Test run of SWAP under artificial conditions

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1. Introduction

The rise of average global air temperature has some width in IPCC 3rd report. However many studies predict the decrease of precipitation in the middle northern hemisphere, i.e. Turkey. Precipitation in Turkey is the most important natural resources for the agricultural production. We predict the plant productivity, which effected by the air temperature, rise of groundwater table, salt concentration of groundwater and distribution of irrigation water, under several climate scenarios.

In order to predict the water balance, solute balance and plant productivity on the field under specific boundary condition, we use the numerical simulation model of Soil-Water-Atmosphere and Plant production model (SWAP). SWAP consists of the one-dimensional numerical model made by finite differential method, and written in FORTRAN language with Graphical Users' Interface. The water movement is calculated as a function of water potential under various boundary conditions.

2. Material and Method

We focused on the Lower Seyhan river basin, which has heavy textured and low permeable soils, and already affected by salinity as see in **Figure 1**. Furthermore, irrigation and drainage channel is not complete in this region. We studied the productivity of maize that is moderate sensitive to salinity, and one of the dominant crops in this area.

For the sensitivity analysis, we selected one of the heavy textured clay in Lower Seyhan river basin. Soil horizon is showed in **Table 1**, and Soil hydraulic properties to estimate retention curve and hydraulic conductivities are in **Table 2**. And depth from 0 to 5 (cm), soil discretization (Δz) equal to 1 (cm), and in the same way Δz =2.5 (cm), from 5 to 25 (cm), Δz = 5.0 (cm) from 25 to 70 (cm), Δz =10.0 (cm) from 70 to 150 (cm), Δz =20.0 (cm) from 150 to 250 (cm) and Δz =30.0 (cm) from 250 to 400 (cm) depth. Where we assumed wetting parameters $\alpha_w (\cong 2\alpha_d)$ of retention curve for the soil water dynamics considering hysteresis (Kool and Parker, 1987).

Table 1 properties of CANAKCI soil

No.	Horizon	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture Class	Porosity (%)	Bulk density (g/cm^3)	Organic matter (%)
1	Ap	0-20	23.5	55.3	21.2	Sil	47.3	1.35	1.44
2	A12	20-40	30.6	48.4	21.0	L	50.3	1.25	0.51
3	A13	42-55	23.4	51.8	24.8	Sil	52.6	1.26	0.96
4	C1	55-110	38.8	46.6	14.6	L	45.6	1.48	0.66
5	C2	110+	25.7	53.7	20.6	SiL	47.2	1.34	0.61

1) Boundary condition

We compare three different bottom boundary conditions as follows; 1) zero flux at the bottom of soil profile, 2) free drainage at the bottom of the profile and 3) calculate bottom flux from deep aquifer. Further, as an initial condition, we assumed groundwater level is 1.0 (m) deep from soil surface, and mineral concentration is 35 (mg/cm^3).

2) Climate conditions

Climate date was collected on daily base at weather station at Wageningen, The Netherlands in 1976. The data set is daily global radiation (kJ/m^2), minimum and maximum temperature (Celcius degree), air humidity (kPa), mean wind speed (m/sec) at 2 (m) height, and total rainfall (mm).

3) Irrigation timing and amount

No irrigation was applied.

4) Crops

The salt tolerance of crops and some other important parameters are shown in **Table 3** (Maas, 1986) and **Table 4**. We selected Maize for the sensitivity analysis, since it is moderate sensitive for salt, and is one of the dominant crops in ADANA region. The maximum rooting depth of Maize is 100 (cm).

5) Water quality of groundwater.

We assumed the concentration of salt in the groundwater is 35 (mg/cm^3).

Table 2 Soil hydraulic properties for Mualem-van Genuchten equation

No.	Residual water content (cm^3/cm^3)	Saturated water content (cm^3/cm^3)	Saturated hydraulic conductivity (cm/day)	Alpha (drying) (1/cm)	Alpha* (wetting) (1/cm)	Exponent hyd. cond. (-)	Parameter n (-)
1	0.01	0.45	23.8	0.024	0.028	-2.266	1.2
2	0.01	0.49	45.7	0.025	0.050	-1.386	1.2
3	0.01	0.48	36.0	0.026	0.052	-2.233	1.2
4	0.01	0.42	30.7	0.028	0.056	-1.366	1.2
5	0.01	0.47	35.5	0.025	0.050	-1.673	1.2

Each of them are parameterized by SWAP sub-program.

