This paper was peer-reviewed for scientific content.
Pages 871-876. In: D.E. Stott, R.H. Mohtar and G.C. Steinhardt (eds). 2001. Sustaining the Global Farm. Selected papers from the 10th International Soil Conservation Organization Meeting held May 24-29, 1999 at Purdue University and the USDA-ARS National Soil Erosion Research Laboratory.

How WEPP Model Responds to Different Cropping and Management Systems

X.C. Zhang, M.A. Nearing and L.D. Norton*

ABSTRACT

One primary goal of developing soil erosion prediction models is to help farmers and land managers developing the best management practices that could conserve soil and water resources. Thus, a successful model must be capable of predicting soil losses accurately for lands under different cropping and management systems. The objective of this study was to evaluate the responses of the Water Erosion Prediction Project (WEPP) model to different cropping and management systems. In order to evaluate general trends of the WEPP model responses, a WEPP "C-factor", which is similar to the USLE C factors, was defined as the ratio of soil loss from cropped conditions to that from the corresponding fallow. The calculated results were then compared to the well-known trends of the C factors established by RUSLE and USLE models. This approach was considered appropriate in light of the fact that the RUSLE and USLE models represent general trends of cropping and management C factors for common cropping systems. The unit plot measurements (9% slope and 22-meter length) were used in the WEPP slope input files. Several common crops (e.g. corn, cotton, and alfalfa) and tillage systems (e.g. conventional, conservation, and no-till) were used to prepare the management input files. Two soils (Cecil sandy clay loam and Providence silt loam) were used. The climate input files were generated by the WEPP climate generator for three locations, representing three distinct climatic regions. The USLE C-factors were directly obtained from Agricultural Handbook 537, and the RUSLE C-factors were derived from version 1.04 of the RUSLE model. Results showed that the WEPP model tended to slightly over-predict annual C-factors compared with RUSLE, while under-predict C-factors relative to USLE. Overall, the WEPP model followed the known trends of cropping and management factors reasonably well for the cropping systems used in this study.

INTRODUCTION

The Universal Soil Loss Equation (USLE) was derived as an empirical model from a large database of soil loss collected beginning in the 1930's (Wischmeier and Smith, 1978). It has been widely used as an erosion prediction and conservation planning tool. The equation takes the form of A=RKLSCP where A is the annual soil loss and R, K, L, S, C, and P represent rainfall erosivity index, soil erodibility, slope length, slope steepness, cropping and management, and control practice factors, respectively. The C-factor was defined as the ratio of soil loss from a cropped plot to that from clean-tilled, continuous fallow plot with the same soil, topography, and climatic input (Wischmeier and Smith, 1978).

The Revised Universal Soil Loss Equation (RUSLE) is based in large part on USLE, but incorporated some new advances in erosion mechanics (Renard et al., 1997). The basic model structure and major predictive factors in RUSLE remain the same as in USLE. The C-factor in RULSE is defined in the same way as is in USLE and is used to represent the relative effect of cover and management on soil loss rate. The C-factor consists of several subfactors to represent the effects of canopy, residue mulch, belowground biomass (root mass and incorporated residue), surface roughness (tillage), and land use residuals. In RUSLE, the C-factor is computed as: C=PLU*CC*SC*SR*SM where PLU, CC, SC, SR, and SM represent, respectively, prior land use, canopy cover, surface cover, surface roughness, and soil moisture subfactors (Renard et al., 1997). Each subfactor is predicted using empirical relationships.

As new theories about fundamental erosion mechanics are verified and become available for application, more robust models, which are based on better scientific definitions and produce more accurate predictions, should be developed by incorporating those new theories and better understandings. The Water Erosion Prediction Project (WEPP) has been developed to cope with new advances in erosion sciences. This improved new technology is process oriented, and is based on modern hydraulic and erosion sciences. Unlike USLE and RUSLE, upland erosion has been explicitly divided into two fundamental erosion processes in WEPP: interrill and rill. Each process is mechanistically simulated, and then integrated along slope profile based on basic sediment transport theories. Due to the process-oriented nature, the integral effects of cropping and management on soil loss rate cannot be represented by one C-factor in WEPP as does in USLE or RUSLE. Each C subfactor has to be bound to the processes in which it has significant effects. Thus, WEPP has a different type of adjustment to cover and management in light of erosion mechanics, compared with USLE and RUSLE.

