Snow Quality Influence on Overwintering of Winter Cereal

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PHYSICAL KNOWLEDGE

- Snow is a bad heat conductor; it protects the soil from cooling if the air temperature and the snow surface are below 0 ° C.
- The insulation effect of the snow is the stronger the brighter it is; in snow filled with water or icy the insulation effect goes down;
- At the temperature above 0 °C, the effect of snow on soil temperature is the opposite. It continues even after melting, because at the time the top layer of soil is saturated with water.

PHYSICAL KNOWLEDGE – CONTINUED

- Snow reduces soil temperature fluctuations, i.e. soil temperatures fluctuations without snow cover are much higher;

- The warming effect of the snow exceeds the cooling effect, the longer the snow cover lies after the frost.

SNOW DENSITY

- Snow density is the ratio of the volume of snow water equivalent to the taken snow volume.
- For freshly caught snow it is from 0.04 to 0.10 (60 to 100 $kg.m^{-3}$).
- Mellow snow density is 0.6 to 0.7 (up to 300 $kg.m^{-3}$).

DENSITY OF FRESHLY SNOWED SNOW DEPENDING ON AIR TEMPERATURE

Air temperature	Snow density		
	Minimum	Middle	Maximum
< -10	0,01	0,07	0,23
-10 to -5	0,01	0,09	0,30
-5 to +5	0,04	0,11	0,45
0 to 2	0,07	0,18	0,53
> 2	0,16	0,20	0,59

FURTHER ON THE DENSITY OF THE SNOW

- During winter, the density of snow cover increases by 10% per month.
- In the winter months, there is an average of 0.2, at the end of winter 0.3 (or more).
- The thermal conductivity of the snow is 10x higher than air and 10x lower than the mineral soil particles.

HEAT TRANSFER COEFFICIENT

- The heat transfer coefficient expresses the properties of the interfaces of two substances of different states in terms of heat dissipation by convection;
- It depends on the type of substances, their states, temperatures and the shape of the interface;
- It is determined by the ratio of the heat flux density at the interface and the temperature difference between the respective substances.

HEAT TRANSFER COEFFICIENT

- $\alpha = \varphi/\Delta T$,

  where φ ... heat density
- Expresses heat output per unit area;
- It is determined by the proportion of the heat flow and the area though it flows perpendicularly.

HEAT TRANSFER COEFFICIENT

- In monitoring of the dynamics of snow cover changes, we preferred a more accurate monitoring of its density and water equivalent, through which it was possible to determine
- HEAT EXCHANGER COEFFICIENT, important for assessing the conditions for wintering of winter cereals.

HEAT TRANSFER COEFFICIENT

- At a snow density of 0.20, the heat transfer coefficient $\alpha = 16.75\ W \cdot m^{-2} \cdot deg^{-1}$
- At a density of 0.30, $\alpha = 25.13\ W \cdot m^{-2} \cdot deg^{-1}$
- At a density of 0.40, $\alpha = 33.51\ W \cdot m^{-2} \cdot deg^{-1}$
- According to G. A. Abels, the heat transfer coefficient α = 280,64 • d2 W • m-2 • deg-1 and therefore is directly proportional to the density quadrate of the snow cover.

TABLE OF HEAT TRANSFER COEFFICIENT

density of snow	coefficient of heat transfer	
0,1	$\alpha_1 =$	8,38 $W \cdot m^{-2} \cdot deg^{-1}$
0,2	$\alpha_2 =$	16,75 $W \cdot m^{-2} \cdot deg^{-1}$
0,3	$\alpha_3 =$	25,13 $W \cdot m^{-2} \cdot deg^{-1}$
0,4	$\alpha_4 =$	33,51 $W \cdot m^{-2} \cdot deg^{-1}$
0,5	$\alpha_5 =$	41,89 $W \cdot m^{-2} \cdot deg^{-1}$

CHANGES CAUSED BY α DYNAMICS

- If the duration of a relatively high snow cover (over 10 cm) is long, the significance of the changes due to the heat transfer coefficient increases
- both in the direction of the flow towards the soil and from the soil to the air (in both cases through the snow cover).

CRYPTOVEGETATION OF WINTER CEREALS

- Even during the winter, the development of wintering winter varieties - so-called cryptovegetation - can usually continue from the phenophase of emergency to the phenophase of tillering.
- It depends very much on the "condition" of the snow cover, i.e. its height and water equivalent.

WINTERING OF WINTER CROPS

- At a low snow height and high water equivalent of ice or drenched snow, winter crops can be severely damaged by sudden drops in the air temperature.

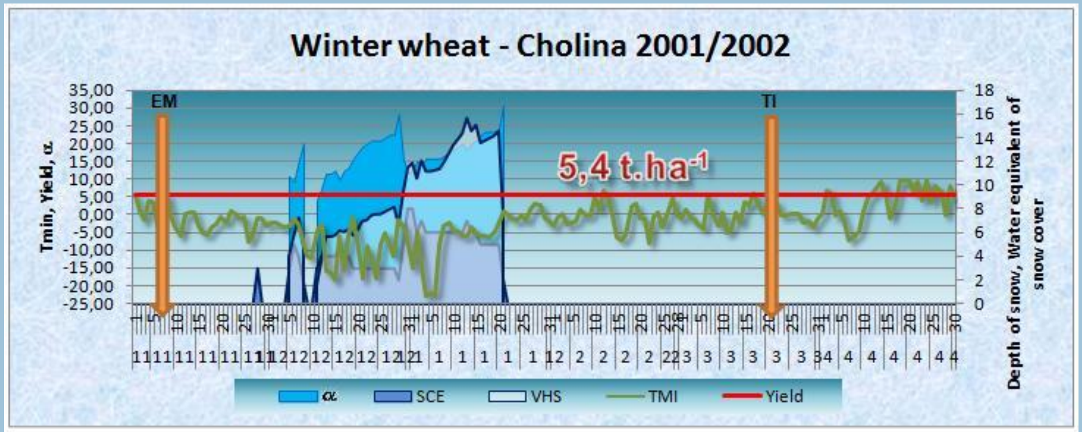
- On the contrary, the dusty fresh snow cover containing high-volume air can effectively reduce the negative effect of large frosts.

WINTERING OF WINTER CROPS

- If the plants have already induced frost resistance, then they are better tolerated by significant drops in the minimum air temperature.

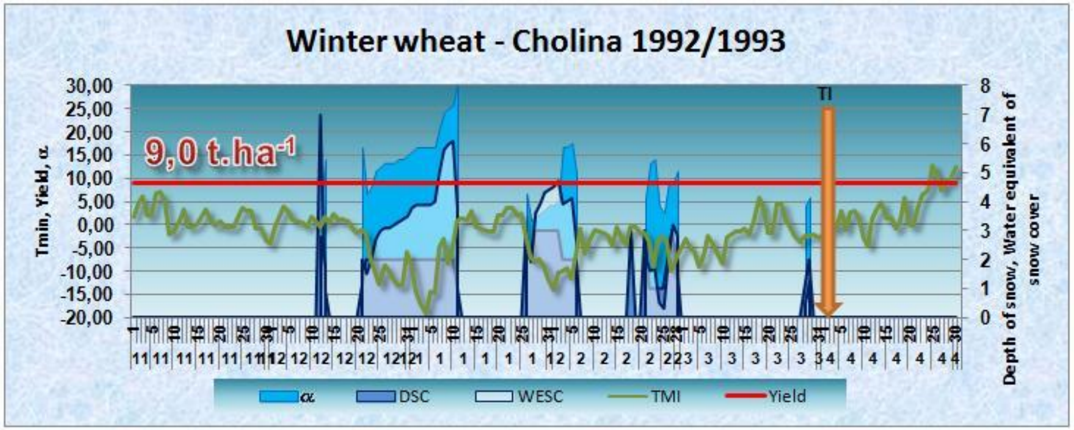
- On the other hand, the temperature fluctuation in the first stage of overwintering is unfavorable in its ability to resist the effects of low temperatures.

