International workshop and course for decion makers on the effective use of water in agricultural crop production

October 6-8.10.2008, Jois, AUSTRIA

The effective use of water in Romanian agricultural crop production and specific measures for adaptation to climate change impact

METEO ROMÂNIA

Dr. Elena Mateescu & Dr. Adriana Marica
National Meteorological Administration, ROMANIA

Presentation outline

⇒ Introduction

⇒ Assessment of climate change effects on water use efficiency in different agricultural crop production, using the CERES type simulation models and different climate change scenarios;

⇒ Recommendation to improve effective use of water by crops - a case study for the pilot station Calarasi);

⇒ Specific measures for adaptation to climate change and for mitigation of agricultural impacts on climate: good practices for farmer benefits/ Romania "The Guide for Adaptation to climate change effects", by Ministry Ordinance No. 1170/29.09.2008;

⇒ Conclusions.

Introduction

⇒ Climate is one of the most important factors determining the productivity pf agricultural production systems;

⇒ Changes in climate, which are likely to occur during future decades, may have significant consequences on agriculture in Romania;

⇒ The aim of this paper is to make decision makers and farmers sensitive to possible consequences of climate change and to offer suggestions in taking appropriate adaptation and mitigation options;

⇒ The concept of Good agricultural Practices has evolved in recent years us a result of the concerns and commitments of a wide range of stakeholders about food production and security, food safety and quality, and the sustainability of agriculture. Good practices may greatly help to decrease vulnerability of agriculture with respect to climate change and variability.

Climate change effects on crop water use efficiency

depend on:

- **genetic type of crop (C3 or C4)**
- **severity of climate change scenarios**
- **levels of CO_2 concentration**
- **local climate conditions (drought / humid conditions)**

and

can be:

- ***positive:*** because increased CO_2 improves growth by enhancing photosynthesis and tends to close stomata and slow down the rate of water loss
- ***negative:*** because drought stress caused by higher evapotranspiration and reduced summer rainfall will result in decreasing yield and WUE

Reasons for choosing winter wheat and maize crop:

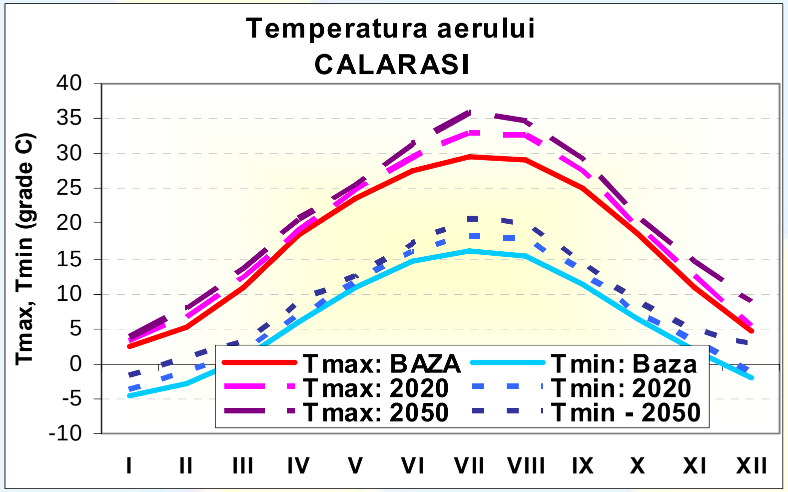
- winter wheat and maize crop are strategic crops cultivated in one of the most vulnerable zones of Romania;
- winter wheat and maize crop are different plants from the genetic point of view, so their response to increased CO2 level is different;
- maize crop is sensitive to water availability, especially in the silking/grain-filling phases, while winter wheat crop is a less water consumptive crop, but is sensitive to water stress in the anthesis phase.

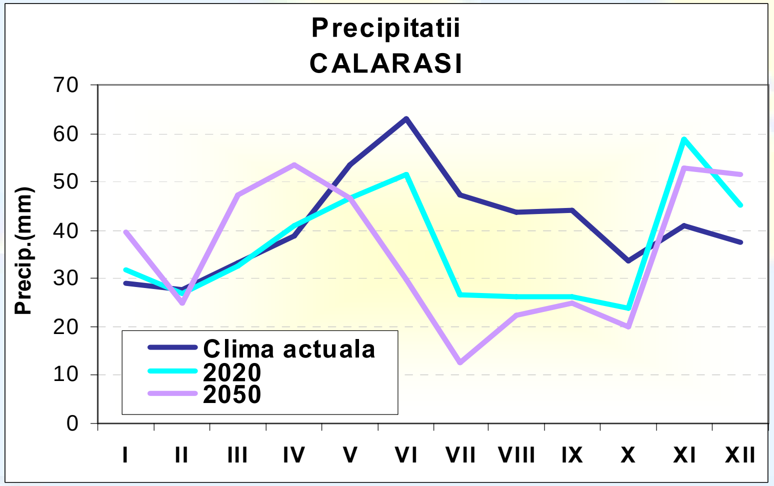
Climate change scenarios used in this study are based on the outputs from global and regional climate models (AOGCMs/RegCM):

- HadCM3/2020s/2050s/SRES A2
- RegCM/2080-2099/SRES A1B

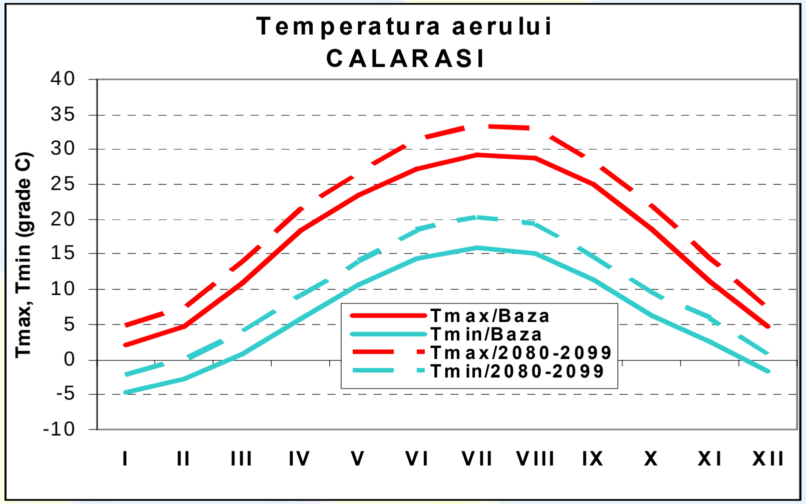
Projected changes in monthly means of min and max temperature and precipitation for decades 2020, 2050, and the period 2080-2099 against the current climate (1961-1990)

