MINERAL FERTILIZATION BY APPLYING OPTIMUM NITROGEN DOSES AT FARM LEVEL

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ABSTRACT

An important measure included in the Code of Agricultural Practices is related to the standards on maximum quantities of nitrogen fertilizers which may be applied on agricultural lands in order to prevent or reduce nitrates pollution of water bodies. For this, fertilizer plans at farm level are reccomended to be carried out. The case study is accomplished within a farm located in Ialomita watershed. This paper shows a fertilization plan obtained by using best practices for efficiently nitrogen use at farm level. Different indicators were needed: expected crop yield at farm level, soil indicators and coefficients of nitrogen use. As much the difference between applied applied nitrogen and exported nitrogen is lower within the farm, as much the nitrogen use efficiency is higher. In case of wheat, the optimum economic nitrogen dose recommended for obtaining 8000 kg/ha is 138 kg/ha of nitrogen. This dose is correlated with the optimum soil nitrogen supply, plant nitrogen need and the lower risk of nitrogen losses in water bodies.

INTRODUCTION

European Nitrate Directive relates to water protection against nitrates pollution from agricultural sources. The Directive was transposed in Romanian legislation by the Government Decision no. 964/2000 with its subsequent amendments which approve the Action Plan for water protection against nitrates pollution from agricultural sources. Its objectives are to reduce water pollution with nitrates from agricultural sources and to prevent this type of pollution. According to the Action Plan in each vulnerable zone, an Action Program has to be accomplished. Taking into account that all national water resources drain into Black Sea which is affected by eutrophication, it wat decided to apply a single Action Program [1] at country level and do not designate vulnerable zones to nitrate pollution from agricultural sources. The Action Program follows the measures established in the Code of Agricultural Practices for water protection against nitrates pollution from agricultural sources [2]. An important measure included in the Code of Agricultural Practices is related to the standards on maximum quantities of nitrogen fertilizers which may be applied on agricultural lands in order to prevent or reduce water pollution with nitrates. For this, fertilizer plans at farm level are reccomended to be carried out. A fertilization plan is based on a soil agrochemical study. Within the agrochemical study, the maximum nitrogen doses which might be applied in soil are calculated. For the calculation of maximum nitrogen doses, soil nitrogen content, soil physical and chemical properties as well as expected crop yield are taken into account. If the maximum calculated nitrogen (mineral and organic) dose is lower than 170 kg nitrogen/ha/year, the maximum nitrogen dose from animal manure which might be applied on agricultural land should not exceed this value.

In order to attain high yields and to increase the soil fertility, a proper fertilizer dose should be applied for increasing soil nutrients content as well as the soil fertility without lossing nitrates by surface runoff or by leaching and avoiding water bodies pollution.

The fertilization plan is accomplished for a period of 4-5-6 years for crops within a certain rotation at farm level farm and contains nutrients economic optimum doses (which ensure a certain level of crop yield at which the maximum benefit is achieved) and technical doses (which take into account the ecological potential and the amount of nutrients needed to maintain / increase the soil fertility and to achieve high crop yields without a certain benefit and possible losses) [3].

The fertilization plan may also contains nutrients technical optimum doses which represents the crop nutrients requirement for accomplishing a crop yields according to to plant species production potential at farm level. All the fertilization doses are established in kg/ha.

In this context, the paper presents a a fertilization plan accomplished by using modern agricultural practices and technologies for efficiently nitrogen use at farm level. The case study is accomplished within a farm located in Ialomita watershed.

MATERIAL AND METHOD

The fertilization plan was carried out going through three stages: the field stage, laboratory stage and desk stage. The field stage included activities related to: obtaining information about the specific conditions of the farm (physical blocks, crop location on physical blocks, previous agrochemical treatments, soil types) and soil sampling according to the instructions of agrochemical studies accomplishing. The soil samples were numbered and identified on the physical blocks within the farm. There were 26 physical blocks covering 2110.23 ha. The laboratory stage included the soil indicators analysis used for nitrogen doses calculation: soil reaction (pH), hydrolitic acidity (Ah), sum of exchangeable bases (SB), exchangeable sodium (Nasch), organic carbon (Corg), available phosphorus (P_{AL}), available potassium (K_{AL}). Based on the agrochemical parameters, the degree of base saturation (V_{Ah}) and nitrogen index (IN) were calculated. During the desk stage cartograms related to soil reaction (pH) and availability of phosphorus (P_{AL}) and potassium (K_{AL}) were accomplished. Each soil sample was located by numbers and agrochemical values on cartograms. Then, fertilization parcels (groups of agrochemical subparcels with agrochemical values included in the same variation interval) were established. Within the 26 physical blocks, 34 fertilization parcels were established. For each fertilization parcels a fertilization plan was accomplished. In this paper the results obtained for one physical block (254) are presented. Economic optimum doses are calculated.