SOME EXAMPLES:

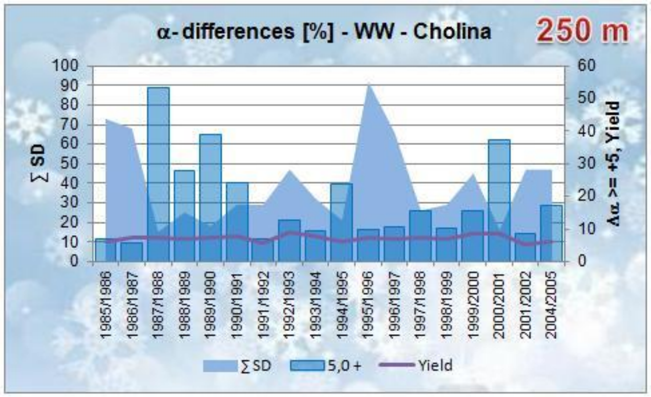


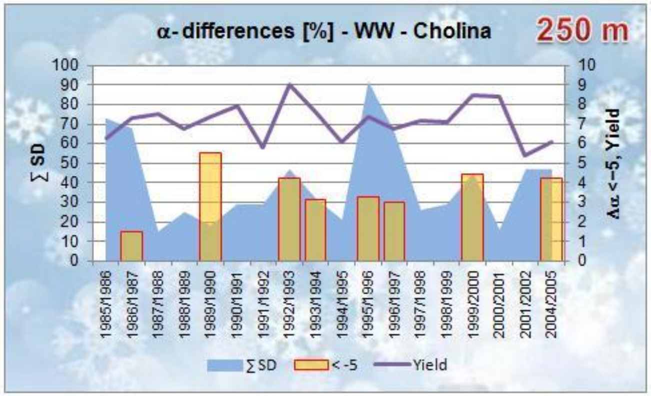
250 m

α ……………….heat transfer coefficient
SCE ≅ DSC .. …depth of snow cover
VHS ≅ WESC .. water equivalent of snow cover
TMI ……………minimum air temperature



INTERDIURNAL DIFFERENCE OF HEAT TRANSFER COEFFICIENT α

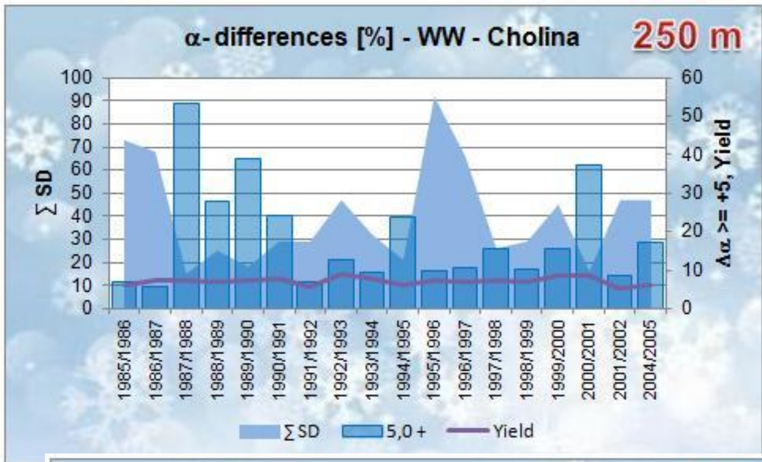


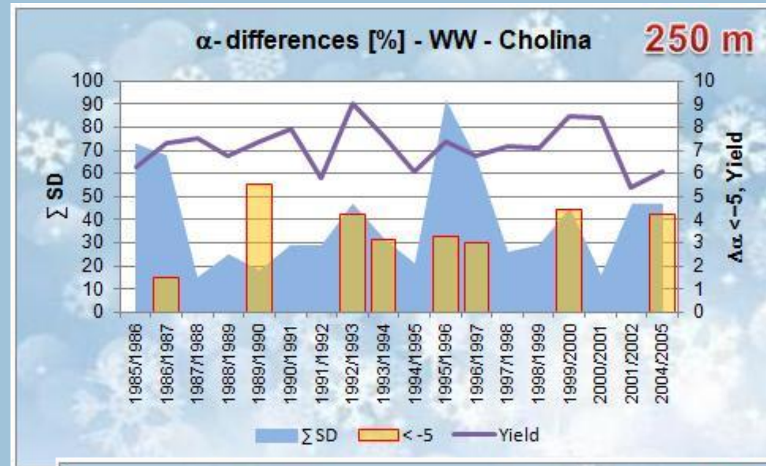


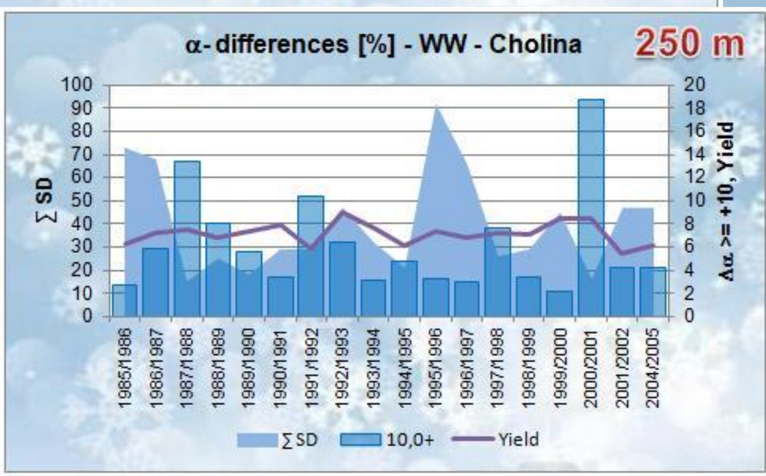
The contents of the following graphs are sums of intermediate differences of the coefficient α on the one hand reaching +5 and more W • m^{-2} • deg^{-1}, then less than -5, ≥ +10 and <-10 W • m^{-2} • deg^{-1}.

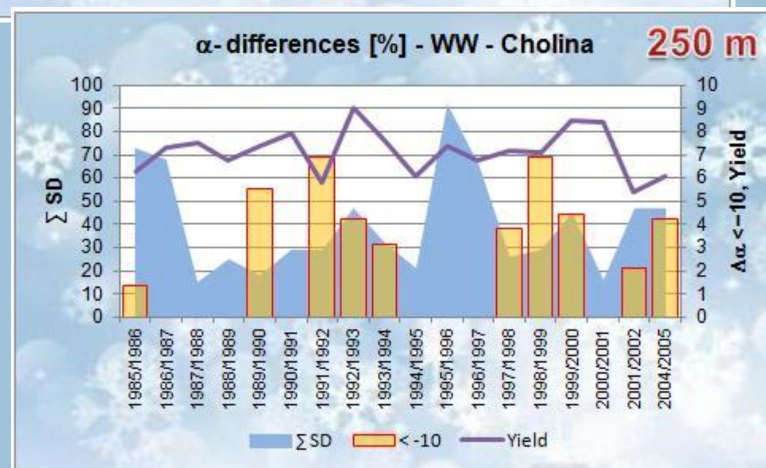
∑ SD … depth of snow cover.

