COMPARISON OF MEASURED AND WEPP PREDICTED RUNOFF AND SOIL LOSS FOR MIDWEST CLAYPAN SOIL

F. Ghidey, E. E. Alberts

ABSTRACT. *Runoff and soil loss predictions from the Water Erosion Prediction Project (WEPP) Hillslope model were compared to measured losses from continuous cultivated fallow and continuous corn and soybean cropping systems under conventional, chisel, and no-till tillage methods. Runoff and soil loss data were collected over an 11-yr period (1983-1993) from the study plots on Mexico claypan soil near Kingdom City, Missouri. For all treatments, the model predicted runoff and soil loss reasonably well for the wet years with annual runoff >200 mm but greatly underpredicted for the dry years with annual runoff <100 mm. During the dry seasons, most of the rainfall events occurred after a long dry period and the model overestimated runoff from several events when little or no runoff was measured. When averaged by tillage treatment, mean annual runoff predictions for continuous corn and continuous soybean were within 15% of those measured. The model overpredicted soil losses from continuous corn and continuous soybean by 22 and 87%, respectively. Both measured and predicted runoff and soil losses from continuous soybean were higher than from continuous corn. When averaged over crop, the model slightly overpredicted mean annual runoff for conventional, chisel, and no-till systems. The model did not show appreciable difference in annual runoff prediction for the different tillage systems. Predicted soil losses for conventional, chisel, and no-till tillage systems were 50, 67, and 29% higher, respectively, than those measured. Runoff and soil loss data were also analyzed by cropstage periods. A tillage year was divided into rough fallow (F), seedbed (SB), rapid growth (P12), reproduction and maturation (P3), and residue (P4) periods. Runoff predictions for the F and SB periods were reasonable. The model overpredicted runoff for the P12 and P3 periods and underpredicted for the P4 period. The model overpredicted soil loss from all periods except for the F period. For continuous corn and soybean cropping systems, more than 50% of the total measured and predicted tillage year soil loss occurred during the SB period. The model was also tested for seven large events that occurred during the study period. Predicted runoff and soil loss for these events compared well to those measured.*

Keywords. *Runoff, Soil loss, Tillage.*

The approach to soil conservation planning in the U.S. is rapidly changing because recent advances in computer technology have made it possible for soil conservationists to use complex hydrologic and erosion models in the field setting. In 1985, the U.S. Department of Agriculture's Agricultural Research Service initiated the Water Erosion Prediction Project (WEPP) to develop models for predicting erosion from a hillslope and small and large watersheds based on specific requirements and knowledge of fundamental hydrologic and erosion processes (Foster and Lane, 1987; Laflen et al., 1991). Once fully developed and implemented, the WEPP Hillslope model will replace the Universal Soil Loss Equation (USLE) technology as the basic tool used in soil conservation planning.

WEPP is a process-based continuous simulation model composed of climate generator, hydrology, plant growth, residue decomposition, irrigation, and erosion components (Lane and Nearing, 1989). Description of processes involved in each component are beyond the scope of this article; however, the approaches used in the erosion component of the model will be briefly discussed.

The WEPP erosion model predicts interrill and rill erosion separately. Interrill erosion is defined as a process of soil detachment by raindrops and transported in thin flow (Foster et al., 1977). In WEPP, interrill detachment rate is computed by:

$$D_i = K_i I I_e S_f \tag{1}$$

where D_i is the interrill sediment delivery rate (kg s^{-1} m^{-2}), K_i is the baseline interrill soil erodibility (kg m^{-4} s), I is the rainfall intensity (m s^{-1}), I_e is the excess rainfall rate (m s^{-1}), and S_f is the slope adjustment factor and is defined by Liebenow et al. (1990):

$$S_f = 1.05 - 0.85 \exp^{-4\sin(\theta)} \tag{2}$$

where θ is the slope angle.

Rill erosion is the removal of soil from within small channels by the concentrated flow of water. The rill detachment rate is computed from (Foster, 1982):

$$D_r = D_c\left(1 - \frac{G}{T_c}\right) \tag{3}$$

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where D_r is rill erosion rate (kg s^{-1} m^{-2}) , D_c is rill detachment capacity (kg s^{-1} m^{-2}), G is sediment load (kg s^{-1} m^{-1}), and T_c is the sediment transport capacity (kg s^{-1} m^{-1}). Rill detachment capacity is computed from:

$$D_c = K_r (\tau_f - \tau_c) \quad (4)$$

where K_r is the baseline rill erodibility (s m^{-1}), τ_f is the flow shear stress (Pa), and τ_c is the critical shear stress (Pa).