In the WEPP model, interrill soil loss, D_i, in kg s^{-1} m^{-2} from the cropped land is calculated as:

$$D_i = K_i \times I \times I_e \times S_f \times SDR \qquad [1]$$

---

*X.C. (John) Zhang, USDA-ARS, Grazinglands Research Laboratory, 7207 W. Cheyenne St., El Reno, OK73036; M. A. Nearing, and L. D. Norton, USDA-ARS, National Soil Erosion Research Laboratory, Soil Building, Purdue University, West Lafayette, IN47907-1196, USA. *Corresponding author: jzhang@grl.ars.usda.gov

where K_i is the baseline interrill soil erodibility in kg s m^{-4}, I is the rainfall intensity in m s^{-1}, I_e is the runoff rate in m s^{-1}, S_f is a dimensionless slope factor, and SDR is the interrill soil delivery ratio (dimensionless). Rill erosion rate D_r in kg s^{-1} m^{-2} is computed by:

$$D_r = K_r (\tau_f - \tau_c)(1 - G/T_c) \qquad [2]$$

where K_r is the baseline rill erodibility in s m^{-1}, τ_f is the shear stress of flowing water acting on soil in Pa, τ_c is the critical shear stress of soil in Pa, G is the sediment load in kg s^{-1} m^{-1}, and T_c is the sediment transport capacity in kg s^{-1} m^{-1}. Unlike RUSLE and USLE, the effects of cropping and management on soil erodibility are explicitly bound to three major soil parameters: K_i, K_r, and τ_c.

The baseline interrill erodibility on cropland (K_i) is multiplied by a set of subfactors to account for various effects, which include canopy cover, ground cover, live roots, dead roots, surface crusting, and freezing and thawing, all of which are estimated within the model. Similarly, the baseline rill erodibility on cropland (K_r) is multiplied by a set of adjustment subfactors, which include incorporated residue, roots, crusting and consolidation, and freezing and thawing. Exposed residue and other surface covers dissipate flowing water shear and therefore reduce soil detachment. This effect is accounted for in part by adjusting hydraulic friction coefficients for both rill and sheet flows. The friction coefficient is used to partition shear stress into forces acting on soil and those acting on residue. The forces that directly act on soils are responsible for soil detachment. As with the interrill and rill erodibilities, the baseline critical shear stress on cropland is multiplied by a set of subfactors to account for temporal variations. The adjustments include random roughness, crusting and consolidation, and freezing and thawing.

Due to the interactive nature of these subfactors, it is infeasible to evaluate the effects of each subfactor separately. However, their collective effects can be grossly assessed by means of soil loss ratio, which is the C factor as defined in USLE and RUSLE. The objective of this paper was to evaluate the general trends of WEPP model responses to cropping and management factors. The WEPP calculated soil loss ratio (thereinafter, called "WEPP C-factor") was compared to those computed from USLE and RUSLE. This approach is justified, since RUSLE and USLE are based on thousands of plot-years of soil loss data collected under common cropped conditions and are considered to adequately represent general erosion trends under these conditions. Thus, the degree of agreement between WEPP, RUSLE, and USLE C values would shed light on how well the WEPP model represents the cropping and management factors.

MATERIALS AND METHODS

Cropping systems and tillage management are tabulated in Table 1. Crops included corn, cotton, alfalfa, and Bermuda grass. Tillage systems consisted of conventional, conservation, and no till. Two yield levels of 5000 kg ha^{-1} and 7900 kg ha^{-1} were selected for corn crop to check the model responses to crop yields. The 5000 kg ha^{-1} level reflected a medium low production level and left approximately 5000 kg ha^{-1} above-ground biomass at harvest, while the other represented a high production level and produced approximately 7400 kg ha^{-1} residue. For conventional till corn, spring and fall turn-plow operations both with and without residue removal were used. For cotton, lint cotton yield was approximately 600 kg ha^{-1} and residue at harvest was about 2600 kg ha^{-1}. Annual average yields for alfalfa and Bermuda grass were between 6.5 and 9 Mg ha^{-1}. Three locations (Hollyspring in Mississippi, Jefferson City in Missouri, and Morris in Minnesota) were selected to represent different climatic conditions. The USLE, RUSLE, and WEPP crop stage C-factors were obtained for each cropping system and then were weighted with rainfall index of the location (Wischemeier and Smith, 1978) to get annual averages.

