Field validation of DRAINMOD in Atlantic Canada

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Shukla, M.B., Prasher, S.O., Madani, A. and Gupta, G.P. 1994. **Field validation of DRAINMOD in Atlantic Canada.** Can. Agric. Eng. 36:205-213. The watertable management model, DRAINMOD, was validated with field data measured in a subsurface-drained field in Atlantic Canada. The 5.4 ha alfalfa field was monitored for three summer months in 1990 and for five months in 1991 for the midspan watertable heights and drain outflows. Three drain spacings, i.e. 3, 6, and 12 m were used. The average mean of the differences, the average absolute deviations, the standard error, the standard deviation, and the correlation coefficient between the average measured midspan watertable heights and the simulated values ranged from -104.97 to 74.8 mm, 96.9 to 210.5 mm, 135.4 to 271.7 mm, 134.3 to 251.9 mm, and 0.45 to 0.87, respectively, for the three drain spacings. For drain outflows, the corresponding values were -0.146 to -0.62 mm/d, 0.6 to 1.42 mm/d, 1.37 to 3.55 mm/d, 1.24 to 3.57 mm/d, and 0.47 to 0.74, respectively. These values are comparable to values reported by others in similar model validation studies. No attempts were made to calibrate the model. Therefore, it can be concluded that DRAINMOD can be used for designing or evaluating subsurface drainage systems in Atlantic Canada.

Le modèle de gestion de la nappe phréatique, "DRAINMOD" a été validé par des mesures faites dans un champ de drainage hémiédaphique de la région atlantique du Canada. Un champ de luzerne de 5.4 ha a été contrôlé pendant 3 mois à l'été 1990 et pendant 5 mois à l'été 1991, pour prendre note de la hauteur de la nappe d'eau souterraine ainsi que de l'écoulement des tuyaux de drainage. Trois différents espacements de drains ont été utilisés: 3, 6 et 12 m. La moyenne des différences, la moyenne absolue des déviations, l'erreur, l'écart type et le coefficient de corrélation entre les mesures de hauteur de la nappe d'eau et les valeurs simulées ont varié de -104.97 à 74.8 mm, 96.9 à 210.5mm, 135.4 à 271.7 mm, 134.3 à 251.9 mm, et 0.45 à 0.87, respectivement, pour les trois espacements de drains. Dans le cas de l'écoulement des tuyaux de drainage, les valeurs ont varié de -0.146 à -0.62 mm/jour, 0.6 à 1.42 mm/jour, 1.37 à 3.55 mm/jour, 1.24 à 3.57 mm/jour, et 0.47 à 0.74 respectivement. Ces valeurs sont comparables à celles obtenues par d'autres lors d'exercices de validation semblables. Aucun essai n'a été effectué afin de calibrer le modèle. Il peut donc être conclu que "DRAINMOD" peut être utilisé pour la conception ou l'évaluation de systèmes de drainage sub-superficiel dans la région atlantique du Canada.

INTRODUCTION

Artificial drainage is necessary to farm some of the most productive soils in Atlantic Canada. Without artificial drainage, planting and harvesting operations will likely be delayed, which, along with poor drainage conditions, results in total crop failure during wet years and reduced yields during moderately wet years.

A properly designed drainage system will ensure trafficable and workable soil conditions in early spring and late fall and a suitable environment for plant growth in summer.

Several computer simulation models have been developed for simulating the performance of subsurface drainage system (Feddes et al. 1978; Kanwar et al. 1983; Skaggs 1978). The most difficult task facing the users of these models is to determine whether these models accurately simulate the changes in the soil water regime brought about by the subsurface drainage systems and if these models could be used in other geographic locations. Field testing and evaluation of existing models over a wide range of climatic and agricultural conditions is, therefore, an essential element in determining the applicability of these models.

OBJECTIVES

The primary objective of this study was to evaluate the performance of DRAINMOD, a watertable management model, in simulating midspan watertable fluctuations and drain outflows in Atlantic Canada. Experimental data used in this study were collected at an alfalfa farm on a loamy soil in Street Ridge, Nova Scotia.

MODEL DESCRIPTION

DRAINMOD was developed by Skaggs (1978) to evaluate multi-component water management systems such as surface and subsurface drainage and subirrigation on a continuous basis over a long period of climatological record. The model predicts on a day-to-day, or hour-by-hour basis, surface runoff, midspan watertable fluctuations, drain outflow, soil water content, and evapotranspiration in response to a given input consisting of climatological data, soil and crop properties, and drainage system parameters. The model was developed for soils with a shallow watertable. It has been used as a tool for optimizing the design of surface and subsurface drainage, and subsurface irrigation systems. The model is also capable of providing the average crop yields that would result from different watertable management practices for humid regions.

The basis of model development is a water balance relationship for a thin section of soil of unit surface area which extends from the impermeable layer to the surface and is located midway between the drains. Using this approach, both above and below the soil surface, DRAINMOD calculates infiltration, drainage, subirrigation, and evapotranspiration on an hourly basis. The water balance for a time increment of t is given as:

$$\Delta V_a = D + ET + Ds - F \qquad (1)$$

where:

ΔV_a = change in the air volume (mm),
D = lateral drainage from, or subirrigation into, the section (mm),
ET = evapotranspiration (mm),
Ds = deep seepage (mm), and
F = infiltration entering the section (mm).