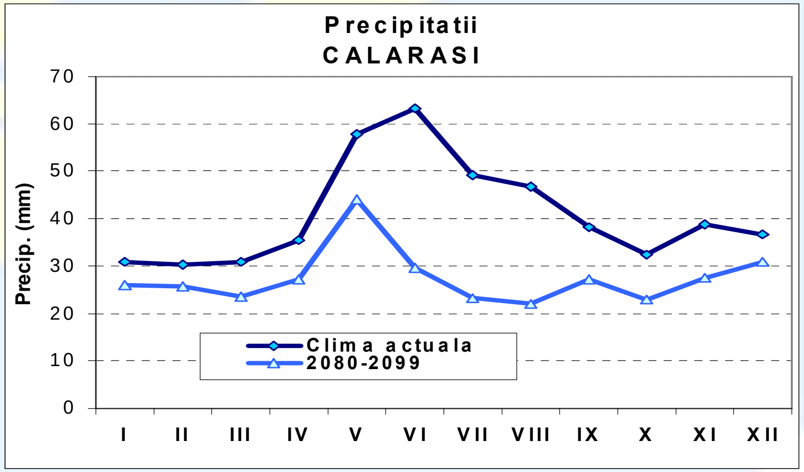
HadCM3 / 2020s / 2050s / SRES A2



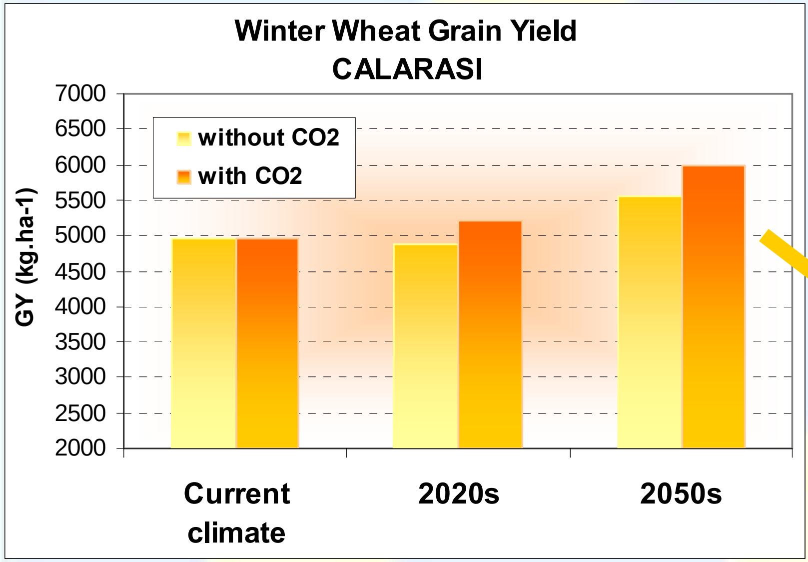


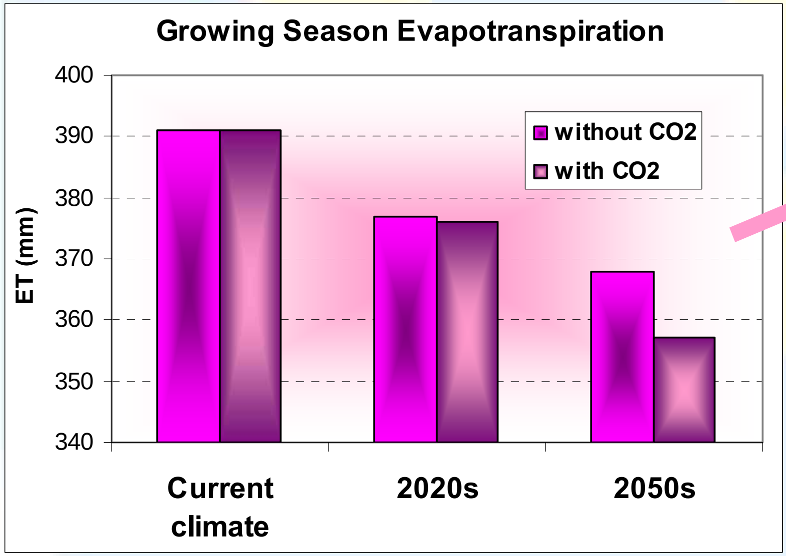
RegCM / IPCC / 2080-2099 / SRES A1B

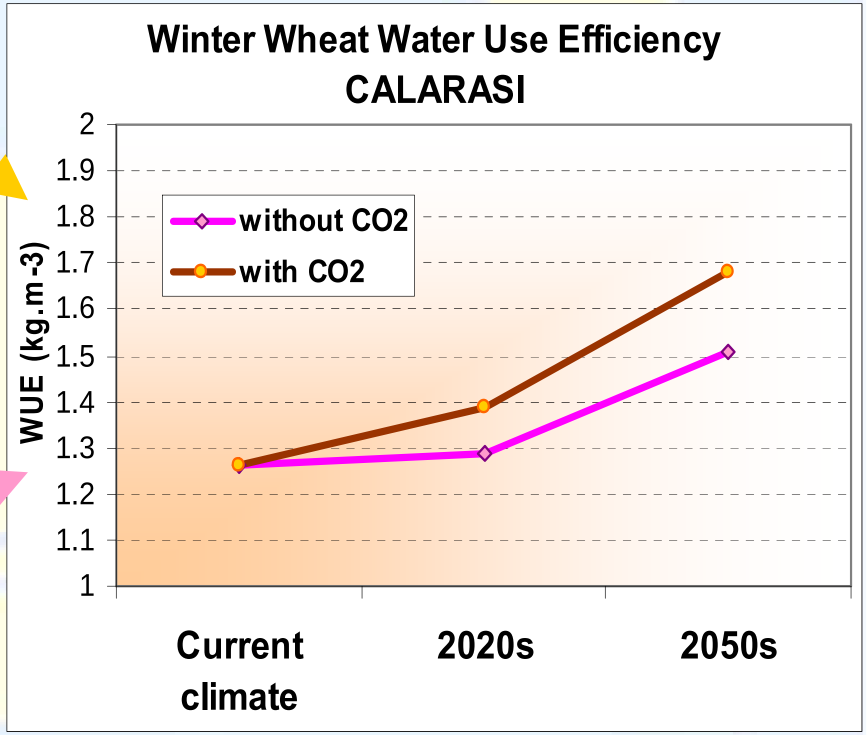




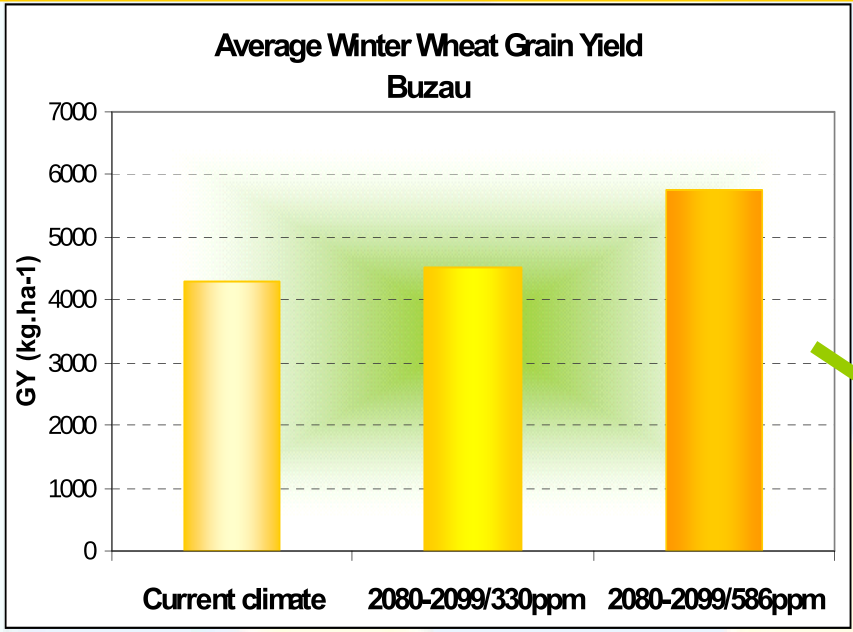
Winter Wheat / HadCM3/2020s / 2050s/ SRES A2 scenario

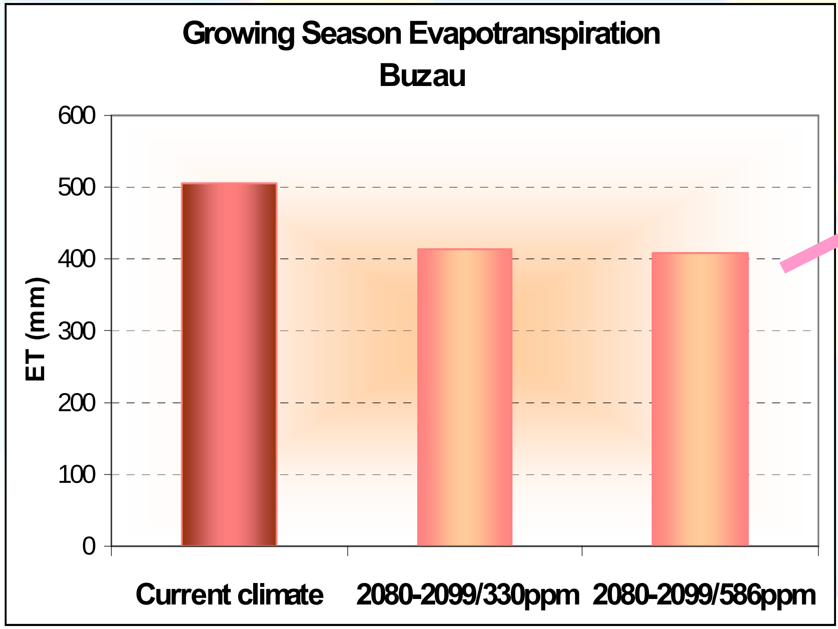


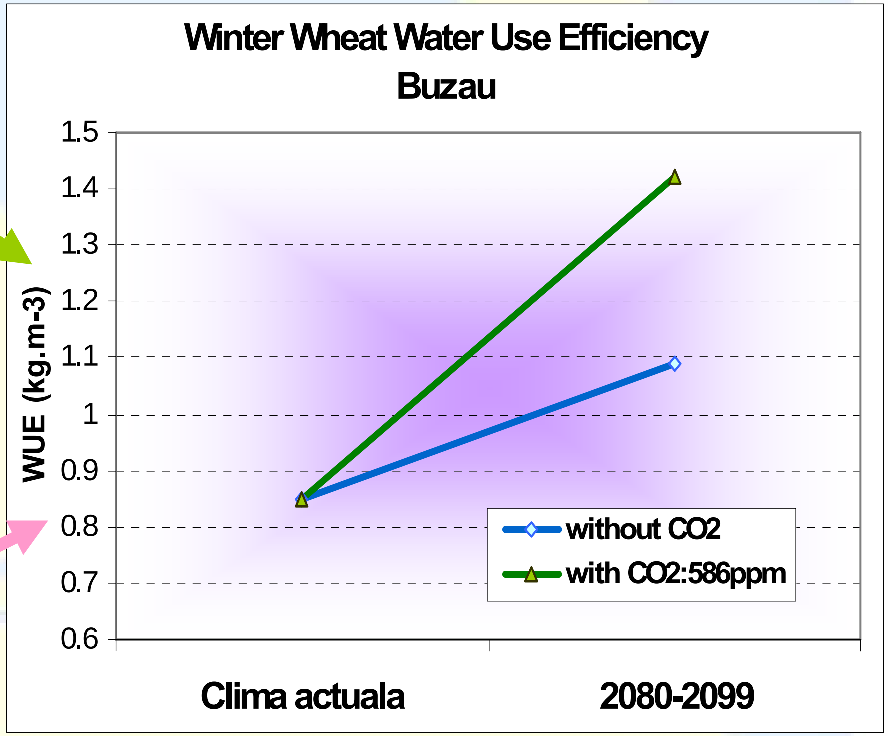




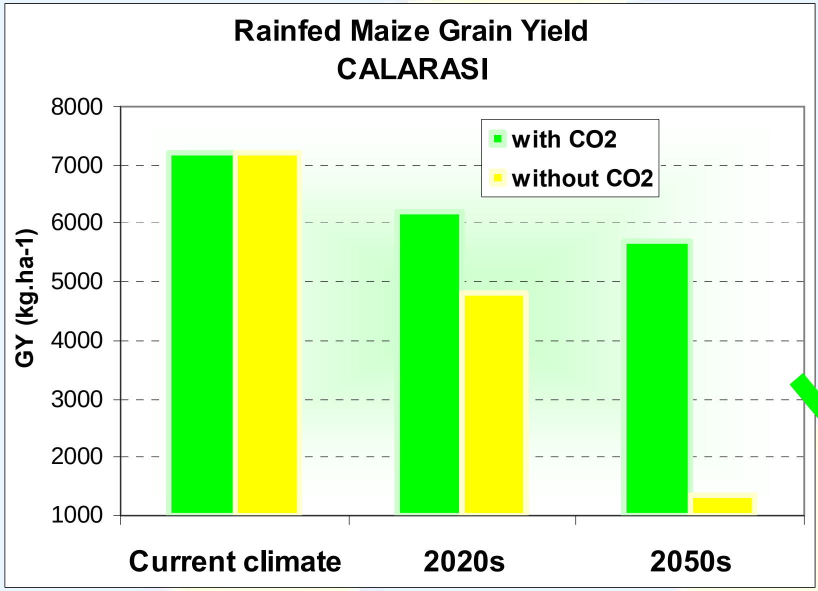
Winter Wheat / RegCM / IPCC / 2080-2099/SRES A1B scenario

