NITROGEN MANAGEMENT EFFECTS ON SPRING WHEAT YIELD AND PROTEIN

Jermuss A., Vigovskis J.
Research Institute of Agriculture of Latvia University of Agriculture, Zemkopibas instituts 7., Skriveri, Aizkraukles distr., Latvia LV 5125, phone: +371 65197529, e-mail aivaram@inbox.lv

Abstract
Wheat fields in Latvia are spatially variable as to soil fertility and crop productivity. Therefore, there is interest in applying variable rates of fertilizers across the landscape. The general objective of this research is to determine the relationships among yield, protein and N rates using the regression analysis of yield data in order to optimize the rate of nitrogen fertilizer strategies in spring wheat.
A three year long (1999- 2001) field study was conducted near Skriveri, Latvia, at the Research Institute of the Agriculture of Latvia University of Agriculture with spring wheat (T*riticum aestivum L.*) ′Munk′ on the optimisation of nitrogen fertilizers. The field trials were conducted on two kinds of Luvisol soil: loam and loamy sand. The influence of the preceding crops- grass, grain and potatoes on efficiency of different nitrogen fertilizer levels (0; 50; 100; 150; 200; 250; kg ha^{-1}) was investigated.
Nitrogen fertilizer has considerably affected the crop yield. The increase of the norm of nitrogen fertilizer from 50 kg ha^{-1} up to 100 kg ha^{-1} and 150 kg ha^{-1} was significant, but a further increase was not significant. The essential difference was observed among all the predecessors as well. The nitrogen fertilizers increased protein content in a linear way and that was dependent on the preceding crops and soil texture.

Key words: spring wheat, nitrogen fertilizers, protein.

Introduction

The rising prices of agriculture production's raw materials and the increase of environmental overload promote more effective agriculture production. More and more importance is given to the fertilization of cultivated plants that must be appropriate to the cultivated soil character and the potential productiveness of plants. In particular, this should refer to field crop fertilization with nitrogen fertilizer since this definitely raises the level of grain productiveness, and nitrogen is also the basic building block of protein, and as a consequence, levels N in the soil have a large influence on grain protein concentration (Flower D. B., 2003). Therefore efficient wheat production systems emphasize the important role that N fertilizer management has in optimizing grain yield and the maintenance of grain quality standards. Nitrogen provision must correspond to the requirements of the plants, taking into account the use of nitrogen from the soil as well. The aim of the work is to explain the influence of three kinds of preceding crops upon the optimal nitrogen rates in two different textures of soil, with different granulometric content, upon grain yield and crude protein content within spring wheat grain.

Material and Methods

A three-year study was conducted during 1999–2001. The spring wheat *(Triticum aestivum L.*) variety ′Munk′ was grown in two different textures of Luvisol soil: loam: pH_{KCl} - 6.3, organic matter – 23 mg kg^{-1} (Tyurin's method), available phosphorus-100 mg P_2O_5 kg^{-1}, available potassium - 135 mg K_2O kg^{-1} (DL-method) and loamy sand: pH_{KCl} - 5.7, organic matter – 22 mg kg^{-1} (Tyurin's method), available phosphorus -142 mg P_2O_5 kg^{-1}, available potassium - 92 mg K_2O kg^{-1} (DL-method). The influence of the preceding crops - grass, grain and potatoes on the efficiency of six different levels of nitrogen fertilizer rates (0; 50; 100; 150; 200; 250; kg ha^{-1}) applied 60 % before drilling, and 40 % at spring wheat stage EC 29 as ammonium nitrate, was investigated. Spring wheat was drilled close to the optimum date (the end of April) at a rate 600 seeds per m^2. One herbicidal (Granstar 15 g ha^{-1}), one fungicidal (Tango 0.8 l ha^{-1}), and insecticidal (Bi-58 1 l ha^{-1}) was applied to control weeds, pathogens, and insects in spring wheat. The data mathematical processing was performed using the MS Excel linear, polynomial regression and anova analysis.

The economically optimal wheat yield was calculated by Danish Agricultural Advisory Service program.