In general, the basic time increment used for simulation in the model is one hour. However, it could be two hours or one day depending upon drainage and *ET* rates under no rainfall conditions. During rainfall events, depth of infiltration and surface runoff are predicted in three minute increments. For each period of simulation, the model predicts several watertable management objective functions, including number of trafficable days, sum of excess watertable rises above a 300 mm depth (SEW_{30}), and yield reduction due to excess soil water, drought, and poor trafficability. An overall reduction is calculated as the function of these three reductions. By running the model over several years and with a range of drain spacings, the system benefits can be optimized.

DRAINMOD is a well documented user-friendly computer software package. Sufficient instructions are given to the user during the execution of the program. The user inputs are checked throughout the program and a chance to re-enter any faulty entry is provided. It runs on an IBM PC or compatible with at least 640 Kb RAM. A math co-processor is strongly recommended. For further details, the reader is referred to Skaggs (1978, 1989a, 1989b).

METHODS AND MATERIALS

Experimental site

The subsurface drainage system used in this study was located on a 5.4 ha field in Street Ridge, 170 km north west of Halifax, Nova Scotia. The soil was a Queens soil which falls into the QUE22 Map Unit. Soils of the QUE22 Map Unit have a plough layer which ranges in thickness from 0.17 to 0.23 m. This surface layer is characterized by dark brown, friable, coarse loamy materials with approximately 5% by volume of gravel. The upper 0.20 to 0.50 m of soil may grade toward a reddish brown, fine loam but consistency remains friable. Somewhere between 0.23 and 0.50 m of the surface, a highly compacted basal silt is encountered. This layer is characterized by a firm, fine loamy parent material and extends to bedrock. It is highly restrictive to both water movement and root penetration. The field was seeded with wheat in 1989, followed by oats under seeded to alfalfa/bromegrass in 1990 and 1991.

Drainage system

The current subsurface drainage system was installed in 1989. It consists of laterals of 100 mm diameter, which drain an area of 3.7 ha out of the 5.4 ha total area. The three drain lateral spacings 3 m, 6 m, and 12 m with three replications were installed at an average depth of 0.72 m. Drain flow measurements were taken with calibrated buckets and watertable depths were recorded by pressure transducers.

MODEL INPUT

The input data for DRAINMOD includes climatological, soils, crop, and drainage system data.

Climatological data

Hourly precipitation data were recorded at the experimental site with a rain gauge. Format for the rainfall input data is hourly amounts in one-hundredths of an inch. The daily pan evaporation data for Napan and Truro were used to calculate the PET, using the mean ratio of calculated PET to pan evaporation as 0.6 (Doorenhos and Pruitt 1977). Reference crop evapotranspiration, ET_0, was obtained from:

$$ET_0 = K_p * E_{pan} \qquad (2)$$

where:

E_{pan} = pan evaporation (mm/d),
K_p = pan coefficient,

and

$$ET_{crop} = K_c * ET_0 \qquad (3)$$

where:

K_c = crop coefficient, and
ET_{crop} = crop evapotranspiration (mm/d).

Values used in this analysis for pan coefficient and crop coefficient were 0.85 and 0.705, respectively, for alfalfa. The PET input format for DRAINMOD is also in one-hundredths of an inch per day.

Soil data

Soil data are very important for reliable evaluation of drainage system design and performance. The physical characteristics of the soil are given in Table I. According to texture, it can be classified as a loam soil.

Table 1. Physical characteristics of soil at Streets Ridge, Nova Scotia

Horizon	Depth (m)	Sand (%)	Silt (%)	Clay (%)	Bulk Density (kg/m^3)	K_{Sat} mm/h	Moisture retention (%)					
							0 kPa	5 kPa	10 kPa	33 kPa	100 kPa	1500 kPa
A_p	0-0.21	39.7	45.0	15.3	1290	33	46.3	39.8	36.3	33.4	30.5	12.2
B_{mg}	0.21-0.37	42.6	39.4	18.0	1300	30	-	-	-	-	-	-
B_{tg}	0.37-0.61	34.2	41.2	24.6	1780	6	30.9	25.3	23.9	22.7	21.3	16.9
C	0.61+	32.1	42.9	25.0	1860	1	29.3	26.2	25.2	24.2	22.8	18.6

- Data are not available for this horizon.