Table 1. Cropping systems, tillage operations, and crop management.

Cropping systems†	Tillage operations and management‡
conv corn, rdl, spring TP	4/15 TP, 5/10 TD, 5/11 FC, 5/12 P, 6/12 RC, 10/15 H
conv corn, rdr, spring TP	4/15 TP, 5/10 TD, 5/11 FC, 5/12 P, 6/12 RC, 10/15 H, 10/20 Rdr
conv corn, rdl, fall TP	5/10 TD, 5/11 FC, 5/12 P, 6/12 RC, 10/15 H, 10/20 TP
conv corn, rdr, fall TP	5/10 TD, 5/11 FC, 5/12 P, 6/12 RC, 10/15 H, 10/16 Rdr, 10/20 TP
conservation corn	5/10 CP, 5/11 shallow TD, 5/12 FC, 5/13 P, 10/15 H
no till corn	5/12 drill, 10/15 H
conv cotton	4/15 TP, 4/16 TD, 4/17 FC, 4/20 P, 5/20 RC, 10/25 H
continuous alfalafa	cutting dates: 5/25, 7/15, 8/20, 9/25
continuous bermuda	cutting dates: 5/25, 7/15
Three year alfalfa and two year corn rotation	
1st year alfalfa	4/20 CP, 5/1 FC, 5/5 drill; cutting dates: 8/1, 9/15
2nd and 3rd year alfalfa	cutting dates: 6/1, 7/5, 9/15
1st and 2nd year corn	4/15 TP, 5/10 TD, 5/11 FC, 5/12 P, 6/12 RC, 10/15 H

† conv, conventional; rdl, residue left; rdr, residue removed; TP, turn-plow.

‡ TD, tandem disk; FC, field cultivation; P, planting; RC, row cultivation; H, harvest; CP, chisel-plow;

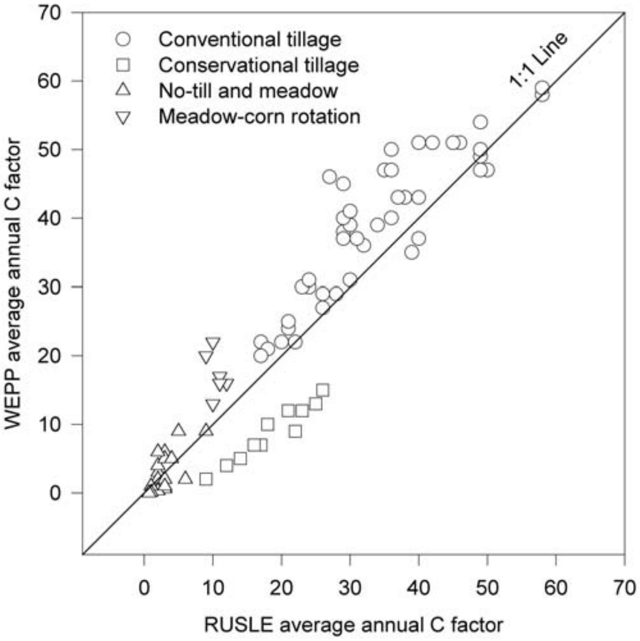

Figure. 1. Relationship between WEPP and RUSLE average annual C-factors for all the cropping systems simulated in two soils and at tree locations.

Crop stage periods defined by Wischmeier and Smith (1978) were used in this study. They are: rough fallow (RF) - inversion plowing to secondary tillage, seedbed (SB) - end of RF until crop has developed 10% canopy cover, canopy establishment (C1) - end of SB until canopy reaches 50%, canopy development (C2) - end of C1 until canopy cover reaches 75%, maturing crop (C3) - end of C2 until harvest, post-harvest (PH) - harvest to plowing or seeding. Daily canopy cover predicted by WEPP was used to determine crop stages on each site. These crop stage periods were used to make comparisons among the three models on each site.

