, determined this variant to rank on the third place in the hierarchy of variants with maize.

Classification on the last place of maize in four-years crop rotation was first of all determined by a lower c.u. yield. Nevertheless, in the case of separating these two maize cultivation variants no obvious differentiation has been recorded.

Variant of N maximum fertilization

In this case, the classification order was the following: 1. wheat in continuous cultivation; 2. wheat in three-years crop rotation; 3. maize in three-years crop rotation; 4. maize in two-years crop rotation; 5. maize in continuous cultivation; 6. wheat in four-years crop rotation; 7. wheat in two-years crop rotation; 8. maize in four-years crop rotation.

Under fertilization conditions of N_{180} the two cultivation variants with wheat held the two first places due to the great quantities of P mobile in the soil, which may appear also as a result of the fact that plant, especially under continuous cultivation, does not use large quantities of nitrogen fertilizers. Because of the lower pH value in the soil, a certain quantity of the tri and bivalent forms of phosphate ions may pass into monovalent forms, which in this way increase the P mobile quantity in the soil.

Furthermore in both cases a strong development of the fascicular root system determines an improvement of the two physical soil indices.

The following places are held by variants with maize. As these have a clearly superior yield and a higher energetic value as compared to the other variants with wheat, the fact is proven that such rates are better utilized by maize, especially under irrigation conditions.

Delimitation between variants in which maize was cultivated in three-years and two-years crop rotation is in this case two less evident. Nevertheless, the superiority of these variants as compared to continuous cultivation of maize is much stronger because of their productive capacity and energetic value.

In this fertilization formula, maize cultivated in four-years crop rotation ranked again on the last place, because of the lower values of agrochemical and physical indicators of the soil, as a result of its cultivation after sugar beet which due to its late harvesting, does not permit soil tillage in optimum moments.

Fertilization variant with N optimum + 10 t manure /ha/year

The classification of results is the following: 1. wheat in two-years crop rotation; 2. wheat in continuous cultivation; 3. maize in two-years crop rotation; 4. maize in three-years crop rotation; 5. maize in continuous cultivation; 6. wheat in three-years crop rotation; 7. wheat in four-years crop rotation; 8. maize in four-years crop rotation.

By adding 10 t manure /ha/year to the optimum rate for these crops, attention is drawn upon the fact that for wheat cropping this formula maintains on the first places only the variants cultivated in two-years crop rotation and in continuous cultivation, while the application of only N_{120} rate determined the ranking of all variants cultivated with wheat on the first places. This may mean that manure utilization is performed better by the predecessor in the case of three-years and four-years crop rotation. In fact, the same as in the case of a less evident differentiation in maize variants from the other fertilization formulae, we may deduce that this observation is valid in this case also for wheat in the variants ranking on the first two places. This differentiation is more evident in variants cultivated with wheat in three-years crop rotation, where yield, energetic value and penetration resistance are much better in the first case. We may consider that the decrease of P mobile in the soil in the variant cultivated in four-years crop rotation is due to the predecessor, namely sunflower, which is known for its capacity of extracting large quantities of nutritive elements from the soil.

The ranking of maize cultivated in two-years, three-years crop rotation and in continaous cultivation ahead of similar variants but cultivated with wheat, the same as in the previous case, may demonstrate that manure, although applied in small quantities, is better used by maize.

We may say that in maize too the difference between variants of cultivation in two-years and three-years crop rotation is not peremptory, but its superiority towards continuous cultivation is due to the great difference in yield and energetic value.

On the other hand, classification on the last place of maize in four-years crop rotation is due not only to the two higher values for the physical soil indicators, but also to a possible decrease of P mobile in the soil, due to the predecessor – sugar beet – which is more pretentious in phosphatic fertilization. The phenomenon may come up under conditions of stimulating microbiological activity in the soil after manure application, so that sugar beet may consume more phosphorus.

At the same time there has to be considered that in order to improve the physical state of the soil on which experiments were made, the quantity of 10 t manure /ha is nevertheless small, even if it is applied annually.

B. Interpretation according to the four criteria

Unfertilized variant

Classification of the two crops was made according to the following order: 1: wheat in continuous cultivation; 2. wheat in two-years crop rotation; 3. wheat in four-years crop rotation; 4. maize in two-years crop rotation; 5. wheat in three-years crop rotation; 6. maize in continuous cultivation; 7. maize in three-years crop rotation; 8. maize in four-years crop rotation.