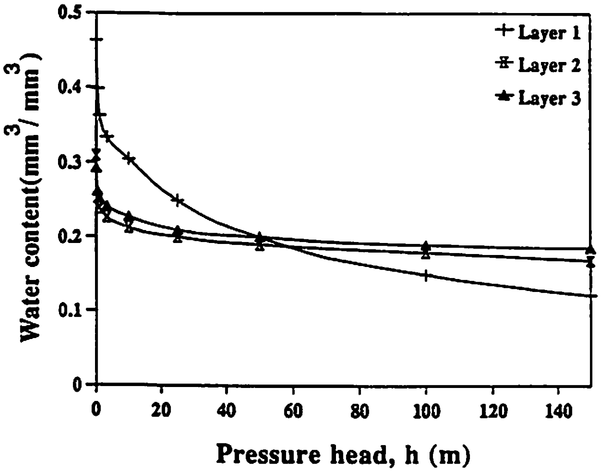

Fig. 1. Soil moisture characteristics of the loam soil.

Soil moisture retention curve

The soil moisture retention curve is a measure of the water content in the soil matrix at various water tensions. Soil moisture characteristic data are entered for the top layer of the soil profile along with the corresponding negative pressure head in the soil data section. The last value of the head should be - 10 m, or smaller. The curve is plotted in Fig. 1.

Saturated hydraulic conductivity

The model uses hydraulic conductivity values in cm/h. The lateral saturated hydraulic conductivity, *k*, must be obtained for each layer up to the effective drainage barrier with as much accuracy as possible since model outputs are very sensitive to hydraulic conductivity values. The *k* values, as determined by the auger-hole method, versus watertable depth, are given in Table II.

Drained volume

The drained volume is the volume of the soil profile that fills with air after the free or gravitational water has drained. DRAINMOD uses this relationship to determine the rise and fall of a watertable when a given amount of water is removed or added. The drained volume versus watertable depth relationship is given in Fig. 2.

Upward flux

The upward flux is the rate of water movement upward from the water-table. The soil moisture characteristic curve given in Fig. 1 was first used to determine the unsaturated hydraulic conductivity for each soil layer. The unsaturated hydraulic conductivity was used to calculate the watertable depth and maximum steady state upward flux relationship, plotted in Fig. 3.

Table 2. Saturated hydraulic conductivity vs water-table depth

Depth in soil (m)	Saturated hydraulic conductivity K_{sat} (mm/h)
0.0 - 0.36	33
0.36 - 0.6	6
0.6 - 5.0	1

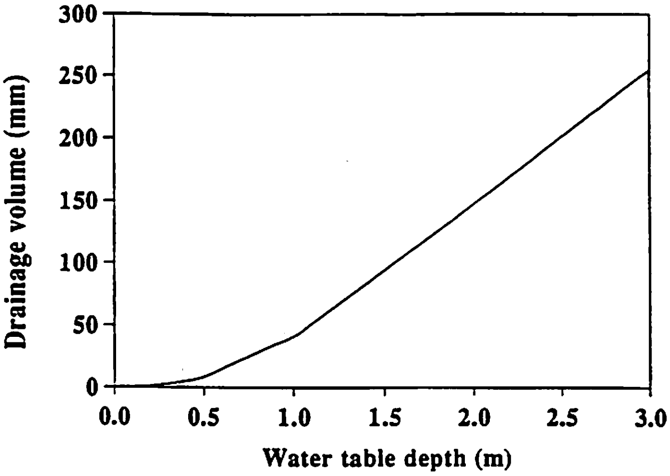

Fig. 2. Relationship between drainage volume and watertable depth.

Infiltration parameters

The Green-Ampt equation is used to determine the rate of infiltration. Two coefficients, *A* and *B* are needed. They can be estimated from:

$$A = K_s M S_{av} \tag{4}$$

$$B = K_s \tag{5}$$

where:

K_s = vertical saturated hydraulic conductivity (cm/h),
M = soil water deficit (cm^3/cm^3), and
S_{av} = average suction at the wetting front (cm).

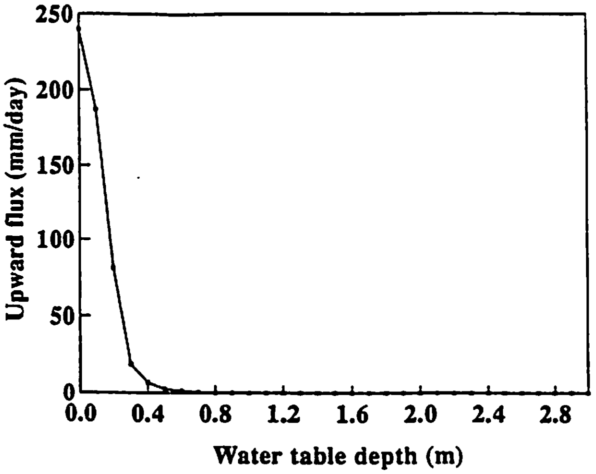

Fig. 3. Relationship between steady state upward flux and watertable depth below the centre of effective crop rootzone.

Table 3. Parameters for the Green-Ampt infiltration equation

Initial watertable depth (mm)	A (cm^2/h)	B (cm/h)
0	0.00	3.30
308	1.17	3.30
571	1.43	2.30
1000	1.22	1.37
3560	0.53	0.46
5860	0.46	0.32
10000	0.20	0.14

Values for A and B as a function of the watertable depth are given in Table III. The value of S_{av} was estimated from Table 5-5 of DRAINMOD Reference Report (Skaggs 1989b). The last value must correspond to a watertable depth of 10 m.