Results and Discussion

In the course of three year long field-tests, the wheat grain yield fluctuated, on average, from 2.23 to 4.25 t ha^{-1}, and the crude protein content, on average, from 10.57 to 15.90 %. Nitrogen rate 50 kg ha^{-1} and its increase up to 100 and 150 kg ha^{-1} improved the grain yield remarkably ($\gamma_{0.05} = 0.382$ t ha^{-1}). Nevertheless, further increase of nitrogen rates did not creat a remarkable increase of grain yield. Within all variants the formation of crude protein in grain was promoted by the increase of nitrogen fertilizer. To characterize the changes within spring wheat grain yield, for the most part, the second grade regression curve was applied and, in several cases, the third grade polynomial equity was needed.

Changes within spring wheat grain crops grown in sandy loam after potatoes are described by the third grade polynomial regression curve $y = 3E\text{-}07x^3 - 0.0001x^2 + 0.0201x + 3.3984$ (Picture 1). This change model of spring wheat grain crop represents 99.3 % of the cases. The determination ratio – $R^2 = 0.9929$. F-test's p-value 0.010622 is below 0.05; therefore the regression equity is a statistically important explanation of the changes within the grain crops.

The economically optimal crop constituted 4.22 t ha^{-1}, and was obtained applying 73 kg ha^{-1} N rate. Crude protein within spring wheat grain increased according to the linear regression $y_p = 0.0148x_p + 10.359$ (Figure 1) which, in statistically crucial terms, explained the changes within crude protein values since value F-test's p-value 0.000273 was below 0.05 corresponding to 97.3 % data of field-tests ($R^2 = 0.9731$). Taking into account the crude protein content within spring wheat grain, the optimal nitrogen fertilizer when spring wheat was grown in sandy loam after potatoes, should be increased from 73 to 77 kg ha^{-1} since only this or a bigger nitrogen fertilizer rate would ensure grain with a crude protein content above 11.5 % that is supposed to be the critical borderline designed for the growing of qualitative food cereals (Commission Regulation EC 824/2000, Ruža A. 1998).

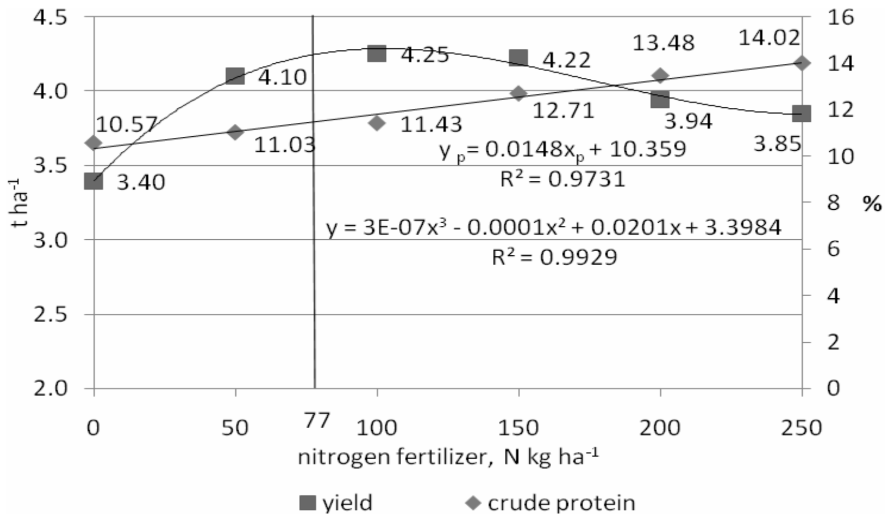

Figure 1. Yield and crude protein changes within loamy sand after potatatoes

Changes within spring wheat grain yield grown in loamy soil after potatoes are represented by the polynomial regression equity $y = -5E\text{-}05x^2 + 0.0129x + 2.9488$ (Figure 2), and they can explain 89.3 % of the changes within spring wheat grain yield ($R^2 = 0.893$). The standard error of the expected value is 0.150093. F-test's p-value 0.0346 is below 0.05; therefore the regression equity is a statistically essential explanation of the changes within spring wheat grain yield. The crude protein content increased in correspondence with the linear connexion $y_p = 0.0145x_p + 11.282$ that is a statistically essential explanation of the crude protein changes since F-test's p-value 0.001787 is below 0.05 within 93.2 % descriptions of field-test data ($R^2 = 0.9318$).

