International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:5, No:11, 2011

The Effectiveness of Mineral Fertilization of Winter Wheat by Nitrogen in the Soil and Climatic Conditions in the Cr

Václav Voltr, Jan Leština

***Abstract*—**The basis of examines is survey of 500 in the years 2002-2010, which was selected according to homogeneity of land cover and where 1090 revenues were evaluated. For achieved yields of winter wheat is obtained multicriterial regression function depending on the major factors influencing the consumption of nitrogen. The coefficient of discrimination of the established model is 0.722. The increase in efficiency of fertilization is involved in supply of organic nutrients, tillage, soil pH, past weather, the humus content in the subsoil and grain content to 0.001 mm. The decrease in efficiency was mainly influenced by the total dose of mineral nitrogen, although it was divided into multiple doses, the proportion loamy particles up to 0.01 mm, rainy, or conversely dry weather during the vegetation. The efficiency of nitrogen was found to be the smallest on undeveloped soils and the highest on chernozem and alluvial soils.

***Keywords*—** Nitrogen efficiency, winter wheat, regression model

I. Introduction

NITROGEN fertilization depends on many factors with different effects on yield. Possibilities of expression of fertility are based on natural conditions for this purpose, especially from the observations of soil productivity achieved by inputs and outputs in production. In terms of Czech Republic results can be in physical relations subsequently applied to the categorization of the agricultural land fund, the foundation of the bonity soil-ecological units (BPEJ). Nutrition of crops, which is mainly represented by the level of nitrogen fertilization, is the subject to permanent soil characteristics, moisture and temperature factors and the technologies of production. The paper analyzed the influence of nitrogen on the yield of agricultural crops such as integrating factor intensity of production. The physical nature of the phenomena will be subsequently used to quantify the indicators described in the code BPEJ.

Supply of nitrogen to the soil is also influenced by the ratio of prices of inputs and outputs. Use of this information provides the ability to create a dynamic model of soil fertility both expressed by in kind and the value indicator.

II. Review Stage

In an international comparison of soil and climatic conditions is used in the evaluation of soil fertility especially grain of soil in combination with soil depth, slope, skeleton, drainage, salinization and soil reaction (Alterra et al. [1]). Another potential approach for comparing soil conditions lies in the definition of certain groups of crops suitable for the type of soil (Reinds et al. [2]), but with similar unifying criteria primarily with the content of clay particles.

Production ability of agricultural land depends on stable factors that retain their character for many decades and whose leaders are under Dabbert [3] configuration of land, soil depth and stoniness, genesis, grain, and soil sorption complex. To evaluate influence of nitrogen, it is necessary to evaluate the influence of short-term factors, such as particular weather conditions, soil structure in order to compare the yields on plots measured between them. Tillage practices and crop residue management in cropping systems, such as grain production, play an important role in how soil receives and retains moisture. It is known that the manner tillage can influence directly and indirectly all physical, chemical and biological properties of soil. It follows from such work as Neudert and Kostelansky [4] and the quality of tillage has largely achieved revenue. The main impact compliance with agro-technical principles that are reflected on less stable soil factors such as soil texture, soil compaction and humus quality, along with the choice of culture, the time sequence of crops and vegetation land cover, is concentrated to environment.Parey [5] indicates that soil quality is determined by the ability of soil to provide and maintain plant growth, which includes factors such as degree of cultivation, organic matter content, soil structure, soil depth, water capacity, permeability, pH, nutrient content, etc. The variability of these elements is relatively large, reflecting the complex structure of soil and the many factors that participate on their development.According to Neuberg et al. [6] based system of plant nutrition in optimal utilization of production - environmental conditions and biological potential of crops shall, to the maximum extent possible to the economy of fertilizer and apply measures to prevent negative impacts on the environment. The recommended methodology of plant nutrition is already stated in 1985 that the nitrogen fertilization is essential to optimize the level of crop production and environmental conditions, with regard to the required quality of harvest and environmental protection. Practical optimization of nitrogen fertilization involves not only benefits but also the form, timing and method of application of nitrogenous fertilizers. In terms of production effects of applied nitrogen and other nutrients in mineral fertilizers is required for the system to fertilization respected the fact that the yield per unit is required progressively higher amount of nitrogen on soils is deteriorating nitrogen regime and other nutrients on soils with their low-supply.

Václav Voltr is with the Institute of Agricultural Economics and Information (phone:+420222000390; fax: 420-222-725-450; e-mail: voltr.vaclav@ uzei.cz).

