THE YEN – CHART ON THE SHARE OF CHEMICAL AND BIOLOGICAL NITROGEN IN THE TOTAL YIELD FORMING OF WINTER WHEAT ON THE EXAMPLE OF GERMANY AND UKRAINE

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We develop a simple model to estimate the proportion of chemical and biological nitrogen on the yield formation of winter wheat.

Мы разрабатываем простую в использовании модель для оценки воздействия химического и биологического азота в почве на формирование урожая озимой пшеницы.

1. Introduction

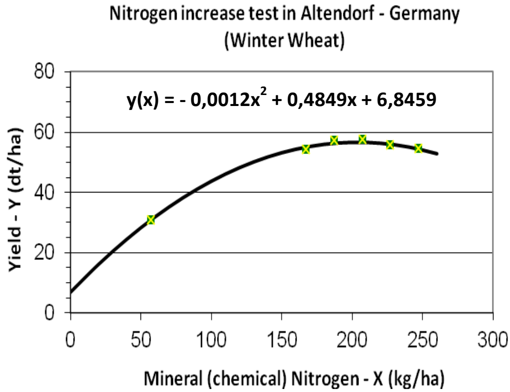
Known nitrogen increase tests, i.e. experiments to determine the yield Y(dt/ha) of winter wheat depending on the use of mineral (chemical) N-fertilizer X(kg/ha) There are many modifications of these experiments with varying parameters: culture, soil quality and number of fields, and many more climatic characteristics, chemical form of nitrogen and its distribution to applying doses.

For adaptation of the experimental material has generally enforced a quadratic approximation:

$$Y(X) = AX^2 + BX + C \qquad (1)$$

X (kg/ha)	57	167	187	207	227	247
Y (dt/ha)	30,9	54,3	57,2	57,6	55,8	54,7

Fig.1
Field experimentsin Altendorf /1/ (Germany)



In Fig.1 a good polynomial approximation, to describe the yield by the Function:

$$Y(X) = -0{,}0012\,X^2 + 0{,}4849X + 6{,}8459 \qquad (2)$$

If no chemical fertilizer is used (X = 0), remains in the example above, the residual income: Y (0) = 6.8459 t / ha, which is covered from other sources of nitrogen in the soil.

2. The YEN - Plot

The YEN- plot allows the biological and chemical nitrogen content of the yield formation to present separately. The yield Y (N) is generally dependent on summaren plant available nitrogen N. This is composed of the current available mineralized nitrogen - Nmin (resulting from biochemical degradation processes of organic compounds, such as plant residues or straw), the biological nitrogen N_{Bio} (which is taken up, for example by atmospheric-N fixing soil bacteria and supplied to the plant roots), and the supplied in the form of chemical fertilizer nitrogen – X:

$$N = N_{min} + N_{bio} + X \qquad (3)$$

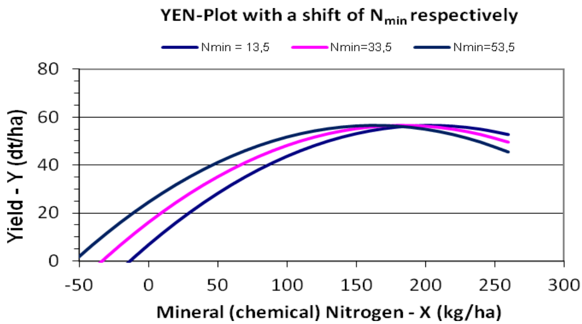
It is approximately the following cumulative relation:

$$Y(N) = Y (N_{min} + N_{bio} + X) = Y_A (N_{min}) + Y_B (N_{bio}) + Y_C (X) \quad (4)$$

Beginning of the last century and up to the time of the soil evaluation in Germany (1934), practically little or no chemical nitrogen was used, and the yield is essentially determined by the biological nitrogen and N_{min}. The soil index (BZ), or with the resulting regional and deductions derived acreage AZ approximately has the same value as the dt/ha-yield of winter wheat. Theoretically, therefore, the N-curves, if they would have been taken in the early years, intersect at the abscissa x = 0 (ie, no additional chemical nitrogen) at a value of Y (0) = AZ.