The erodibility parameters (K_i, K_r, and τ_c) are adjusted on a daily basis for canopy cover, residue cover, incorporated residue, live and dead roots, surface roughness, and soil consolidation.

The advantage of WEPP over empirically based models such as RUSLE (Revised Universal Soil Loss Equation) is principally in terms of increased functionality, rather than improved accuracy of prediction of average annual soil loss under common, cropped, agricultural conditions (Nearing et al., 1995). The primary objective of this study was to compare annual and seasonal runoff and soil loss predictions from the WEPP Hillslope model to measured losses for seven cropping and management treatments where runoff and soil losses had been measured over an 11-year period. Six of the seven treatments were a factorial of two crops (continuous corn and continuous soybeans) and three tillage practices (conventional, chisel-plow, and no-till). The seventh treatment was continuous cultivated fallow.

Another objective of this article was to compare runoff and erosion predictions from the WEPP Hillslope model to measured losses for large events. Prior research has shown that much of the measured erosion occurs from a few events with low return frequencies. Edwards and Owens (1991) reported that for a 28-year period (1942-1969), five events accounted for 85% of the total soil loss from a continuous corn cropped watershed in the eastern Corn Belt (Ohio). In the western Corn Belt (Iowa), Hjelmfelt et al. (1986) showed that only 3% of the erosion events accounted for more than 50% of the total erosion on a 33.5 ha watershed cropped to continuous corn using conventional tillage practices. Wischmeier (1962) showed the role of a few large storms in producing 86% of the erosion measured from natural erosion plots in Georgia. For WEPP to be successful, the model must accurately predict soil erosion from large events.

MATERIALS AND METHODS

Runoff and soil losses were measured at the Claypan Experimental Farm (previously called the McCredie Erosion Station) located near Kingdom City, Missouri. Forty natural rainfall erosion plots have operated continuously since their establishment in 1941. Each plot is 3.2 m wide × 27.4 m long. The soil is a Mexico silt loam (fine, montmorillonitic, mesic Udollic Ochraqualf) on a slope of 3.0 to 3.5%.

Each erosion plot is instrumented with two runoff collection tanks in series. Runoff leaving a plot moves into a 3.2 m wide collector which is connected to the first tank with a 125 mm diameter pipe. When the first tank is filled (about 6.4 mm of plot runoff), additional runoff and sediment moves through a nine-slot vertical divisor in a trough which connects the two tanks. One-ninth of the runoff enters the second tank. Total collection capacity of both tanks is about 150 mm of plot runoff.

After each runoff event, the depth of water in each tank was measured. The sediment was resuspended by vigorously stirring the contents of each tank using specially designed paddles. Two samples were then collected from each tank to determine the sediment concentration using gravimetric procedures. The water depth and sediment concentration data were used with the tank calibrations to calculate runoff and soil losses. Where multiple rainfall events occurred that prohibited tank sampling and cleaning, measured losses represent multiple rainfall and runoff events.

A weather station is located near the erosion plots. Precipitation was measured using a recording rain gauge. The rain gauge charts were processed to determine event characteristics such as event rainfall, rainfall duration, peak intensity, and time-to-peak intensity. Daily measurements include maximum and minimum air temperatures, pan evaporation, and average wind speed. Other climatological data needed to run the WEPP model were obtained from the National Weather Service Station in Columbia, Missouri, which is about 37 km west of the research site.

A study evaluating the effect of seven cropping and management treatments on runoff and soil loss was initiated on the erosion plots in 1982. The experimental design for the treatments was a completely randomized block design with four blocks. The treatments were continuous cultivated fallow (FAL), continuous corn conventionally tilled (CCCT), continuous corn chisel-plowed (CCCP), continuous corn in no-till (CCNT), continuous soybeans conventionally tilled (BBCT), continuous soybeans chisel-plowed (BBCP), and continuous soybeans in no-till (BBNT). Conventional tillage consisted of spring moldboard plowing, primary and secondary disking, planting, and cultivation for weed control. Chisel tillage had similar cultural operation dates and types to conventional tillage except that a chisel plow was used instead of a moldboard plow. Minor soil disturbance occurred at planting in no-till from a fluted coulter which prepared a narrow seedbed. Continuous fallow consisted of spring moldboard plowing, disking, and three to four cultivations for weed control.