* Assumption of $\alpha_w \cong 2\alpha_d$ (Kool and Parker, 1987).

Table 3 Relative salt tolerance of dominant crops at emergence and during maturity

Common name	Botanical name	Electorical conductivity of saturated soil extract (dS/m)				Rating
		50% Yield	50% Emergence	Threshold	Slope	
Corn	*Zea Mays*	5.9	21-24	1.7	12.0	MS
Cotton	*Gossypium Hirsutum*	17	15	7.7	5.2	T
Wheat	*Triticum aestivum*	13	14-16	6.0	7.1	MT

MS: moderate sensitive, T: tolerance, MT: moderate tolerance

Table 4 Important values of water potential for Maize development

Start to extract water from soil (cm)	Extract water optimally (cm)	Cannot extract water optimal (cm)	Wilting point (cm)	Max. rooting depth (cm)
-15.0	-30.0	-325.0	-8000.0	100

Table 5 Simulation result of *Ta*/*Tp* under the various condition

	1) Zero flux	2) free drainage	3) cal. of bottom flux
Drying simulattion	0.921	0.906	0.938
Hysteresis simulation	0.885	0.920	0.942

6) Sensitivity analysis

A sensitivity analysis is required to evaluate that the input parameters and data set affects of simulation results. Relative transpiration ***T**a/**T**p* is one of the criteria to assess the effects of input data to the simulation results. Where ***T**a* is the cumulative actual transpiration and ***T**p* is the cumulative potential crop transpiration (cm). The relative transpiration can be related to the reduction of plant photosynthesis, and thus to reduction of crop yield (Dam, 2001).

3. Result and Discussion

Table 5 shows the result of numerical simulation of ***T**a/**T**p*. The most sensitive condition is the no flux at the bottom considered hysteresis.

Hear after we compare extreme 2 conditions, free drainage and zero flux at the bottom. **Figure 2** shows the typical simulation result of solute concentration in the soil profile to compare with free drainage and zero flux at the bottom. Simultaneously we compare with the result of drying simulation and hysteresis simulation. In the condition of free drainage, solute moves downward freely. However in the zero flux condition, solute does not moves and accumulated in the soil.

Figure 3 shows the water potential profile in the soil at the end of August 1976. From soil surface to depth of 100 (cm), which is root zone, water potential simulated very different in drying simulation. However in hysteresis simulation, difference of water potential in both simulations are not significant.

Figure 4 shows the water content profile in the soil at the end of August 1976. The drying simulation indicates completely different water content in the whole soil profile. However the difference between two conditions became small in hysteresis one.

Hysteresis simulation is one of the most reliable procedures to predict water balance in root zone (Aoda and Yoshida, 1995), and makes minor difference in water content predictions root zone in between two conditions. Further discussion is needed to improve the study of water dynamic at Lower Seyhan river basin. In order to tuning up the numerical simulation, one should have followed information; 1) Climate data in the previous years measured at ADANA to calibrate parameters, 2) Geophysical profile and groundwater level for proper boundary condition.