Rooting depth

DRAINMOD requires effective rooting depth with time as input. The effective rooting depth refers to the depth to which the majority of the roots are located. No field measurements, however, were made to determine this function. Table IV gives the estimated rooting depth versus the day of the year relationship for alfalfa (Doty et al. 1986).

Drainage system parameters

Input data required to describe a drainage system include depth of drains, drain spacing, depth of the impermeable layer, effective "open" drain diameter, and surface storage. These data are summarized in Table V. Actual distance from the drains to impermeable layer is used to calculate the equivalent depth in Hooghoudt's formula (Wessling 1983). Its value increases with the actual distance from the drains to the impermeable layer, until distance equals to one-quarter of drain spacing. For larger values of actual depth of the barrier, the equivalent depth remains approximately constant. Apparently, the flow pattern is not affected then by the impermeable layer. For the simulation, actual depth was taken equal to one-quarter drain spacing plus the drain depth.

Table 4. Assumed effective alfalfa rooting depth vs day of the year

Month of the year	Day of the month	Root depth (mm)
1	1	30
2	28	30
3	31	30
4	30	30
5	1	30
5	15	90
6	8	250
6	20	300
7	31	300
7	31	300
8	31	300
9	30	300
10	31	300
11	15	30
12	31	30

Table 5. Summary of the input parameters for subsurface drainage system

Parameter	Input value
Effective radius of drains	5.1 mm
Drain depth	20 mm
Drain spacing	3 m, 6 m, 12 m
Actual distance from drain to impermeable layer	1.47, 2.22, 3.72 m
Equivalent depth from drain to impermeable layer	0.223, 0.395, 0.707 m
Maximum depth of surface ponding	15 mm
Drainage coefficient	12 mm/d
Initial watertable depth	0.53 m
Surface storage that must be filled before water can move to drain	5 mm

METHODS OF EVALUATION

The model was evaluated by both graphical and statistical methods. In the graphical approach, the measured and simulated values were plotted against time. The response of the model can, therefore, be quantified visually. In the second approach, the agreement between the measured and simulated daily watertable depths and drain outflows were statistically quantified by calculating the average mean of the differences, average absolute deviation, standard error, standard deviation of the differences, and correlation coefficient. Statistically, the average mean of the differences gives information on whether a model is under- or over-estimating; the average absolute deviation and standard error are indicators of quantitative dispersion between the measured and simulated values; the standard deviation of differences gives a measure of the range of errors in the probability distribution of error occurrences; and the correlation coefficient represents agreement between the measured and simulated values.

The average mean of differences (*A.* Mean) was calculated as:

$$A.\,Mean = \frac{\sum (Y_m - Y_p)}{n} \qquad (6)$$

where:

n = number of days in the test period,
Y_m = measured value at the end of each day (m), and
Y_p = predicted value at the end of each day (m).

The average absolute deviation (*A.D.*) was computed as:

$$A.D. = \frac{\sum |Y_m - Y_p|}{n} \qquad (7)$$

The standard error (*S.E.*) was calculated as:

$$S.E. = \sqrt{\frac{\sum (Y_m - Y_p)^2}{n}} \qquad (8)$$

The standard deviation of differences was calculated as:

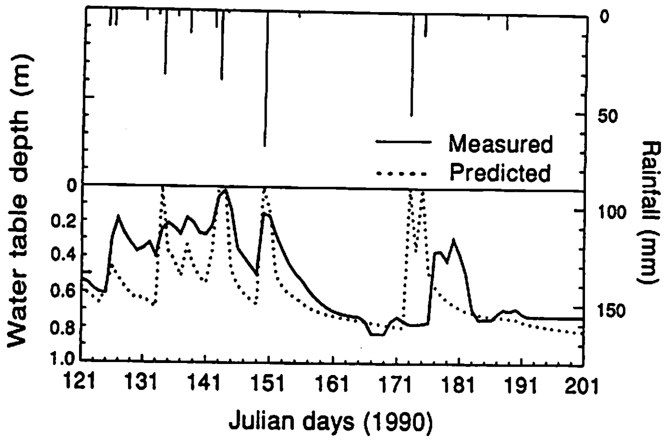

Fig. 4. Measured and predicted watertable depths in 1990 in test plots with 3m drain spacing.

$$S.D. = \sqrt{\frac{\sum (Y_m - Y_p)^2 - (\sum (Y_m - Y_p))^2/n}{(n-1)}} \qquad (9)$$

Ideally, the values of the *A*.mean, *A.D.*, *S.E.* and *S.D.* should be close to zero and the value of correlation coefficient, R^2, equal to 1.

DRAINMOD was run for 121 to 201 Julian days in 1990 and for 121 to 254 days in 1991. Watertable depth at mid-spacing and subsurface drain outflow were used to compare the simulated and measured values.

RESULTS AND DISCUSSION

In this section, first the results of simulated and measured watertable heights are given for the three drain spacings. Next, the corresponding results for drain outflows are described.