This analysis will focus on comparing WEPP predictions to measured runoff and soil losses for these seven cropping and management treatments for an 11-year period 1983 through 1993. The WEPP Hillslope model requires four input files climate, soil, topography, and cropping and management (USDA, 1995). Measured daily precipitation and minimum and maximum temperature values were used along with other measured climatic variables. Actual tillage dates and implements for each year of the simulation were included in the seven cropping and management files. For a detailed description of the input files refer to the WEPP User Manual (USDA, 1995).

RESULTS

PRECIPITATION

Annual precipitation from the runoff/erosion plots in 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, and 1993 were 1040, 891, 1173, 865, 732, 673, 599, 1238, 919, 934, and 1324 mm, respectively. The 53-yr (1941-1993) mean annual precipitation from this site is

930 mm which is slightly lower than the 944 mm mean annual precipitation measured during this study period.

MEAN ANNUAL RUNOFF

Mean annual runoff and soil losses from six of the seven treatments were summarized by averaging over tillage and crop type. When averaged over tillage, the mean annual runoff and soil losses for continuous corn and continuous soybean were computed by averaging annual soil loss and runoff values from conventional, chisel, and no-till tillage systems. When averaged over crop, the mean annual soil loss and runoff from conventional, chisel, and no-till systems were computed by averaging annual soil loss and runoff values from the corn and soybean cropping systems.

The model overpredicted surface runoff by 7.8 and 15.1% for continuous corn and continuous soybean averaged over tillage (fig. 1). Measured and predicted runoff from continuous soybean were slightly higher than that from continuous corn indicating the effects of canopy and residue cover. For continuous fallow, the model overpredicted surface runoff by 8.4%. Predicted and measured runoff from continuous fallow were more than 70% higher than that from continuous corn or continuous soybean.

When averaged over crop, the model did not show appreciable difference in runoff prediction among the tillage systems (fig. 1). The predicted mean annual runoff from conventional, chisel, and no-till tillage systems was 201, 203, and 207 mm, respectively. However, the measured runoff from the three tillage systems showed an appreciable difference. Measured runoff from conventional, chisel, and no-till tillage systems was 180, 167, and 201 mm, respectively.

Mean annual runoff (11-yr average) for the seven treatments is shown in figure 2. In all cases, the model slightly overpredicted runoff. All mean annual predictions were within 15% of the measured values, except for BBCP where the model overpredicted by 32%. The model predicted well for no-till corn and soybean where the differences between measured and predicted values were <6.0%.

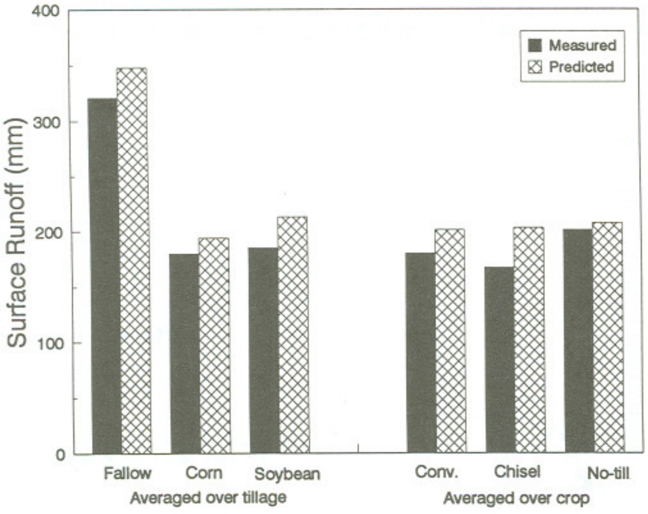


Figure 1–Measured and predicted mean annual surface runoff averaged over tillage and crop type. Only corn and soybean data were included in the average over crop.

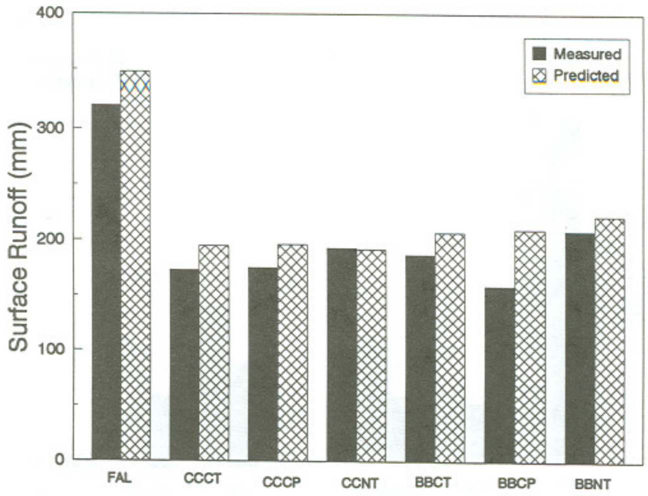


Figure 2–Measured and predicted mean annual runoff for the seven cropping and management treatments.