INTERDIURNAL DIFFERENCE OF HEAT TRANSFER COEFFICIENT α



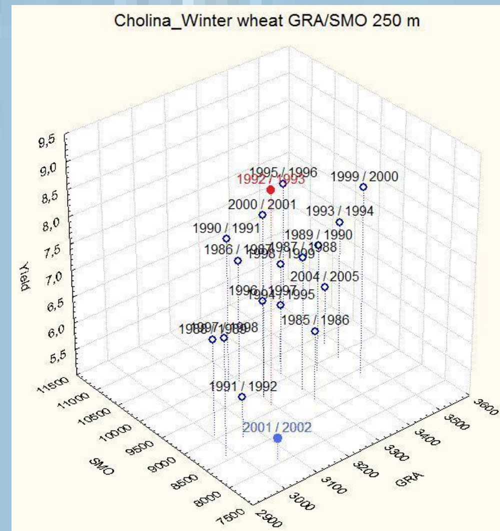


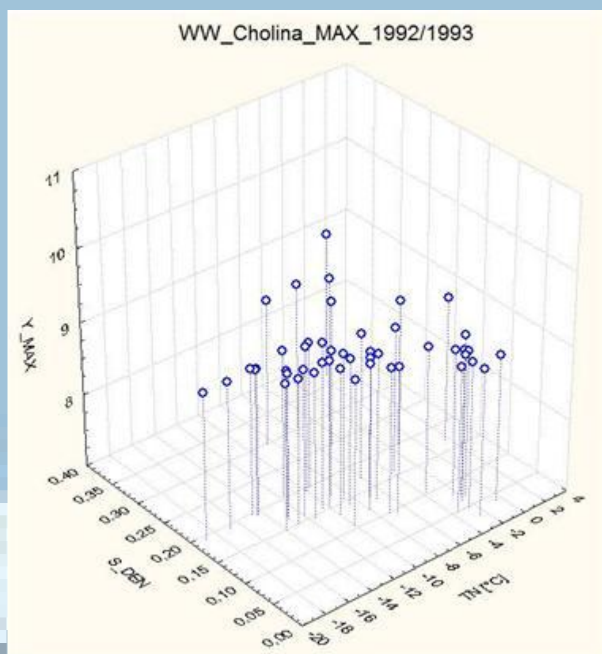


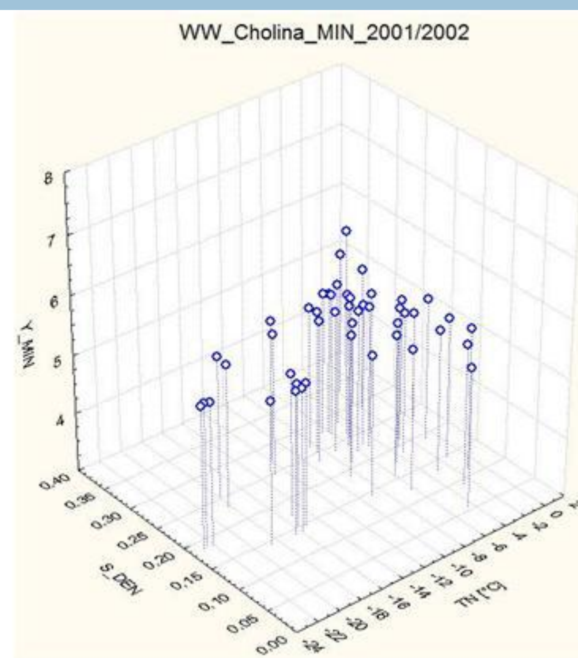


VIRTUAL CUBE

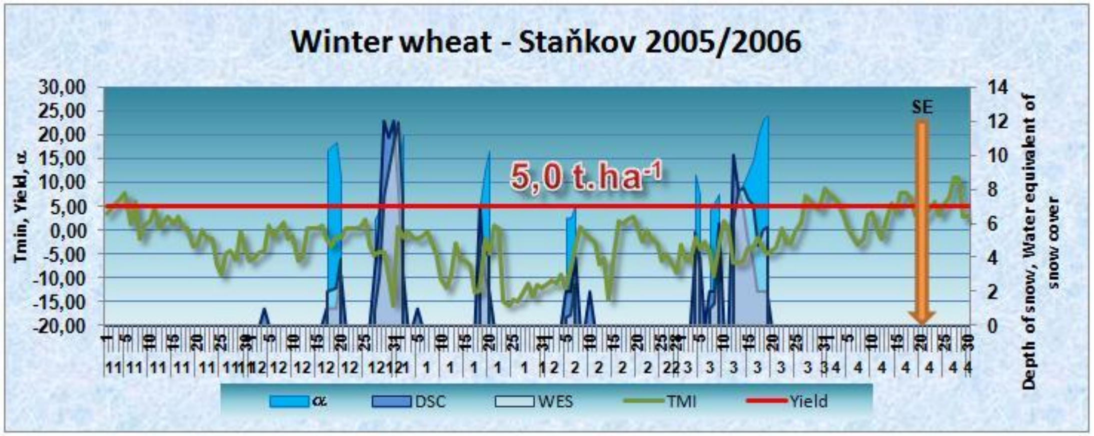
- If we express the relation between the sums of global radiation, soil moisture and yields, we can easily distinguish the diametrically different conditions for the lowest and highest harvest of the winter grain observed.
- Subsequent depictions reflect the influence of snow density at a certain minimum air temperature on the resulting maximum and minimum yields.


Cholina_Winter wheat GRA/SMO 250 m
Yield
SMO
GRA
1999 / 2000
1995 / 1996
1992 / 1993
2000 / 2001
1993 / 1994
1990 / 1991
1989 / 1990
2004 / 2005
1985 / 1986
1991 / 1992
2001 / 2002

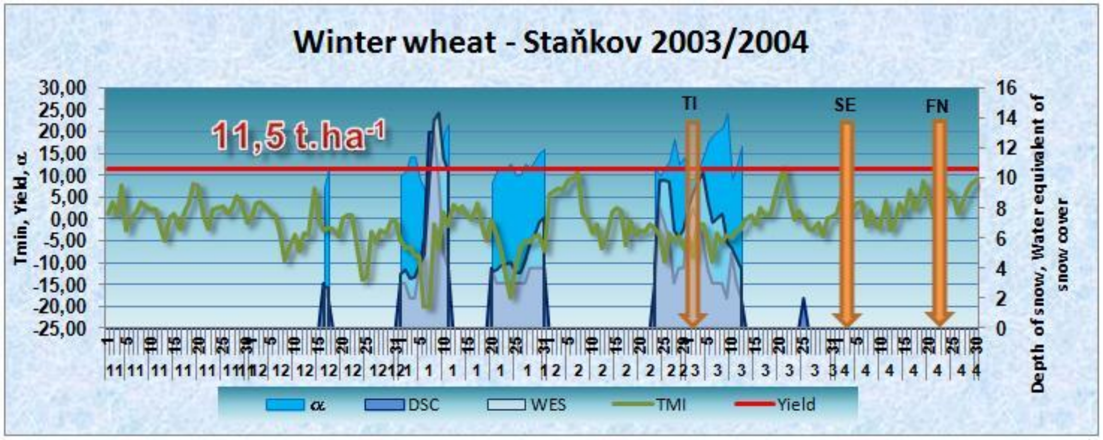

WW_Cholina_MAX_1992/1993
Y_MAX
S_DEN
TN [°C]


WW_Cholina_MIN_2001/2002
Y_MIN
S_DEN
TN [°C]

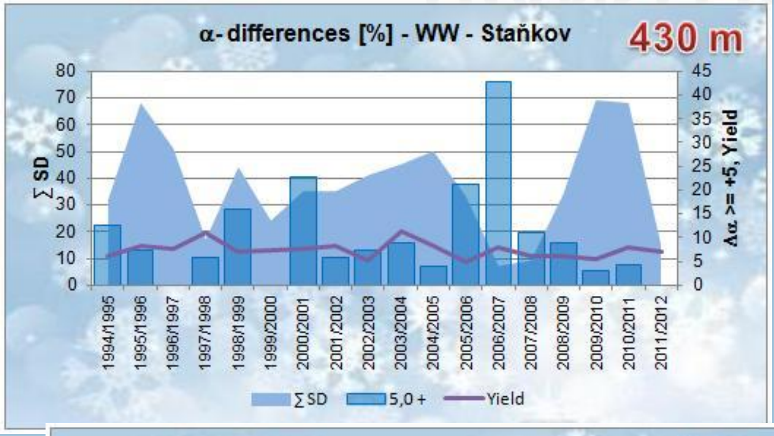
SOME EXAMPLES:

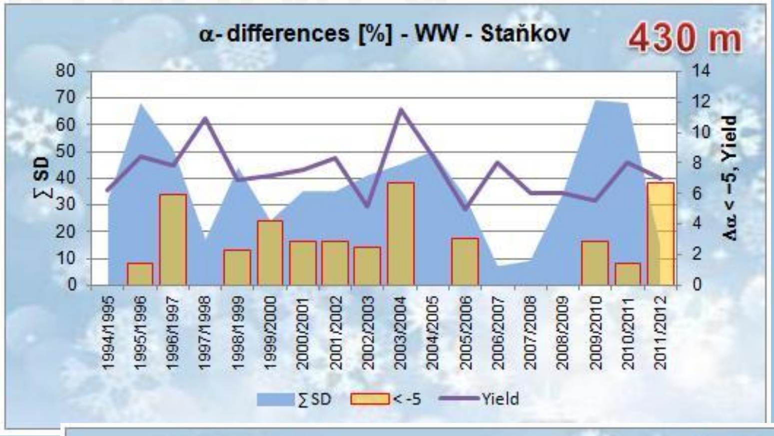


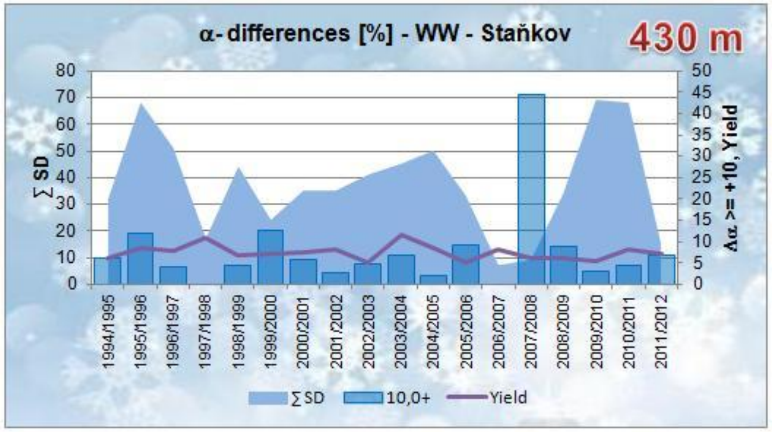
430 m

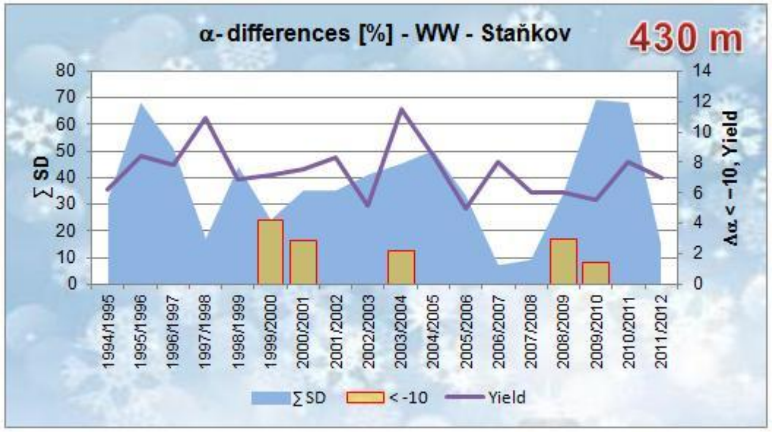


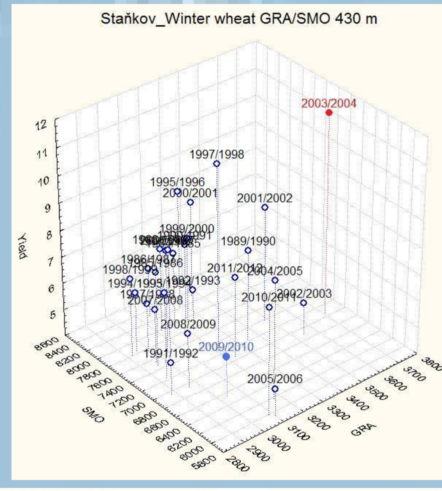
INTERDIURNAL DIFFERENCE OF HEAT TRANSFER COEFFICIENT α

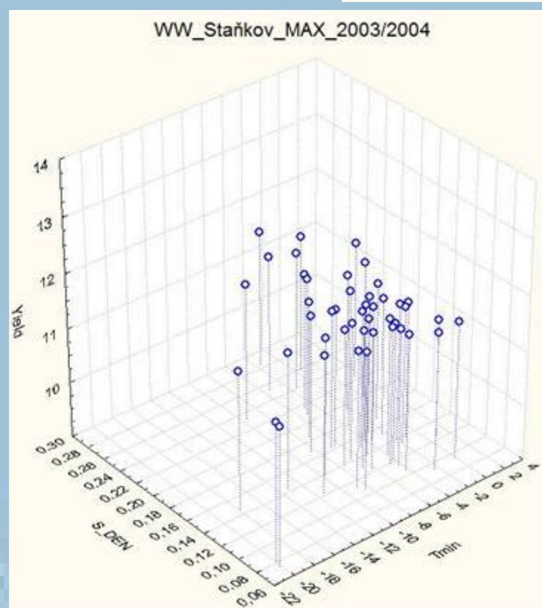


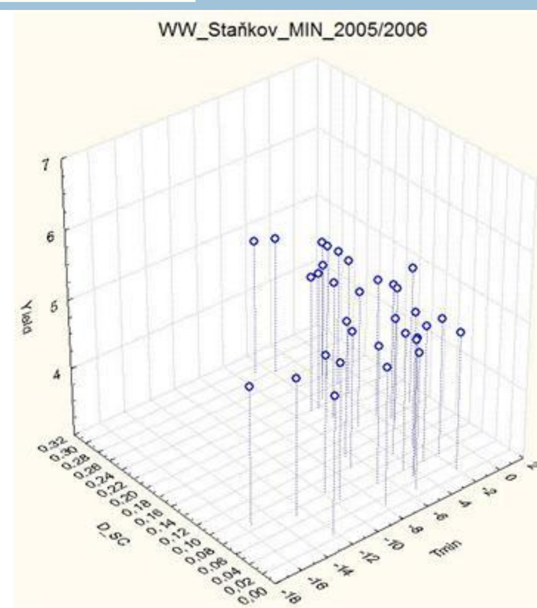




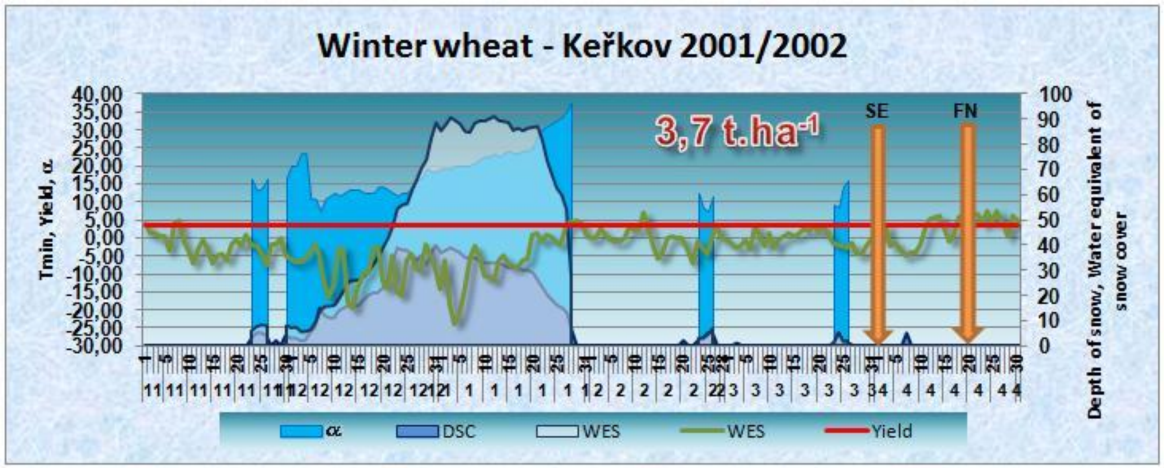



Staňkov_Winter wheat GRA/SMO 430 m
2003/2004
1997/1998
1995/1996
2001/2002
1989/1990
2011/2012
2004/2005
2002/2003
2008/2009
2009/2010
1991/1992
2005/2006
Yield
SMO
GRA