RESULTS AND DISCUSSIONS

The soil fertility and availability of the nutrients are strongly affected by the soil properties. Because of these it is very important to evaluate periodically the soil fertility and to correlate the applied fertilization doses with the plant needs. Besides these, in the Action Plan for water protection against nitrates pollution from agricultural sources it is mentioned that for the farms which practice irrigated agriculture and for that’s where the planned crop yield requires higher amounts of nitrogen than those given by the maximum standards set out in the Code of Good Agricultural Practices for water protection against nitrate pollution from agricultural sources [2], it is mandatory to accomplish the fertilization plan based on agrochemical study.

The soil type in the studied area is a Chernozem.

The cartograms related to soil reaction (pH) and fertilization parcels are presented in Figure 1 and Figure 2. Each soil sample was located by numbers and agrochemical values on cartograms.

Within the physical block 254, four fertilization parcels (254/1, 254/2, 254/3, 254/4) were established (Figure 2) by fitting the agrochemical subparcels with agrochemical values included in the same variation range. In Figure 2 the average values of soil reaction (pH), hydrolitic acidity (Ah), sum of exchangeable bases (SB), exchangeable sodium (Nasch), organic carbon (Corg), available phosphorus (P_{AL}), available potassium (K_{AL}), the degree of base saturation (V_{Ah}) and nitrogen index (IN) for the established fertilization parcels are also presented.

The soil pH values within the studied physical block varied between 6.57 – 7.95, which highlighted a lightly alkaline soil (Figure 1 and Figure 2). The moderate alkaline reaction of soil indicates a saturation of the soil in bases above 95-98%, which indicates a good soil fertility.

Application of animal manure has a positive effect on soil reaction. By applying animal manure the lightly alkaline and neutral reaction of soils is conserved by blocking aluminum ions in the organic and mineral complexes. The organic acids and salts from manure have buffering function on soil reaction. Because of positive effect on soil reaction but also on soil organic matter and soil nutrients, it is recommended to apply partially decomposed manure in proper doses but in this physical block was not needed.

Soil nitrogen content was evaluated by using nitrogen index (IN) and it was moderate (the IN values were at the lower limit of the variation range) (Figure 2). The average values of nitrogen index (IN) were classified as medium nitrogen content and the values ranged between 3.17 – 4.33. The soil nitrogen content is affected by the the degree of base saturation (V_{Ah}) and this indicator had high values, more than 91% (Figure 2). This indicates a good fertility level of the soil at the farm parcel level.

The soil available phosphorus content was moderate – very good, with average values on fertilization parcels ranging from 18 – 216 mg/kg. On such soils with a good fertility, the fertilizers doses containing phosphorus should be applied according to the plant needs, soil phosphorus content, expected yield.

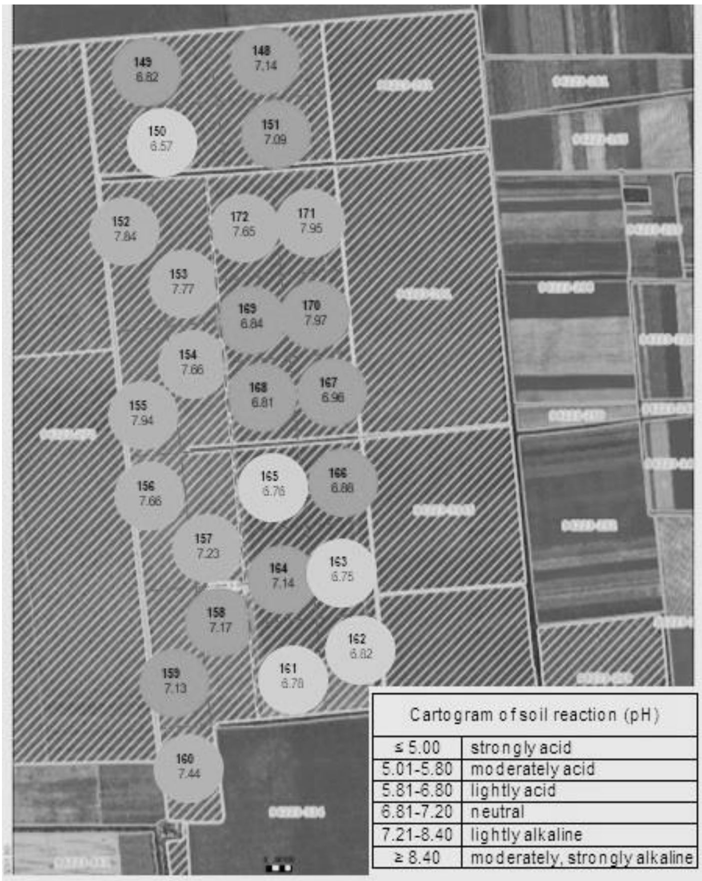
The soil available potassium content, generally, was good and very good, but not enough for accomplishing crop yields according to the genetic potential of the cultivated species/ varieties.