S. B. Jan Leština is with the University of South Bohemia, České Budějovice (e-mail: lestina@ef.jcu.cz).

The need of nitrogen for plant nutrition changes during the year. For example Zimolka et al. [7] provided in connection with winter wheat, the proportion of nitrogen removed in the fall is not greater than 12% of total consumption, for example therefore high doses of nitrogen applied before sowing is unnecessary and non-organic. Consumption of nitrogen increases in the spring, when plants over the winter to recover biomass. Growth is increasing its use until the end of flowering. After flowering the plant requirements on nitrogen is relatively lower. At the end of the vegetation in the grain is piled up to 75% nitrogen. Calculated per tonne of grain and the quantities of wheat straw and roots, drains an average of 25 kg of nitrogen.

Limitation of plant nutrition in legislative defined a series of legislative standards, especially according to Council Regulation No 1782/2003 and related implementing regulations No. 796/2004. Protective measures are also included in the Fertiliser Act No. 156/1998 Coll., As amended, the Act No. 254/2001 Coll waters., As amended, and Government Regulation č.103/2003 Coll., As amended (in the Nitrate Directive) and other laws (eg Act No. 114/1992 Coll. on nature and landscape). These constraints ultimately limit agricultural entrepreneurs in the supply of nitrogen to the soil in terms of both dose and time of use. Some of these restrictions are subject to availability of financial aid management, for example on good agricultural practices (GAEC). The use of nitrogen fertilizer price is also given sessions of nitrogen fertilizer, which acts as a further limiting factor. This factor must be consistent with those of its supply of products to ensure the prosperity of business in agriculture.

III. Material and Methods

Relations in soil-plant complex are expressed in the form of production functions, which are assessed due to differences in soil-climatic conditions.

Crop production function can be described by Dabbert [3] by a primary formula:

$$X_t = f(W_{t-n};U_{t-n};A_{t-n};S_{t-n};P_{t-n};E_{t-n};L_{t-n};T) \qquad (1)$$

Where Y= yield, t = monitoring period (year) W = climate variables S = type and condition of the soil, Z = plant nutrition; P = level of chemical protection of plants, L= soil preparation, T: technological progress,

while the level of food crops is defined by function

$$X_t = f(W_{t-n};U_{t-n};A_{t-n};S_{t-n};P_{t-n};E_{t-n};L_{t-n};T) \qquad (2)$$

Where X= the level of nutrition, t-n= the period preceding the period t and n and variables W= climatic factors; U= land use; A=: tillage; S= type, type and condition of the soil; P= the use of chemical plant protection; E= The configuration of the landscape; L= the quality of the landscape; T= technological progress.

These relationships were used to derive the efficiency of nitrogen in the production of winter wheat based on the results achieved in the agricultural operation.Methodology for the specification of these relationships uses information from approximately 500 homogenous lands in agricultural use in the CR (Voltr, [8]). In this monitoring are detailed information of technological parameters of production in the major soil and climatic conditions, with a total area of 9.2 thousand hectares, including 127 represented the most BPEJ and 65 major soil units (HPJ). Results interpret three quarters of total arable land in the country. Monitoring is carried out on homogeneous lands with majority representation of the main soil units from 80% of land with total area of 5 ha. As part of this work relationship is observed between the supply of nitrogen mineral fertilizers, winter wheat yield and other production factors in the period 2002 - 2010.

The values of consumption of nitrogen are listed in the Table I.

The share of nitrogen per tone is descripted also on the Fig. 1 on the example of the type of soil categorization including differentiation of the tillage system. Reduced tillage is used indifferently on the soil type and the best efficiency of nitrogen is reached on the best types of the soil (chernozem).Efficiency of nitrogen per main texture category is described on the Fig. 2.

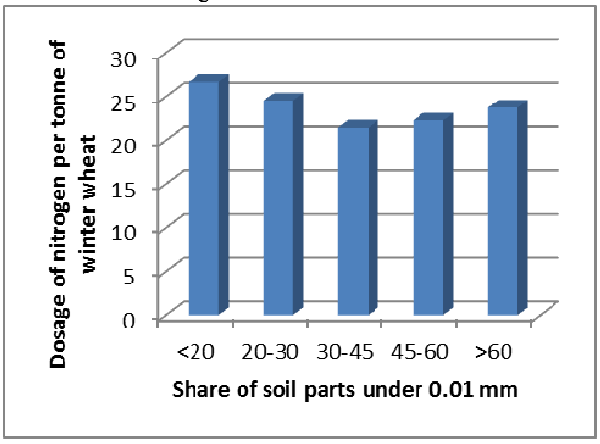

Fig. 2 Dosage of mineral nitrogen by the main soil texture category

Specification of texture is continuously searched to each plot pursued and evaluated in relation to other production factors that are detailed in the [8]. The basis of the information on soil of texture obtained in the sampling of soil for example and from national complex soil survey data (KPP), which contains data on grain soil parameters in each category, as well as many other monitoring. The most important is the general description of land by type of soil, sorption complex characterization, soil texture and pH in topsoil and subsoil.