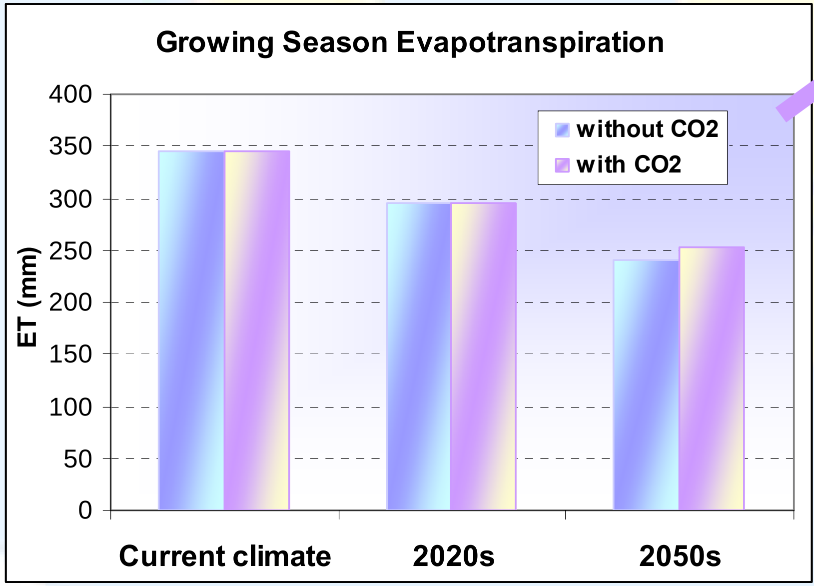


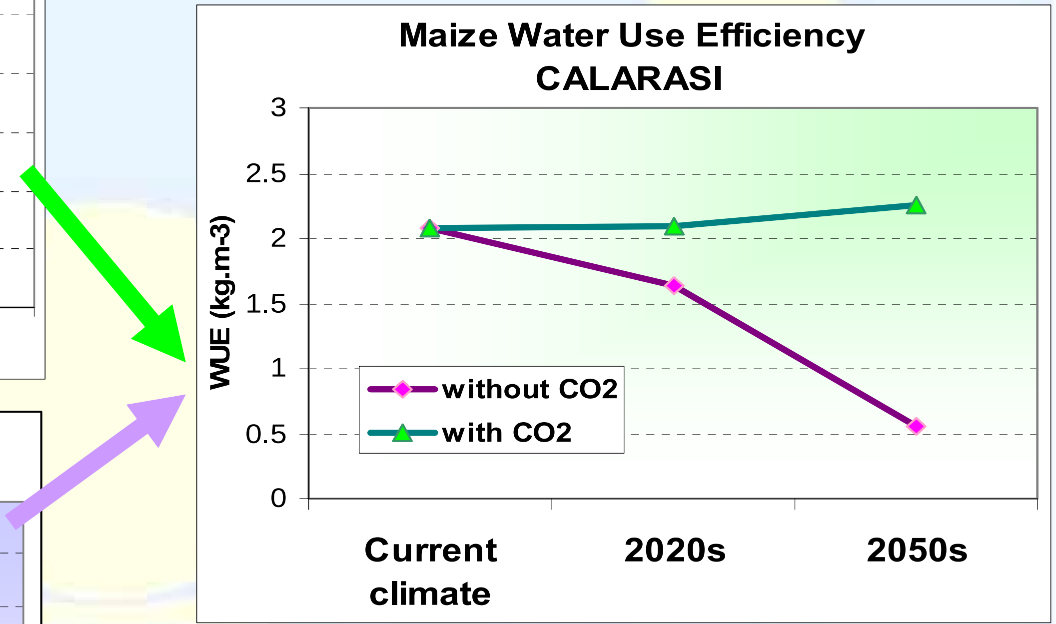




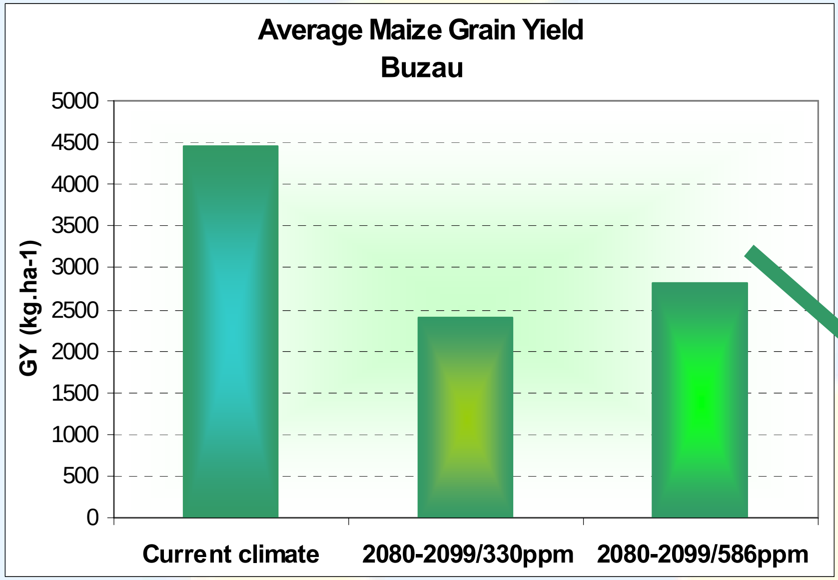
Maize
HadCM3/ 2020s / 2050s/ SRES A2 scenario

