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MANAGEMENT RECOMMENDATIONS AND OPTIONS TO IMPROVE CROP SYSTEMS AND YIELDS ON SOUTH-EAST ROMANIA IN THE CONTEXT OF REGIONAL CLIMATE CHANGE SCENARIOS OVER 2020-2050

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Abstract

Climate is one of the most important factors determining the productivity of agricultural production systems. The aim of this paper is to analyze possible climate change effects on winter wheat and maize growth, development and yielding, using the results and conclusions provided by six S-E Romania agrometeorological stations and applying the simulation models CERES-Wheat and CERES-Maize in combination with the RegCM3 climatic predictions at a very fine resolution (10 km) over 2020-2050.

A comparative analysis of the results obtained showed that future changes in regional scenario-based climate evolutions can have negative effects upon yield increase, development and formation. For both analyzed crops, the vegetation season gets shorter and there are fewer days available to reaching full ripeness. This shortening of the vegetation season is more marked in maize crops than in winter wheat. Such a forcing is mainly due to a probable increase in air temperature, estimated by the regional model. As to the possible effects of climate change upon yields, they depend on the genetic type (C_3 or C_4), direct effects of increased CO2 concentrations on photosynthesis, local conditions and the severity of changes in climate evolution according to the two scenarios.

INTRODUCTION

Romania is characterized by a warmer and moderately dry climate, with a large variability in the monthly precipitation amounts and their distribution.

Climate change has a major impact in agriculture by affecting the quantity and quality of yields and altering the soil water balance, plant water requirements, and length of vegetation period. Future climate projections show that the Romanian agricultural areas may be affected in a negative way by a number of climate changes that are predicted by regional climate models. Adapting to climate change through a better crop system management will benefit mainly from the knowledge given by our responses to severe climate events, when plans to adapt to and mitigate predictable climate change risks are implemented.

MATERIAL AND METHODS

The present paper deals with the effects of possible climate change effects on winter wheat and maize growth, development and yielding, using the results and conclusions provided by six S-E Romania agrometeorological stations and applying the simulation models CERES-Wheat and CERES-Maize in combination with the RegCM3 climatic predictions (Georgi et al. 1993) at a very fine resolution (10 km) over 2020-2050. This model has been continuously improved through user contributions provided by research centers worldwide, including Romania (Caian, 1998).

The simulation models CERES-Wheat (D.C. Godwin et al., 1989) and CERES-Maize (J.T. Ritchie et al., 1989) as well as the Seasonal Analysis Program, integrated in the DSSAT v3.5 decision system, were used in assessing the impact of climate change upon winter wheat and maize crops.

As regards the specific data on winter wheat and maize phenological development and growth, there were chosen only species whose genetic coefficients represent the average conditions over 1961-1990, as they are closer to the real values (phenology, yields) recorded in fields or standard platforms at the agrometeorological stations involved. Used as inputs, the management variables of wheat crops resulted from calibrating and validating the model and they take different values according to the agro-climatic area; mean seeding date ranges between 8 and 11 October, average seed density 600-400 pl/m^2, distance between rows 8-12.5 cm and seeding depth 4-6 cm. As to maize crops, seeding date and density were chosen according to the current average conditions: seeding date 15-22 April, density 45,000-60,000 pl/ha.

To assess the winter wheat and maize response in the current clime conditions, there were used 1961-1990 climate data series: low and high temperatures, standard deviation in high and low temperatures, precipitation, and standard deviation in precipitation, asymmetry coefficient for precipitation distribution, probability of a “dry” day (no precipitation) after a rainy one, probability of a wet day after a wet day, number of days with precipitation and solar radiation.

RESULTS AND DISCUSSION

To evaluate the climate change impact upon maize and winter wheat, CERES models were run for current climate conditions (1961-1990) as well as for the 2020-2050 regional climate scenario-anticipated conditions, considering the direct effect of increased CO_2 concentrations (from 330 to 450 ppm) upon the photosynthesis processes. The results simulated under climate change conditions were compared to those obtained for the current climate. Thus, changes in yield levels and the length of vegetation period, as well as in cumulated precipitation and evapotranspiration during the vegetation season were quantified.

According with the RegCM3/2020-2050/SRES A1B scenario, climate predictions indicate lows higher by 2.4°C- 6.9°C, mostly in the warm season. Monthly mean highs are 2-5°C lower than in current climate conditions. Changes in monthly precipitation range from -33.8 mm to +29.7 mm. Precipitation amounts increase on the whole about 6-29.7 mm in the cold season (X-IV) and decrease during the warm season (V-IX) by 4-33.8 mm in comparison with the current clime conditions (Figure 1- for ex. Fundulea station).