As there may be observed, the first three places were held by wheat variants, defferentiated among each other especially by the quantity of P mobile, as a result of the export through harvest and the penetration resistance. This last indicator has a lower value due to the continuity of wheat crop and the improvements brought to the soil through the fascicular root system. Differentiation according to pH and apparent density is less evident.

Classification of maize in two-years crop rotation ahead of wheat cultivated in four-years crop rotation may be explained by the difference existing in P mobile and pH. This may be also due to the consumption in sunflower, which is the predecessor of wheat in four-years crop rotation. As regards apparent density and penetration resistance, oscilations are almost inexistent.

With regard to continuous cultivation in maize and wheat in three-years crop rotation, penetration resistance and apparent density have higher values in maize due to the characteristics of its root system. The pH value is also lower and because of this reason wheat becomes more favourable than maize as regards conservation of productivity features of the soil, even under non-fertilization conditions.

On the last place ranked maize cultivated in three-years and four-years crop rotation, due to a decrease of P mobile in the soil exported through the higher yields in this variant and the high values of apparent density and penetration resistance, motivated by the high number of machine passages in tillage and maintenance works which are more frequent in maize than in wheat.

Variant of N minimum fertilization

In this variant the following hierarchy resulted: 1. wheat in continuous cultivation; 2. wheat in two-years crop rotation; 3. wheat in three-years crop rotation; 4. wheat in four-years crop rotation; 5. maize in two-years crop rotation; 6. maize in continuous cultivation; 7. maize in four-years crop rotation; 8. maize in three-years crop rotation.

As there may be observed, the first places are held by wheat crop, while the delimitation between the different cropping systems was especially due to the values of apparent density and penetration resistance. These were lower in the case of continuous cultivation because of the same reasons that were shown previously, while in agrochemical indicators, oscillations were very small. The difference between wheat in three-years crop rotation and the one cultivated in four-years crop rotation, was established especially by considering P mobile content in the soil and pH value. This situation may be also admitted as a consequence of the fact that sunflower was the predecessor of wheat, as already mentioned above.

Maize crop holds the last places determined by the decrease of P mobile in the soil as a consequence of the high yields and the high penetration resistance.

Differentiation between the two cropping systems may be done by grouping the variants together by twos. Thus, two-years crop rotation is ahead of continuous cultivation because of the quantity of P mobile in the soil which is in agreement with the yields, and because of penetration resistance as a result of wheat intervention once in two years. In four-years crop rotation, which recorded lower yields, greater P mobile quantities could be identified in the soil as compared to the situation of three-years crop rotation. This places it ahead of the other one, while in the remaining criteria differences are minor.

Variant of N optimum fertilization

Classification achieved was as follows: 1. wheat in continuous cultivation; 2. wheat in two-years crop rotation; 3. wheat in three-years crop rotation; 4. wheat in four-years crop rotation; 5. maize in two-years crop rotation; 6. maize in continuous cultivation; 7. maize in four-years crop rotation; 8. maize in three-years crop rotation.

As in the previous variant, wheat crop ranked ahead of maize, by holding the first four places. This is due to the high value of agrochemical indicators of the soil and the lower value of the physical ones. This may be explained by the yield quantity and the characteristics of the root system.

Differentiation of cropping variants in wheat was mainly due to variation of P mobile content in the soil as well as its penetration resistance.

Maize in continuous cultivation and in two-years crop rotation ranked ahead of the one cultivated in four-years and three-years crop rotation, depending on oscillations of P mobile in the soil (correlated with the yield), apparent density and penetration resistance (correlated with the possibilities of soil tillage in the optimum moment and according to irrigation standards).

Variant of N maximum fertilization

The classification order obtained was the following: 1. wheat in continuous cultivation; 2. wheat in two-years crop rotation; 3. wheat in three-years crop rotation; 4. wheat in four-years crop rotation; 5. maize in continuous cultivation; 6. maize in two-years crop rotation; 7. maize in three-years crop rotation; 8. maize in four-years crop rotation.

Differentiation of continuous cultivation in wheat ahead of its cultivation in two-years crop rotation was due to the achievement of the optimum values in agreement with the requirements of the analysis method, in all the four criteria considered. On the last place in wheat variants ranked its cropping in a four-years rotation, due to the higher values of apparent density and penetration resistance. This may be explained by the return of wheat on the some plot after a much longer time interval, as compared to continuous cultivation or two-years crop rotation.