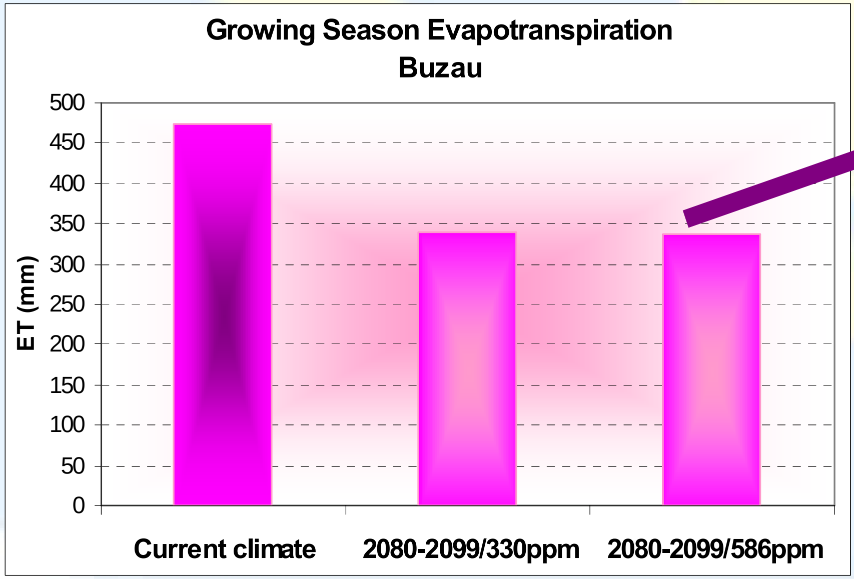


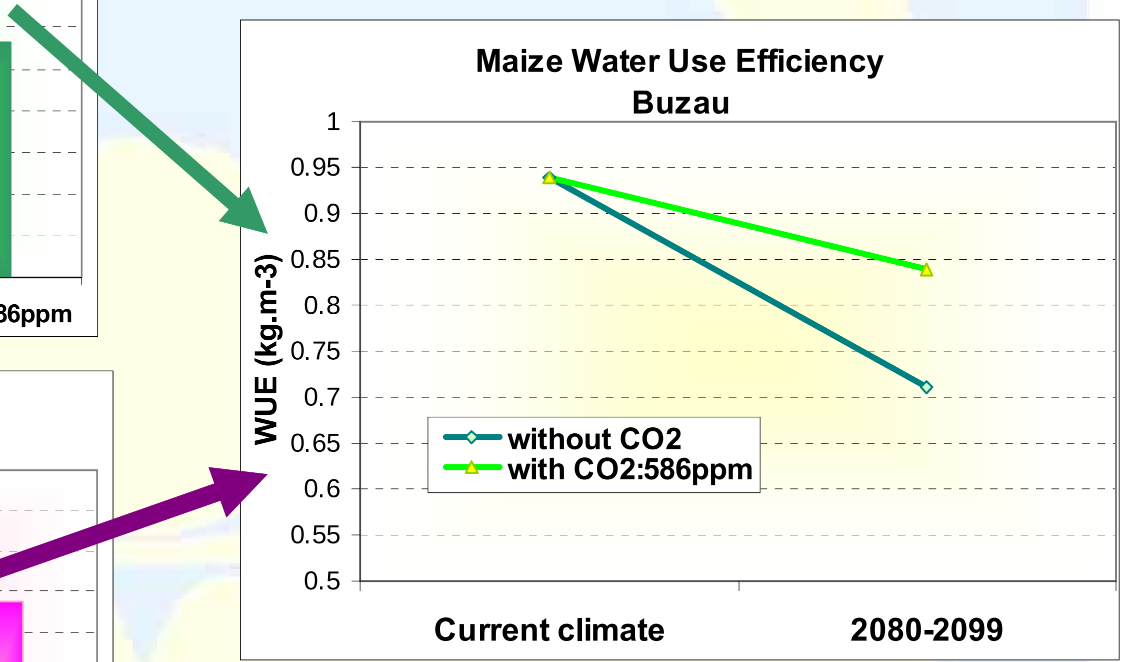




Maize
RegCM / IPCC /2080-2099/SRES A1B scenario

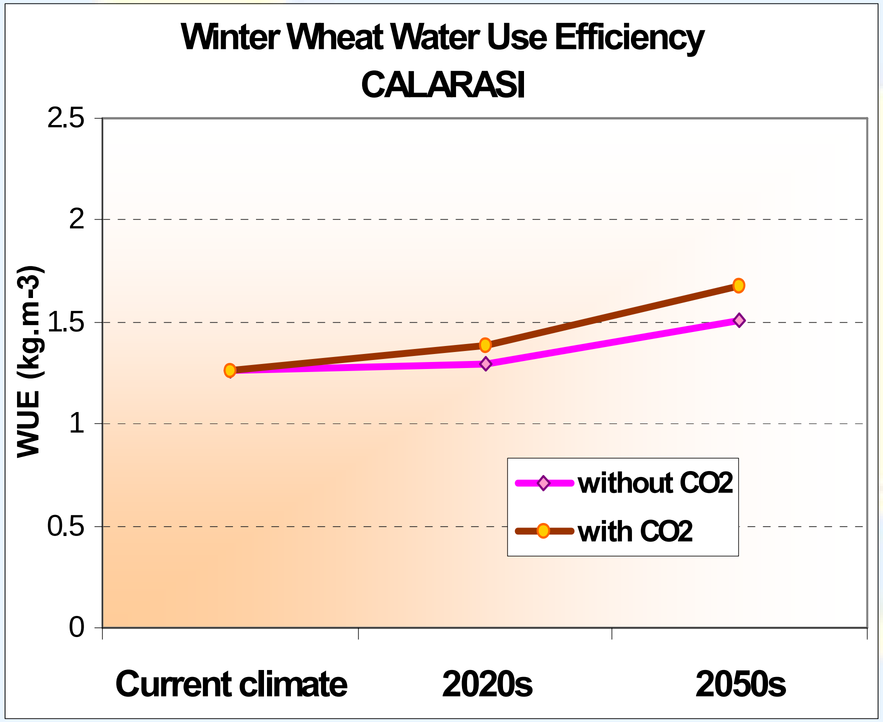


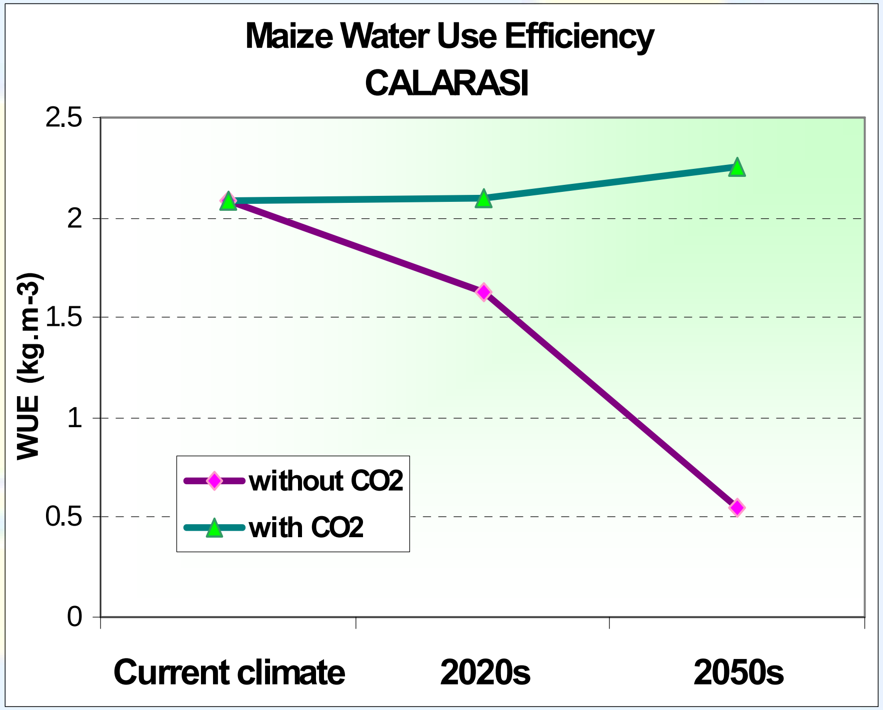




Comparison between
Winter wheat & Maize Water Use Efficiency

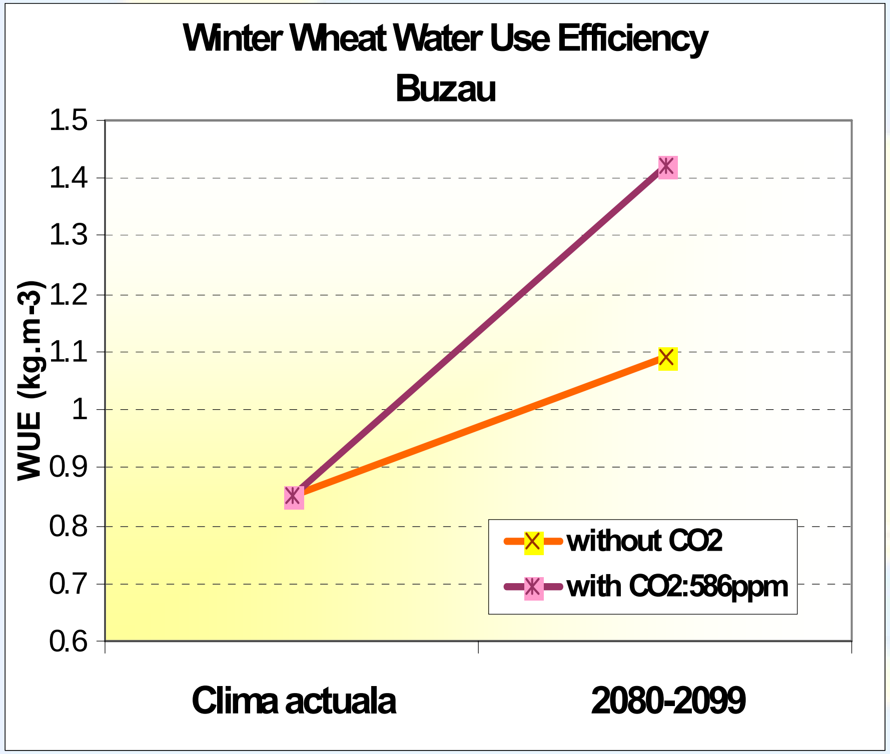
HadCM3 / 2020s / 2050s / SRES A2 scenario

