**TMT+ Bangladesh: Food Security Workshop**

#### Exercise

**Will the people of Quzhou ever brew their own beer?**



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# **Exercise outline**

## **Time**

0.5/1 day.

**Objectives**

To provided practice in procedures to calibrate a crop growth simulation model in quantitative land use systems analysis. Please summarize your findings on paper and hand these over to the Chinese authorities (through your liaison Mr. V. Venus).

**Software**

\*Microsoft Excel, PSn-model

## **Data – located on Blackboard “Exercise data”**

1. Info included in exercise description (this document).

\* Optional.

# **Introduction**

This exercise falls within the “Crop growth modeling for Food Security Monitoring” group of application techniques, and focuses on estimation of crop productivity. In the next sections we will describe the dataset, which is available for this exercise, explain the relevance of calibrating a crop growth simulation model based on some results of experimental field trial.

# **Background**

The people of Quzhou drink 'Peking Beer' ([pijow] in Chinese) that is imported from Beijing Municipal Area, some 600 km to the north-east. At least one foreigner ('lao wai') wondered why they don't grow their own barley and drink pijow from Quzhou. He was informed that there have been trials with barley at Quzhou Experiment Station but that the idea to grow barley was dropped in spite of good experimental results. The information on record was scant:

On 1 June 1986, barley was sown in two concurrent trials on loam soils at Quzhou Station. One experiment was fully fertilized and irrigated and another was grown rain-fed. In both experiments the crop emerged 10 days after sowing. Ears were formed 2 months after emergence when the crop's LAI had reached its peak value. At that moment, a partial harvest showed that the LAI of the irrigated crop was 3.7 m2 m-2 and the total dry mass of `straw' (above-ground only!) was 5.5 tons/hectare. The rain-fed crop's LAI at ear initiation was 3.2 m2 m-2 and the total straw production at that time was some 4.25 tons/ha. Both crops were harvested on 1 September 1986 (we may assume that maturity was reached 10 days earlier). The irrigated crop produced an exceptional 7.2 tons/ha before threshing; the rain-fed crop produced 6.4 tons/hectare.

# **Exercise**

Task 1: Reconstruction

Before we reconstruct the crop file, we must interpret the relevant information collected though field trials at agricultural experimental stations or literature. The RDS at which storage organ growth starts (i.e. ear initiation) can be found in Annexes of these lecture notes. Use this value to calculate the corresponding value of SLA according to Danalatos (1992):

SLA = SLAmin - 0.5 \* (SLAmax - SLAmin) \* 10log(RDS)

A survey of Chinese literature revealed that SLA values of barley range between 26 m2 kg -1 at emergence and 16 m2 kg -1 at maturity.

* Rewrite relation (8.8) in the lecture notes to calculate the living leaf mass at the time of ear initiation in both experiments.

If you can't find certain values for barley from literature, you might try those of (better-researched) wheat. Note that barley is generally considered more drought tolerant than wheat; a PSI-leaf value of 17000 hPa might be apt. Check if your crop file is halfway- realistic by using PSn (trying) to reproduce the inferred organ masses at ear initiation and at physiological maturity. Use the following management specifications: (for PS-1) emergence on 10 June 1986; use 150 kg seed; and (for PS-2) ECe = =4 inS cm 1; ECgnv = 3 mS cm l; initial PSI = 1000 hpa; surface storage capacity = 1 cm; groundwater at 250 cm depth with forced drainage installed.

* Now reconstruct the crop file of "BARLEY (cv J050-214)". Do several simulation runs and adjust the appropriate values in your reconstructed crop file until you obtain yield/production data that are within 10% of the reconstructed values.

BE AWARE that default values can be helpful but may not always apply to the situation under study. In particular, TSUM-values may vary rather widely (there are short duration and long duration varieties) but other parameters may also need attention. You may substitute -20 °C for TLOW (not in your lecture notes but hardly relevant; barley is frost tolerant and low temperatures do not occur in the summer). For TCM you may use a value of 1.15 (reasonably tall crop, small fields, open plain).

The very first version of the crop file should be made with tabulated default values (see also Appendix II). If you can't find certain values you might try those of wheat. Be aware that default values can be helpful but do not always apply. In particular TSUM values need attention (there are short duration and long duration varieties). For TLOW and TCM (not in your lecture notes) you may substitute -20 and 1.15 respectively.

Task 2: Are peak LAI values good indicators of (relative) crop performance?

Assimilating leaf mass is the driving force behind plant production. The peak LAI values (just before the start of generative growth) are known; one hopes for a correlation with yield.

Investigate if we could have predicted irrigated and rain-fed yields already at the time of ear initiation by:

(1) substituting average weather data for the period from ear initiation until maturity,

(2) calculating the fully irrigated yield potential, and

(3) estimating the rain-fed yield potential by multiplying the estimated irrigated yield potential by the ratio of LAI-values at ear initiation ?

Task 3: Is rain-fed barley a secure crop with an acceptable yield potential?

Calculate rain-fed yield and production potentials for the years 1981 through 1990. Set the ECe at 4 mS cm -1, the initial soil moisture potential at 1000 hPa, ASSC at 1 cm, and the groundwater level at 250 cm below the surface with forced drainage installed. The electric conductivity of the groundwater is assumed to be 3 mS cm"'. Emergence takes place in the second half of June; use 100 kg seed per hectare.

* Is irrigation necessary for dependable production of summer barley in Quzhou?
* If you have to irrigate, could summer barley compete with maize (in terms of bio-physical production)?

Task 4: Can we grow rain-fed summer barley in rotation with irrigated winter wheat in Quzhou?

