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Comparison of two models for soil moisture prediction in wheat crop

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ABSTRACT

Five varieties of wheat viz., HD 2285, HD 2329, PBW 175, PBW 343 and C 306 were raised in two consecutive *rabi* seasons of 1998-99 and 1999-2000 in the research farm area of Indian Agricultural Research Institute with four replications in randomised block design.Campbell-Diaz and Soil-Plant-Atmosphere-Water (SPAW) models were calibrated with the first season data and were tested for their performance with the second season data. The SPAW model was found to perform better for soil moisture prediction in the individual soil layers than the Campbell-Diaz model. The root mean square errors in case of SPAW were 3.0-4.2, 2.0-3.4, 2.78-3.88 and 1.65-2.77 (% by volume) for 0-15, 15-30, 30-45 and 45-60cm layers respectively compared to Campbell-Diaz values of 5.2-7.4, 3.1-4.4, 6.0 and 8.7-10.0 (% by volume).

Key words: Model, SPAW, Campbell-Diaz, Soil moisture

Soil moisture availability is one of the key parameters that has significant bearing on crop growth and development. At times it is difficult to estimate soil moisture status with desirable spatial and temporal frequencies. In this context, the dynamic simulation models have become handy. However before the use of such models in regions other than where they are developed, they need standardization and calibration with locally measured soil, plant and weather parameters. A number of water balance models have been developed and tested in various climatic situations (Ritchie, 1972; Ritchie, 1985; Campbell and Diaz, 1988). The SPAW model developed by Saxton *et al.* (1974) and the Campbell and Diaz model (1988) are less data intensive and provide a suitable compromise between the levels of details and the volume of input data requirement. However not much of work has been done in our country to check the potential of these two models for predicting soil moisture status in varied climatic conditions. Keeping this in view, an experiment was carried out to calibrate and evaluate the performance of these two models in the semi-arid environment of Delhi.

MATERIALS AND METHODS

The experiment was carried out taking five wheat cultivars viz., HD 2285, HD 2329, PBW 175, PBW 343 and C 306 in two consecutive *rabi* seasons of 1998-99 and 1999-2000 in the research farm of Indian Agricultural Research Institute, with four replications in a randomised block design following the recommended agronomic

practices. The soils range from silty clay loam in the surface to sandy loam type in the deeper layers. With the first season data, the two models were calibrated and with the second season data, the models were validated. The Campbell-Diaz model was calibrated by making the advection correction in the actual transpiration calculation. A correction factor of 1.03 was found suitable up to 70 days after sowing in all the five varieties whereas for the rest of the period up to maturity, 1.12 was found suitable. The SPAW model was calibrated by parameterization of the root water extraction pattern. Then, the calibrated models were tested with an independent data set of the second crop season, i.e., 1999-2000 rabi season. The predicted values were compared with those observed both in the individual soil layers and in the whole soil profile.

RESULTS AND DISCUSSION

The simulations of soil moisture contents for different layers for one cultivar HD2285 are shown in Figs. 1 and 2 for Campbell-Diaz and SPAW respectively as identical results were obtained in respect of other four cultivars. The comparison in terms of error obtained by the simulation for individual soil layers and the whole 60cm profile are presented in Tables 1 and 2 respectively. The findings are described layerwise as below.

First soil layer (0-15cm)

In most cases, there was underestimation of soil moisture content. The root mean square error (RMSE) varied from 5.2 to 7.4% V (Table 1) in the five varieties studied. The SPAW model was found to predict the soil moisture content in this zone with reasonable accuracy though there was some variation after 90 days of sowing. The RMSE values ranged from 3.0-4.2% V for the five varieties.

Second soil layer (15-30cm)

Both the models were found to perform better in this layer as compared to that in the 0-15cm profile. The RMSE values for Campbell-Diaz model were of the order of 3.1-4.4% V in the five varieties. The values predicted by the SPAW model were close to the observed values in the active growth period upto 100 DAS. The RMSE involved in prediction was in the range of 2.03-3.44% V.

Third soil layer (30-45cm)

Both the models overestimated the soil moisture content in this layer. But the error observed in the Campbell-Diaz model was comparatively higher (RMSE of about 6.0% V) than that in the SPAW model (RMSE of 2.78-3.88% V).

Fourth soil layer (45-60cm)

The Campbell-Diaz model overestimated in this layer, the RMSE values being in the range of 8.7-10.0%V. The SPAW model however proved to be better and the RMSE varied from 1.65-2.37% V, which was the least as compared to the other layers.

The whole 60 cm profile

To see how the models perform in predicting irrigation schedules, the soil

Table 1: Root mean square error(%V) of soil moisture content simulated by Campbell-Diaz (I) and SPAW (II) models at different depth under five wheat cultivars in 1999-2000 season.

Variety	0-15cm		15-30cm		30-45cm		45-60cm	
	I	II	I	II	I	II	I	II
HD 2285	6.73	3.99	4.40	3.39	5.85	2.78	8.76	1.65
HD 2329	5.60	3.05	4.07	3.44	6.45	3.88	9.55	2.37
PBW 175	5.20	4.01	3.44	2.03	5.89	2.90	9.31	1.83
PBW 343	5.66	4.10	3.19	3.04	6.11	3.04	9.53	1.95
C 306	7.48	4.22	4.42	3.31	6.28	3.31	10.06	2.20

Table 2 : Error(cm) in 60cm profile moisture content as simulated by Campbell-Diaz (I) and SPAW (II) models at different irrigation levels under different wheat cultivers in 1999-2000 season.