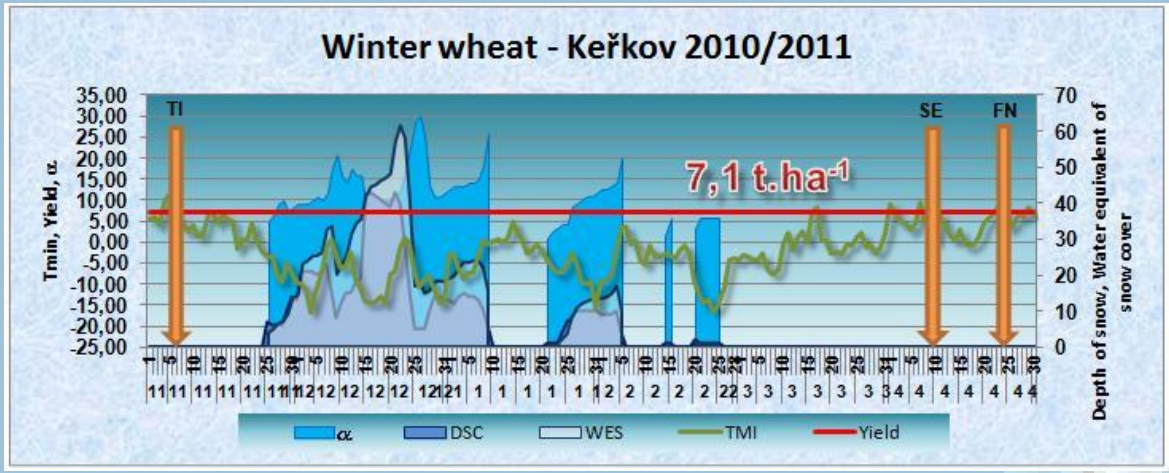

WW_Staňkov_MAX_2003/2004
Yield
S_DEN
Tmin


WW_Staňkov_MIN_2005/2006
Yield
D_SC
Tmin

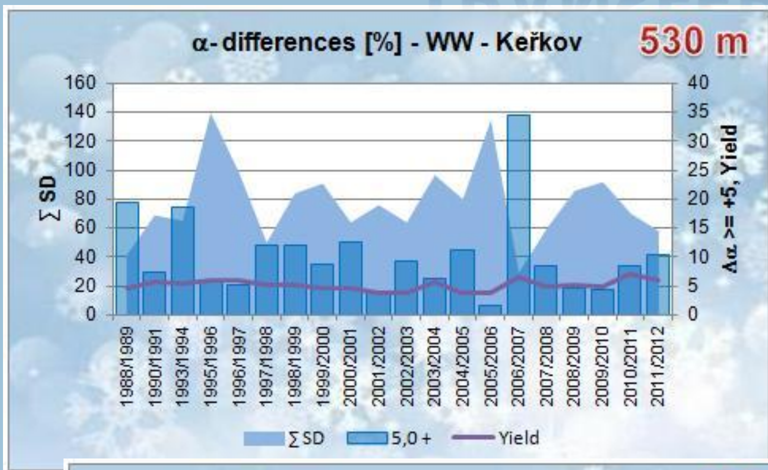
SOME EXAMPLES:

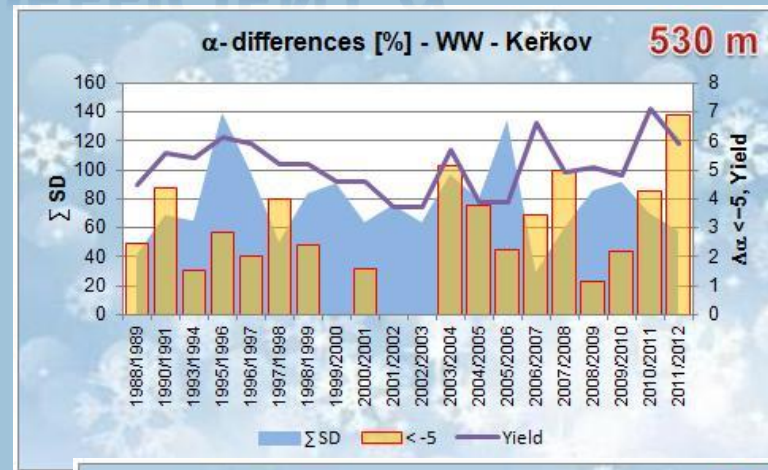


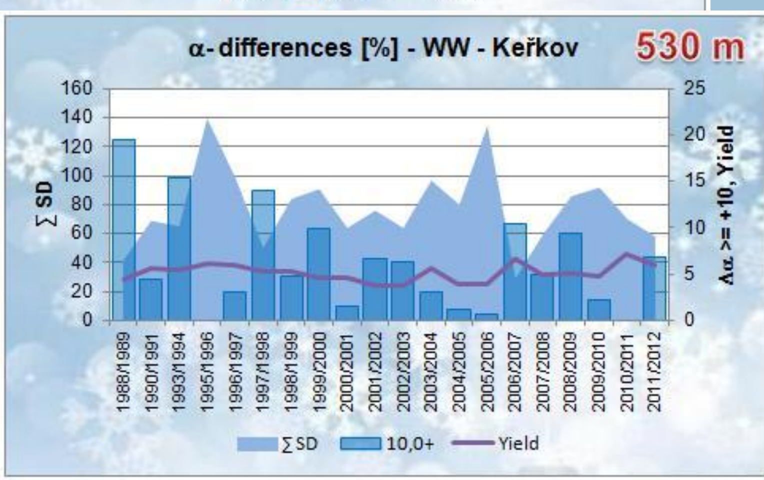
530 m

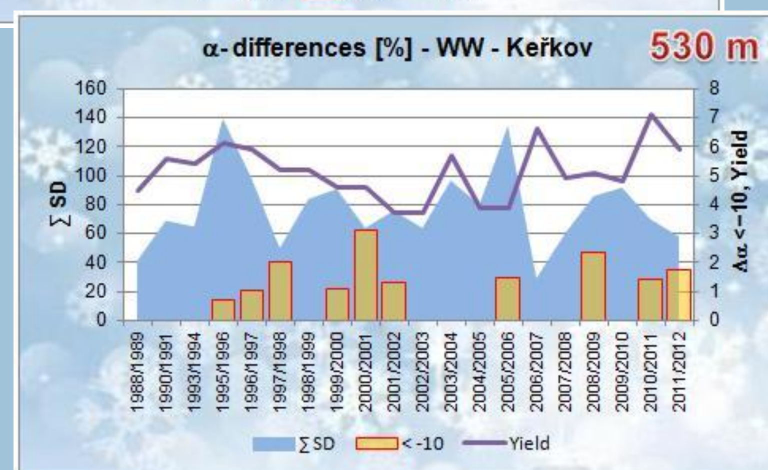


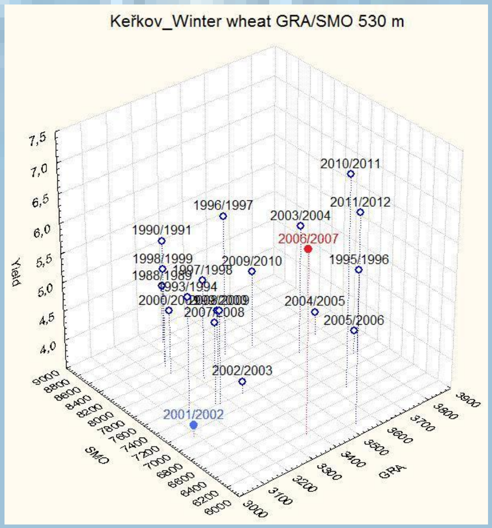
INTERDIURNAL DIFFERENCE OF HEAT TRANSFER COEFFICIENT α

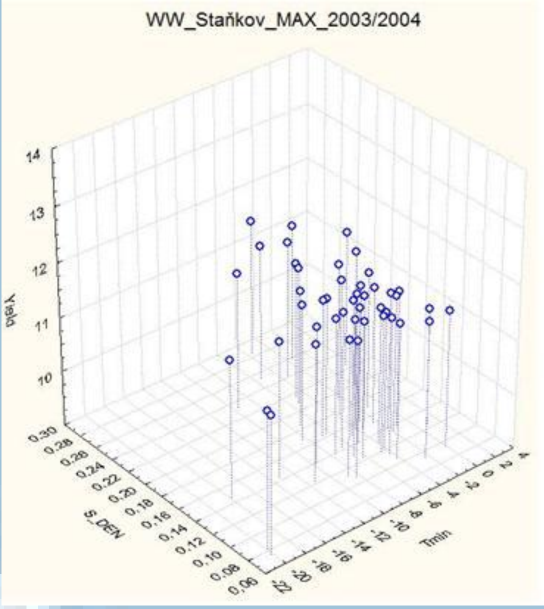


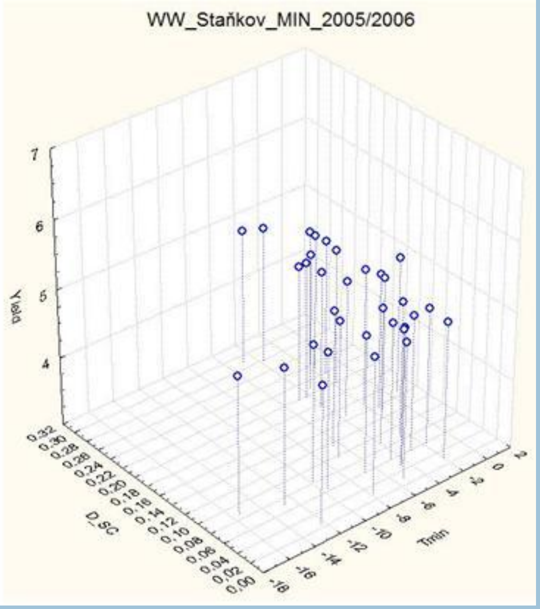




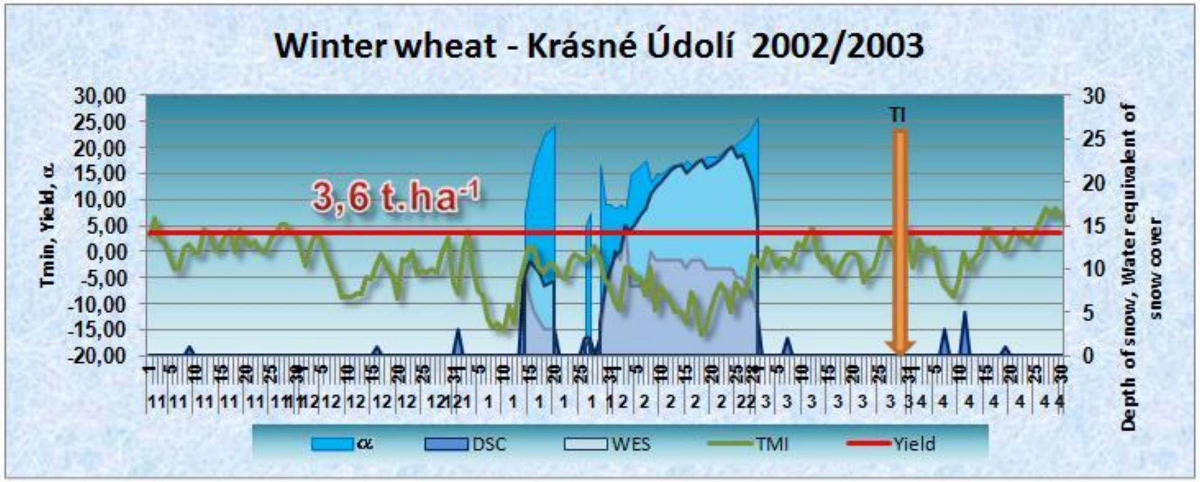



Keřkov_Winter wheat GRA/SMO 530 m
Yield
SMO
GRA
2010/2011
2011/2012
1996/1997
2003/2004
1990/1991
2006/2007
1998/1999
1995/1996
2009/2010
1997/1998
1988/1989
2004/2005
2007/2008
2005/2006
2002/2003
2001/2002

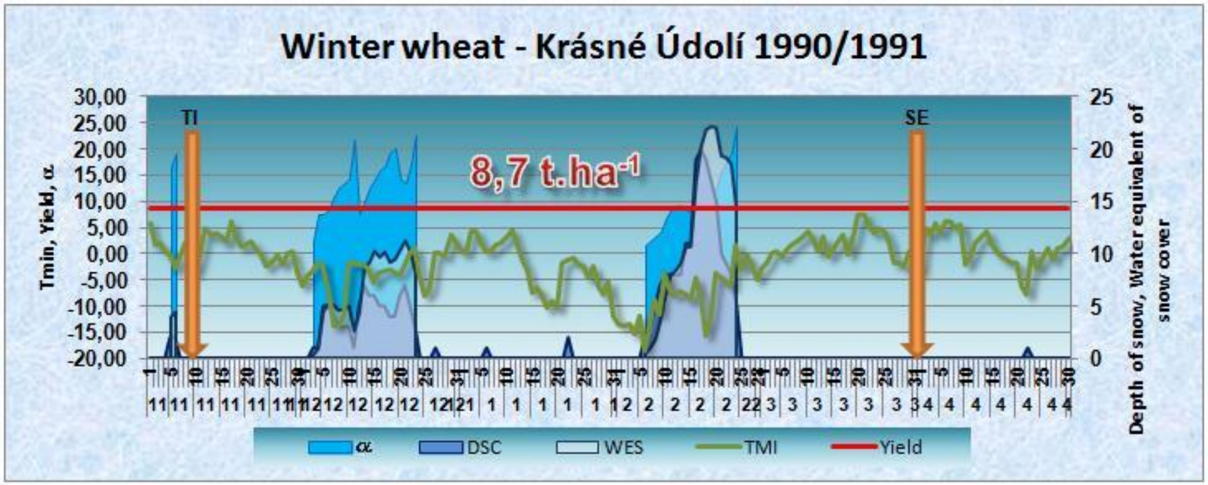

WW_Staňkov_MAX_2003/2004
Yield
S_DEN
Tmin


WW_Staňkov_MIN_2005/2006
Yield
D_SC
Tmin

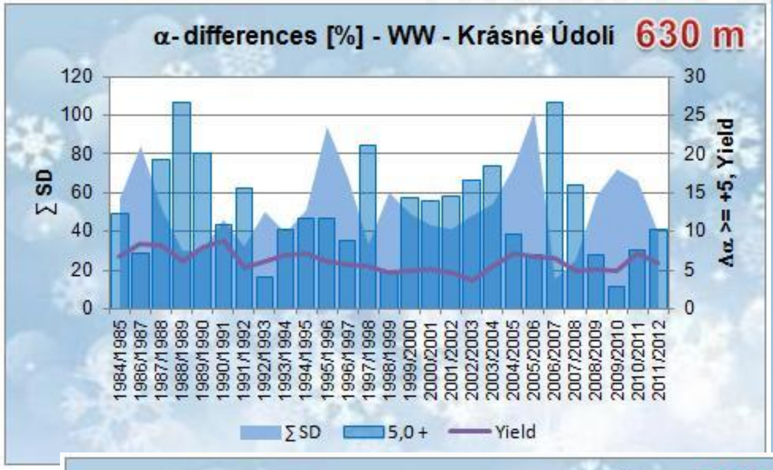
SOME EXAMPLES:

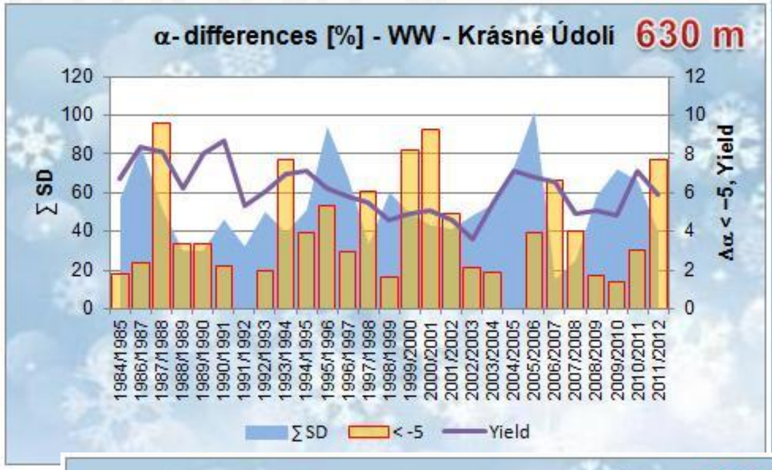


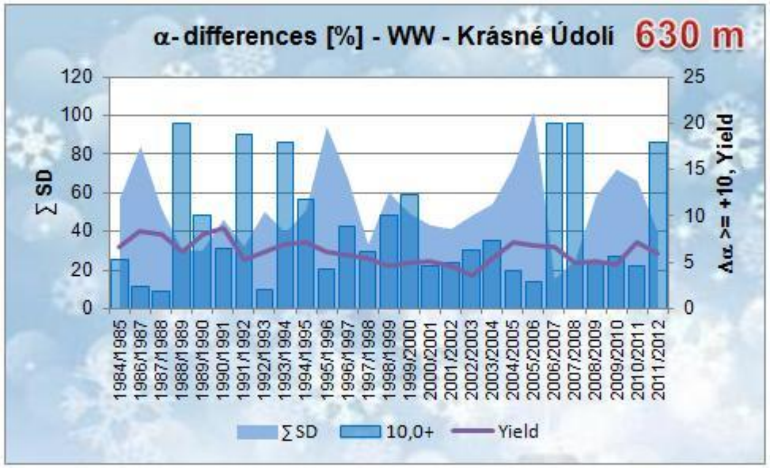
630 m

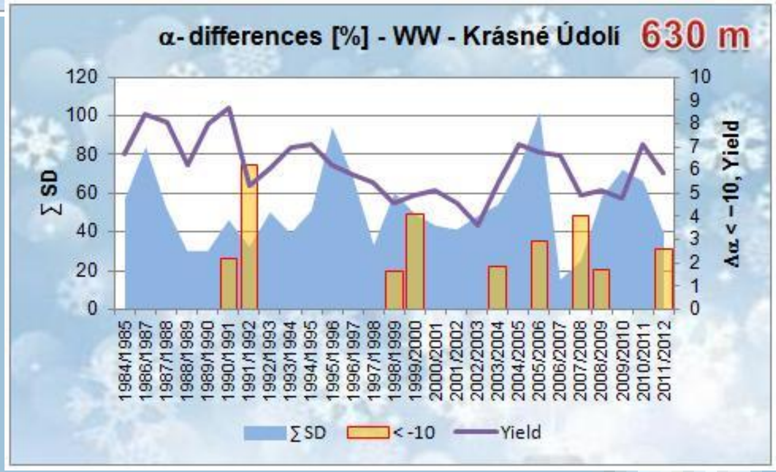


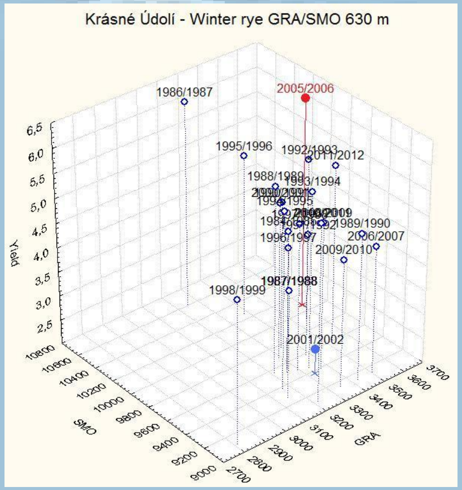
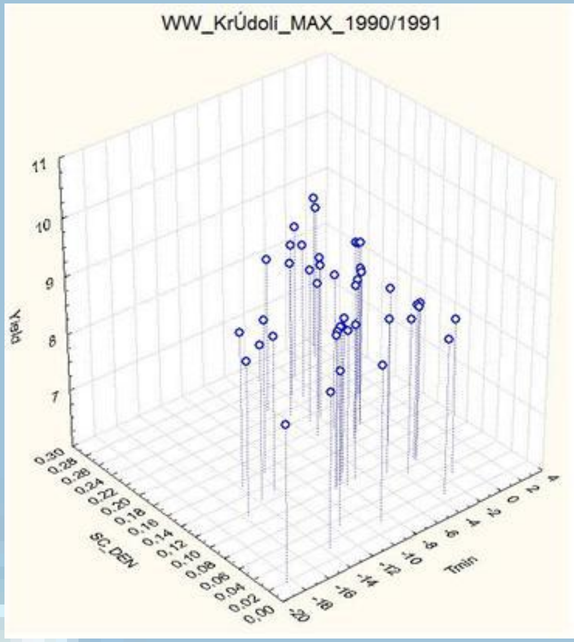
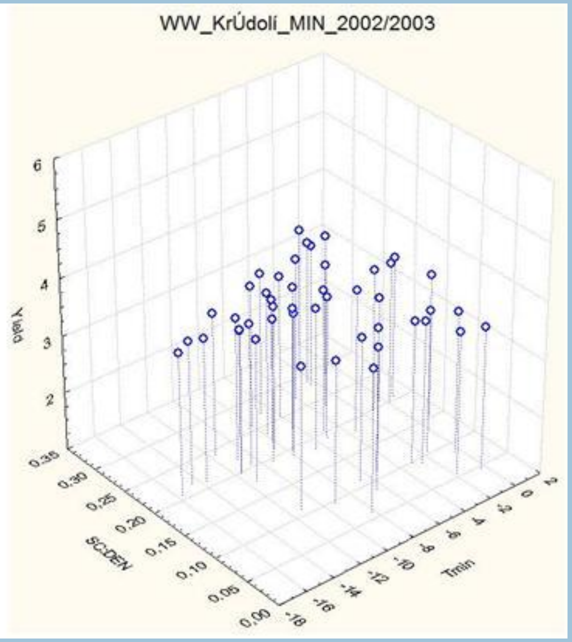
INTERDIURNAL DIFFERENCE OF HEAT TRANSFER COEFFICIENT α



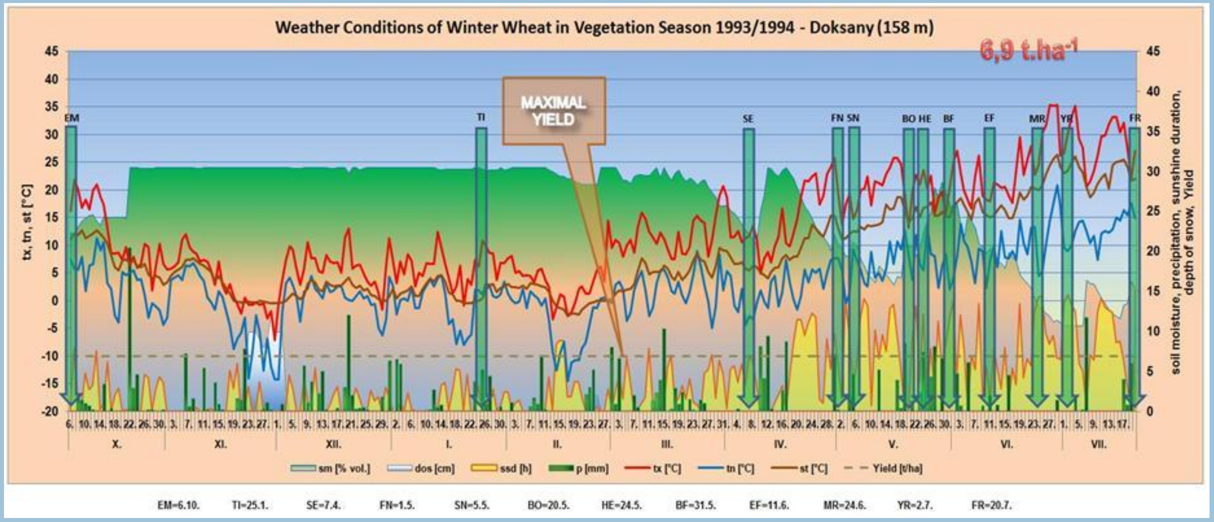







Krásné Údolí - Winter rye GRA/SMO 630 m
Yield
SMO
GRA
1986/1987
2005/2006
1995/1996
1992/1993
2011/2012
1988/1989
1993/1994
1989/1990
2006/2007
1996/1997
2009/2010
1987/1988
1998/1999
2001/2002