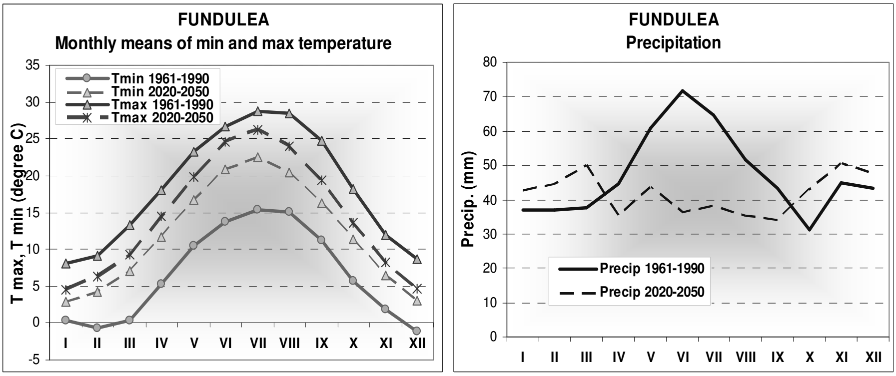

Fig. 1. Multi-annual monthly means of air temperature highs/lows and precipitation amounts under current climate conditions (1961-1990) and RegCM3 / 2020-2050 / SRES A1B predictions at Fundulea station

Analyzing the results simulated on the grounds of 2020-2050 climate change estimations made by regional climatic models highlighted that the future climate evolutions may he have important effects upon crops and they are conditioned by an interaction between the following factors: current climate changes on a local scale, severity of climate scenario-forecasted parameters, how the increased CO_2 concentrations influence photosynthesis, and the genetic nature of plant types.

Table 1

The winter wheat growing season duration

Site	Current climate / 1961-1990	Scenario / 2020-2050	Absolute differences (days)
Buzau	274 days	263 days	-11
Calarasi	269 days	254 days	-15
Fundulea	279 days	262 days	-17
Grivita	284 days	268 days	-16
Rm. Sarat	270 days	255 days	-15
Galati	272 days	259 days	-13

Under current climate conditions, the mean length of the vegetation season (from seeding time to ripeness) ranges between 269 and 284 days, decreasing by

11-17 days with climate change. The fastest growth occurs at Fundulea station, where the winter wheat ripens 17 days earlier than under current clime conditions (Table 1).

For the winter wheat crop the most suitable genotype under climate condition 2020-2050 are varieties with high vernalization (P1V=6.0) and with moderate photoperiod requirement (P1D=3.5), Figure 2.

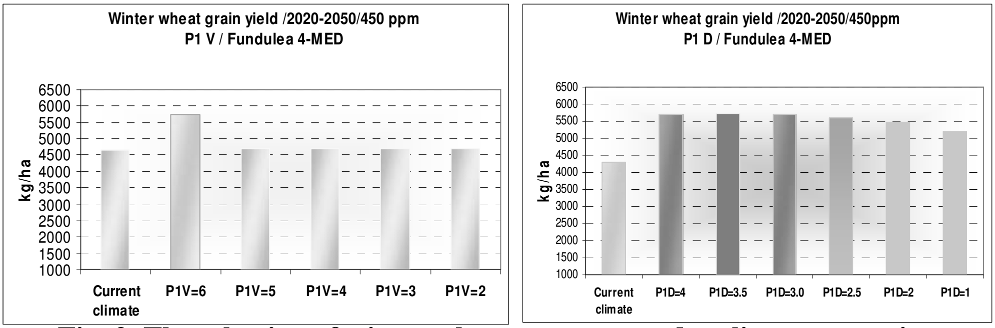

Fig. 2. The selection of winter wheat genotype under climate scenario

A 30-year mean of winter wheat yields, simulated under current climate conditions, ranges between 3599 kg/ha at Galati and 5016 kg/ha at Calarasi. Given the probable climate conditions according to the RegCM3/2020-2050/SRES A1B scenario-predicted future evolution, the mean wheat yield is higher by 8.5% - 58.9% than the 1961-1990.

If climate changes according to the analyzed scenario, the maize yields will decrease at every analyzed station due to higher temperatures that shorten the vegetation season (Table 2), coupled with a water stress, mainly during the phenological phases of grain formation and filling.

Table 2

The changes of maize growing season duration under climate scenario

Site	Current climate / 1961-1990	Scenario / 2020-2050	Absolute differences (days)
Buzau	138 days	118 days	-20
Calarasi	139 days	119 days	-20
Fundulea	141 days	115 days	-26
Grivita	148 days	119 days	-29
Rm. Sarat	144 days	122 days	-22
Galati	140 days	117 days	-23

In current clime conditions, the average maize yield ranges between 4463 kg/ha at Buzau and 7005 kg/ha at Calarasi. Analyzing the simulated results highlighted that for maize, which is more sensitive than wheat to local climate and future climate severity, average grain yields tend to decrease lightly on the whole by roughly 2-

4% at Grivita, Rm. Sarat and Galati, and more abruptly, by 18-33% as against the current climate conditions at the other three stations (Figure 3). Maize yields get lower due to a shortening of the vegetation season by 20-29 days, following an increase in temperature, as well as due to water stress during grain filling, caused by diminished scenario-forecasted precipitation amounts. Being also a C4 plant, maize benefits less from the effect of increased CO_2 concentrations upon photosynthesis.