WEPP C-factor Calculation

To calculate WEPP C-factor, continuously clean-tilled reference fallow has to be defined. In this study, reference fallow (also called corresponding fallow) was defined as the fallow plots, which receive the same tillage operations as used in the cropped plots. Fifty-year simulations were conducted for each cropping system. Mean C-factor for a given crop stage period was calculated as the ratio of total soil loss within the period from cropped plot to that from reference fallow plot. Annual average C-factor was obtained by weighting crop stage C-factors with rainfall index of the location.

Management information in Table 1 was used to build the WEPP management input files. Climate input files were generated by CLIGEN (climate generator, Nicks et al., 1993) for each location. Two soils, Cecil sandy clay loam (67% sand, 20% clay, and 0.89% organic matter) and Providence silt loam (2% sand, 20% clay, and 0.81% organic matter), were used. Optimized baseline conductivities (Risse et al., 1995) were utilized for each soil. Baseline erodibility values of K_i, K_r, and τ_c were calculated using WEPP estimation equations (Flanagan and Nearing, 1995). Other parameters in the soil input files were estimated by averaging all of information available for the soil. A soil profile with a depth of 1.5 m was used to allow adequate plant root growth. The unit plot with a uniform slope of 9% and a length of 22.1 m was chosen to build the WEPP slope input files.

USLE C-factor

The USLE C-factors by crop stages were directly obtained from the tables compiled by Wischmeier and Smith (1978), except for the period after harvest. Since modern combines leave more residues flat than those used before 60's, post-harvest C-factors in the USLE Table 5 were replaced by those from USLE Table 5c to account for more flat residues (Wischmeier and Smith, 1978). USLE Table 5c tabulates C-factors for the post harvest period when stalks are chopped and distributed without tillage. The average surface cover predicted by WEPP for post-harvest period was used to get an equivalent C-factor from USLE Table 5c (to have a fair comparison between the models). For corn, surface residue mass and cover used to determine C-factors in USLE Table 5 were predicted by WEPP on identical conditions. Based on WEPP plant growth output, the selection of 65% final canopy cover and 30% initial residue cover after harvest in USLE Table 5a was used to obtain C-factors for cotton. For alfalfa-corn rotation, USLE Table 5d was used to account for residual effect of turned sod on C-factors of subsequent corn. Alfalfa C-factor in USLE Table 5b was used for both perennial grasses. It should be pointed out that the C-factors developed from these tables are normally used for evenly distributed interrill and rill erosion conditions and are independent of soil properties.

RUSLE C-factor

The RUSLE C-factors of selected cropping systems on the three locations were obtained by running RUSLE version 1.04 on identical conditions as used in WEPP. The C-factor of each crop stage was computed by weighting half-month C values with rainfall index over the period. Crop stages were based on canopy cover predicted by WEPP plant growth model on each location. It should be mentioned that the RUSLE C-factor was independent of soil properties, but varied with prevailing erosion mechanisms. Based on WEPP predicted interrill versus rill soil loss ratio, dominant rill erosion mode was used in predicting C-factors for Cecil soil, while normal erosion mode (interrill and rill erosion evenly distributed) was used for Providence soil.

RESULTS AND DISCUSSION

Average Annual C-factors

The WEPP model was run continuously for 50 years for all the cropping systems as well as their reference fallow plots (Table 1). Average crop stage C-factors were computed as the soil loss ratio of cropped plot over the reference fallow plot using daily soil loss output. Based on the WEPP predicted ratio of rill versus interrill soil loss, a normal erosion condition was used for running RUSLE on Providence soil, while dominant rill erosion was used on Cecil soil.

The WEPP and RUSLE average annual C-factors for all the cropping systems on the two soils and three locations are plotted in Figure 1. In general, WEPP responded reasonably well to the cropping and management factors compared with RULSE. The general trends of the C-factors were well mirrored by the WEPP model. That is, the C-factors of different cropping and management systems decreased from conventional tillage to conservation tillage to perennial grasses and no-till. Compared with RUSLE, WEPP tended to over-predict C-factors for conventional tillage systems, and under-predict C-factors for conservation tillage systems, with no-till and perennial grasses being close. Results indicated that WEPP C-factors were somewhat independent of soil properties, since the C-factors of two soils were close (data not shown). This is also true for RUSLE and USLE C-factors.