WW_KrÚdolí_MAX_1990/1991
Yield
SC_DEN
Tmin

WW_KrÚdolí_MIN_2002/2003
Yield
SC_DEN
Tmin

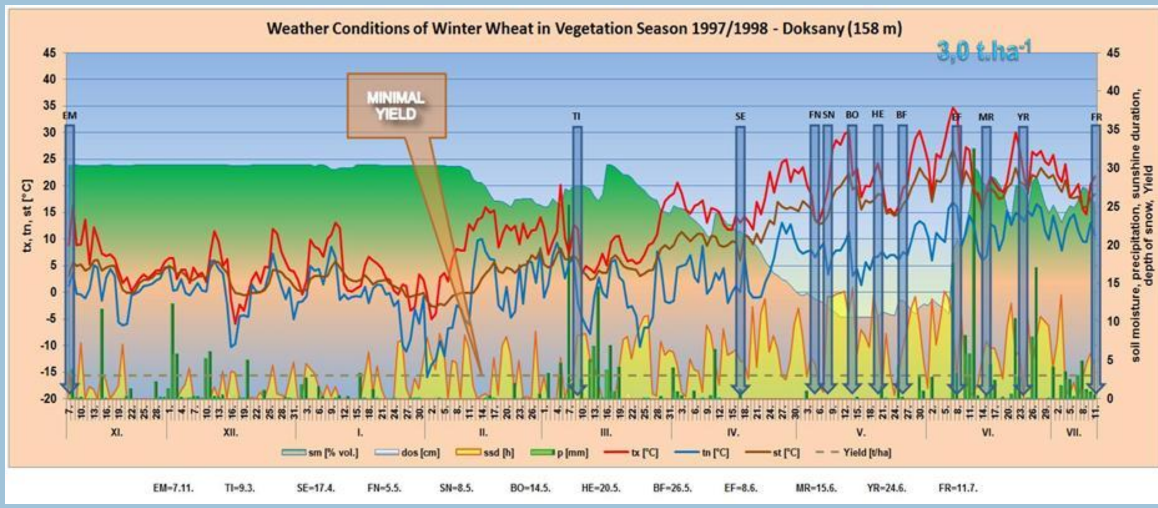
ANALYSIS OF VEGETATION PERIODS 1



158 m

Exceptionally early snow cover in the local conditions provided good insulation against the negative effects of the deep minimum air temperature drops at the end of November.

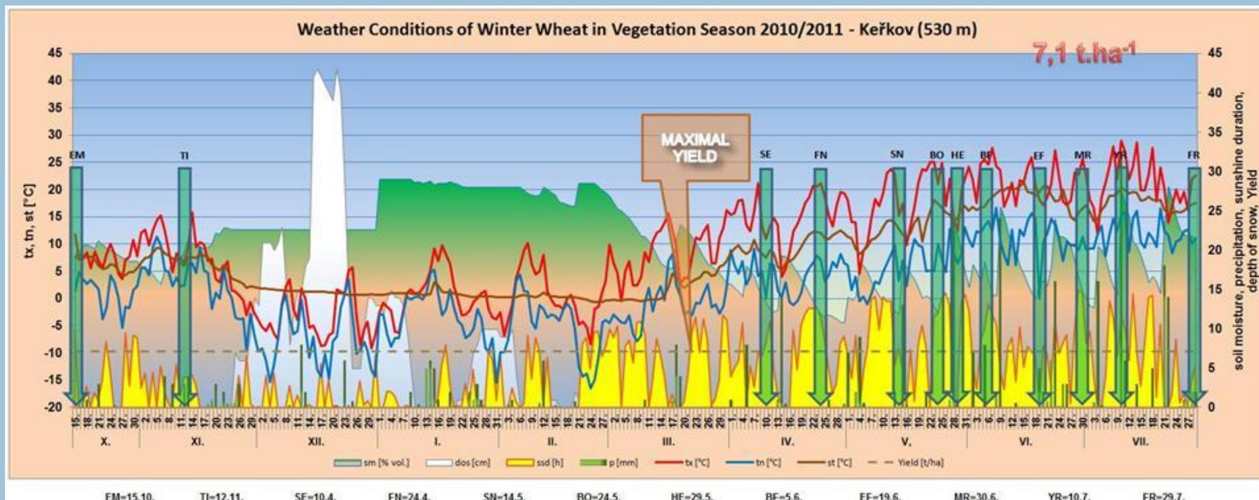
ANALYSIS OF VEGETATION PERIODS 2



158 m

Insufficient hardening of emerged plants from significant drops in minimum air temperature in the middle of December, late January and early February mainly. Damaged due to the March frosts was stressful, too.

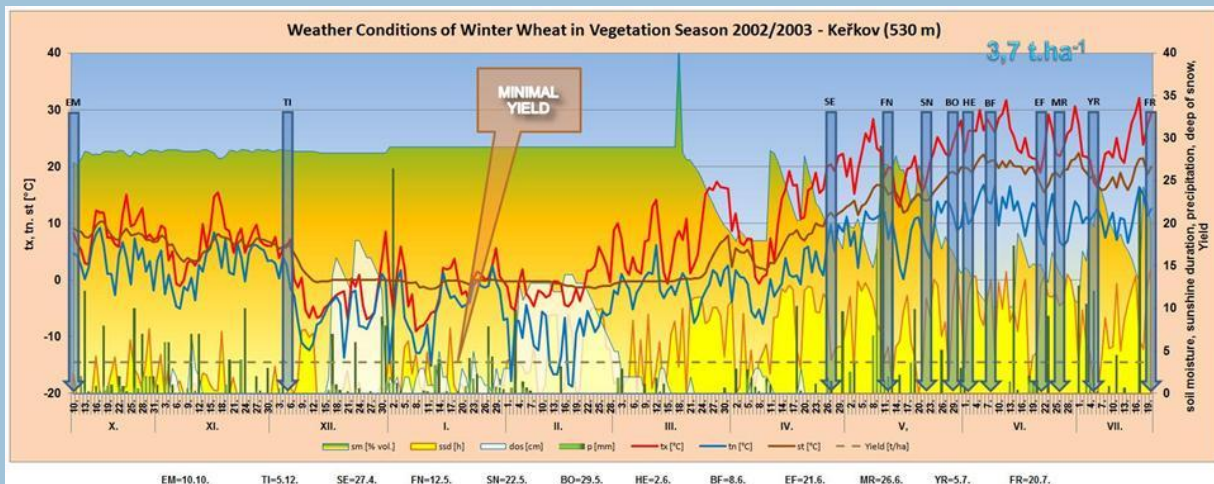
ANALYSIS OF VEGETATION PERIODS 3



530 m

Gradual hardening plants to frost damage in November, along with heavily insulated snow at the time of occurrence of major frosts in December and at the turn of January and February made it possible to overcome the further decline minimum air temperature at the end of February.

ANALYSIS OF VEGETATION PERIODS 4



530 m

The temperature drop and a further decline in the first half of January they have been compensated due to the insulating snow. The plants did not have enough time for cold resistance against frost damage. Also in February were bad snow conditions which did not protect the winter growths through strong frosts.

CONCLUSION 1

- Although many other meteorological and biotic elements contribute to the generation of the yield, the condition of the snow cover is one of the major contributor.
- As mentioned, it can act positively and negatively, mainly according to the water value and the time of occurrence.

CONCLUSION 2

- A α heat transfer coefficient was a very successful indicator of the quality of snow and its impact on the level of future crops.
- The sum of its interdiurnal differences exceeding 10 or more (or -10 and below) had a significant effect on further plant development.

CONCLUSION 3

- The work was done with the knowledge of the importance of the interaction of phytopathological and physiological influences, whose impact on the vegetative and generative stages of plant development which is not yet fully explored.

THANK YOU

FOR YOUR KIND ATTENTION