Extend your crop file with one more crop: Iranian winter wheat variety "Navid (T2)", a `durum' or 'hard' wheat that is genetically the same as the Turkish "Kirkpinar" wheat. The crop data below were borrowed from LEECON Consulting, Wageningen:

“WINTER WHEAT (cv Navid (T2))"

"C3",1,1600,1000,-35,.58,125,10,14000

22,15,.55,1.1,.017,.01,.015,.01,0

.72,.72,.68,.78,.011,.003,.0016,.0004

8

0,.16,.2,.3,.5,.53,.58,1

.5,.54,.6,.35,.15,.06,0,0

.5,.45,.25,.15,.1,.02,0,0

0,.01,.15,.5,.75,.66,0,0

0,0,0,0,0,.26,1,1

Do PS-1 calculations for the years 1981 through 1989. Emergence in mid October (say DAY 290 in the year) and use 200 kg seed per hectare as the Iranian farmers do. Record for each year the DAY number at which maturity is reached and the yield potential in kg/ha.

* Is this potentially a good variety for use in combination with summer barley in Quzhou?

Task 5: Salinity aspects of rain-fed summer barley in Quzhou

During this practical we have identified 1985 as a relatively dry year. The rain-fed yield potential of summer barley in 1985 was relatively low (as you have calculated before). Perhaps its yield could be increased by not draining to a depth of 250 cm but allowing the water-level to rise to shallower depth. In depression areas that should not be a problem.

Compare water table depths of 50 cm, 75 cm, 100 cm, and 250 cm, with and without drainage installed (i.e. both "Fixed" and "Variable"). Do this for a situation with poor quality groundwater (ECgrw = 3 mS cm-1) and with good water (ECgrw = 0.1 mS cm-1).

* Record the yield (S(s.o.)) and the final ECe.
* Is it necessary to keep the water table at a depth of 250 cm to prevent gradual salinisation? Is groundwater quality a matter of concern'?
* If ECe of the upper 50 cm of the soil increases from 4.0 to 5.5 mS cm-1, how much salt has accumulated in this layer? (Recall that 1 mS cm -1 corresponds with 0.6 grams/liter; assume a total pore fraction of 50%).

Task 6: Adequacy of available irrigation facilities

If summer barley would benefit from irrigation, we might use the existing facilities that are used to irrigate winter wheat provided that the capacity of that system is sufficient.... Calculate how much irrigation would be needed to produce 85% of the constraint-free yield potential of Navid wheat (you have established/recorded the constraint-free yield potential when you examined the possibility of a wheat-barley rotation). Use the same soil parameters as suggested for rain-fed barley. You need not to be very accurate because the irrigation requirements are likely to vary strongly between years and we only want to have an idea of the capacity that the irrigation system must have (e.g. 3500 in 3/hectare.crop). Use irrigation water with an electric conductivity of 0.5 mS cm'. Keep an eye on the ECe of the root zone.

• Is there a danger of (gradual) salt accumulation?

• Can you combat salinisation by adapting the irrigation regime? (Try to keep a downward water movement going by irrigating frequently (many small applications are more effective than a few large applications). Do this for one year only, 1985 seems worth trying.

APPENDIX I FILE-FORMAT DESCRIPTIONS

WEATHER.DAT (and all other climate or weather files):

line # 1: "SITELABEL$", LAT (degree), LON (degree), ELEVATION (m)

lines # 2-366: Julian DAY nr, Tmax (oC), Tmin (0C), PREC (cm/d), RHA (0-1),

E0 (cm/d), SUNH (h/d), ET0 (cm/d)

CROP.DAT:

line #1: "CROPLABEL$"

line #2: C3/C4, T0 (oC), Tsum (oCd), Tleaf (oCd), Tlow (oC),

RDSroot (0-1), RDm (cm), RDint (cm), PSIleaf (cm)

line #3: SLAmax (m2/kg), SLAmin (m2/kg), ke, TCM, r(leaf), r(root),

r(stem), r(s.o.)

line #4: Ec(leaf), Ec(root), Ec(stem), Ec(s.o.), MCY(N) (kg/kg),

MCSTR(N) (kg/kg), MCY(P) (kg/kg), MCSTR(P) (kg/kg)

line #5: NRPTS

line #6: RDS 0 1 2 3 ..... NRPTS

line #7: fr(leaf). . . . ..... .

line #8: fr(root). . . . ..... .

line #9: fr(stem). . . . ..... .

line #10: fr(s.o.). . . . ..... .

SOIL.DAT:

line #1: "SOILLABEL$"

line #2: SM0 (cm3/cm3), GAM (cm-2)

line #3: PSImax (cm), K0 (cm/d), ALFA (cm-1), AK (cm-2.4 d-1)

line #4: S0 (cm/d0.5), Ktr (cm/d)

line #5: dummy value

APPENDIX II TENTATIVE RDS fr(org) RELATION¬S

The mass fractions of gross assimilate production that are apportioned to leaves, roots, stems and storage organs (fr(org)) are a function of the relative development stage (RDS) of the crop.

To determine RDS fr(org) relations, PS 1 experiments must be repeatedly harvested. Monitoring temperature and radiation during the experiments allows to calculate relative development stages at successive harvests. The increments in organ mass between harvests (WIH(org)) are measured. Efficiencies of assimilate conversion (Ec(org)) are known (Table 8.2); gross production of assimilates (FgassH) and mainten¬ance respiration losses between harvests (MRLH(org)) can be calculated.

fr(org) = (WIH(org) / Ec(org) + MRLH(org)) / FgassH

Linear interpolation between combinations of RDS and fr(org) is allowed.