ANNUAL RUNOFF

Measured and predicted annual runoff for the six treatments cropped to corn and soybean are presented in figure 3. The model generally overpredicted runoff for the years with annual runoff events <200 mm. The largest overpredictions were for the low runoff years of 1986, 1987, 1988, and 1989 where annual runoff losses were <100 mm. For the high runoff years of 1983, 1985, 1990, and 1993, WEPP runoff predictions were generally within 20% of the measured values. The model performed well for the years with annual runoff events >200 mm, except 1984 where the predicted annual runoff was 40% less than that measured. The probable reason is that more than 70% of the runoff in 1984 was measured from January until mid-April, and the model always underpredicted runoff for this period of the year (this is discussed in detail in the following sections).

MEAN ANNUAL SOIL LOSS

Mean annual soil loss when averaged over tillage and crop is presented in figure 4. When averaged over tillage, the model overpredicted soil loss from continuous corn and

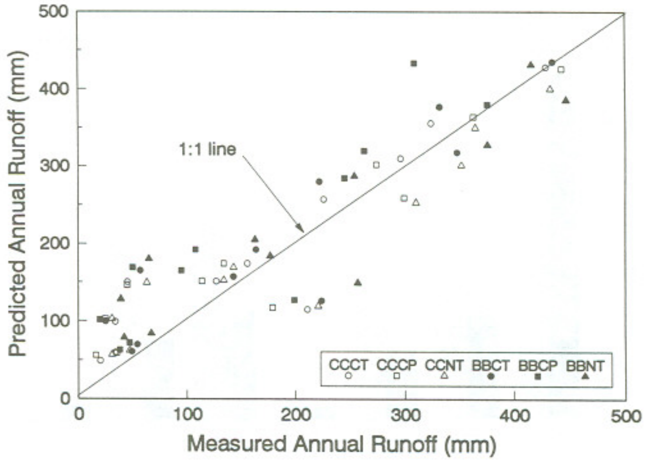


Figure 3–Measured and predicted annual runoff from six treatments cropped to corn and soybean.

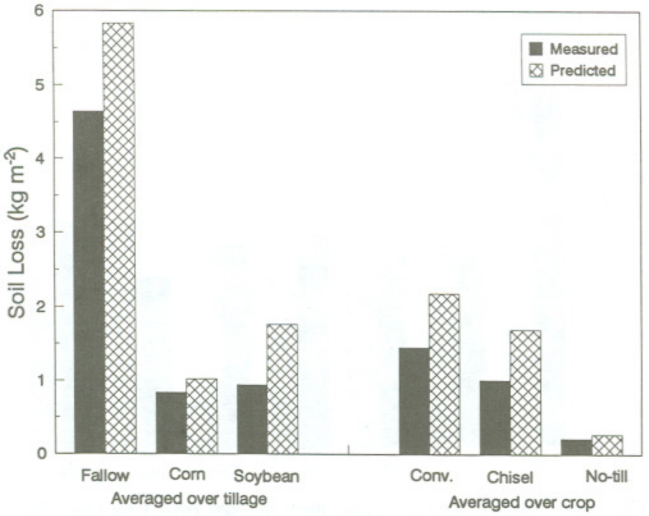


Figure 4–Measured and predicted mean annual soil loss averaged over tillage and crop type. Only corn and soybean data were included in the average over crop.

continuous soybean by 22 and 87%, respectively. For continuous fallow the model overpredicted by 27%. Measured soil loss from continuous fallow was almost five times higher than that from continuous corn or continuous soybean. Measured soil loss from continuous soybean was 12% higher than that from continuous corn. Soil loss predictions were highly sensitive to crop effects. The predicted soil loss from continuous soybean was 74% higher than that from continuous corn. When averaged over crop, the model overpredicted soil losses by 50, 67, and 29% for conventional, chisel, and no-till tillage systems, respectively. Measured and predicted soil losses from conventional tillage were 44 and 29% higher than from chisel plow. Measured soil loss from no-till was seven times lower than conventional and five times lower than chisel plow even though no-till runoff was greater than that for either conventional tillage or chisel plow (fig. 1).