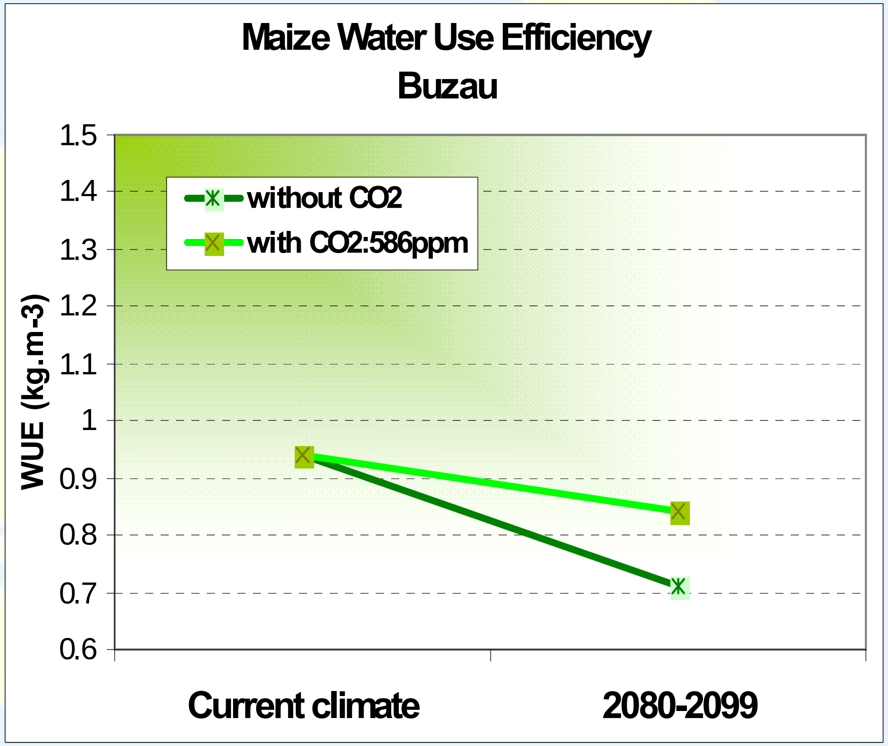


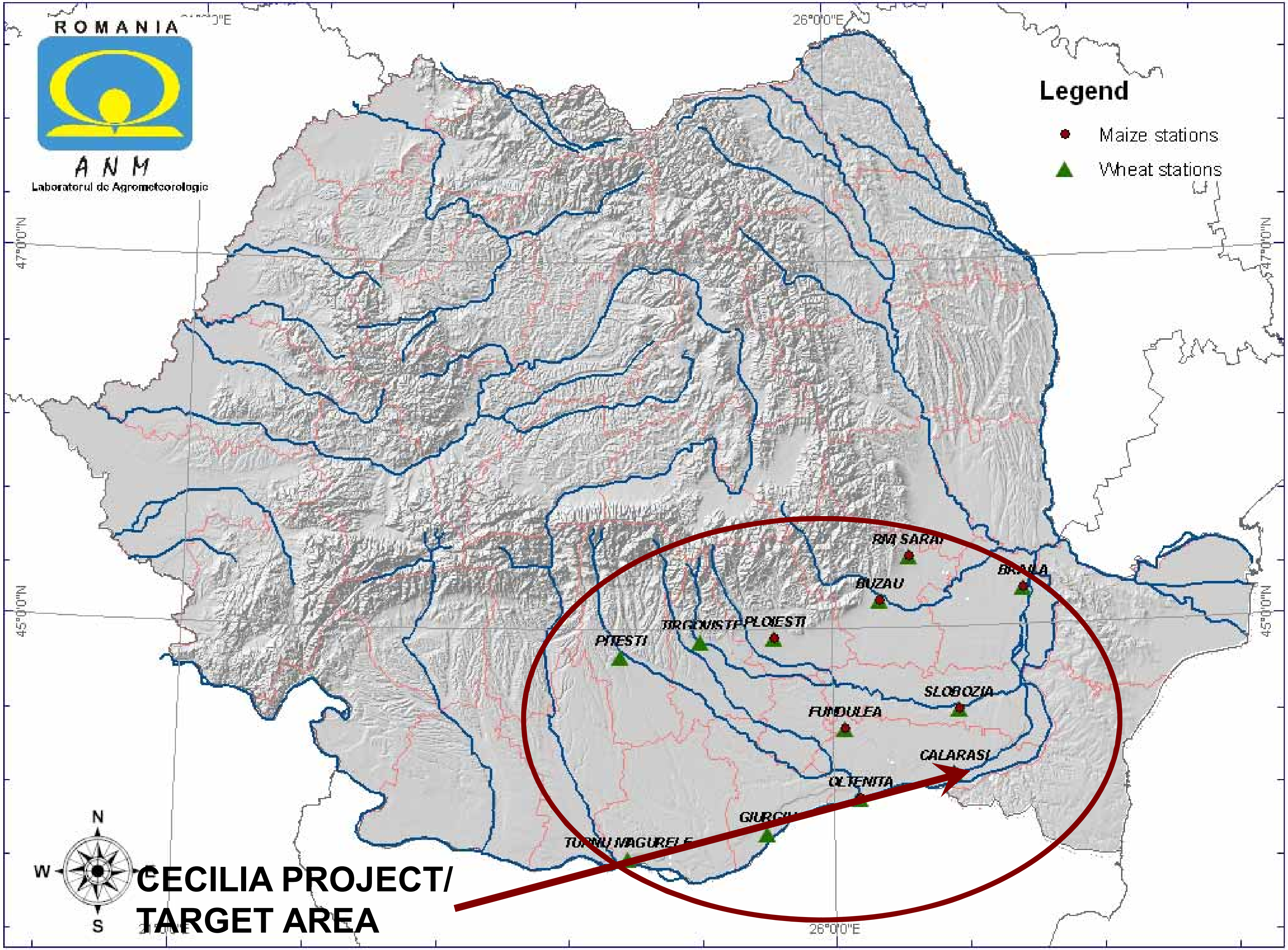


Comparison between Winter wheat & Maize Water Use Efficiency

RegCM / IPCC / 2080 -2099 / SRES A1B scenario



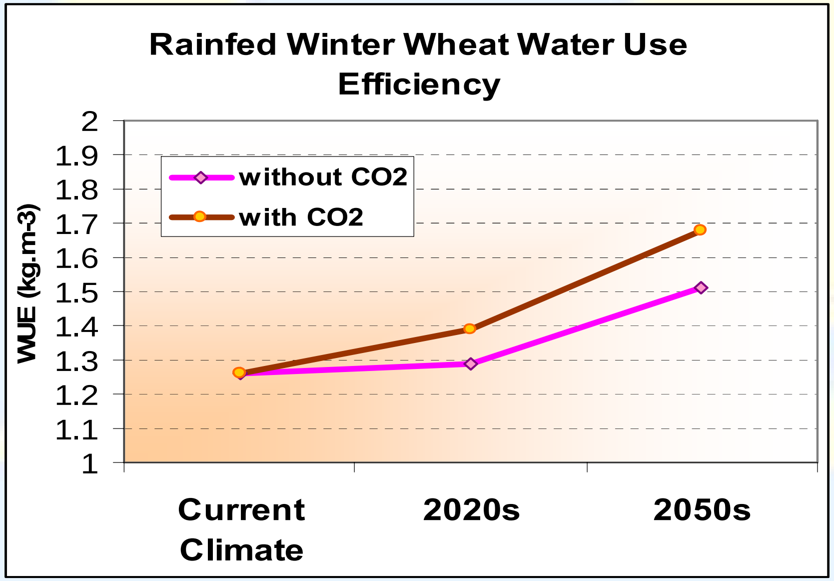


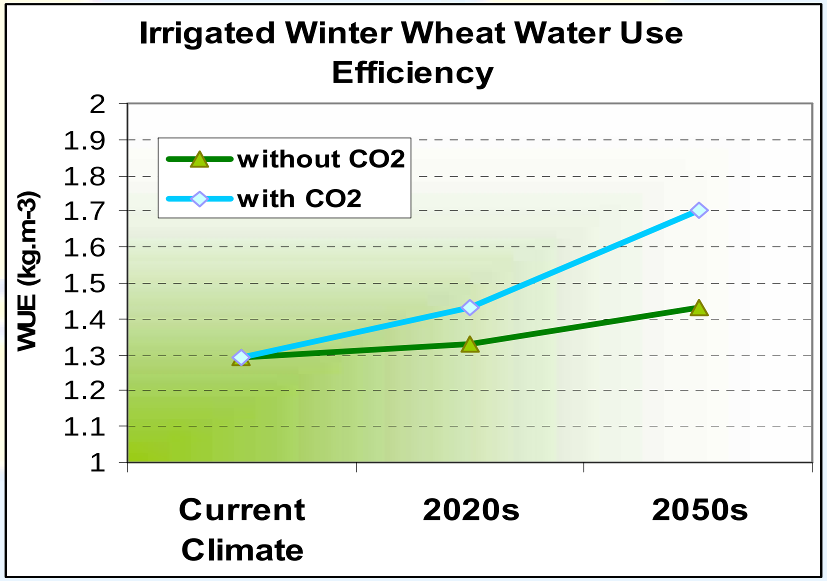

ROMANIA
ANM
Laboratorul de Agrometeorologie
Legend
Maize stations
Wheat stations
26°0'0"E
47°0'0"N
45°0'0"N
RM SARAT
BRAILA
BUZAU
TIRGOVISTE
PLOIESTI
PITESTI
SLOBOZIA
FUNDULEA
CALARASI
OLTENITA
GIURGIU
TURNU MAGURELE
N
W
S
CECILIA PROJECT/
TARGET AREA

Recommendations to improve effective use of water by crops - a case study for Calarasi site

I. Application of irrigation / Winter wheat

Specific.	Scenario	Rainfed GY (kg.ha-1)	Rainfed ET (mm)	Rainfed WUE (kg.m^{-3})	Irrigated GY (kg.ha-1)	Irrigated ET (mm)	Irrigated WUE (kg.m^{-3})
Without CO_2	**Base** 2020s 2050s	**4945** -1.5% +12%	**391** -3.6% -5.9%	**1.26** +2.4% +19.8%	**5833** -1.2% -	**452** -4.0% -9.7%	**1.29** +3.1% +10.9%
With CO_2	2020s 2050s	+5.6% +20.9%	-3.8% -8.7%	+10.3% +33.3%	+3.9% +13.0%	-6.2% -14.2%	+10.9% +31.8%

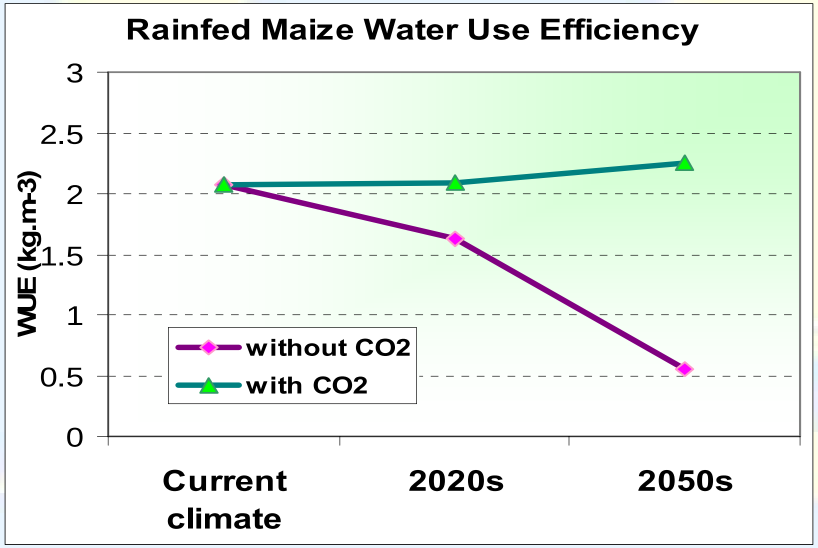




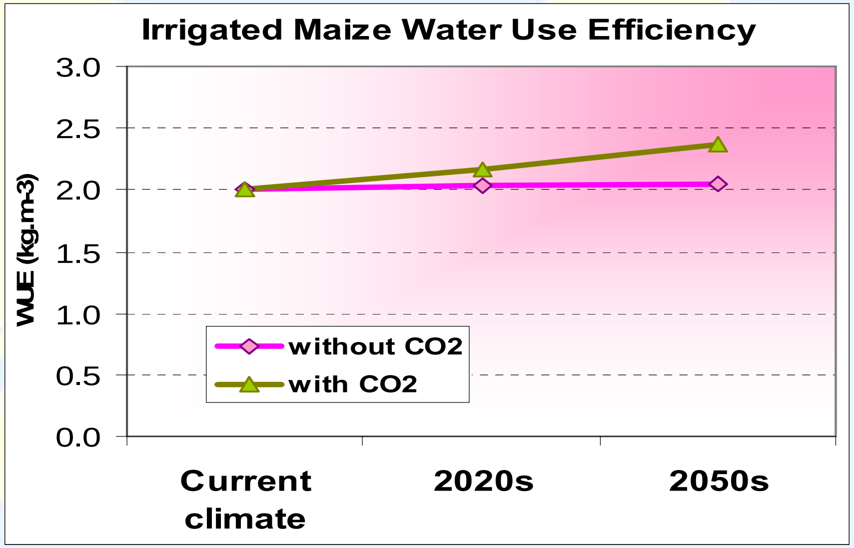
Winter wheat crop uses the available soil water more efficiently in both scenarios, particularly in the case of 2050 scenario, Taking into account the CO2 effect on both rainfed and irrigated winter wheat, the WUE increases significantly by 10-11% in 2020 and by 32-33% in 2050, compared with the current conditions, due mainly to the increased CO2 assimilation rate