The expected yields and achievable yields at the farm level are presented in Table 1. The achievable yields were established based on the land mark in the studied area. For example, in case of winter wheat the achievable yield is 4.0 t/ha. The expected yields are higher if new and modern agricultural techniques and practices are applied. In case of winter wheat the expected yield are 8.0 t/ha.

Table 1

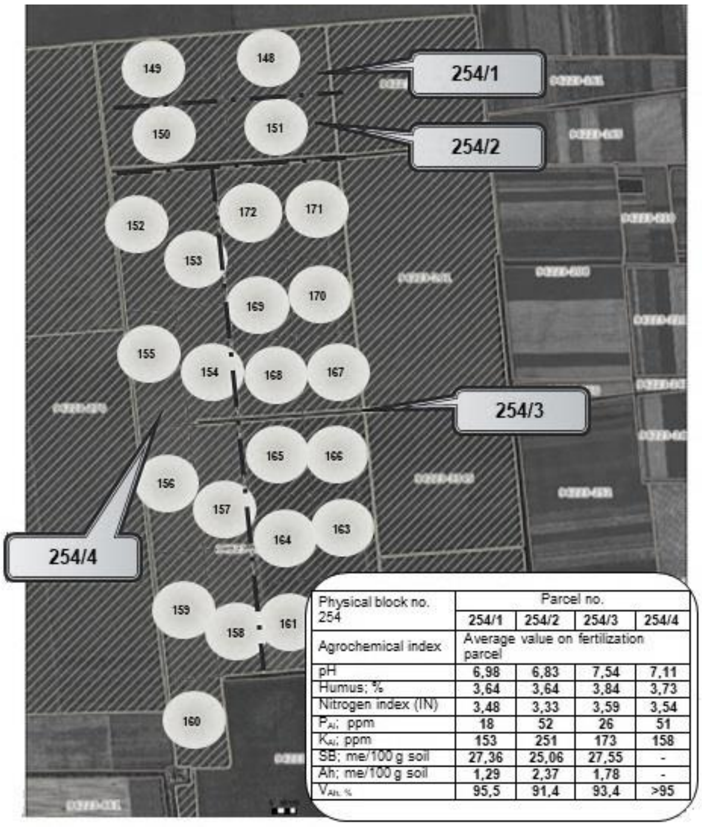
Expected crop yields and achievable crop yields in the studied area

Crop	Expected yields of the farmer (t/ha)	Achievable yields, (t/ha)
Winter wheat	8.0	4.0
Spring barley	7.0	4.0
Maize	13.0	7.5
Sunflower	4.0	2.7
Rape	4.0	2.9
Soybean	4.0	2.6



Cartogram of soil reaction (pH)	
≤ 5.00	strongly acid
5.01-5.80	moderately acid
5.81-6.80	lightly acid
6.81-7.20	neutral
7.21-8.40	lightly alkaline
≥ 8.40	moderately, strongly alkaline

Figure 1. Cartogram of the soil reaction (pH)



Physical block no. 254	Parcel no.			
	254/1	254/2	254/3	254/4
Agrochemical index	Average value on fertilization parcel			
pH	6,98	6,83	7,54	7,11
Humus; %	3,64	3,64	3,84	3,73
Nitrogen index (IN)	3,48	3,33	3,59	3,54
P_{Al}; ppm	18	52	26	51
K_{Al}; ppm	153	251	173	158
SB; me/100 g soil	27,36	25,06	27,55	-
Ah; me/100 g soil	1,29	2,37	1,78	-
V_{Ah}, %	95,5	91,4	93,4	>95