Irrigation	HD 2285		HD 2329		PBW 175		PBW 343		C 306	
No.	I	II	I	II	I	II	I	II	I	II
1	3.40	1.20	3.40	1.20	3.60	1.40	3.63	1.48	3.67	1.45
2	3.35	0.35	3.35	0.35	3.96	0.38	3.20	0.36	3.51	0.15
3	1.28	1.24	1.24	1.24	0.57	0.59	1.64	1.71	1.44	1.43
4	4.05	0.86	4.05	0.86	3.49	0.30	3.36	0.30	3.23	0.37
5	0.36	1.95	0.29	1.95	0.59	1.07	0.39	2.40	0.25	2.28

moisture contents of individual soil layers were integrated over the whole 0 to 60 cm profile before different irrigation dates. The errors involved in case of SPAW were lower than those in case of Campbell-Diaz model (Tables 1 and 2)

Thus from the above comparisons it is seen that as calibrated here, the SPAW model performed relatively better than Campbell-Diaz model in simulating the soil moisture content both in the individual soil layers and also when integrated over the whole 60cm profile. Earlier findings have shown that the Campbell-Diaz model had predicted well the soil moisture content under Delhi conditions in wheat, chickpea (Dutta, 1992) and Brassica (Bhattacharya, 1995) crops. The soil had lower clay content in the profile with depth, silty clay loam being replaced by sandy loam in the lower layers. The Campbell-Diaz model uses field capacity, permanent wilting point and air-dry water content, averaged for the whole profile and not for individual layers whereas the SPAW

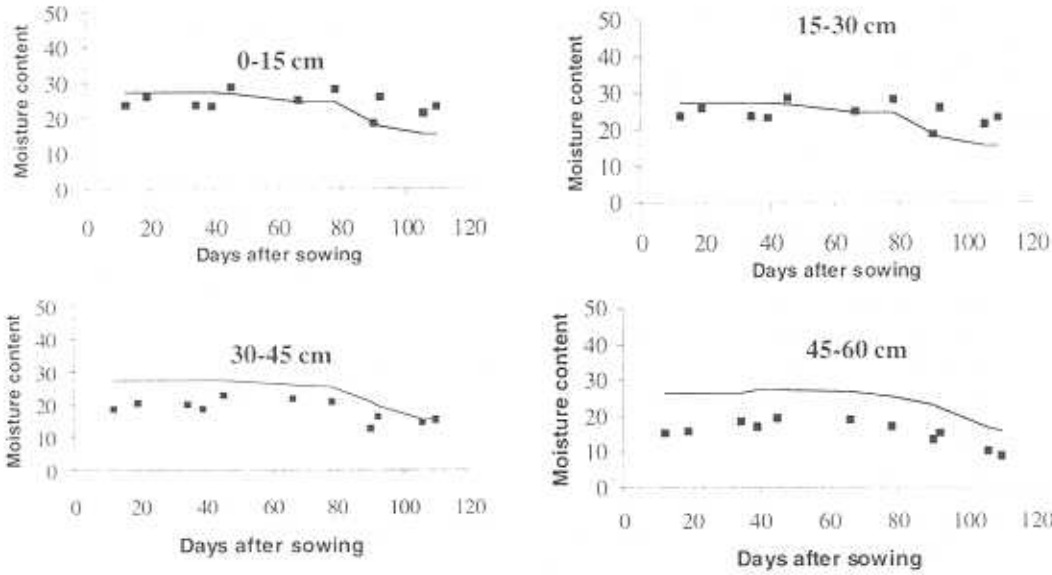

Fig. 1: Observed (▪) and simulated (-) soil moisture content (%V) for different layers by Campbell - Diaz model in HD 2285.

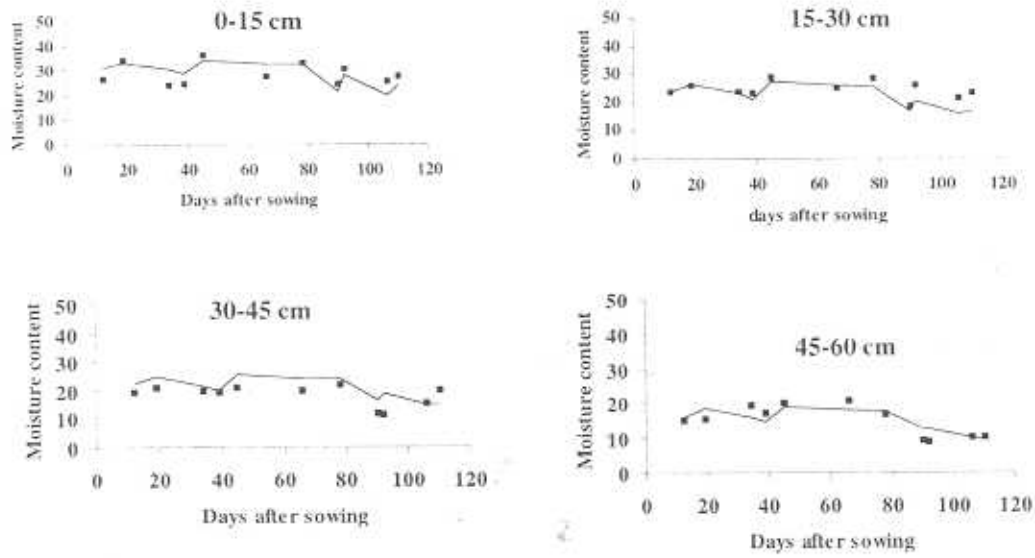

Fig. 2: Observed (▪) and simulated (-) soil moisture content (%V) for different layers by SPAW model in HD2285.

model takes the texture and retention characteristics of individual soil layers separately as input, leading to differences in the observed RMSE values. However both the models gave similar results from 15-30cm soil layer.

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