I. Application of irrigation / Maize

Specific.	Scenario	Rainfed GY (kg.ha-1)	Rainfed ET (mm)	Rainfed WUE ($kg.m^{-3}$)	Irrigated GY (kg.ha-1)	Irrigated ET (mm)	Irrigated WUE ($kg.m^{-3}$)
Without CO_2	**Base**	**7196**	**346**	**2.08**	**10198**	**510**	**2.0**
	2020s	-32.9%	-14.4%	-21.6%	-3.9%	-5.5%	+1.5%
	2050s	-81.5%	-30.3%	-73.5%	-9.8%	-12.2%	+2.5%
With CO_2	2020s	-13.7%	-14.4%	+0.1%	-2.9%	-10.2%	+8.0%
	2050s	-20.8%	-26.9%	+8.2%	-8.6%	-23.1%	+19.0%



In the rainfed conditions, without taking into account the CO2 effect, WUE decreases significantly by 22% in 2020 up to 74% in 2050

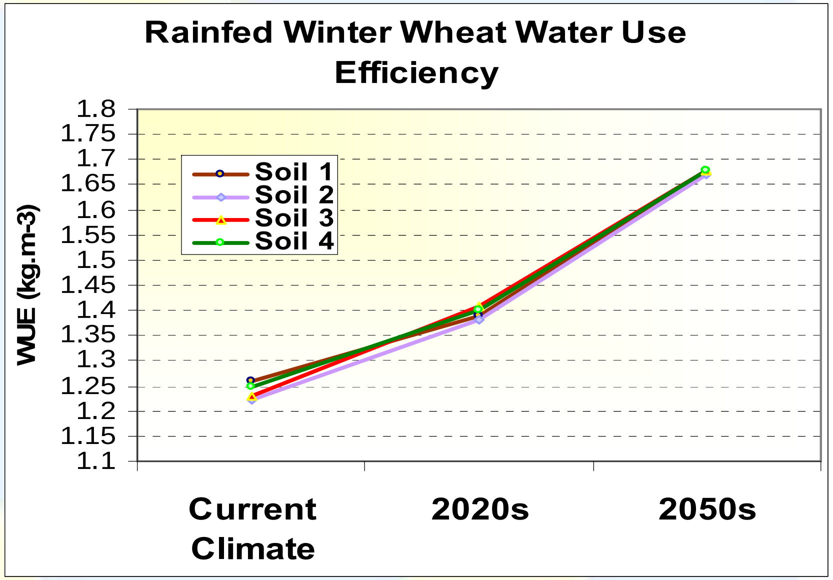


By application irrigation, the water use efficiency increases for both scenarios by 1.5-2.5% (without CO2) up to 8-19% (with CO2), compared with the current climate

II. Using different soil classes

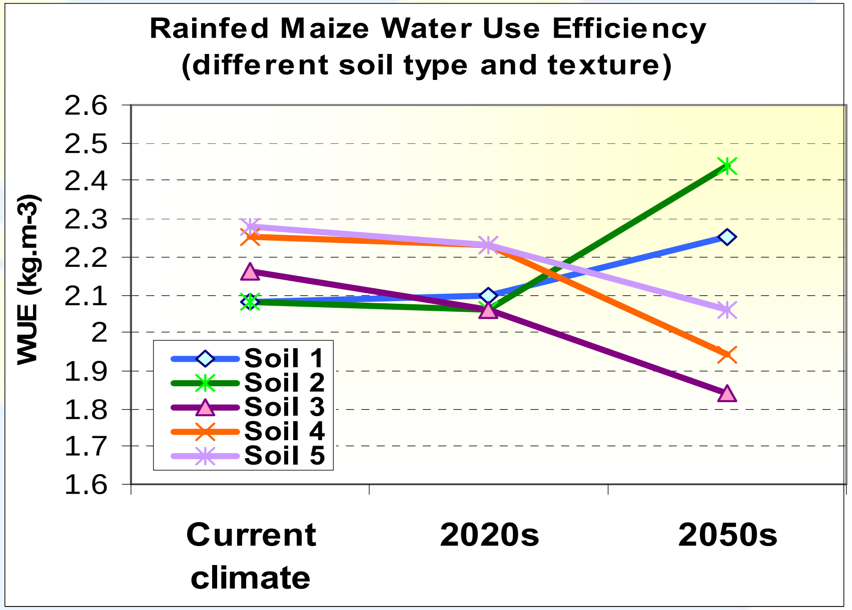
Soil classes	WUE ($kg.m^{-3}$) Base	WUE ($kg.m^{-3}$) 2020s	WUE ($kg.m^{-3}$) 2050s
Soil 1: Cambic chern.-clay loam	1.26	1.39	1.68
Soil 2: Cambic chern.-clay	1.22	1.38	1.67
Soil 3: Cambic chern.-sandy loam	1.23	1.41	1.68
Soil 4: Brown reddish-fine loamy sand	1.25	1.40	1.68

Winter wheat WUE shows an increasing trend for all soil classes, but there are not differences between the four soil classes

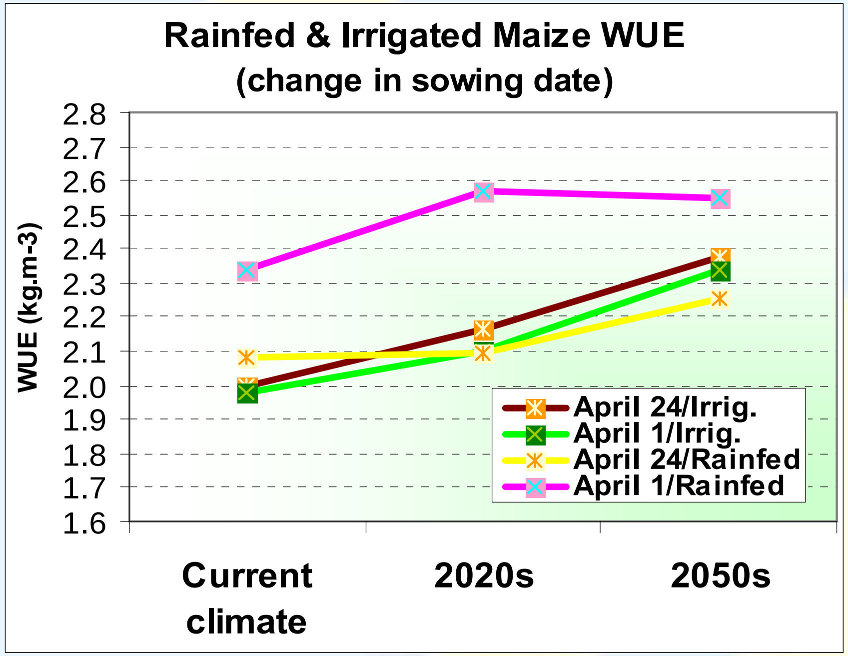


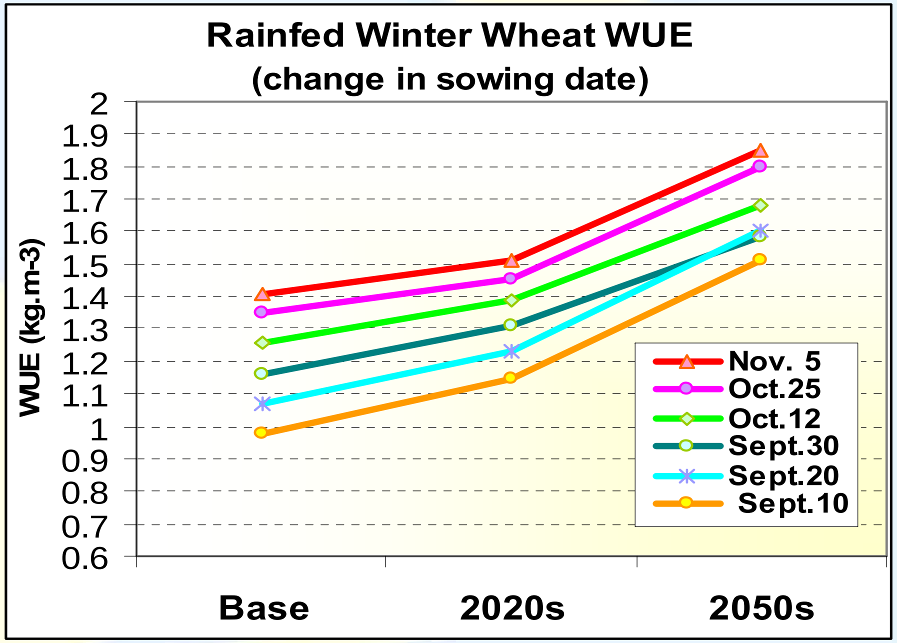
Soil classes	WUE ($kg.m^{-3}$) Base	WUE ($kg.m^{-3}$) 2020s	WUE ($kg.m^{-3}$) 2050s
Soil 1: Cambic chern.-clay loam	2.08	2.10	2.25
Soil 2: Cambic chern.-sandy clay	2.08	2.06	2.44
Soil 3: Cambic chern.-sandy loam	2.16	2.06	1.84
Soil 4: Brown reddish – clay	2.25	2.23	1.94
Soil 5: Brown reddish – fine loam	2.28	2.23	2.06

The highest increase of maize WUE, up to 8.2 -17.3% in 2050, can be expected for the medium Cambic Chernozems soils (sandy clay and clay loam).