4. References

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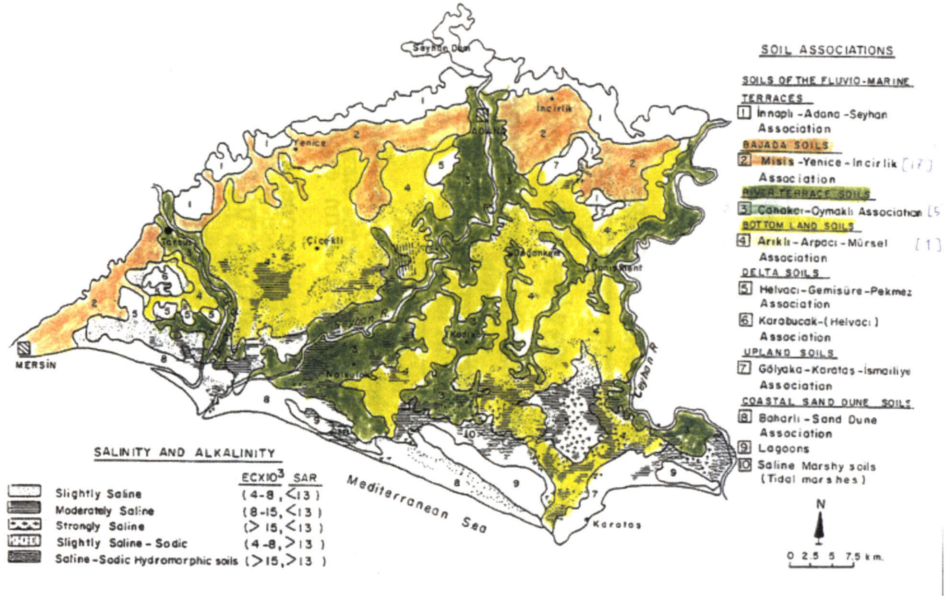

Figure 1 Lower Seyhan river basin affected salinity

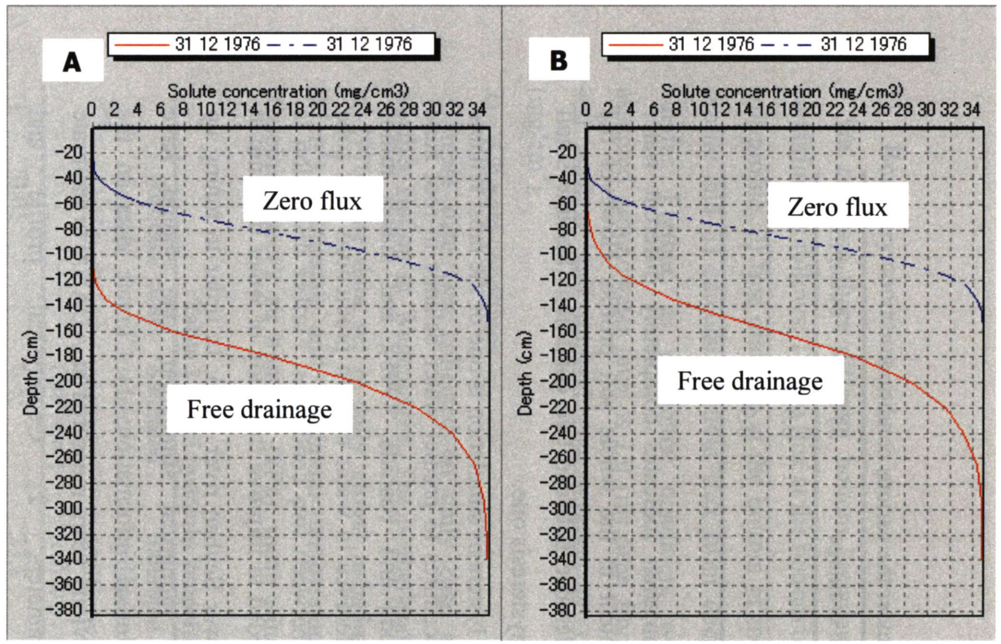

Figure 2 Solute concentrations in the soil profile at the end of 1976; (A) drying simulation, (B) hysteresis simulation