Maize crop in continuous cultivation ranked after the variant of cultivation in simple rotation with wheat only due to the small quantity of P mobile in the soil. It is possible that in two-years rotation a residual effect of P mobile should come up in the soil, from wheat crop which utilizes the high rates of phosphatic fertilizer at a slower rhythm.

Continuous cultivation and two-years crop rotation were superior in maize as compared to three-years and four-years crop rotation, because of the apparent density and penetration resistance which had more reduced values. At the same time, the fact may be observed that between the variants with maize cultivated in three-years and in four-years crop rotation, three are no essential differences as regards agrochemical and physical indicators of the soil.

Fertilization variant with N optimum + 10 t manure /ha/years

The data processed show that the classification order is as follows: 1. wheat in continuous cultivation; 2. wheat in two-years crop rotation; 3. Wheat in three-years crop rotation; 4. wheat in four-years crop rotation; 5. maize in continuous cultivation; 6. maize in two-years crop rotation; 7. maize in four-years crop rotation; 8. maize in three-years crop rotation.

As three may by observed, classification is the same as in the case of using only the optimum rate of nitrogen fertilizer. This demonstrates that the annual contribution of the 10 t/ha semifermented manure is too small to produce great changes in agrochemical and physical indicators of the soil, considered under irrigation conditions, during the seven years of experimentation. Furthermore, by analysing the value of these indices, no great changes can be observed between maize cropped in continuous cultivation or in simple rotation with wheat.

CONCLUSIONS

The method of multi-criteria analysis requires a previous evaluation of the criteria considered to differentiate among variants, depending on the aim for which this analysis is carried through. The higher the number of criteria – involving also the existence of correlative links between them – the better results will be obtained, whose causality could be scientifically explained.

In the case in which the number of indicators that characterize certain chemical and physical features of the soil is higher than the number of indicators characterizing the yield, the information obtained refers to the present agrophysical state of the respective soil type and not to the influence of the technological sequence on the achievement of grain yields.

Conservation of the productive soil features, characterized by certain agrochemical and physical indicators, is better done through wheat crop than through maize cultivation under irrigation conditions. Maize cultivation in a four-years crop rotation which includes sugar beet as predecessor, and sunflower or wheat in other cropping systems, may give rise to a diminishing of productive soil capacity through irrigation, if no steps are taken to correct physical and agrochemical indices by adequate soil tillage and organo-mineral fertilization.

In the case in which only agrochimical and physical indicators of the soil are taken into consideration, we may obtain an almost identical ranking of wheat and maize cultivation variants in different cropping systems, even if different fertilization rates are used.

The annual adding of 10 t manure /ha in the variant of optimum nitrogen fertilization has no implications on certain evident modifications of some agrochemical and physical indices that characterize soil productivity.

REFERENCES

Baghinschi, V., 1979. Production functions and their applications in agriculture (in Romanian), Edit. Ceres, Bucharest.

Cabelguenne, M., Jones, C., Marty, J.R., Quinones, H., 1988. Contribution à l' étude des rotations cultureles: tentative d' utilisation d'un modèle, Agronomie, 8 (6), 549 – 557.

Fardeau J. C., 1993. Dynamics of phosphates in soils (IAEA Report, Nov. 1993).

Le Floch, D., 1986. La monoculture du mais est - elle possible? Contraintes et limites de la culture de maïs grain ou ensillage en France (Les rotations céréalières intensives. Dix années d'études concertées, INRA-ONIC-ITCF 1973-1983, Paris).

Gachon, L., (ed), 1988. Phosphore et potassium dans les relations sol-plante: conséquences sur la fertilisation, INRA, Paris.

Gantzer, J. C., Blacke, R. G., 1978. Physical characteristics of Le Sueur clay loam soil following no till and conventional tillage. Agronomy Journal, 70 (5): 853 – 858.

Nedelciuc, C., Nedelciuc, M., Iagăru, Gh., 1996. Influence of fertilization within crop rotations in winter wheat (in Romanian) Cereals and Technical Crops 1:1.

Nica, S., Hera, C., Alecu, I., Toncea, I., Croitoru, C., 1983. Optimization of cropping system in agricultural units (in Romanian). Edit. Ceres, Bucharest.

Schimek, V., 1992. Multi-criteria analysis (in Romanian – manuscript).