Detailed annual WEPP, USLE, and RUSLE C-factors using Providence soil were tabulated by cropping systems and locations in Table 2. In addition to the general trends shown in Fig. 1, the results further indicated that the WEPP C-factors reflected the effects of cropping and management well among various conventional tillage systems. For example, the WEPP C-factors for conventional corn with residue removal were much greater than those with residue left in place. The WEPP C-factors with fall turn-plow were much greater than those with the following spring turn-plow. Overall, the WEPP C-factors tended to be lower than USLE C-factors but greater than RUSLE C-factors. For the low yield level of conventional corn, the WEPP C-factors were closer to USLE C-factors. However for the high yield level, the WEPP C-factors were closer to RUSLE C-factors (Table 2). This result is promising, since RUSLE is believed to be more reliable in high yield range while USLE in low to medium yield ranges. This is due to the fact that USLE was developed on the soil loss data that were collected from low to medium yield ranges, and RUSLE was revised to accommodate high crop yields that are common in modern agricultural production. Climate also affected the average annual C-factors. For conventional tillage systems, the smallest discrepancies between WEPP C-factors and USLE and RULSE C-factors were shown at the Hollysprings site, while the largest at the Morris site, with the Jefferson City site in between (Table 2). That is, WEPP tended to increasingly under-predict C-factors from south to north compared with USLE, but increasingly over-predict C-factors compared with RUSLE. However, the over-prediction decreased as crop yields increased while the under-prediction decreased as crop yields decreased.

WEPP C-factors for conservation tillage systems were consistently lower than those of USLE and RULSE C-factors, with the values being closer to USLE (Table 2). Instead of the over-prediction of C-factors for conventional tillage corn, WEPP considerably under-predicted C-factors for conservation tillage corn compared with RULSE. This could be due to differences in the soil consolidation subroutines of the two models. WEPP model has a greater consolidation adjustment factor than RUSLE model. For no-till systems and perennial meadow, the C-factors of the three models are fairly close, showing the overwhelmed effects of the residue and plant biomass.

WEPP C-factors for cotton row crop were lower than those of USLE and RULSE, with WEPP being much closer to USLE (Table 2). The RUSLE C-factors might be a bit too

Table 2. Comparisons of WEPP, USLE, and RUSLE annual C-factors for normal erosion conditions by crop management systems at three locations.[†]

Cropping systems[‡]	Hollysprings, MS			Jefferson City, MO			Morris, MN		
	WEPP	USLE	RUSLE	WEPP	USLE	RUSLE	WEPP	USLE	RUSLE
					%				
Continuous corn with a grain yield of 5000 kg ha^{-1} and an above-ground biomass of 5000 kg ha^{-1} at harvest									
Conv., rdl, spring TP	30	29	30	36	34	32	38	39	29
Conv., rdr, spring TP	54	55	49	51	53	42	47	49	35
Conv., rdl, fall TP	47	45	50	43	45	38	39	38	30
Conv., rdr, fall TP	58	63	58	51	59	45	47	53	36
Conservation tillage	13	17	25	15	18	26	12	20	23
No-tillage	9	6	9	9	5	5	6	5	2
Continuous corn with a grain yield of 7900 kg ha^{-1} and an above-ground biomass of 7500 kg ha^{-1} at harvest									
Conv., rdl, spring TP	22	23	22	24	29	21	22	35	17
Conv., rdr, spring TP	43	51	40	37	51	31	30	47	23
Conv., rdl, fall TP	37	41	40	29	41	26	21	40	18
Conv., rdr, fall TP	49	62	49	39	58	34	30	51	24
Conservation tillage	7	10	17	7	12	16	4	14	12
No-tillage	5	4	4	4	3	2	2	3	1
Cotton, meadow, and alfalfa-corn rotation; 600 kg ha^{-1} lint cotton and 2600 kg ha^{-1} residue, 6.5 to 9 Mg/ha hay, and 5000 kg ha^{-1} corn grain									
Cotton, rdl, spring TP	46	51	27	45	53	29			
Alfalfa	6	2	3	5	2	3	2	2	2
Bermuda/bromegrass	3	2	2	2	2	2	0.4	2	1
Three year alfalfa-two year corn	16	9	12	17	12	11	22	10	10†

[†] WEPP C-factor was predicted on a unit plot using Providence soil, USLE C-factor was from HB537, and RULSE C-factor was calculated using v. 1.04 for normal erosion conditions.

