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Liming and Fertilization Effects on Triticale (XTriticosecale W.) Yield Between 1999 and 2006

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Abstract: Precipitation amount, distribution and nitrogen (N)-, phosphorus (P2O5)-, potassium (K2O)-, calcium (CaO)-, and magnesium (MgO) fertilization interaction effects were studied on a sandy acidic lessivated brown forest soil; WRB: Haplic Luvisol in the 44 year old Nyírlugos Field Trial (NYFT) in a Hungarian fragile agro-ecosystem in Nyírség region (N: 470 41' 60" and E: 220 2' 80") on triticale (X Triticosecale W.) yield from 1999 to 2006. At the trial set up in 1962, the soil had the following agrochemical properties: pH (H2O) 5.9, pH (KCl) 4.7, hydrolytic acidity 8.4, hy1 0.3, humus 0.7%, total N 34 mg kg-1, ammonlactate (AL) soluble-P2O5 43 mg kg-1, AL-K2O 60 mg kg-1 in the plowed (0-25 cm) layer. From 1980 to 2006, the experiment consisted of 32x4=128 plots in randomised block design. The gross plot size was 10x5=50 m2. The average fertilizer rates in kg ha-1 year-1 were nitrogen 75, phosphorus 90 (P2O5), potassium 90 (K2O), calcium 437.5 (CaCO3) and magnesium 140 (MgCO3). The groundwater table has had at a depth of 2-3 m below the surface. The main results are as follows. During drought conditions the respective yield of the control areas was -25% less than for average years. The application of N alone, or of NP and NK treatments, led to yield reduction of -19.7%, while that of NPK, NPKCa, NPKMg or NPKCaMg caused an -28.3% drop during these types of years. In the wet years, the yield decreased by -22.2% on the unfertilized soils; in the case of N, NP, or NK nutrition with an -14.1%; and increased at 13.8% on NPK, NPKCa, NPKMg and NPKCaMg treated plots. In the very wettest year, the yields were dropped -43.1% on control soils, -39.3% of N, NP, or NK loadings and -35.8% on NPK, NPKCa, NPKMg and NPKCaMg treatments to those in the average year. The relationships between rainfall quantitiy during the vegetation period N, P, K, Ca and Mg nutrition and yield were characterised by polynomial correlations (control: R= 0.7212***, N: R = 0.7410***, NP: R = 0.6452***, NK: R = 0.6998***, NPK: R = 0.5555***, NPKCa: R = 0.5578***, NPKMg: R = 0.4869**, NPKCaMg: R = 0.4341**). However, the total regression coefficients ranged from 0.43 to 0.74 in depence on the different nutrient application. Maximum yields of 5.8-6.0 t . ha-1 were achieved in the rainfall range of 580-620 mm. At values above and below this domain of the precipitation the grain yield reduced quadratically. So, it can be stated that both, drought and excess rainfall conditions resulted dramatically in significant negative effects between fertilization (N, P, K, Ca, Mg) and triticale yield.

Keywords: precipitation, fertilization, liming, triticale, yield

Introduction: The hazards associated with climate change are depend on the interaction of several systems with many variables (Johnston, 2000). Accummulation of carbon dioxide, methane, water vapor, ozone, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons, chlorofluorocarbons (build-up of greenhouse gases) in the atmosphere and trends in their emissions suggest that we can expect significant environmental changes in the 21th century (Cynthia and Ana, 2006; Eric 2006). However, a recent consensus has emerged that between the greenhouse gases rising of atmospheric concentrations of carbon dioxide could become the more dangerous bacause it causing the global warming (Láng, 2005).

Today, most researchers believe that higher temperature, drought and rainfall excess caused by climate change will depress crop yields in many places in the coming decades (Kádár et al., 2000; Jolánkai, 2005). Thus, in the last decades many agricultural investigations focused on understanding the relation between mean climate change and crop production (Runge, 1968; Várallyay, 1992). Changes in weather patterns were observed thoughout Europe including Hungary as early as 1850. Among the natural consequences of changing weather patterns, years of drought (rainfall deficit) and wet (rainfall excess) conditions, resulted in problems among plant nutrition and field crop production (EU, 2003). Triticale (Kádár et al., 1999; Márton, 2002) is a crop of worldwide importance, limited research exists about the effects of climate change on these crop. The crop is sensitive to the prevailing weather conditions (such as rainfall) and, for this reason, understanding the effects of anthropogenic climate change on it's production is important (Márton, 2006). In addition to growing season triticale conditions (e.g., soil agrochemical properties, fertilization, liming) affect the growth and yield of crop (Lobell and Asner, 2003) and cause yield variations. Understanding the fertilization, liming and rainfall effects have been a continuous endeavor toward improving farming technology and management strategy to reduce the negative impacts of fertilization, liming and rainfall and to increase crop yield (Kádár and Szemes 1994; Várallyay 1994; among others).