Sin, G., Bondarev, I., Nicolae, H., 1979. Behaviour of podbearing plants for grain within certain crop rotations (in Romanian), Annals of RICIC – Fundulea, XLIV, 311 – 319.

Table 1

Cumulated multicriteria analysis (1987) in wheat and maize

Crops	Total yield u.c. (q)	Emerg. value (MkWh)	P mobile soil ppm	pH water	Apparent density (g/cm3)	Penetr. resis-tance (1 gf/cm2)	Ranking A	Ranking B
1	2	3	4	5	6	7	8	9
				Unfertilized				
M. W	197.4	153.3	90.1	6.03	1.33	33.8	4	1
M. M	423.5	431.2	85.0	6.01	1.36	43.3	3	6
W. R 2	193.2	149.8	89.5	6.08	1.34	36.7	5	2
M. R 2	420.0	427.7	89.0	6.20	1.35	40.8	1	4
W. R.3	251.3	181.3	76.3	6.15	1.34	40.8	7	5
M. R 3	469.0	465.5	73.8	5.90	1.36	43.9	2	7
W. R.4	235.9	177.1	87.9	6.12	1.34	40.8	6	3
M. R.4	427.0	429.1	72.9	5.98	1.37	44.3	8	8
				N minimum				
M. W	296.1	205.8	75.4	5.86	1.33	33.2	2	1
M. M	586.2	569.1	69.2	5.75	1.35	43.0	5	6
W. R 2	308.7	214.9	80.2	5.83	1.34	35.1	1	2
M. R 2	616.7	598.5	74.8	5.69	1.38	42.4	3	5
W. R.3	353.5	235.2	79.5	5.85	1.35	42.4	4	3
M. R 3	641.9	623.0	62.8	5.57	1.37	44.3	6	8
W. R.4	331.1	228.9	75.3	5.66	1.35	42.1	7	4
M. R.4	609.0	591.5	64.7	5.55	1.37	44.3	8	7

				N optimum				
M. W	347.9	234.5	76.3	5.56	1.32	34.5	1	1
M. M	688.8	668.5	67.5	5.52	1.35	43.4	6	6
W. R 2	366.8	241.5	73.5	5.51	1.34	39.8	4	2
M. R 2	707.7	686.7	70.7	5.40	1.37	42.1	5	5
W. R.3	415.1	276.5	72.8	5.66	1.34	41.1	2	3
M. R 3	740.6	703.5	62.9	5.62	1.38	44.3	7	8
W. R.4	382.9	260.4	76.1	5.56	1.35	42.3	3	4
M. R.4	720.3	697.2	68.0	5.50	1.37	44.0	8	7
				N maximum				
M. W	378.0	253.4	83.3	5.47	1.32	31.6	1	1
M. M	733.6	680.9	77.7	5.39	1.34	40.8	5	5
W. R 2	394.8	263.2	78.9	5.39	1.33	37.0	7	2
M. R 2	800.8	738.5	75.5	5.30	1.33	39.9	4	6
W. R.3	426.3	285.6	78.2	5.44	1.33	39.2	2	3
M. R 3	800.8	738.5	76.9	5.40	1.36	43.0	3	7
W. R.4	409.5	274.9	79.1	5.46	1.36	40.2	6	4
M. R. 4	781.2	718.1	71.3	5.40	1.39	43.0	8	8
				N optimum + 10 t/ha/year of manure				
M. W	365.4	245.0	85.1	5.90	1.32	31.0	2	1
M. M	711.2	688.1	83.5	5.73	1.36	41.1	5	5
W. R 2	388.5	259.0	87.0	5.82	1.33	34.7	1	2
M. R 2	725.9	702.1	86.3	5.68	1.38	39.5	3	6
W. R.3	416.5	275.8	83.1	5.80	1.33	35.1	6	3
M. R 3	756.7	732.2	80.6	5.73	1.36	42.4	4	8
W. R.4	394.1	264.6	80.8	5.92	1.34	38.6	7	4
M. R.4	738.5	702.8	77.9	5.73	1.39	42.1	8	7

M.W – continuous cultivation wheat; M.M - continuous cultivation maize; W.R 2 – wheat two-years crops rotation; M.R 2 - maize two-years crops rotation; W.R. 3 - wheat three-years crops rotation; M.R 3 - maize three-years crops rotation; W.R. 4 - wheat four-years crops rotation; M. R. 4 – maize four-crops rotation.