In the context of monitoring crops are collected varieties, yields and principal by-product, dry matter content, sugar content, technology, tillage, crop establishment schedule, fertilizer and pesticide pest management, subjective evaluation of the state of vegetation and possible damage of vegetation and weather data, especially moisture soil, temperature for example and from precipitation. Weather data were derived by the Czech Hydrometeorological Institute (CHMI) per month, including the identification of five-day period during which there is a decrease in soil moisture below the wilting point in the cultivation of winter wheat (Voltr[9]). Variables for assessing the effect of nitrogen were selected from MetaDataBase containing more than 300 variables according to the correlation coefficients.Evaluation of relationships was performed using multivariate regression. It is assumed that the values of yield (Yi) linearly depend on several variables X1, X2, ..., Xk written for the ith observation as follows:

$$Yi = \beta_1 + \beta_2 X_{2i} + ... + \beta_k X_{ki} + u_i \qquad (3)$$

where u_i = a random component, βj = j-th regression coefficient or parameter (for j = 1, 2, ..., k), i is the number of observations, which are subject to i = 1,2, .., n, β1 = is the absolute constant member, or level.The behavior of farming corresponds to the effort to maximize profits. It follows that the benefits achieved nutrients closer to the optimum benefits mainly from an economic point of view and attention the company is devoted to influence of nitrogen on yield. Absolute doses of nitrogen thus approximately correspond to the economic and soil-climatic conditions of production in each period.The shape of the production function influence of nitrogen on yield can generally have different forms. In principle, it may be considered neoclassic parabolic shape (Heady [10])

$$y = a * N^2 + b * N + c \qquad (4)$$

Where a,b,c = constants, N= input of Nitrogen

The course of the quadratic production function is affected by crop level doses of nitrogen and nitrogen losses during the cropping based on soil and climatic conditions. For this reason, the multi-dimensional regression function included quadratic members that linearize the quadratic function. These quadratic members are also included in some other context, especially depending on the grain size. The equation of linear regression model and the effectiveness of winter wheat doses of nitrogen has the form in Table II, with model description in the table III.Statistical results are significant enough and also Durbin-Watson statistic near by 2 indicate low autocorrelation.

IV. Discussion

The results of the model show very good significance, which allows estimation of the consumption of nitrogen per ton of production at a good level, although linear regression method is somewhat simplistic. If the coefficient B is a negative, sign causes increase nitrogen efficiency, with positive coefficient is efficiency of nitrogen reduced.

The model described in this work is created by the complex system of data in the description of production of individual plots.

Processing may lead to inaccuracies and bias in the robustness and the deviation parameter estimates for the method of least squares. These problems are solved with fixed effect models (FEM) or random effects (REM), which are available in software (SPSS - mixed models, general linearized models) limited number of variables. Another problem in the specification of these models is their multidimensional character, which limits the use of these models. The present study analyzes the benefits in terms of nitrogen in relation to the formation of winter wheat yield in terms of natural parameters. The obtained results show the significance of nitrogen doses on the dose of nitrogen, which is aggravated by its effectiveness in line with expectations. Other factors identified with the of increase in efficiency of fertilization, involved in supply of organic nutrients, tillage, soil pH, past weather, the humus content in the subsoil and grain content is 0.001 mm. The decrease in efficiency is mainly influenced by the total dose of mineral nitrogen, although it is decomposed into multiple doses, the proportion loamy particles up to 0.01 mm, rainy, or, conversely, dry weather during the vegetation. The humus content, identified on the base COx, has an positive impact in the under soil, in the topsoil has reached the negative effect.