Average annual soil loss (11-yr average) for each treatment is shown in figure 5. In all cases, the model overpredicted soil loss. The highest overprediction was for BBCP, BBCT, and CCCP where predicted soil loss was almost double measured soil loss. The model overprediction for CCCT and FAL was less than 25%.

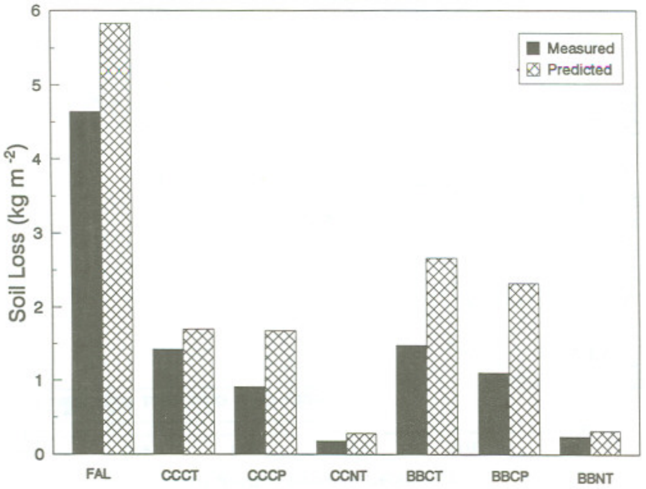


Figure 5–Measured and predicted mean annual soil loss for the seven cropping and management treatments.

ANNUAL SOIL LOSS

Measured and predicted annual soil loss for the six treatments cropped to corn and soybean are illustrated in figure 6. Except for the high runoff years of 1983, 1990, and 1993, measured annual soil losses from all treatments were <1.0 kg m^{-2}. The model generally overpredicted for the years with low soil loss which corresponded to the higher runoff prediction for the same years. Measured annual soil losses from all events were the highest in 1990. Measured annual soil loss in 1990 from CCCT, CCCP, BBCT, and BBCP were 9.1, 6.6, 8.4, and 6.4 kg m^{-2}, representing 58, 67, 52, and 53% of the total soil loss measured from the treatments over the 11-yr period. Predicted annual soil losses in 1990 from CCCT, CCCP, BBCT, and BBCP were 7.9, 5.0, 11.4, and 9.7 kg m^{-2}, respectively. The model underpredicted soil losses from the continuous corn treatments and overpredicted from continuous soybean treatments. The second largest soil loss event occurred in 1983. Annual measured and predicted soil losses in 1983 for CCCT, CCCP, BBCT, and BBCP were 2.9 and 2.7, 1.8 and 1.0, 4.0 and 5.0, and 3.2 and 3.4 kg m^{-2}. Again, the model overpredicted from continuous soybean and underpredicted from continuous corn treatments.

SURFACE RUNOFF AND SOIL LOSS BY CROPSTAGE

Measured and predicted surface runoff and soil loss data were summarized by cropstage periods through a tillage year. For each tillage year, five periods were identified based on uniform ground cover and management effects (Wischmeier and Smith, 1965; Laflen and Moldenhauer, 1979). These periods are: rough fallow period (F) from primary tillage to secondary tillage and planting; seedbed period (SB) from planting to 30 d after planting; rapid growth period (P12) from 30 d after planting to 60 d after planting; reproduction and maturation period (P3) from 60 d after planting to harvest; and residue period (P4) from harvest to primary tillage the next spring. As an example, tillage year for 1983 started on 26 April 1983 and ended on

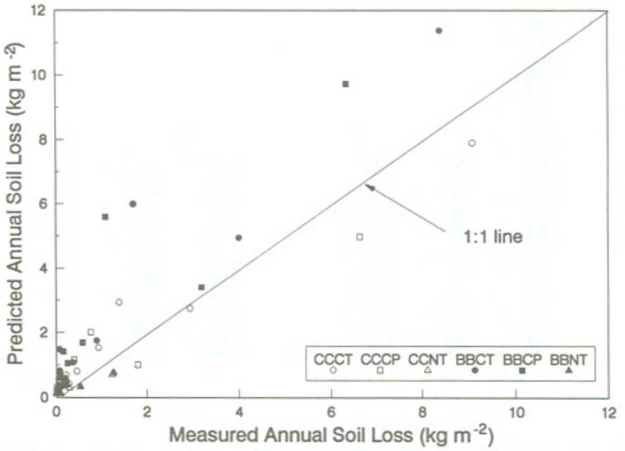
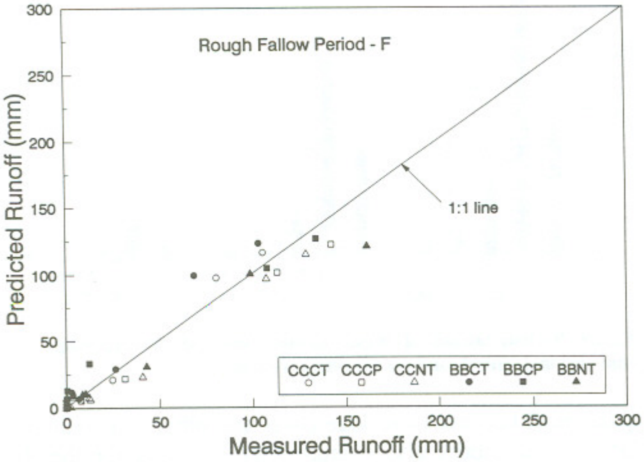