To the spring wheat grown in loamy soil after potatoes, in order to obtain economically optimal yield: 3.85 t ha^{-1}, there should be applied a 112 kg ha^{-1} N fertilizer rate. Already the 15 kg ha^{-1}

nitrogen fertilizer rate provided grain with 11.5 % crude protein content proving that a high level of crude protein content could be obtained with minor nitrogen fertilizer rates if spring wheat was grown in loamy soil after potatoes.

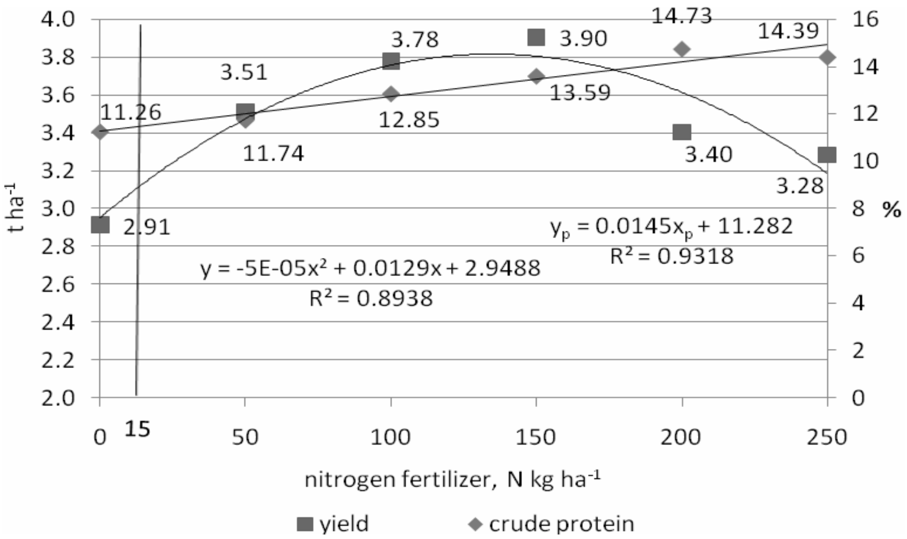

Figure 2. Yield and crude protein changes within loam after potatatoes

Changes within the yield of spring wheat grown in sandy loam after cereals are demonstrated by the second stage polynomial regression equity $y = -5E\text{-}05x^2 + 0.0159x + 2.7308$ (Figure 3). This equity represents 96.2 % of changes within cereal yield caused by the increase of nitrogen fertilizer rate, $R^2 = 0.962$. The standard mistake of the expected value is 0.126929. And this points to the successfully chosen, data describing the mathematical model. F-test's p-value 0.0072 is below 0.05; therefore the regression equity is statistically essential for the explanation of the changes within cereal yield. Statistically essential crude protein value changes are explained (Figure 3) by the linear regression equity $y_p = 0.0119x_p+11.135$ since F-test's p-value 0.001914 is below 0.05 describing 92.9 % of the field-test data ($R^2 = 0.9294$).

