SIMULATING SPRING BARLEY YIELDS AT REGIONAL LEVEL

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ABSTRACT

Four districts in western Slovakia were chosen to simulate spring barley yields at two levels of phenological input data using a WOFOST crop growth model during the period of 1981-1995. Firstly the simulated inputs derived from meteorological data were used and secondly the real measured data were processed as inputs. Simulated yields were finally compared to the real statistical yields. The usage of real phenological data increases the accuracy of simulated yields by 5 to 10 percent. Simultaneously, the effect of rainfall network density on the simulated yields accuracy was tested, but the increase in the number of measuring points from four to fifty has not shown any significant increase in the simulated yields accuracy.

INTRODUCTION

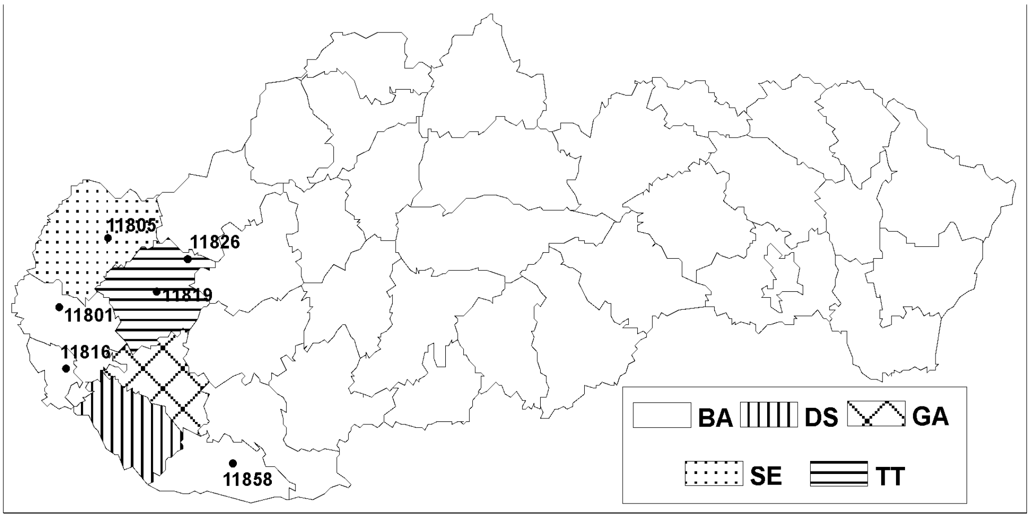
Agrometeorological modeling is one of the standard techniques of yield estimation according to the weather, soil and agronomic conditions. The aim of this work is to utilize the WOFOST crop growth simulation model for spring barley yields estimation, but also to test some impacts of various data inputs on the final results. The region under investigation covered cca 6000 km^2 and belongs to the most productive areas as for the agriculture production in Slovakia; about 80% of the area are under cultivation. Cereals - including spring barley are the main crops in this region. The cultivated part of the selected area belongs to only one climatic region.

WOFOST SIMULATION

WOFOST is a computer model, which simulates growth and production of annual crops under specified soil and weather conditions. Potential and limited production can be simulated with various nutrient level and ground water level. Crop specification is defined according to the variety with the respect to the geographical occurrence -growth. Daily weather data are used for the simulation, so that the crop growth can be investigated day by day during the whole season of vegetation. Crop growth is simulated or simply according to the meteorological conditions or with the usage of real crop growth (phenological) data.

The period of simulation was for 15 years, 1981 – 1995. The crop growth and the yields were simulated at the potential level and at the water limited level. First run of simulation was based on the calculated sowing dates that were derived out of the weather condition. Next run was done over the observed phenological dates according to the particular station. Emergence date was used for the start of simulation and the simulation stopped at full ripe date. Two types of daily meteorological data sets were used to get the aggregated regional yields. Firstly the simulation was performed over the data from four climatic stations, secondly to each climatic station a few precipitation stations were allocated so that the simulation was run for 49 locations within the selected region.

INVESTIGATED AREA – WESTERN SLOVAKIA CCA 6000 KM^2
AND METEOROLOGICAL NETWORK



THE DATABASE

Five types of data entered the simulation:

1. soil data – selected area is more or less flat and homogenous, so that just one soil type was used for the simulation
2. nutrition data – no reliable data were accessible, standard nutrition N,P,K = 60,10,60 kg/ha was used
3. ground water – for the major part of the selected area the ground water level is below 5 m and deeper so that no ground water was considered
4. crop (phenological) data – the simulation was performed with the usage of real (observed) sowing, emergence and full ripe date from four phenological stations (identical with climatic stations) and simultaneously with estimated data derived from the weather data
5. meteorological data - four climatic stations with reliable daily weather data were selected for the basic simulation. As the second step daily rainfall data from 49 precipitation stations from the selected area were used together with the climatic stations. Crop and meteorological data were collected for the period 1981 – 1995

   The results of simulated yields were compared to the district and regional yields statistic.

RESULTS

All the results presented in tables and graphs represent the regional averages of the simulation over four/forty nine stations. The real dates of phenological phases occurrence in the regional assessment were expressed as the averages in Julian days while the crop growth and yield simulation was run according to the observed data at the particular station.