Figure 2. Establishment of fertilization parcels within the physical block

In this context a fertilization plan for each fertilization parcel was accomplished. It contains economic optimum doses - DOE (which ensure a certain level of crop yield at which the maximum benefit is achieved) for a six years crop rotation, winter wheat – spring barley - maize – sunflower – rape - soybean. In Table 2 the fertilization plan is presented for the physical block no. 254. For the calculation of the optimum economic doses (DOE) different aspects were taken into account: prices of mineral fertilizers, nutrients crop requirements, soil nutrients content and economic aspects. DOE also is calculated for achieving at farm level the expected yields.

By using traditional agricultural practices within the farm it might be achieved a wheat yield of 4.0 t/ha. By using modern agricultural practices and technologies at farm level it might be achieved a wheat yield of 8.0 t/ha. The recommended optimum nitrogen dose for obtaining a wheat yield of 8.0 t/ha, for the three fertilization parcels, is around 138 kg of nitrogen per ha. As much the difference between applied nitrogen and exported nitrogen is lower within the farm, as much the nitrogen use efficiency is higher [4]. This dose is correlated with the optimum soil nitrogen supply, plant nitrogen need and the lower risk of nitrogen losses in water bodies.

Table 2

Fertilization plan

Crop	Physical block 254				
	Fertilization plan				
	Parcel No.	*254/1*	*254/2*	*254/3*	*254/4*
	Doses of amendments, organic fertilizers				
	$CaCO_3$; t/ha	-	-	-	-
	Partially decomposed animal manure; t/ha	-	-	-	-
	Doses of nitrogen, phosphorus and potassium on parcels within the physical block				
	Dose type (kg/ha)	DOE	DOE	DOE	DOE
Wheat	Nitrogen (N)	139	140	138	137
	Phosphorus (P_2O_5)	82	33	64	50
	Potassium (K_2O);	52	24	44	50
Spring barley	Nitrogen (N)	107	108	106	105
	Phosphorus (P_2O_5)	78	35	62	36
	Potassium (K_2O)	42	22	36	40
Maize	Nitrogen (N)	192	194	190	190
	Phosphorus (P_2O_5)	73	34	60	60
	Potassium (K_2O);	88	26	74	84
Sun-flower	Nitrogen (N)	82	83	81	81
	Phosphorus (P_2O_5)	80	47	90	48
	Potassium (K_2O)	60	31	53	59
Rape	Nitrogen (N)	87	88	86	86
	Phosphorus (P_2O_5)	90	47	71	41
	Potassium (K_2O);	55	31	47	53
Soybean	Nitrogen (N)	58	59	56	57
	Phosphorus (P_2O_5)	90	50	71	51
	Potassium (K_2O)	48	28	41	46

CONCLUSIONS

A fertilization plan was established in a physical block located within a farm from Ialomita watershed. It contains economic optimum doses - DOE (which ensure a certain level of crop yield at which the maximum benefit is achieved) for a six years crop rotation, winter wheat – spring barley – maize – sunflower – rape – soybean. The following conclusions have been established:

- The soil indicators analyzed were not correlated with the plant needs. The soil reaction is neutral to moderate alkaline and no limestone amendments are required. The soil nitrogen content is classified as moderate to medium being affected by the degree of base saturation and this indicator has high values. The soil available phosphorus content is moderate – very good. The soil available potassium content, generally, was good, in some in some parcels being moderate but not enough for accomplishing crop yields according to the genetic potential of the cultivated species/varieties.
- The achievable yields were established based on the land mark in the studied area and taking into account that a traditional agricultural technology is used. In case of winter wheat, for example, the achievable yield is 4.0 t/ha. The expected yields are higher if new and modern agricultural techniques and practices are applied. In case of wheat the expected yield are 8.0 t/ha. The recommended optimum nitrogen dose for obtaining the expected wheat yield of 8.0 t/ha, for the four fertilization parcels analyzed, is around 138 kg of nitrogen per ha. As much the difference between applied applied nitrogen and exported nitrogen is lower within the farm, as much the nitrogen use efficiency is higher. This dose is correlated with the optimum soil nitrogen supply, plant nitrogen need and the lower risk of nitrogen losses in water bodies.

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