Watertable depth

The predicted and measured watertable heights were plotted against time for both years. For 1990, the results are given in Figs. 4, 6, and 8. Figures 10, 12, and 14 contain the results for 1991.

From the figures, it is clear that the trend between the measured and simulated data is similar, except for some discrepancy in Fig. 4. The measured and simulated values are out-of-sync at around Julian day 171. This appears to be caused by a measurement error. The measured values are showing a much delayed increase in watertable height around this time. In Figs. 6 and 8 for the other two drain spacings, the measured watertable heights respond quite quickly to the rainfall for this time, similar to the simulated values. Therefore, it is more likely to be a malfunctioning of the equipment for this treatment for this set of measurements.

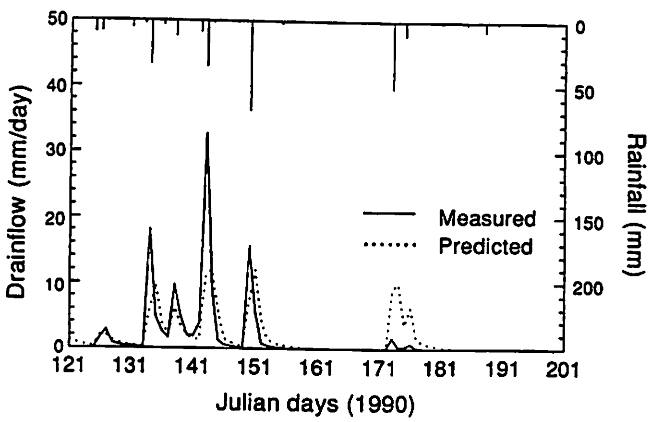

Fig. 5. Measured and predicted drain outflow in 1990 in test plots with 3m drain spacing.

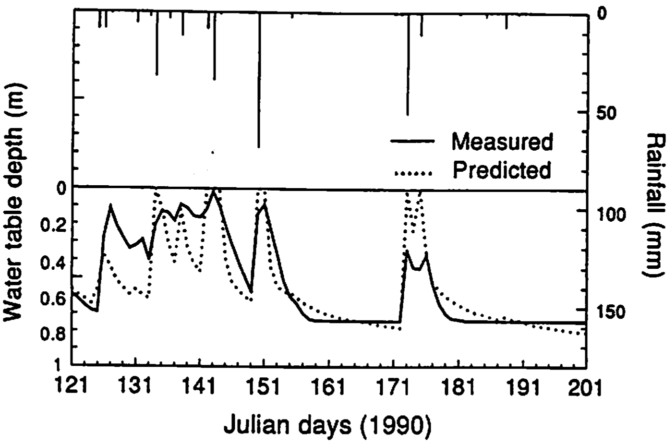

Fig. 6. Measured and predicted watertable depths in 1990 in test plots with 6m drain spacing.

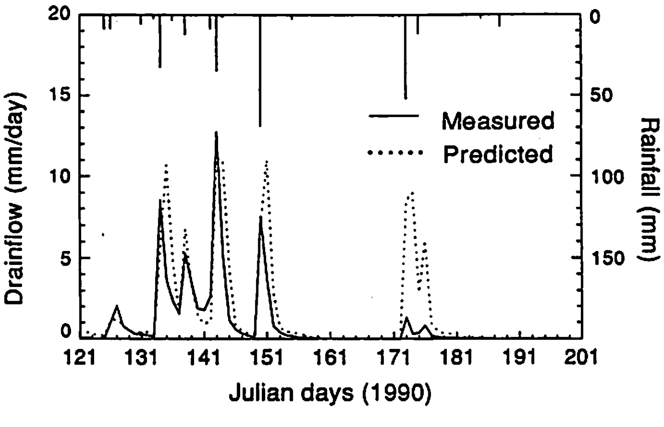

Fig. 7. Measured and predicted drain outflow in 1990 in test plots with 6m drain spacing.

The model seems to simulate fluctuations in midspan watertable heights quite well. The measured and simulated peaks are quite similar in the three figures. The model, however, seems to be more sensitive to rain than what the measured data show. This could be the result of smaller drainable porosities values used by the model. It should be noted that no attempts were made to calibrate the model; the measured data were used as such. An underestimation of crop evapotranspiration could not have caused this rapid rise because usually it is quite less during the rainfall events.

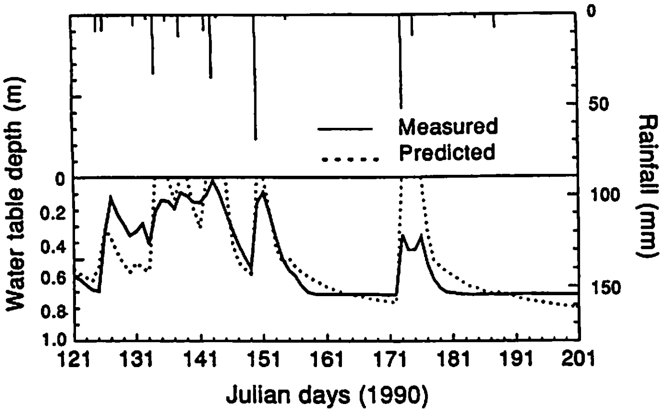

Fig. 8. Measured and predicted watertable depths in 1990 in test plots with 12m drain spacing.