Acknowledgement

The article was prepared with the support of Czech national agricultural research agency in the project NAZV QH72257

References

[1] Alterra, INRA, 2005. New soil information for CGMS (Crop Growth Monitoring System) (SINFO). In: Alterra - INRA, Wageningen, pp. 219.
[2] Reinds, G.J., Van Lanen, H.A.J., 1992. Crop production potential of rural areas within the European Communities. II. A physical land evaluation procedure for annual crops and grass. In: Publication of the Scientific Council for Government Policy. Scientific Council for Government Policy, The Hague. meeting of American Geosciences Union, 10-14 th December 2007, San Francisco.
[3] Dabbert, S.: Ekonomik der Fruchtbarkeit. Stuttgart, Ulmer 1994, p. 201. ISBN 3-8001-4092-6
[4] Neudert, L.; Kostelanský, F.: The effect of the proportion of cereals in the crop rotation and of tillage techniques on soil physical properties. In: Proc. European Society for Agronomy 5th Congress, 28 June-2 July 1998, Nitra, The Slovac Republic, Short Communications, pp.215-216
[5] Parey, P.: Bodennutzung und Bodenfruchtbarkeit, Band 1 Bodenfruchtbarkeit, Hamburg und Berlin, 1991, p.155, ISBN 3-490-35515-6
[6] Neuberg, J. a kol.: Komplexní metodika výživy rostlin. Metodiky zavádění výsledků výzkumu do praxe. (The complex methodology of plant nutrition. Methodology for implementation of research results into practice) Ústav vědeckotechnických informací pro zemědělství, Praha, 1990. Heady, E.O., Dillon, J.L.: Agricultural production functions. Iowa State University Press, 1961, p. 599
[7] Zimolka, J. a kol.: Pšenice, pěstování, hodnocení a užití zrna. (Wheat, production, evaluation and use of grain). Profi Press, s.r.o., Praha 2005, ISBN 80 8672609-6
[8] Voltr. V.: Metodika hodnocení zemědělského půdního fondu se zohledněním ochrany životního prostředí. (Methodology for evaluation of agricultural land with the environmental impact Ekonomika poľnohospodárstva, VIII, No. 4, 2008. Bratislava. ISSN 1335-6186
[9] Voltr, V.; Leština, J.; Froněk, P.: Návrh lineárních modelů produkčních funkcí plodin v ČR. Acta Universitatis Bohemiae Meridionales, XIII., č.3, 2010, ISSN 1212-3285, pp 73 – 82
[10] Heady, E.O., Dillon, J.L.: Agricultural production functions. Iowa State University Press, 1961, p. 599

International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:5, No:11, 2011

TABLE I
CONSUMPTION OF MINERAL NITROGEN IN THE YEARS 2002-2010

Year	Yield (t/ha)	Total supply of mineral nitrogen per 1 ha (kg/ha)	Total supply of organic nitrogen per 1 ha (kg/ha)	Total supply of nitrogen (kg/ha)	Dose of nitrogen per tone of production (kg/t)	Ratio of the number of chemical applications per tonne of production	Ratio of the number of fertilizer applicitions per tonne of production
2002	5.53	125	9	134	24.27	0.50	0.54
2003	5.18	122	20	142	27.47	0.57	0.57
2004	6.67	128	29	157	23.52	0.50	0.46
2005	5.92	137	38	175	29.54	0.54	0.50
2006	5.70	144	43	187	32.74	0.64	0.58
2007	5.96	132	41	173	29.03	0.55	0.48
2008	6.66	139	30	169	25.40	0.43	0.46
2009	6.48	131	33	164	25.29	0.44	0.30
2010	6.13	134	20	153	25.00	0.51	0.38
Total	6.04	132	29	161	26.72	0.52	0.48