III. Change in sowing date



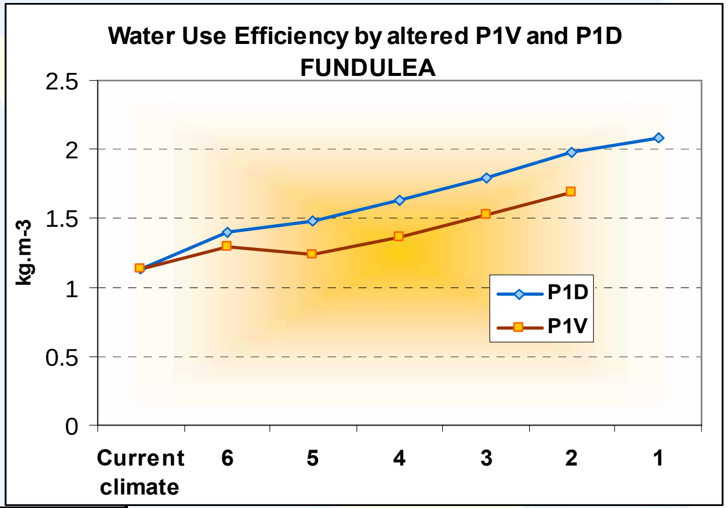


The predicted WUE of maize crop increases by 6.1-18.2% in both scenarios (2020s and 2050s), with an earlier sowing date (April 1) in comparison with current dates (April 24).

In the case of winter wheat, water is used more efficiently with the later sowing date, October 25 and November 5, respectively.

IV. Altered genetic coefficients (P1V and P1D) for genotype selection

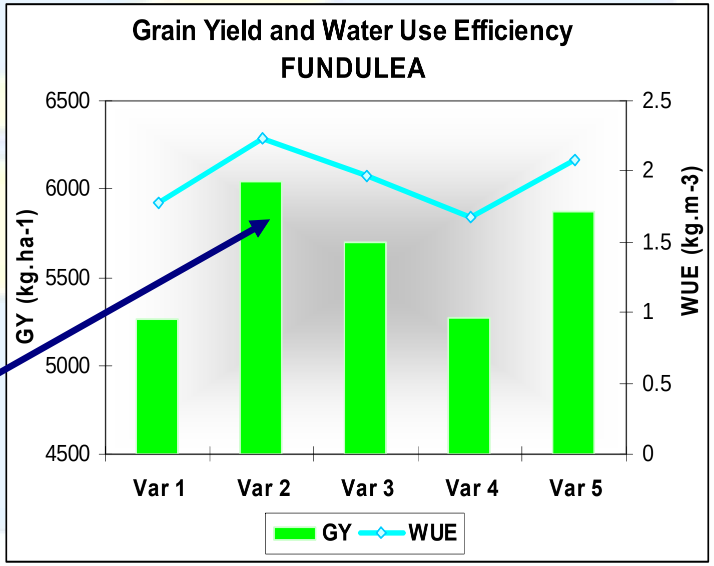
Specific.	Current climate P1V=6.0	P1V=6.0	2080-2099 P1V=5.0	SRES A1B P1V=4.0	scenario P1V=3.0	P1V=2.0
GY (kg.ha-1)	4656	4395	4073	4543	4996	**5256**
ET (mm)	410	337	329	332	326	311
WUE (kg.m-3)	1.13	1.30	1.24	1.37	1.53	1.69



Specific.	Current climate P1D=4.0	P1D=4.0	2080-2099 P1D=3.5	SRES A1B P1D=3.0	scenario P1D=2.5	P1D=2.0	P1D=1.0
GY (kg.ha-1)	**4656**	4719	4882	5234	5582	5830	**5869**
ET (mm)	410	336	329	322	311	294	282
WUE (kg.m-3)	1.13	1.40	1.48	1.63	1.79	1.98	2.08

Specific.	Var 1 P1V=2/P1D=1	2080-2099 Var 2 P1V=3/P1D=2	SRES A1B Var 3 P1V=4/P1D=2.5	scenario Var 4 P1V=5/P1D=3	Var 5 P1V=6/P1D=1
GY (kg.ha-1)	5263	**6043**	5694	5267	5869
WUE (kg.m-3)	1.78	2.23	1.97	1.67	2.08

The most suitable combination: winter wheat varieties with moderate vernalization and low photoperiod requirements



Specific measures for adaptation to climate change and for mitigation of agricultural impacts on climate

► Romania approved "The Guide for Adaptation to climate change effects", by Ministry Order No.1170/29.09.2008;

►The Guide contain specific measures for 12 domains – biodiversity, agriculture, water resources, forests, infrastructure, tourism, energy, industry, insurance, etc;

►Each chapter – opportunities, risks and specific measures for adaptation;

►Agriculture sector – crop management and land use, pests and disease, soil erosion, fertilisation, water management – irigation, livestock management,

►The Ministry of Environment and Sustainable Development established for every institution specialized on the related fields (biodiversity, agronomy, forestry, hydrology, pedology, tourism, etc) responsabilities to evaluate the current status of the results/studies and next steps to implement a National Research Program, for 2009-2013 period.

Good practices for farmer benefits / *Code of Attitudes*
This measures summarizes risks for agriculture that are due to climate change.

1. Crop management and land use

1.1. Varietal selection

Good practices

- Use of cultivars resistant to abiotic stresses (i.e. water shortage, drought, high temperature;
- Selection of cultivars with shorter germination period and shorter growing season;
- Selection of varieties that are naturally resistant to specific diseases.

Farmer benefits

- Improved water management in agriculture
- Better use of the soil moisture conditions after sowing
- Increased yield production with less chemicals
- Reduced CO_2 emissions and increased yield and biomass production

1.2. Cropping system

Good practices

- Use of adapted crop rotation as main crop system for the farm.
- Use of mixed cropping, catch cropping, cover cropping, as multiple crop in the same space or in the farm to increase biodiversity.

Farmer benefits

- Reduction of the effect of adverse weather, through planting and harvesting at different times.
- Improving soil structure and fertility and organic matter by alternating deep-rooted plants.
- Slower trends of spreading of pest and diseases during the growing season.
- Balance of the fertility demands of various crops to avoid excessive depletion of soil nutrients.

1.3. Practices favouring C sequestration

Good practices

- Planted fallows, cover crops and catch crops.
- Conservation tillage and mulch farming techniques, to reduce soil emissions of CO_2.
- Forestation and agro forestry.
- Science-based agriculture with judicious chemical inputs.

Farmer benefits

- Reduction of tillage costs.
- Reduced soil degradation, erosion, and salination.
- Better protection of land from desertification and degradation (erosion).
- Improved crop production, reduced soil and underground water pollution, more efficient use of natural resources.

2. Soil management and fertilization

2.1. Erosion control: water erosion

Good practices

- Maintain crop residue cover above 30 percent until crop canopy closure.
- Alternate summer crops with winter crops and perennial crops.
- Use cover crops during periods when the soil would have insufficient residue.
- Contour farming – crops are planted nearly on the contour (especially for moderate slopes, 2-6%).
- Contour strip-cropping – alternating strips with high-residue cover or perennial crops with strips with low residue cover. The strips should be laid out close to the contour.
- Construction of level terraces.

Farmer benefits

- Soil surface directly exposed to rain drops splash is reduced.Increase the time with vegetation cover.
- Reduces runoff and rain splash.
- Protection from water erosion on moderate slopes.
- Soil eroded from the bare or low-residue strips is deposited in strips with high residue or dense vegetation because runoff is decreased.
- Change of slope steepness.

2.2. Erosion control: tillage erosion

Good practices

- Eliminate or reduce tillage.
- If it is not possible to eliminate tillage, it is recommended to avoid down-hill plowing. It is beneficial to plow on the contour or uphill.
- Turn soil uphill with contour tillage (not recommended for steep slopes).
- Transport topsoil from depositional areas to hill crests.

Farmer benefits

- Tillage erosion can be completely eliminated.
- Reduced erosion and maintenance of more constant yields.
- Reduced tillage erosion.
- Rehabilitation of eroded slopes.
- Better use of plant nutrients.

2.3. Tillage methods

Good practices

- Convert to a no-till tillage management system.
- If tillage is necessary, avoid autumn tillage and wait for spring.
- Reduce the number of tillage passes.
- Set chisels and disks to work shallower.
- Drive slower on tillage operations.

Farmer benefits

- Better protection of land against erosion, degradation; reduced amount of tractor power, fuel, etc.
- Fuel economy, reduced costs, and reduced soil compaction.
- Reduced drag of the chisels and disks, with implications in fuel economy. In addition, soil moisture is better conserved.
- Driving fast throws more soil and covers residue, with negative impact on preserving soil moisture.

2.4. Mineral fertilization

Good practices

- Adapt or optimize the application of mineral fertilizers, especially nitrogen.
- Use crop rotation systems.
- Perform periodical soil analysis and tests, in order to assess and correct the limiting factors which hinder the normal growth and development of plants (acidity, nutrient excess or deficit, etc.).
- Use of natural organic fertilizers, adapted to needs/demands.