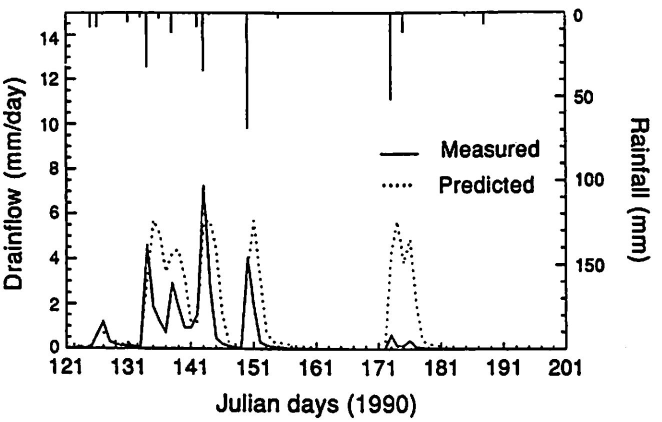

Fig. 9. Measured and predicted drain outflow in 1990 in test plots with 12m drain spacing.

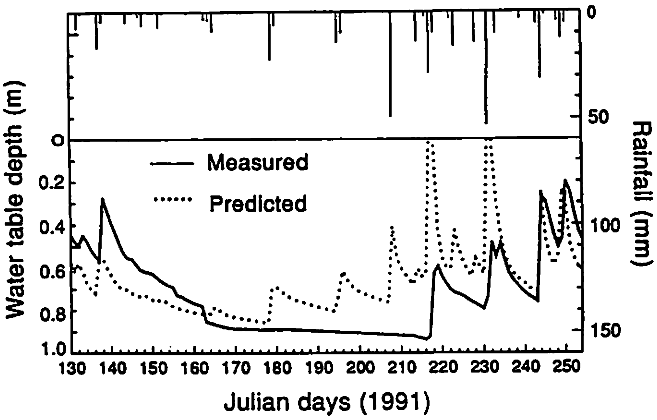

Fig. 10. Measured and predicted watertable depths in 1991 in test plots with 3m drain spacing.

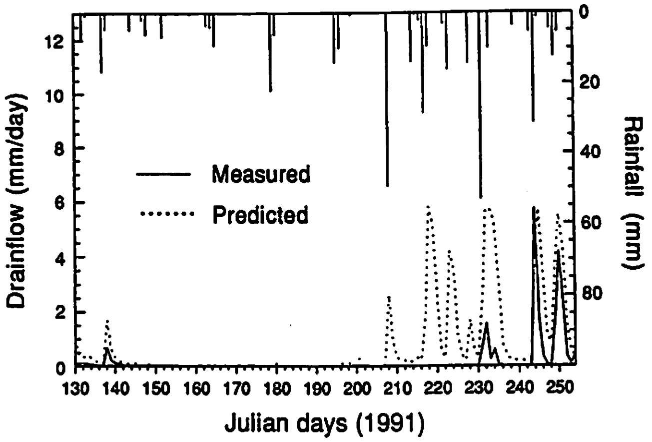

Fig. 11. Measured and predicted drain outflow in 1991 in test plots with 3m drain spacing.

Moreover, DRAINMOD was provided with "measured" potential evapotranspiration values, derived from the measured pan evaporation data. So, there was little possibility for DRAINMOD to underestimate evapotranspiration during or between rainfall events.

The simulated watertable depths are generally shallower than the measured values in 1991. Some errors in the measurement equipment were encountered. Observations between 186 and 212 Julian days were lost due to equipment malfunction. Early in the season, the measured values are higher than the simulated values. However, the reverse is true for most of the remaining season. The trends between the measured and simulated values are similar during other intervals. Towards the end of the measurement period, the simulated and measured watertables depths are quite close to each other.

The results of the statistical analysis are given in Table VI. They include the average mean of differences, the average absolute deviation, the standard error, the standard deviation, and the correlation coefficient. The values of the average mean of differences is negative in all runs except for 3 and 6 m drain spacings in 1990. This indicates that the model is over-estimating the watertable heights. However, the magnitude of average differences is -104.9 mm to 74.8 mm which is acceptable since the model was not calibrated. The average absolute deviation ranges from 96.9 to 210.5 mm. This means, for example, that the predicted values are at most 210 mm on either side of the average for the 12 m drain spacing in 1991. The standard error was found to range from 135.4 to 271.7 mm for all runs. The standard deviation of differences ranged from 134.3 to 251.9 mm which indicates that there is good probability of obtaining simulated values within 134 to 251 mm of the difference in all cases. The range for the correlation coefficients is 0.45 to 0.87.

The statistical results show that, on the whole, there is good agreement between the measured and simulated values. The statistical analyses results for the year 1991 are poor mainly because of the missing measured data between 186 and 212 Julian days.