To make the experimental parameters for the N-curves comparable, it must be known, how much nitrogen is already avialable in the soil ba biochemical degradation processes (Nmin). By default, it is assumed that the individual N-enhancement curves shift by an amount corresponding to the difference of Nmin values, in parallel with X-axis (Fig. 2).

Fig.2 Field experiments in Altendorf (Germany) with respect to N_{min}



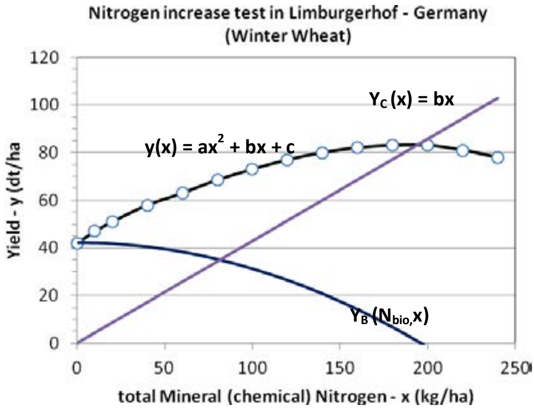
The N_{min} values for ecological reasons must now be measured or calculated annually, to avoid over-fertilization with nitrogen chemical.

In the nitrogen increase test the value N_{min} usually is interpreted as an additional part of the used chemical nitrogen. The measured (reduced) yield y is therefore plotted as a function of the total chemical nitrogen use x = (N_{min} + X):

$$y = f(x) = f(N_{min} + X) \quad (5).$$

In the example Fig. 3 which are listed from the Düngerfiebel (fertilize efficiently - YARA) results of a test of BASF (Limburgerhof, 1986-1998) played in winter wheat /2/. The points correspond to the measured yield values.

Fig.3
Nitrogen increase test in Limburgerhof 1986-1998 /2/ (Germany)



The experimental points of Figure 3 can be fitted in a good approximation by a quadratic equation y (x) = ax 2 + bx + c with the parameters: a = - 0.0011, b = 0.4286, c = 42.203 (solid line).

3. Disskussion of Fig.3

Area A - No use of chemical nitrogen (x = 0) For x = 0, i.e. if the use of chemical nitrogen is zero, the quadratic equation intersects the y-axis at a value c = 42,203 dt/ha. This gain value is the share of biological yield Y_B (N_{bio}, x = 0), which is determined solely by the biological nitrogen N_{bio}.

Area B - Less use of chemical nitrogen (x = 10 to 30 kg/ha). In this area, the yield increases linearly with the use of chemical nitrogen (tangent function): $y(x) = Y_B(N_{bio}, x = 0) + Y_C(x) = Y_B(N_{bio}, x = 0) + bx$.

Area C - Increased use of chemical nitrogen (x = 40 to 200 kg/ha)

With the increasing use of chemical nitrogen x the yield increase is lower. The biological nitrogen N_{bio} (x) decreases, becouse the plants are not motivated, and lead about their roots in the soil less and less nutrients (mainly carbon from photosynthesis) for the development of the N-soil bacteria. The soil bacteria - for example the easily measurable atmospheric-N fixing bacteria - are sometimes unemployed. As a result, the proportion of biological yield $Y_B = Y_B(N_{bio}, x)$ with increasing use of chemical nitrogen x will become smaller.

4. Calculation of the biological yield fraction $Y_B = Y_B(N_{bio}, x)$. The total yield after the cumulative relation (4) is the sum of organic share $Y_B = Y_B(N_{bio}, x)$ and the chemical share: $Y_C(x) = Y_A(Nmin) + Y_C(X)$. The chemical yield component can be represented by the straight line function $Y_C(x) = bx$ in case of the validity of the approach. Thus, the following applies:

$$y(x) = ax^2 + bx + c = Y_B(N_{bio}, x) + Y_C(x) = Y_B(N_{bio}, x) + bx \quad (6)$$

and after conversion

$$Y_B\,(N_{bio,}\,x) = ax^2 + bx + c - bx = ax^2 + c \qquad (7)$$

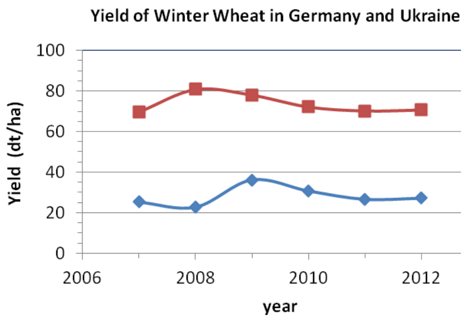
The calculated share of biological yield Y_B ($N_{bio,}$ x), where x is a function of the chemical nitrogen application, also shown in Figure 3. In our example, the biological yield proportion of chemical nitrogen applications of 200kg/ha reached zero.