[‡] Conv, conventional tillage; rdl, residue left; rdr, residue removed.

low because these values were even lower than those of the low yield corn that left one fold more residues after harvest than cotton crop. For three year alfalfa-two year corn rotation, WEPP C-factors were greater than those of USLE and RUSLE. The over-prediction increased from south to north. The greater WEPP C-factors indicated that the WEPP model under-estimated the effects of previous land use, especially the residual effects from perennial meadow when turned under.

Cropstage C-factors

Since the closest agreements of annual C-factors between WEPP and USLE and RULSE were obtained at the Hollysprings site, it is more relevant to examine temporal changes of C-factors across the crop stages on this site. Crop stage C-factors of USLE, RUSLE, and WEPP for a corn crop under several common cropping systems were tabulated by yield levels in Table 3. For the conventional till corn with residue removal, WEPP C-factor was much less than those of USLE and RUSLE for both yield levels at the rough fallow (RF) stage, indicating WEPP might have a greater surface roughness adjustment subfactor. From seedbed (SB) stage to canopy stage 3 (C3), the C-factors decreased more rapidly for RULSE and USLE than for WEPP. At C3, WEPP over-predicted C-factors, especially at the high yield level. This might indicate that the canopy adjustment was insufficient for WEPP compared with RUSLE. However, the WEPP C-factors from canopy stages 1 and 2 (C1 and C2) matched well with RUSLE C-factors for both yield levels. The over-prediction of WEPP C-factors for C3 might be due to the fact that canopy cover was adjusted only to interrill erosion in the WEPP, while the adjustments were made to total soil loss in both USLE and RUSLE. This could make a big difference in C-factors when canopy cover was relatively high such as at C3 stage. However, the over-prediction would not occur with small grains and meadows because an additional friction factor due to live biomass was used in WEPP to reduce the portion of shear stress acting on soil. For the post harvest (PS) stage, the WEPP C-factors were somewhere in between, with the values being closer to RUSLE at the high yield level and to USLE at the low yield level.

For the conventional till corn with residue left in place, the WEPP C-factors were very close to those of USLE at the RF stage. Similar to the case of residue removal, the WEPP C-factors were close to those of RUSLE, but were lower than those of USLE at C1 and C2, especially for the high yield level. The WEPP predicted greater C-factors than RUSLE and USLE at C3 before harvest. Again, this might

Table 3. Cropstage C-factors of USLE, RUSLE, and WEPP for a corn crop at Hollysprings, MS†.

Cropping Systems	Spring residue	C-factors of various cropstages‡							Annual C
		Model	RF	SB	C1	C2	C3	PH	
	kg ha^{-1}		------------------------------ % ---------------------						
With a corn yield of 5000 kg ha^{-1}, representing 5000 kg ha^{-1} residue at harvest									
Conventional tillage		USLE	36	60	52	41	22	17	29
residue left		RUSLE	57	73	49	37	27	10	30
spring turn-plow	3800	WEPP	41	68	52	34	33	11	30
Conventional tillage		USLE	67	75	66	47	25	62	55
residue removed		RUSLE	70	78	52	39	28	49	49
spring turn-plow		WEPP	52	78	59	39	36	58	54
Conservation tillage		USLE		25	22	19	16	14	17
		RUSLE		65	46	35	26	12	25
	5000	WEPP		19	16	12	16	9	13
No-tillage		USLE		5	5	5	5	6	6
		RUSLE		16	13	11	9	6	9
	5000	WEPP		12	11	6	7	8	9
With a corn yield of 7900 kg ha^{-1}, representing 7400 kg ha^{-1} residue at harvest									
Conventional tillage		USLE	31	55	48	38	20	9	23
residue left		RUSLE	47	66	39	23	13	5	22
spring turn-plow	5000	WEPP	33	58	36	20	25	7	22
Conventional tillage		USLE	66	74	65	47	22	56	51
residue removed		RUSLE	64	74	42	25	13	41	40
spring turn-plow		WEPP	46	70	43	24	28	45	43
Conservation tillage		USLE		18	15	13	12	7	10
		RULSE		55	35	22	12	6	17
	6800	WEPP		11	7	5	9	6	7
No-tillage		USLE		3	3	3	3	4	4
		RUSLE		11	8	5	4	3	4
	6800	WEPP		8	5	3	4	5	5