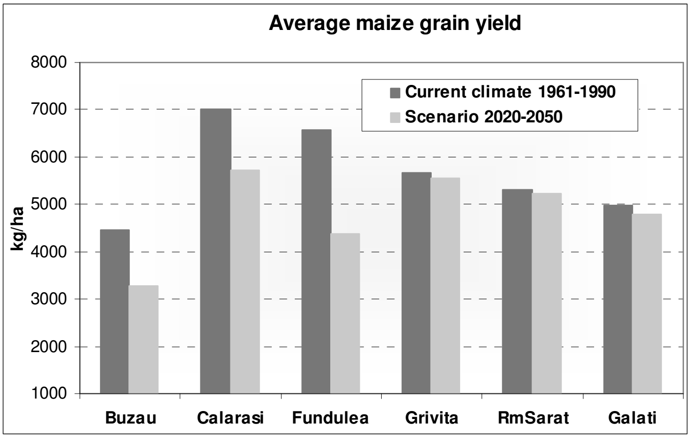

Fig. 3. Average maize yield simulated under current conditions and RegCM3/2020-2050/SRES A1B scenario

Site	Current climate / 1961-1990	Scenario / 2020-2050	Relative differences (%)
Buzau	4463 kg/ha	3290 kg/ha	-26.3
Calarasi	7005 kg/ha	5722 kg/ha	-18.3
Fundulea	6585 kg/ha	4383 kg/ha	-33.4
Grivita	5675 kg/ha	5569 kg/ha	-1.9
Rm. Sarat	5314 kg/ha	5224 kg/ha	-1.7
Galati	4970 kg/ha	4781 kg/ha	-3.8

A comparative analysis of the results obtained showed that future changes in regional scenario-based climate evolutions can have negative effects upon yield increase, development and formation. For both analyzed crops, the vegetation season gets shorter and there are fewer days available to reaching full ripeness. This shortening of the vegetation season is more marked in maize crops than in winter wheat. Such a forcing is mainly due to a probable increase in air temperature, estimated by the regional model.

As to the possible effects of climate change upon yields, they depend on the genetic type (C_3 or C_4), direct effects of increased CO_2 concentrations on photosynthesis, local conditions and the severity of changes in climate evolution according to the two scenarios. So, maize yields decrease at every analyzed station in comparison with the current clime case, due to higher temperatures leading to shorter vegetation seasons associated with water stress, mainly during the phenological stage of grain formation and filling. In winter wheat, grain yields are higher than in current clime conditions at every station of the six analyzed, due to a positive effect of increased CO_2 concentrations in the atmosphere (from 330 ppm to 450 ppm) upon photosynthesis and water use, which counterbalances the negative effect of a shorter vegetation period.

CONCLUSIONS

1. Analyzing the results simulated on the grounds of 2020-2050 climate change estimations made by regional climatic models highlighted that the future climate evolutions may he have important effects upon crops and they are conditioned by an interaction between the following factors: current climate changes on a local scale, severity of climate scenario-forecasted parameters, how the increased CO_2 concentrations influence photosynthesis, and the genetic nature of plant types. Winter wheat can benefit from the interaction between increased CO_2 concentrations and higher air temperatures, while maize is vulnerable to climate change, mainly in the case of a scenario predicting hot and droughty conditions.
2. As against the current climate conditions, the RegCM3 scenario estimates that air temperature increases will shorten the vegetation season for every analyzed station and both crop types.
3. If climate changes according to the analyzed scenario, the maize yields will decrease at every analyzed station due to higher temperatures that shorten the vegetation season, coupled with a water stress, mainly during the phenological phases of grain formation and filling. In winter wheat, the yields will increase in comparison with the current clime conditions as a consequence of increased CO2 concentrations in the atmosphere (affecting photosynthesis) and of using water supplies to counter-balance the negative effect of shorter vegetation periods.
4. The cumulated amounts of water lost to evapotranspiration during the vegetation season in both crop types will decrease in every analyzed case, to a higher degree in maize crops, following an interaction between the two opposite processes: a high temperature-related shortening of the vegetation period and the physiological effect of increased CO_2 concentrations upon crops. Beside maize, wheat is more efficient in using the available soil water reserves given the regional climate predictions over 2020-2050 as against the current conditions due to higher CO_2 assimilation rates, though this

interaction can be restricted by higher temperatures and smaller amounts of available soil water.

5. The results shown in this paper are very important and they can contribute to laying the grounds of and developing management options to adapt to and mitigate climate change-related negative effects affecting crop systems.

ACKNOWLEDGEMENTS

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