Figure 6–Measured and predicted annual soil loss from six treatments cropped to corn and soybean.

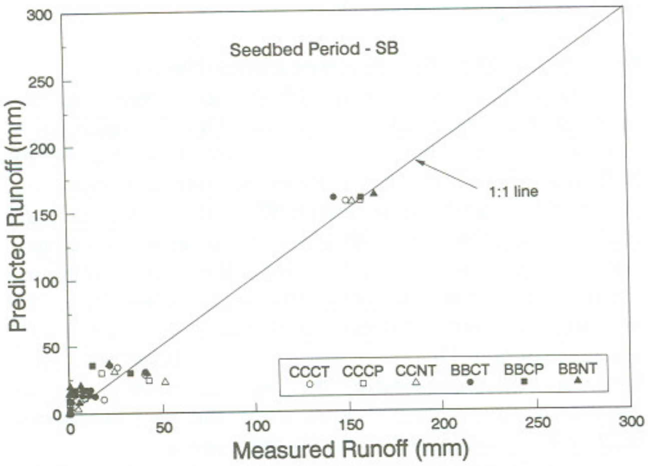
10 May 1984. The average durations for cropstages F, SB, P12, P3, and P4 were 30, 30, 30, 98, and 177 days. The tillage year for chisel plow and no-till was defined as the same period as for conventional tillage.

The average tillage year precipitation during the 11-yr period was 957 mm. The average distributions of the precipitation for the F, SB, P12, P3, and P4 periods were 88, 94, 104, 273, and 398 mm, representing 9.2, 9.8, 10.9, 28.5, and 41.6% of the total tillage year precipitation, respectively.

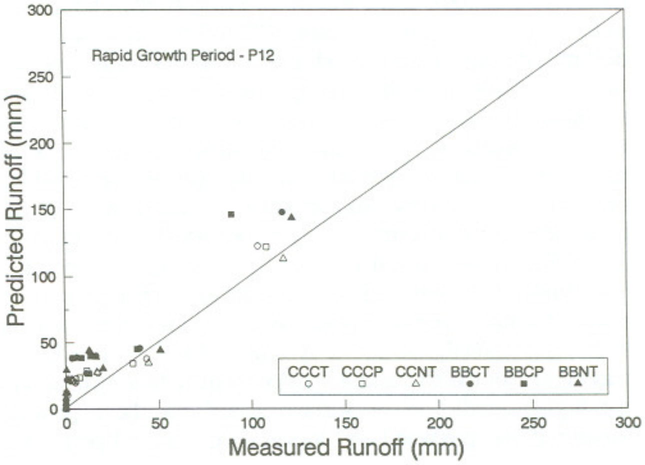
Annual measured and predicted runoff by cropstage from the six treatments cropped to corn and soybean are given in figure 7. The model predicted runoff reasonably well during the F and SB periods. Cumulative runoff from F and SB periods accounted for 25% of the mean runoff measured in the tillage year. The model overpredicted for the P12 and P3 periods. During these periods, the model overestimated several runoff events where no or little runoff was measured. Most of these rainfall events were small (<50 mm) and occurred after a long dry period during which soil surface cracking occurred in the field. The rapid movement of water through soil cracks is the most obvious reason for the measured runoff to be significantly less than those predicted. The model underpredicted runoff during the P4 period. This is the period from harvest (early Oct) until primary tillage the following year (mid April). During this period, the soil was consolidated due to repeated wetting and drying during the growing season which may have resulted in the measured runoff being significantly higher than that predicted. Another