† WEPP C-factor was predicted on a unit plot using Providence soil, RUSLE C-factor was estimated with v. 1.04 for normal erosion conditions, USLE C-factor was obtained from HB 537. ‡ RF, rough fallow; SB, seed bed; C1,2,3, canopy stages 1,2,3; PH, post-harvest.

indicate that the canopy adjustment was inadequate in the WEPP model. At the PH stages, the C-factors of three models agreed reasonably well.

For the conservation till corn, WEPP consistently predicted the lowest C-factors for all the crop stages; however, the WEPP C-factors were in line with USLE C-factors. For the no-till systems, C-factors of the three models agreed reasonably well for all the crop stages.

SUMMARY

In general, WEPP predicted C-factors followed the known trends of RUSLE and USLE reasonably well for all the cropping systems used in this study. Overall, WEPP C-factor tended to be greater than those of RUSLE and less than those of USLE. Compared with RUSLE, WEPP predicted C-factors well for no-till and perennial meadow systems, but tended to over-predict C-factors for conventional till corn and to under-predict for conservation till corn. These discrepancies tended to increase from Hollysprings to Jefferson City to Morris (i.e. from south to north), indicating the interactive effects of climate conditions on C-factors. WEPP predicted C-factors for a cotton crop were slightly less than USLE C-factors, but were much greater than RULSE C-factors. The WEPP model under-predicted the residual effects of previous land use, especially for meadow-corn rotations after sods were turned under.

Under conventional tillage, WEPP C-factors at rough fallow stage were lower than those of USLE and RULSE C-factors, especially for the cases when residue was removed at harvest, indicating that WEPP might have a greater surface roughness adjustment subfactor. WEPP C-factors agreed well with RUSLE at the stages of SB, C1, and C2; however, WEPP over-predicted C-factors at C3 during which canopy cover was high. This indicated that canopy adjustment subfactor was insufficient in WEPP compared with RUSLE and USLE. This could be due to the fact that the canopy adjustments were only made to interrill erosion in WEPP, while to total soil loss in USLE and RUSLE. Under conservation tillage, WEPP under-estimated C factors for all crop stages compared with the USLE and RUSLE C factors. For no-tillage systems, WEPP crop stage C factors were between those of RUSLE and USLE but somewhat closer to RUSLE.

REFERENCES

Flanagan, D.C. and M.A. Nearing. 1995. USDA-water erosion prediction project: Technical documentation. NSERL Report No. 10. West Lafayette, Ind. USDA-ARS-NSERL.

Nicks, A.D., L.J. Lane, G.A. Gander and C. Manetsch. 1993. Regional analysis of precipitation and temperature trends using gridded climate station data. p.497-502. In S.Y. Wang (ed.) Advances in hydro-sciences and engineering. Vol. I. (Proc. of the First Int. Conf. on Hydro-Sciences and Engineering.)

Renard, K. G., G.R. Foster, G.A. Weesies, D.K. McCool and D.C. Yoder. 1997. Predicting soil erosion by water: A guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). USDA Agric. Handbook 703. U.S. Gov. Print. Office, Washington, D.C.

Risse, L.M., M.A. Nearing and X.C. Zhang. 1995. Variability in Green-Ampt effective hydraulic conductivity under fallow conditions. J. Hydrol. 169:1-24.

Wischmeier, W.H. and D.D. Smith. 1978. Predicting rainfall erosion losses:A guide for conservation planning. USDA Agric. Handbook. 537. U. S. Gov. Print. Office, Washington, D.C.