<u>Crop growth assessment</u>

- Crop (phenological) data derived out of weather conditions differ to observed data considerably in the beginning of the vegetation cycle. Sowing date was too early. The simulation with automatically estimated crop data prolonged mainly the early phases of the vegetation cycle. During the generative phases the differences became much smaller. It looks that the daily temperature as a simple indicator of possible start of vegetation cycle is not sufficient enough (see Table 1). The only year when the estimated and real sowing date were in harmony was an extreme year 1990 when the sowing was done already in the first half of February. But the average sowing date within the investigated area is in the third decade of March.

- The difference in simulates yields with usage real and estimated crop data became much higher during the years with frequent occurrence of stress days (Graph 1).
- The simulation with automatically estimated sowing date prolongs the duration of the whole vegetation cycle and the yields became higher. The usage of observed phenological data (emergence and full ripe) has brought the simulated yields closer to the real yields up to 10 % (Table 2).

Regional yield assessment

- The calculated relative yields (water-limited/potential yield) were in two thirds of years near 100 %, what indicates good water supply of the crop during the cycle of vegetation in these years. It claims good rainfed condition for spring barley growth in selected region. Even during the years with the stress days occurrence the relative yield was over 80 % (Graph 2).
- Simulated regional yields overestimate the real yields over 20 %. The cause can be explained find firstly because of no farming (nutrition) information. Manure dosages were drastically restricted by many growers in the recent years and the real yields went down. This fact was visible mainly in the first half of nineties when despite of stabile simulated yields real yields considerably declined and the difference to simulated yield rises up. (Graph 3). Next reason of relatively high differences can be in harvest loss, estimation of which was neglected.
- The density of meteorological inputs does not play any meaningful role. The increase of the precipitation stations from 4 to 49 changed the simulated yields just up to 4 % in average. It indicates that the region can be sufficiently represented by four stations. (Tab. 3)

KEYWORDS – simulation, spring barley, emergence, full ripe

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Table 1. THE DIFFERENCES IN DAYS BETWEEN REAL AND SIMULATED PHENOLOGICAL DATE OF SPRING BARLEY

YEAR	SOWING	EMERGENCE	DURATION	FULL RIPE
1981	40	14	-4	10
1982	39	10	-4	6
1983	25	15	-12	3
1984	28	6	3	9
1985	59	18	-7	11
1986	53	15	-8	7
1987	52	17	-8	9
1988	49	16	-7	9
1989	32	21	-14	7
1990	0	38	-31	7
1991	40	21	-18	3
1992	28	23	-20	3
1993	49	17	-21	-4
1994	29	14	-4	-4
1995	53	46	-38	8
AVG	38,4	19,4	-12,9	5,6

Notice : negative value means earlier observed date than simulated

Table 2. SIMULATED WATER LIMITED YIELDS OF SPRING BARLEY [t/ha] WITH USAGE REAL AND ESTIMATED CROP (PHENOLOGICAL DATA

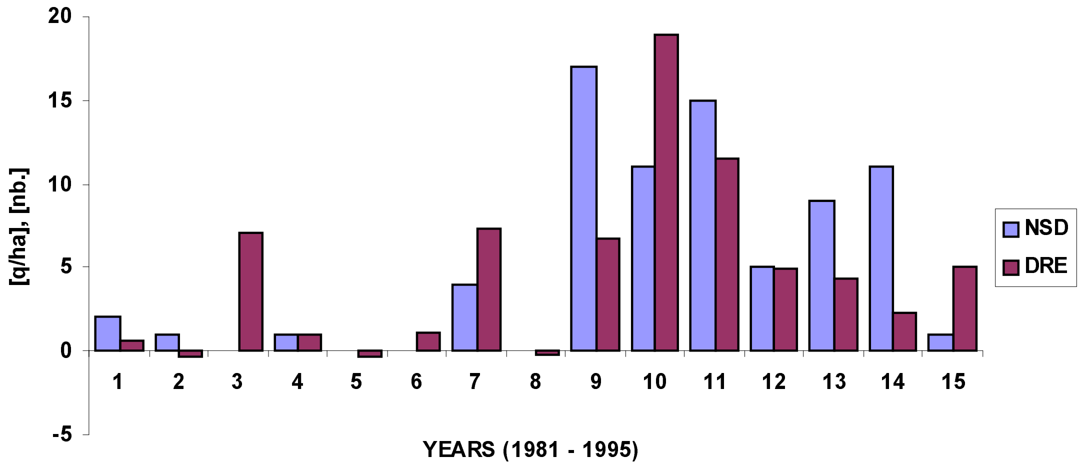
	Yobs	SYRsd	SYEsd	(Yobs)-(SYRsd)	(Yobs)-(SYEsd)	(SYRsd)-(SYEsd)
1981	3,93	6,16	6,22	-2,23	-2,29	-0,07
1982	4,75	7,13	7,10	-2,38	-2,35	0,03
1983	5,04	7,10	7,82	-2,06	-2,78	-0,71
1984	6,17	8,07	8,16	-1,90	-1,99	-0,09
1985	5,29	7,27	7,24	-1,98	-1,95	0,04
1986	4,85	6,97	7,08	-2,12	-2,23	-0,11
1987	5,34	6,36	7,09	-1,02	-1,75	-0,73
1988	5,07	6,99	6,97	-1,92	-1,90	0,02
1989	5,66	6,72	7,39	-1,06	-1,73	-0,67
1990	5,66	5,66	7,55	0,00	-1,89	-1,89
1991	5,86	5,38	6,53	0,48	-0,67	-1,15
1992	5,15	6,55	7,04	-1,40	-1,89	-0,50
1993	4,11	6,91	7,35	-2,80	-3,24	-0,44
1994	4,86	7,04	7,27	-2,18	-2,41	-0,23
1995	4,50	6,51	7,02	-2,01	-2,52	-0,51
AVG	5,08	6,72	7,19	-1,64	-2,11	-0,47