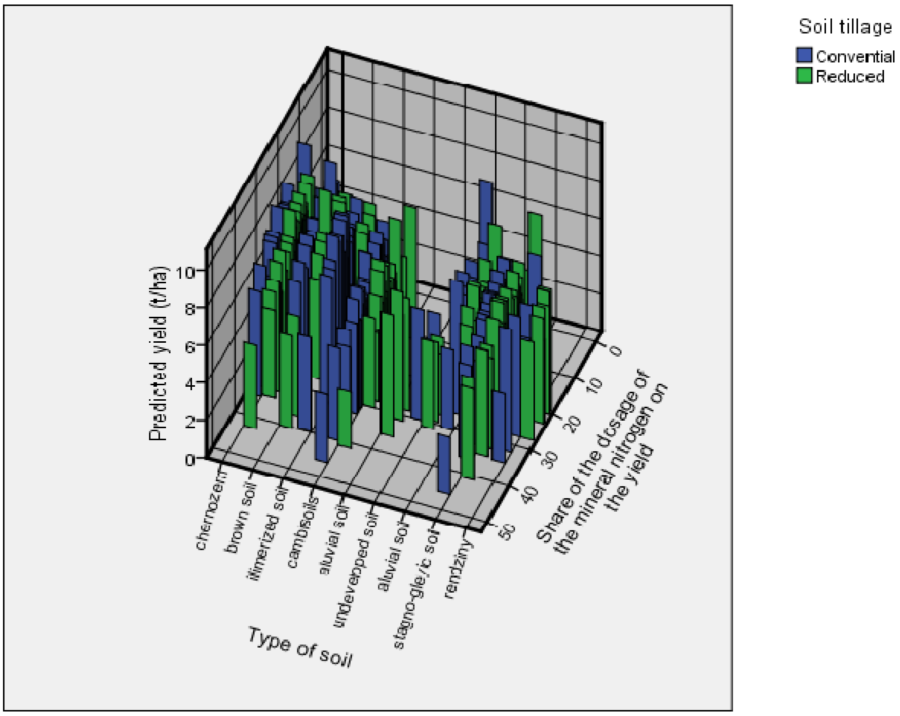

Fig. 3 The share of nitrogen per tone of the winter wheat

TABLE II
REGRESSION MODEL OF EFFECTIVENESS OF MINERAL FERTILIZATION OF WINTER WHEAT, BACKWARE METHOD

Model description	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	2.984	2.610		1.143	.253
Nitrogen dosage (kg/ha)	.201	.005	.865	38.301	.000
Square of nitrogen dosage (kg^2/ha^2)	.000	.000	.089	5.364	.000
pH of soil	-.736	.181	-.093	-4.073	.000
Kalium contens in soil (Mehlich II)	.004	.001	.069	3.723	.000
Number of chemical applications	-.877	.083	-.219	-10.607	.000
Number of fertilization of mineral nitrogen	2.374	.265	.171	8.944	.000
Missing of ploughing (1;0)	.495	.201	.044	2.467	.014
Share of parts of soil under 0.001mm in the topsoil (%)	-.138	.068	-.204	-2.032	.042
Square of share of parts of soil under 0.001mm in the topsoil ($\%^2$)	.004	.002	.226	2.192	.029
Share of parts of soil under 0.01mm in the topsoil (%)	.100	.023	.190	4.277	.000
Share of parts of soil under 0.25 mm in the topsoil (%)	.083	.018	.127	4.515	.000
Share of parts of soil under 2 mm in the topsoil (%)	-.053	.036	-.114	-1.498	.134
Square of share of parts of soil under 2 mm in the topsoil ($\%^2$)	.003	.001	.250	3.568	.000
Share of humus in the topsoil (%)	1.137	.125	.205	9.076	.000
Share of parts of soil under 0.001 mm in the undersoil (%)	.074	.057	.123	1.296	.195
Square of share of parts of soil under 0.001 mm in the topsoil ($\%^2$)	-.002	.001	-.199	-2.085	.037
Share of humus in the undersoil (%)	-.212	.121	-.032	-1.755	.079
Maximal adsorbing capacity in the topsoil	-.059	.035	-.060	-1.652	.099
Share of the exchange base of the adsorption complex in the topsoil	-.071	.032	-.078	-2.246	.025
Sum of average temperature in the months in common year (centigrade)	-.067	.010	-.156	-6.741	.000
Sum of reinfall in common year (mm)	.006	.001	.123	5.661	.000
Sum of reinfall in September and October (mm)	-.008	.003	-.052	-2.832	.005
Average number of dryness days under lentocapilar point of vadnuti in pentades in May. Juni.July[1)]	-.290	.022	-.283	-12.956	.000
Average number of dryness days under lentocapilar point of vadnuti in pentades in September and October[1)]	.081	.010	.155	8.095	.000
Category of stoiness in soil[3)]	.284	.195	.032	1.455	.146
Slope (grads)	.176	.057	.058	3.107	.002
Deep of the soil[4)]	2.027	.580	-.090	-3.497	.000

Dependet variable: share of the mineral dosage on the yield of winter wheat

1) Into each 5 days were calculated number of days, when soil moisture decreased under 30% of maximal soil moisture capacity. The base of soil moisture were computed from the base for grass.

3) Category 1-without share of stones, 2-Medium share of stones, 3- High share of stones

4) 1- deep of soil over 0.6 m; 1.5- deep of soil between 0.3 m and 0.6 m

TABLE III
STATISTICAL DESCRIPTION OF THE MODEL

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson statistic
,851[v]	0,723	0,716	2,97573	1,82

Anova

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	24598,49	28	878,518	99,212	,000[v]
Residual	9403,974	1062	8,855		
Total	34002,47	1090			