Our main objective of this research it was study and clarify the precipitation amount and distribution and nitrogen (N)-, phosphorus (P2O5)-, potassium (K2O)-, calcium (CaO)-, and magnesium (MgO) fertilization interaction effects on a sandy acidic lessivated brown forest soil; WRB: Haplic Luvisol in the 44 year old Nyírlugos field trial in a Hungarian fragile agro-ecosystem in Nyírség region on triticale (X Triticosecale W.) yield from 1999 to 2006. Furthermore, it was our intent to emphasize that the net effect of multiple environmental changes is far more important than the effect of a single factor on the crop.

Materials and Methods: The net-influence of rainfall (quantity, distribution) and mineral fertilization (N, P2O5, K2O, CaO, MgO) were studied in a long term field experiment established at the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences Experiment Station (RISSAC-HAS ET) in Hungary on a Haplic Luvisol (sandy acidic lessivated brown forest soil) with triticale (X Triticosecale W.) indicator crop under fragile agro-ecological circumstances at Nyírlugos for 8 years from 1999 to 2006. The main experiment's soil agrochemical characteristics in the plowed (0-25 cm) layer are presented in Table 1. at the experimental set up in 1962 (Láng, 1973). From 1980 to 2006 the experiment consisted of 32x4=128 plots in randomized block designs. The gross plot size has been having 10x5=50 m2. The experimental treatments and combinations are shown in Table 2.

The fertilizers were applied in the form of 25% calcium ammonium nitrate, 18% superphosphate, 40% potassium chloride, calcium carbonate and magnesium sulphate. The groundwater table has had at a depth of 2-3 m below the surface. The plant samples had had taken by manually at the harvest time. Rainfall amounts (deviation in rainfall from the average over many years: dry year -10 - -20%, drought year -20% over, wet year +10 - +20%, year with excess rainfall +20% over) and other related data determined on traditional Hungarian (Harnos, 1993) and Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences (Márton, 2004) standards, and MANOVA (Multivariate Analysis of Variance) by SPSS test (SPSS Inc., 2000).

Table 1: The main soil agrochemical properties in the plowed (0-25 cm) layer at the experiment set up. (Brown forest soil, acid sand; WRB: Haplic Luvisol, Nyírség region Nyírlugos 1962)
Content PH HA* Hy1 Humus Total AL**
(H2O) (KCl) nitrogen P2O5 K2O
5.9 4.7 8.4 0.3
% 0.7
mg . kg-1 34 43 60
* Hydrolytic acidity, ** ammoniumlactate (AL) soluble

Table 2: Fertilization and liming treatments in the experiments, kg ha-1 year-1 (Brown forest soil, acid sand; WRB: Haplic Luvisol, Nyírség region Nyírlugos)
TreatmentLevels Applied kg ha-1 yr-1
N P2O5 K2O CaCO3 MgCO3

0 0 0 0 0 0
1 50 60 60 250 140

2 100 120 120 500 280
3 150 180 180 1000 -

Note: In the form of Ca-ammonium-nitrate, Superphosphate, potassium cloride, powdered limestone and dolomite.

Results and Discussion: During drought conditions, in conformity with Adams et al. (1995), Rosenzweig and Tubiello (1997) and McMaster (1999) the respective yield of the control areas was -25% less than for average years. The application of N alone, or of NP and NK treatments, led to yield losses of -19.6%, while that of NPK, NPKCa, NPKMg or NPKCaMg caused an -28.3% drop during these types of years. In the wet years, the yield decreased by -22.2% in the unfertilized plots; in the case of N, NP, or NK nutrition with an -14.1%; and increased at 13.8% on NPK, NPKCa, NPKMg and NPKCaMg treatments. In the very wettest year, the yields were dropped -43.1% on control soils, -39.3% of N, NP, or NK loadings and -35.8% on NPK, NPKCa, NPKMg and NPKCaMg treatments to those in the average year, reverse of Asbjorn et al. (2004). The relationships between rainfall quantitiy during the vegetation period N, P, K, Ca and Mg nutrition and yield were characterised by polynomial correlations (control: R= 0.7212***, N: R = 0.7410***, NP: R = 0.6452***, NK: R = 0.6998***, NPK: R = 0.5555***, NPKCa: R = 0.5578***, NPKMg: R = 0.4869**, NPKCaMg: R = 0.4341**). However, the total regression coefficients ranged from 0.43 to 0.74 in depence on the different nutrient application. Maximum yields of 5.8-6.0 t . ha-1 were achieved in the rainfall range of 580-620 mm. At values above and below this range the grain yield reduced quadratically.

To sum up we can say climate change will gradually and, at some point, be even abruptly affects Europa and Hungary agriculture. Warming temperatures and a greather incidence and intensity of extreme weather events possible lead to significant reductions in triticale yield. Expanded ranges of crop agrochemicals and altered transmission dynamics of different irrigation solutions might exacarbate these reductions. Since farmers' strategies grow out of experience, they can find that the past will be a less reliable predictor of the future.

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