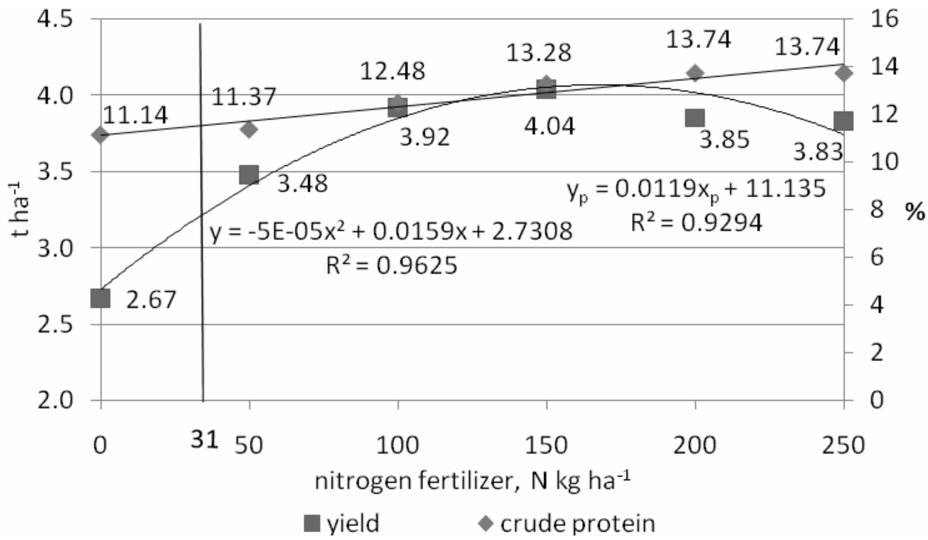

Figure 3. Yield and crude protein changes within loamy sand after cereals

The economically profitable nitrogen fertilizer rate for sandy loam after cereals has been fixed at 120 kg ha^{-1}, in order to obtain 4.00 t ha^{-1} of spring wheat grain. The critical crude protein content within wheat grain could be gained already with a 31 kg ha^{-1} nitrogen fertilizer rate, and the determination of the economical optimum of nitrogen fertilizer would not be further affected (Figure 3).

The changes within spring wheat grain yield grown in loamy soil after cereals, are represented by the second stage regression equity $y = -3E\text{-}05x^2 + 0.0113x + 2.3204$ (Figure 4) that explains 90.1 % of the cases, $R^2 = 0.901$. F-test's p-value 0.031 is below 0.05; therefore the regression equity is a statistically essential explanation of the changes within the cereal yield. The crude protein increase within spring wheat grain should be described with the linear regression equity $y_p = 0.0129x_p+12.662$ that is a statistically essential explanation of the crude protein changes since F-test's p-value 0.01242 is below 0.05 describing 82.4 % of the test data ($R^2 = 0.8237$).

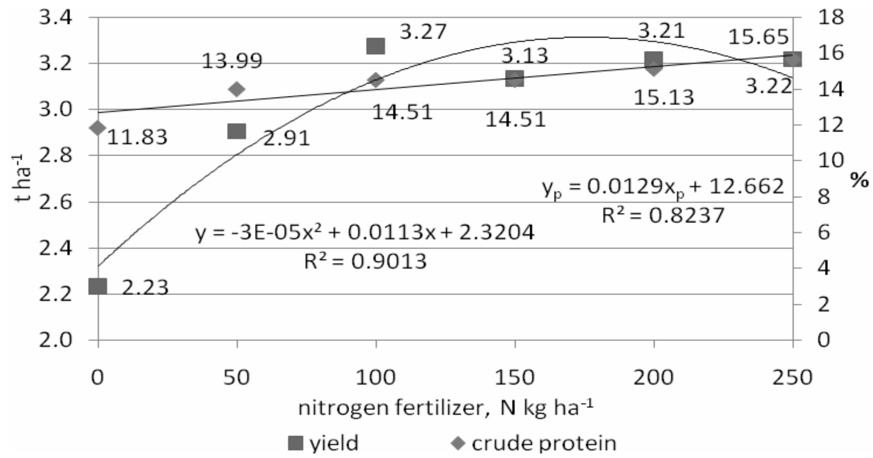

Figure 4. Yield and crude protein changes within loam after cereals

For spring wheat yield grown in loamy soil, to attain the economically optimal level: 3.23 t ha^{-1}, there should be applied a 94 kg ha^{-1} N fertilizer rate, and, in addition, the critical crude protein content border 11.5 % was attained already applying the variant without nitrogen fertilizer, and that did not affect the optimal yield estimates.

In the third stage the polynomial regression equity $y = 2E\text{-}07x^3 - 0.0001x^2 + 0.0132x + 2.6319$ characterizes the changes within spring wheat grain yield grown in sandy loam after grass (Picture 5). To fix the optimum of nitrogen fertilizer, the third stage polynomial regression equity was applied that essentially explained the changes within the grain yield when influenced by a increased nitrogen fertilizer rate (F-test's p-value 0.00118 below 0.05). Spring wheat grown in experimental conditions, in order to obtain the optimal yield, would need only a 61 kg ha^{-1} N fertilizer rate. Such regularity corresponds to 99.9 % of cases, $R^2 = 0.999$ (Figure 5). The crude protein content within spring wheat grain is reflected by the linear equity $y_p = 0.013x_p+11.701$ that was statistically essential since the F-test's p-value 0.002621 was below 0.05 when describing 91.8 % of the field-test data ($R^2 = 0.9176$).