Farmer benefits

- Lower soil and underground water pollution with nitrates.
- Preservation and improvement of the natural soil fertility.
- Creation of adequate mineral nutrition conditions based on accurate information from soil testing.
- Reduced costs, use of readily available by-products of the farm (manure), and less negative impact on soil and water quality in the farm, compared to using mineral fertilizers.

2.5. Organic matter and fertilization

Good practices

- Use of minimum tillage techniques to decrease speed of organic soil matter degradation.
- Add natural organic fertilizer to improve fertility of cultivated soil. Natural organic fertilisers are produced by agricultural and livestock farms or obtained from vegetation material. They can be fresh and in different stages of fermentation. The most widespread natural organic fertilisers are produced by animal husbandry. Among the most important natural organic fertilisers are manure (that can be used fresh, partially or completely fermented), liquid animal waste (also called slurry), compost and green manure mixed with vegetal materials used for bedding. (see glossary for definition of manure, compost and green fertilizers).

Farmer benefits

- Increasing soil fertility and amount of carbon in the soil that promote the grow of beneficial bacteria. Organic matter may be considered as "revolving nutrient bank account". It gives and absorbs nutrients in plant available form.
- Improving soil structure, aeration, water infiltration and resistance to erosion and crusting by binding small soil particles into larger aggregates.
- Increasing the nutrient holding capacity (caption exchange capacity) and other soil properties by the resistant or stable fraction of soil organic matter.
- Higher water holding capacity.

3. Water management

3.1. Irrigation best management practises

Good practices

- Rate irrigation highly within the management system.
- Know the soils property like capacity of soil to hold water, and where in the soil profile the roots of the crop are.
- Design and maintain irrigation systems correctly. Irrigation system setup, age, and maintenance are limiting factors in their ability to manage irrigation
- Monitor all aspects of each irrigation event before, during and after the irrigation. Deciding of when, monitoring of where water is going, both during the irrigation, by measuring system performance and uniformity of application, and after the irrigation, by assessing under- and over-irrigation.
- Use more than one objective monitoring tools to schedule irrigation. The most common and simplest included digging holes to check soil water, observation of the appearance of plants, and the checking of test-wells or drain flows after irrigation and subsequent adjustment in practice at the next irrigation.
- Retain control of irrigation scheduling. With modern technology, it is possible to set up irrigation systems to operate entirely automatically, based on the readings from a probe or a set of probes.
- Use software for water balance, running on personal computers or on web servers. Models for practical use must be simple, avoiding too many parameters, useful only for experimental purposes.

Farmer benefits

- Optimal use of irrigation water.

3.2. Choosing an irrigation method

Good practices

Choose the most suitable irrigation method according to the following natural conditions:

- **Soil type:** sandy soils have a low water storage capacity and a high infiltration rate. They therefore need frequent but small irrigation applications, in particular when the sandy soil is also shallow. Under these circumstances, sprinkler or drip irrigation are more suitable than surface irrigation. On loam or clay soils all three irrigation methods can be used, but surface irrigation is more commonly found. Clay soils with low infiltration rates are ideally suitable for surface irrigation. When a variety of different soil types is found within one irrigation scheme, sprinkler or drip irrigation are recommended as they will ensure a more even water distribution.
- **Slope:** Sprinkler or drip irrigation are preferred above surface irrigation on steeper or unevenly sloping lands as they require little or no land leveling. An exception is rice grown on terraces on sloping lands.
- **Climate:** Strong wind can disturb the spraying of water from sprinklers. Under very windy conditions, drip or surface irrigation methods are preferred. In areas of supplementary irrigation, sprinkler or drip irrigation may be more suitable than surface irrigation because of their flexibility and adaptability to varying irrigation demands in the farm.
- **Water availability:** Water application efficiency is generally higher with sprinkler and drip irrigation than surface irrigation and so these methods are preferred when water is in short supply. However, it must be remembered that efficiency is just as much a function of the irrigator as the method used.
- **Water quality:** Surface irrigation is preferred if the irrigation water contains much sediment. The sediments may clog the drip or sprinkler irrigation systems and increasing cost of maintenance. If the irrigation water contains dissolved salts, drip irrigation is particularly suitable, as less water is applied to the soil than with surface methods. Sprinkler systems are more efficient that surface irrigation methods in leaching out salts.

3.2. Choosing an irrigation method

Choose the most suitable irrigation method considering:

- **Type of crop:** Surface irrigation can be used for all types of crops. Sprinkler and drip irrigation, because of their high capital investment per hectare, are mostly used for high value cash crops, such as vegetables and fruit trees. They are seldom used for the lower value staple crops. Drip irrigation is suited to irrigating individual plants or trees or row crops such as vegetables and sugarcane. It is not suitable for close growing crops (e.g. rice).
- **Type of technology**: The type of technology affects the choice of irrigation method. In general, drip and sprinkler irrigation are technically more complicated methods. The purchase of equipment requires high capital investment per hectare. To maintain the equipment a high level of 'know-how' has to be available. Also, a regular supply of fuel and spare parts must be maintained. Surface irrigation systems - in particular small-scale schemes - usually require less sophisticated equipment for both construction and maintenance (unless pumps are used). The equipment needed is often easier to maintain.
- **Previous experience with irrigation**: The choice of an irrigation method also depends on the irrigation tradition within the region or country. Introducing a previously unknown method may lead to unexpected complications. It is not certain that the farmers will accept the new method. The servicing of the equipment may be problematic and the costs may be high compared to the benefits. Often it will be easier to improve the traditional irrigation method than to introduce a totally new method.
- **Required labour inputs:** Surface irrigation often requires a much higher labour input - for construction, operation and maintenance - than sprinkler or drip irrigation. Surface irrigation requires accurate land levelling, regular maintenance and a high level of farmers' organization to operate the system. Sprinkler and drip irrigation require little land levelling; system operation and maintenance are less labour-intensive.
- **Costs and benefits:** Before choosing an irrigation method, an estimate must be made of the costs and benefits of the available options. On the cost side not only the construction and installation, but also the operation and maintenance (per hectare) should be taken into account. These costs should then be compared with the expected benefits (yields). It is obvious that farmers will only be interested in implementing a certain method if they consider this economically attractive.

3.3. Save-water techniques

Good practices

- Wind barriers to control soil water, wind erosion and ambient dust. The most common species for annual barriers is silage maize, although sunflowers are also popular.
- Mulching to reduce evaporation. A chaff spreader may be considered one of the least expensive and most effective soil and water conservation investments. Plastic mulches can be also used.
- Cover crop in orchards. It prevents degradation of soil structure, creating an optimal soil structure for water infiltration and storage, allowing moreover a better access to the trees for cultural and harvest activities.
- Reducing irrigated area in orchards. In situations of reduced water availability, it can sometimes be more profitable to provide optimum water to part of an orchard and produce good marketable fruit, rather than watering the whole orchard and producing small unmarketable fruit. Avoid to irrigate the inter-row space.

Farmer benefits

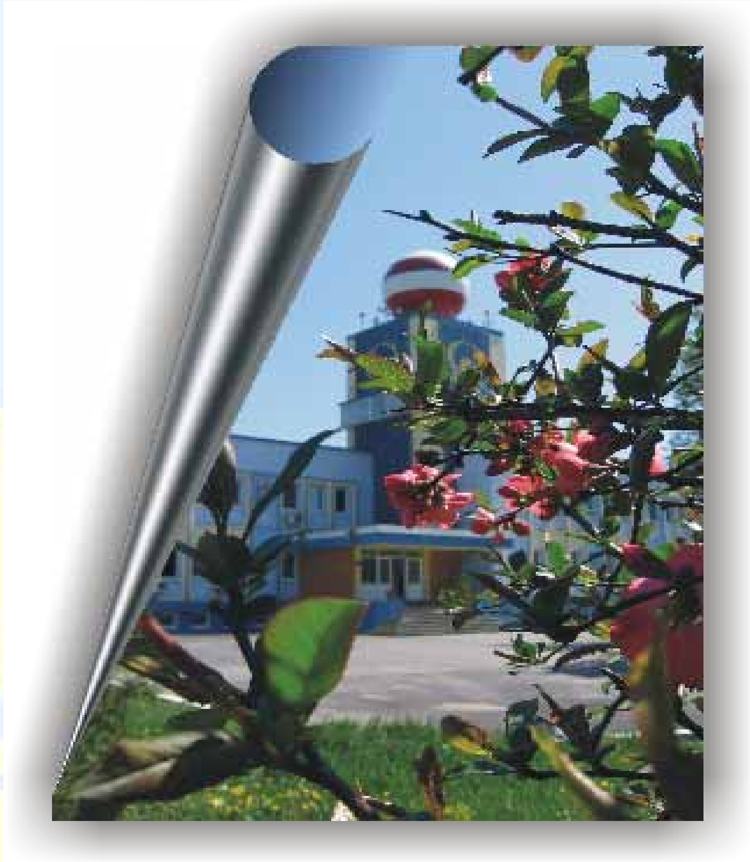
- Evaporation, transpiration and run-off are reduced.
- The soil structure and permeability are optimized.
- Crop yields are improved.

CONCLUSIONS

- Climate change effects on crop water use efficiency can be positive or negative depending on the crop type, severity of climate scenarios, CO_2 concentration levels and local climate conditions;
- The winter wheat WUE greatly increases under climate change conditions, particularly in the case of increased CO_2 levels;
- The maize WUE decreases
- Winter wheat crop used the soil available water more efficiently than maize;
- High CO_2 gives more grain yield for less water consumed;
- The irrigation application that increases grain yield and minimizes evapotranspiration is likely to increase more significantly the efficiency of water utilization by the both crops;

THANK YOU!

elena.mateescu@meteoromania.ro



http://www.meteoromania.ro