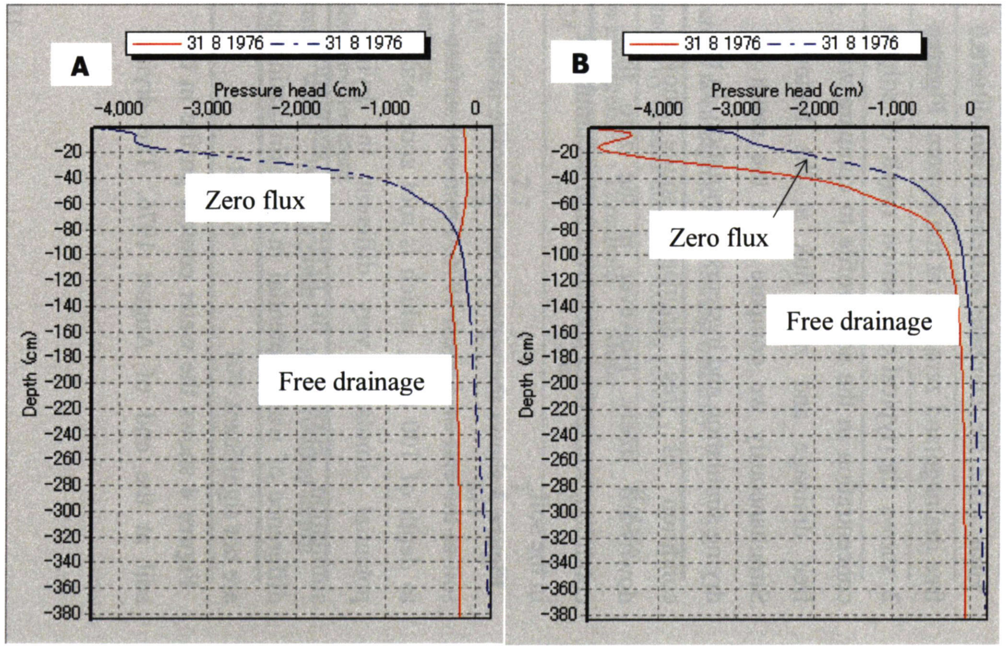

Figure 3 Water potential in the soil profile at the end of August 1976; (A) drying simulation, (B) hysteresis simulation

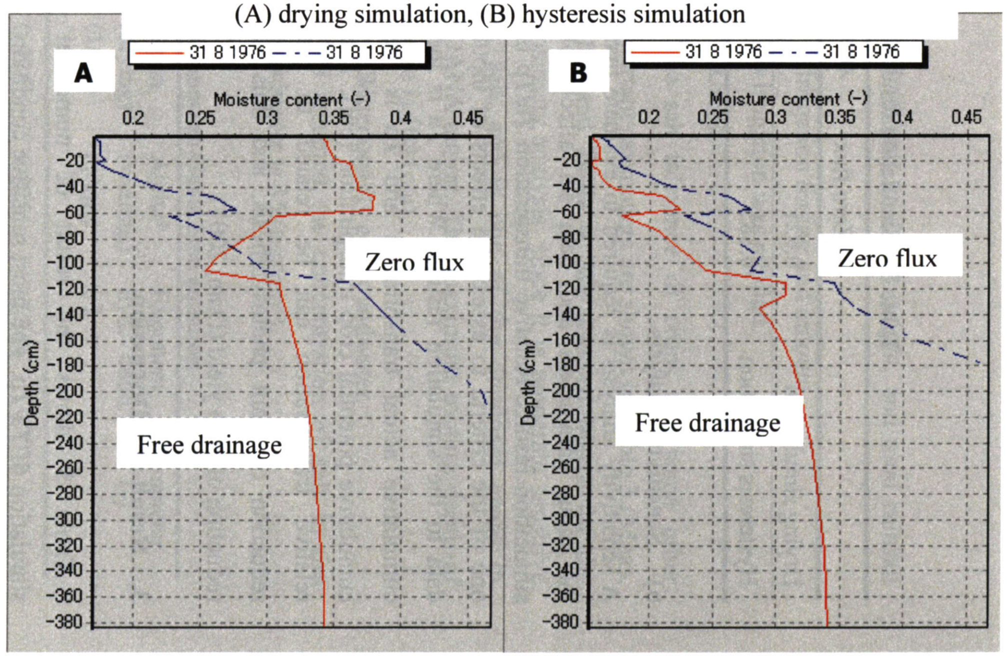

Figure 4 Water content in the soil profile at the end of August 1976; (A) drying simulation, (B) hysteresis simulation