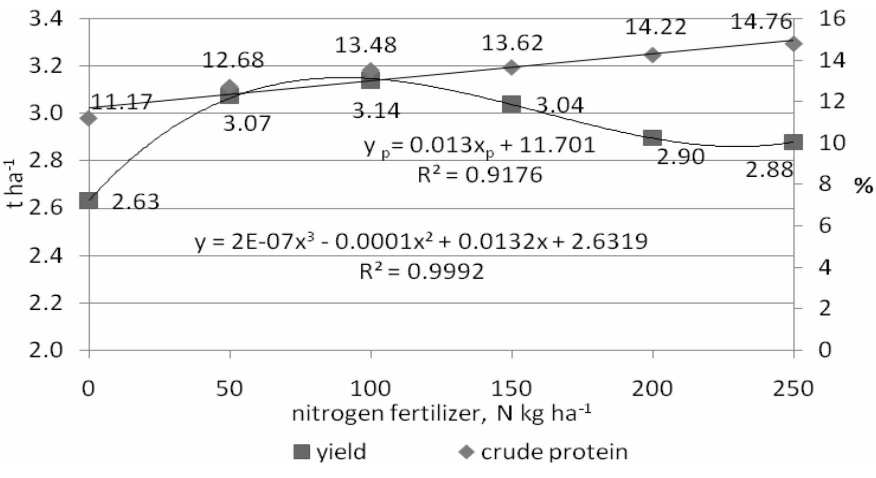

Figure 5. Yield and crude protein changes within loamy sand after grass

With of 61 kg ha^{-1} N rate could be obtained supposedly 3.11 t ha^{-1} of grain crop. The critical crude protein content within the grain supposedly would be attained already with minor nitrogen fertilizer rates, not affecting the optimal norm of nitrogen fertilizer.

For spring wheat grown in loamy soil after grass, in order to demonstrate the changes within the grain yield, the most appropriate was the second stage polynomial regression equity $y = -2E\text{-}05x^2 + 0.0069x + 2.749$ (Figure 6).

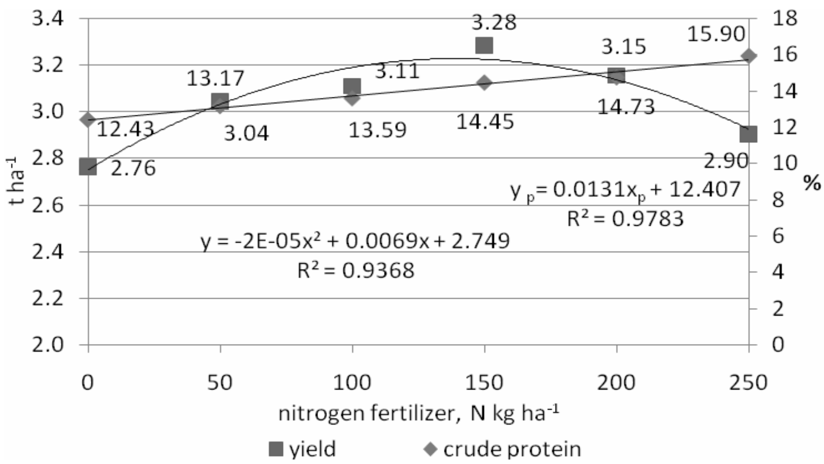

Figure 6. Yield and crude protein changes within loam after grass

The polynomial regression model can explain 93.7 % of changes within spring wheat grain yield affected by the increase of the nitrogen rate. The determination ratio is $R^2 = 0.937$. Changes within the grain yield of spring wheat grown in loamy soil after grass is represented at the second stage polynomial regression equity (Figure 6), the standard mistake of the expected value being 0.0604. F-test's p-value 0.0158 is below 0.05, therefore the regression equity is a statistically essential explanation of the changes within spring wheat grain yield.

The crude protein content within spring wheat grain increased in a linear way: $y_p = 0.0131x_p+12.407$, that is a statistically essential explanation of the crude protein value since F-test's p-value 0.000178 is below 0.05 describing 97.8 % field-test data (determination ratio $R^2 = 0.9783$). Based on the regression equity, the spring wheat grown in experimental conditions, in order to obtain economically optimal yield – 3.03 t ha^{-1} should need only 45 kg ha^{-1} N fertilizer rate, and the crude protein level would definitely be above the critical border since even without nitrogen fertilizer the obtained spring wheat grain yield contained 12.43 % of crude protein.