The from the nitrogen increase tests (Fig. 3) calculated and graphed numerical values are summarized in the following table again.

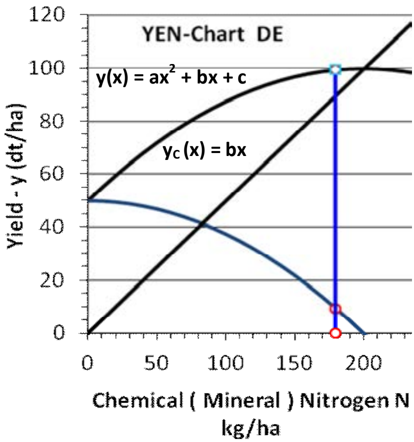
x	y		y (x)	Y_B ($N_{bio,}$ x)	Y_C (x)
chemical	measured	Tangent	Total Yield (dt/ha)	Share (dt/ha)	Share (dt/ha)
N kg/ha	Yield (dt/ha)	Value	Polynomic Approximation	Biological Yield	Chemical Yield
0	42	42,30	42,302	42,30	0,00
10	47	46,59	46,478	42,19	4,29
20	51	50,87	50,434	41,86	8,57
40	58	59,44	57,686	40,54	17,14
60	63	68,02	64,058	38,34	25,72
80	68,5	76,59	69,55	35,26	34,29
100	73	85,16	74,162	31,30	42,86
120	77	93,73	77,894	26,46	51,43
140	80	102,30	80,746	20,74	60,00
160	82	110,88	82,718	14,14	68,58
180	83	119,45	83,81	6,66	77,15
200	83	128,02	84,022	-1,70	85,72
220	81	136,59	83,354	-10,94	94,29
240	78	145,16	81,806	-21,06	102,86

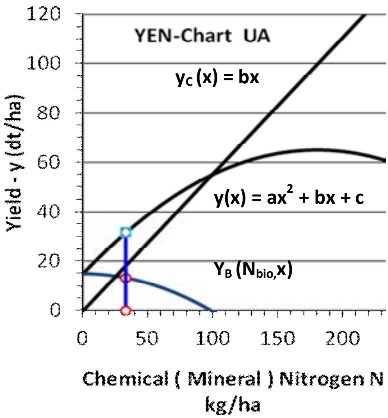
5. Calculation of the situation in Germany and Ukraine

Fig. 5
The average yield y (dt/ha) of winter wheat in the Ukraine and Germany for the past 6 years:



As shown in fig. 5, the yields for winter wheat in Germany and Ukraine are permanently different /3/. There are many factors which are responsible for these differences. For this purpose, in addition to the general soil fertility are mainly the different rainfall and other climatic conditions in winter and during the growing phase, the used wheat varieties, the culture of cultivation, the harvesting technology and in particular the high differences in the use of mineral fertilizers. We have tried to create the YEN-Charts for Germany and Ukraine, using only some available statistic reports /3,4/.





The interpretation of these images is important in the future assessment and comparison of certain agrchemical and agrobiological activities in both countries. According to our calculations, the biological nitrogen in Germany has a share of only 10% in the formation of the total income, in the Ukraine the share is over 40%.

Literature

1. J.Maier, University of Bonn, (results from Rhein-Stickstoff-AG, Altendorf, Germany)
2. YARA-GmbH, Düngefiebel, 2. Edition, p.27, (results from BASF, Limburgerhof, 1986-1998)
3. www.proplanta.de (statistic-maps)
4. S.P. Ponomarenko, Recommandations, p.24, Kiev, 2009 (some results from Agro-Sojus, UA)