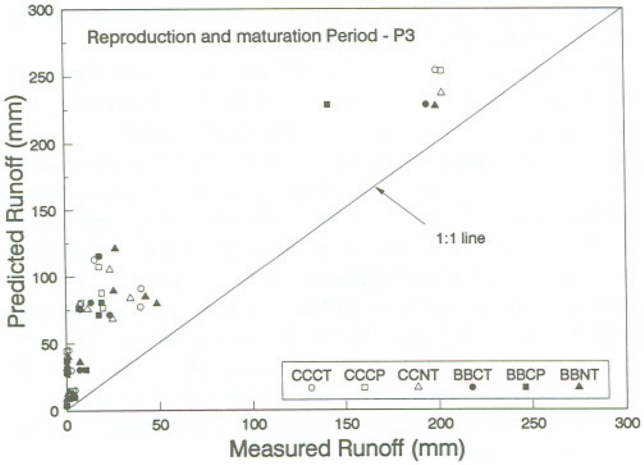
Rough Fallow Period — F



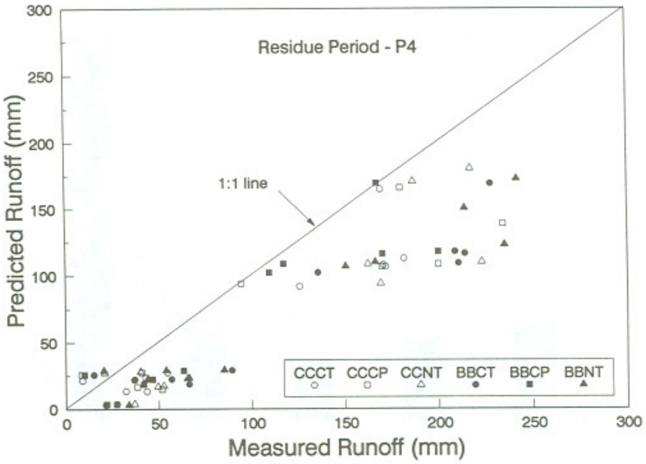
Seedbed Period — SB



Rapid Growth Period — P12



Reproduction and Maturation Period — P3



Residue Period — P4

Figure 7–Measured and predicted runoff by cropstage from six treatments cropped to corn and soybean.

possible explanation for underprediction could be that the model might have underestimated runoff from snowmelt.

The mean distribution of runoff by cropstage from all six cropped treatments is plotted in figure 8. The mean percent distribution of measured runoff for the F, SB, P12, P3, and P4 periods was 12.7, 11.5, 8.7, 13.4, and 53.7%, respectively. The mean percent distribution of predicted runoff for the F, SB, P12, P3, and P4 periods was 11.6, 12.5, 13.6, 30.6, and 31.7%, respectively. The mean tillage year measured and predicted runoff from all treatments were 195 and 214 mm, respectively, representing a 10% overprediction. Although the predicted mean runoff values were close to those measured, the relative differences between predicted and measured runoff were appreciably greater for periods P12, P3, and P4. The mean predicted and measured runoff losses for period F were the same. The model overpredicted for the period SB by less than 20%. The model, however, overpredicted for the periods P12 and P3 by 72 and 150%, respectively, and underpredicted for P4 by more than 35%.

The distribution of tillage year mean soil loss by cropstage is given in figure 9. For conventional tillage 26, 54, 14, 4, and 2% of the total measured soil losses occurred during the F, SB, P12, P3, and P4 periods, respectively. For chisel plow 29, 53, 13, 3, and 2% of the total measured soil losses occurred during the F, SB, P12, P3, and P4 periods, respectively. The highest measured soil loss (more than 50% of the total soil loss) occurred during the SB period. During the SB period, the soil has gone through primary tillage (moldboard plowing) and secondary tillage (disking) which left the soil in a very erodible condition. The smallest measured soil loss occurred during the P3 and P4 periods. This is a period during which the soil is covered by crop residues. Although 67% of the measured runoff occurred during the P3 and P4 periods, only 5% of the measured soil loss occurred during these periods. The model overpredicted soil loss in all cropstage periods except for the F period where the model underpredicted for both conventional and chisel systems. Model overprediction was higher for the P12 and P3 periods which directly relates to the higher prediction of surface runoff for these periods. Measured and predicted soil losses during the P4 period are quite small because of residue cover and other soil condition factors. The model also overpredicted soil loss for the SB period. Differences between measured and predicted soil losses during the SB period for conventional and chisel tillage were 24 and 43%, respectively.