Yobs - observed regional yields
SYRsd - simulated yields with usage real crop (phenological) data
SYEsd - simulated yields with usage estimated crop (phenological) data

Table 3. AGGREGATED REGIONAL YIELDS OF SPRING BARLEY [t/ha] WITH USAGE THE DIFFERENT DENSITY OF METEOROLOGICAL INPUTS

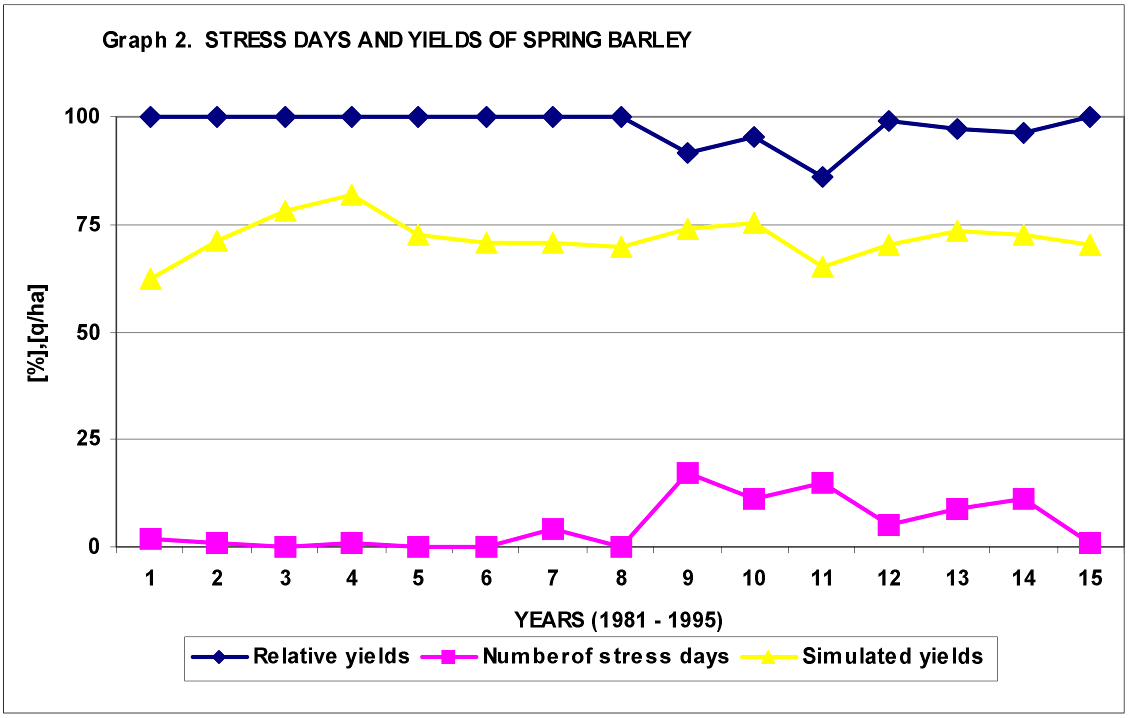
YEAR	BASIC CLIMATIC NETWORK (4 STATIONS)	EXTENDED CLIMATIC NETWORK (49 STATIONS)	REAL YIELDS
1981	5,96	6,12	3,93
1982	6,49	6,96	4,75
1983	7,29	7,57	5,04
1984	7,65	7,66	6,17
1985	7,08	6,99	5,29
1986	6,85	7,13	4,85
1987	6,30	6,51	5,34
1988	6,57	6,67	5,07
1989	7,28	7,65	5,66
1990	7,05	7,29	5,66
1991	6,48	7,12	5,86
1992	6,48	6,48	5,15
1993	6,53	6,78	4,11
1994	6,67	7,40	4,86
1995	6,43	6,68	4,50
AVG	6,74	7,00	5,08

Graph 1. DIFFERENCES IN SIMULATED YIELDS OF SPRING BARLEY WITH USAGE REAL AND ESTIMATED CROP DATA AND STRESS DAYS FOR 15 YEARS



NDS – number of stress days

DRE – difference between simulated yields [q/ha] with usage real and estimated crop (phenological) data



Relative yield : (water limited/potential yield) [%]

Simulated yield [q/ha]