Changes within crude protein after the same preceding crop in soils with a different texture when increasing the nitrogen fertilizer rate were rather similar. The crude protein content within grain was more affected by various preceding crops whereas the granulometric content of soil affected the crude protein only within the variant without nitrogen fertilizer. Fixing the economically optimal nitrogen fertilizer rate for spring wheat and grain crop, the crude protein content, in most cases, was not a limiting factor if it is supposed that an 11.5 % high crude protein content within the grain is sufficient for qualitative grain standards. Only within sandy loam after potatoes, fixing the economically optimal nitrogen fertilizer norm had to be slightly increased in order to attain the crude protein content's 11.5 % borderline within the grain, and the reason could be the decline of soil nitrogen mineralizing potential due intertilled crops grown in the previous year, especially within lighter soils.

Conclusions

The essential increase of spring wheat grain yield was insured by a 50 – 150 kg h^{-1} high nitrogen fertilizer rate. Further increase of nitrogen fertilizer did not create an essential increase of wheat grain yield.

The results of the polynomial regression demonstrate that the optimal nitrogen fertilizer rates applied in soils with different granulometric contents after various preceding plants were from 45 to 120 kg ha^{-1}.
With economically optimal nitrogen fertilizer rates, all the variants, except the variant after potatoes in sandy loam, provided a crude protein content within the grain above 11.5 %.
The crude protein content within different tipes of grainhe increased, in direct ratio, with the increase of nitrogen rate – up to 200, 250 kg ha^{-1}.

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SLĀPEKĻA MĒSLOJUMA IETEKME UZ VASARAS KVIEŠU GRAUDU RAŽU UN KOPPROTEĪNA SATURU

Jermušs A., Vigovskis J.

Latvijas teritorijā vasaras kviešu lauki gan augsnes auglības gan kultūraugu produktivitātes ziņā ir dažādi. Tādejādi pastāv ieinteresētība lietot dažādas minerālmēslu normas. Šī pētījuma mērķis ir noskaidrot likumsakarības starp graudu ražu, kopproteīna saturu un dažādu slāpekļa normu izmantojot graudu ražas datu regresijas analīzi slāpekļa mēslojuma normas optimizēšanai vasaras kviešiem.
Slāpekļa mēslojuma efektivitātes noteikšanai Skrīveros, Latvijas Lauksaimniecības Universitātes aģentūras Zemkopības Zinātniskā Institūta dažāda granulometriskā sastāva (mālsmilts un smilšmāla) Luvisol tipa augsnēs no 1999. līdz 2001. gadam tika ierīkoti lauka izmēģinājumi ar vasaras kviešiem 'Munk' pēc atšķirīgiem priekšaugiem – zālāja, graudaugu un kartupeļiem ar dažādām slāpekļa minerālmēslu normām (0; 50; 100; 150; 200; 250; kg ha^{-1}).
Slāpekļa mēslojums būtiski ietekmēja graudu ražu. Slāpekļa mēslojuma normas palielināšana no 50 līdz 100 un 150 kg ha^{-1} bija būtiska, bet turpmākai slāpekļa normas palielināšanai nebija būtiska. Visi pētītie priekšaugu varianti arī būtiski ietekmēja graudu ražu. Pieaugošs slāpekļa mēslojums lineāri palielināja kopproteīna saturu vasaras kviešu graudos, kas bija atkarīgs no priekšauga un augsnes granulometriskā sastāva.

THE AGRONOMIC AND QUALITY CHARACTERISTICS OF SPRING CEREALS GROWN AT DIFFERENT INPUT LEVELS OF FERTILIZERS AND CHEMICALS

Kangor T., Tamm I., Tamm Ü., Ingver A.
Jõgeva Plant Breeding Institute, 1Aamisepa St., 48309 Jõgeva, Estonia, phone: +372 77 66901, e-mail: tiia.kangor@jpbi.ee

Abstract

The spring cereals are the most important grains in Estonian farming. The input of fertilizers and chemicals used by farmers for spring cereal production is quite different. Successful farmers prefer high input. They utilize high levels of fertilizers, herbicides, fungicides, insecticides and growth regulators (Ministry of Agriculture, 2008).
The aim of this paper was to investigate the influence of the different levels of fertilizers and chemicals to the agronomic and quality characteristics of spring wheat, barley and oats.
The trial was established with two varieties of each spring cereal at the Jõgeva Plant Breeding Institute during 2006-2007. Two input levels of fertilizers and chemicals (high and low input) were