DRAINMOD has been evaluated in the past by many researchers for different soil and climatic conditions. Sanoja et al. (1988), Kanwar and Sanoja (1988), Workman and Skaggs (1989), and Fouss et al. (1987) have compared the measured and simulated outflows and watertable elevations. In these studies, the standard errors for midspan watertable depths ranged from 100 to 440 mm and the average absolute deviations ranged from 60 to 380 mm. The average absolute deviation values and the standard errors obtained from this study are quite comparable to these published values.

Table 6. Average mean of differences (A.Mean), Average Absolute Deviation (A.D.), Standard Error of Estimate (S.E.), Standard Deviation (S.D.) and Correlation Coefficient for measured vs predicted watertable depths

Year	Julian day	Drain spacing	Statistical analyses				
			A.Mean (mm)	A.D. (mm)	S.E. (mm)	S.D. (mm)	Correlation coefficient
1990	121-201	3 m	74.83	149.14	208.54	195.9	0.609
		6 m	24.95	98.44	140.50	139.1	0.837
		12 m	-23.11	96.98	135.45	134.3	0.873
1991	130-254	3 m	-30.85	145.98	202.57	201.2	0.432
		6 m	-41.84	148.81	212.18	209.1	0.491
		12 m	-104.97	210.55	271.77	251.9	0.451

Subsurface drain outflow

The simulated and measured drain outflows for the three drain spacings are plotted against time in Figs. 5, 7, and 9 for 1990 and in Figs. 11, 13, and 15 for 1991. For 1990, the graphs show a good agreement between the measured and simulated values. The time to peak and the peak flow rates are quite close. For 1991, there is quite a difference between the measured and predicted drain outflows, especially between 208 and 230 Julian days. There are quite a few rain events during this duration, but there is no drain outflow. For other intervals, there is reasonable agreement, though there are some differences in peak outflow rates.

The statistical analyses for drain outflows for three treatments are given in Table VII. The average mean of differences ranges from -0.146 to -0.62 mm/d for all cases which indicates that the model is over-estimating the drain outflows. However, its magnitude is not that significant. The average absolute deviation ranges from 0.61 to 1.42 mm/d which indicates that, on an average, the simulated results are different from the measured values by 0.61 to 1.42 mm/d on either side of the mean for the three drain spacings. The standard error ranges from 1.37 to 3.55 mm/d for all cases. The standard deviation ranges from 1.24 to 3.57 mm/d which shows that there is always good probability to get simulated results within 1.24 to 3.57 mm/d of the measured drain outflow. The correlation coefficient ranges from 0.47 to 0.74. Given the fact that the model was not calibrated, the values for the various statistical parameters are quite satisfactory.

The standard errors in drain outflow in previously mentioned studies on the validation of DRAINMOD ranged from 0.8 to 1.3 mm/d and the average absolute deviations from 0.6 to 0.7 mm/d. So, the values obtained in this study are quite comparable to these published values.

Some additional remarks

The spatial variability in soil physical properties also could have caused some differences between the measured and predicted values. Usually, quick rising and falling watertables are indicators of lower drainable porosity values. Since they are indirectly considered in DRAINMOD through the volume drained versus watertable depth relationship and this relationship is calculated from the soil moisture retention curve, it appears that the soil moisture retention characteristic curve needs a careful examination. Also, the assumption of drained-to-equilibrium soil profile might not be a very justifiable assumption in a layered soil profile. In this study, no attempts were made, however, to obtain a better fit through model calibrations.

Therefore, the model performance seems to be satisfactory when field variability and the approximate nature of many of the model inputs are considered. The results show that DRAINMOD has the capability to simulate drain flow and watertable depths for agricultural soils in Atlantic Canada.

SUMMARY AND CONCLUSIONS

The watertable management model, DRAINMOD, was evaluated as a tool for designing subsurface drainage systems in Atlantic Canada. Model simulations were checked against the measured watertable depths and drain outflows

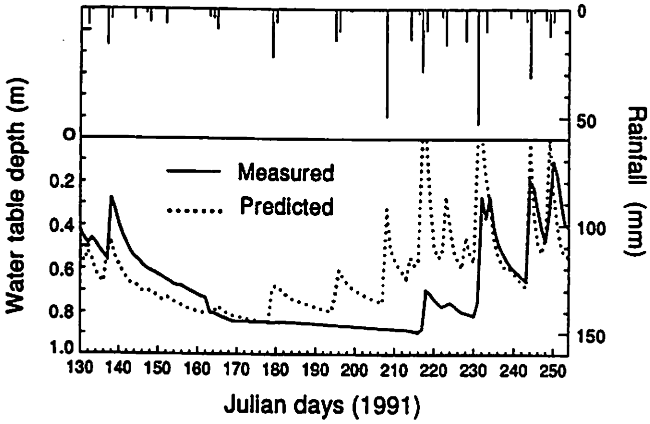

Fig. 12. Measured and predicted watertable depths in 1991 in test plots with 6m drain spacing.

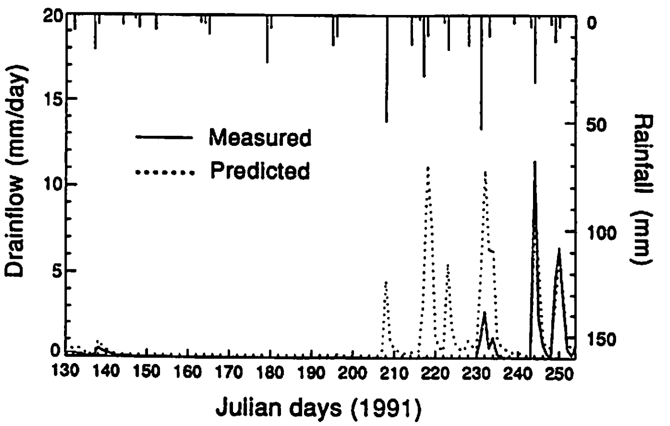

Fig. 13. Measured and predicted drain outflow in 1991 in test plots with 6m drain spacing.

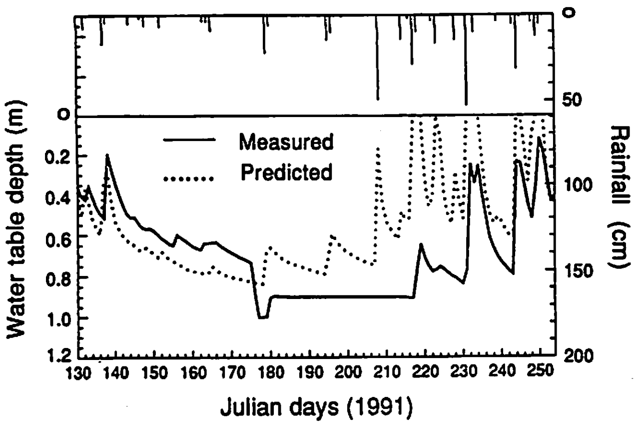

Fig. 14. Measured and predicted watertable depths in 1991 in test plots with 12m drain spacing.

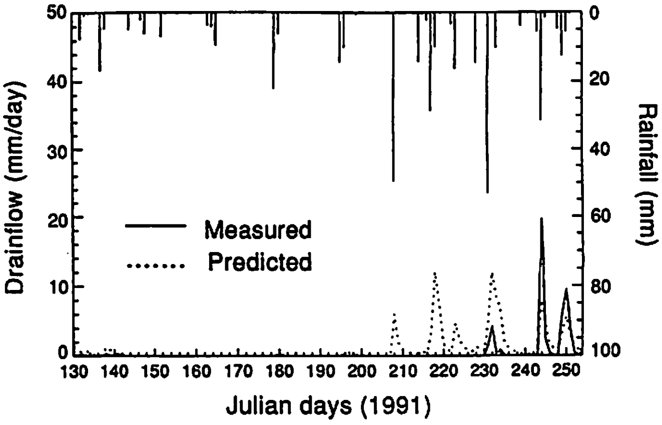

Fig. 15. Measured and predicted drain outflow in 1991 in test plots with 12m drain spacing.

Table 7. Average mean of differences (A.Mean), Average Absolute Deviation (A.D.), Standard Error of Estimate (S.E.), Standard Deviation (S.D.) and Correlation Coefficient for measured vs predicted drain outflows

Year	Julian day	Drain spacing	Statistical analyses				
			A.Mean (mm/d)	A.D. (mm/d)	S.E. (mm/d)	S.D. (mm/d)	Correlation coefficient
		3 m	-0.146	1.420	3.55	3.58	0.647
1990	121-201	6 m	-0.613	0.848	2.05	1.97	0.744
		12 m	-0.620	0.737	1.52	1.40	0.647
		3 m	-0.605	0.924	2.27	2.20	0.473
1991	130-254	6 m	-0.598	0.693	1.87	1.78	0.537
		12 m	-0.584	0.610	1.37	1.24	0.576

for three months in 1990 and for five months in 1991. The experimental data were available for three drain spacings, 3 m, 6 m, and 12 m. Generally, good agreement was found between the simulated and measured midspan watertable heights and drain outflows for the three drain spacings.

For watertable depths, the average mean of differences, the average absolute deviation, the standard error, the standard deviation, and the correlation coefficient values varied from -104.9 to 74.8 mm, 96.9 to 210.5 mm, 135.4 to 271.70 mm, 134.3 to 251.9 mm, and 0.45 to 0.87, respectively. For drain outflows, the corresponding values were -0.146 to 0.62 mm/d, 0.6 to 1.42 mm/d, 1.37 to 3.55 mm/d, 1.24 to 3.57 mm/d, and 0.47 to 0.74, respectively.

Based on the results of this study and given the fact that no attempts were made to calibrate the model, it can be concluded that DRAINMOD can be used to design drainage system in Atlantic Canada. Since DRAINMOD can also be used to design other watertable management systems, such as controlled drainage or subirrigation systems, we recommend further evaluation of DRAINMOD in Atlantic Canada.

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