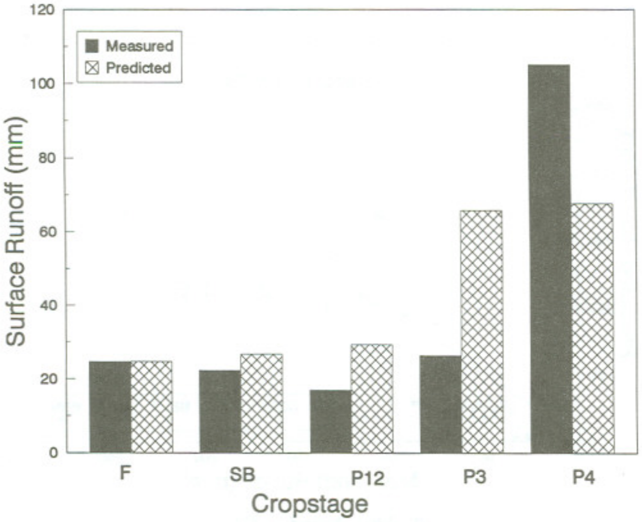


Figure 8–Distribution of mean annual runoff by cropstage from the six cropped treatments.

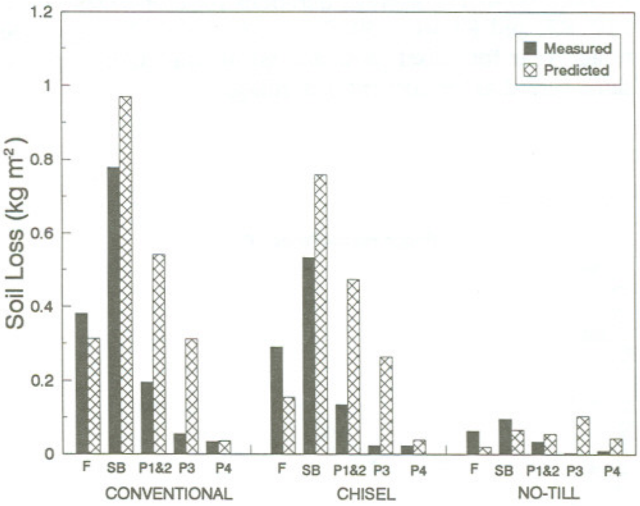


Figure 9–Distribution of mean annual soil loss by cropstage for conventional, chisel, and no-till tillage systems.

RUNOFF AND SOIL LOSSES FROM LARGE EVENTS

Data from conventionally tilled continuous corn and soybean cropping systems (CCCT and BBCT) were used to compare runoff and erosion predictions from the WEPP Hillslope model to seven measured large events that occurred over an 11-yr period (1983-1993). The CCCT and BBCT treatments were selected in this analysis because highest soil losses occurred from these two cropping treatments. For both treatments, the seven events accounted for more than 80% of the total measured soil loss during the 11-yr period. One event accounted for about 50% of the total loss. This emphasizes the importance of accurately predicting single large events since the overall erosion prediction is dominated by only a few events.

Except for the 30 April 1983 event, all events occurred soon after corn and soybean planting (cropstage SB) when the soil was more erodible. The 30 April 1983 event occurred after moldboard plowing but before secondary tillage and planting (cropstage F).

Measured and predicted runoff and soil losses for these events are presented in tables 1 and 2. Considering the complexity of the model and infrequent nature of large events, model predictions for large events were reasonably good. Except for the 30 April 1983 event for conventional soybean, the differences between measured and predicted runoff values were within 20%. The model performed extremely well for the largest event (6 Jun 1990) where the model overpredicted by < 10%. Cumulative measured and predicted runoff from the seven events were 451 and 466 mm for CCCT and 444 and 493 for BBCT, respectively. The measured runoff represented 24 and 22% of the total measured runoff from CCCT and BBCT for the 11-yr period, respectively.

Cumulative measured soil loss from the seven events was 12.7 and 13.3 kg m^{-2} for CCCT and BBCT, which represented 81 and 82%, respectively, of the total measured

Table 1. Measured and predicted runoff for seven large events observed during the 1983 through 1993 period

		Event Surface Runoff (mm)					
		Conventional Corn			Conventional Soybean		
Date	Rainfall (mm)	Measured	Predicted	(% Diff)	Measured	Predicted	(% Diff)
4-30-83	120	78.4	90.6	15.5	68.1	91.6	34.5
5-21-83	58	29.3	24.1	(17.8)*	30.7	24.8	(19.2)
6-17-85	49	30.8	24.7	(19.8)	27.6	25.2	(8.7)
5-11 to 5-15-90	159	93.9	109.1	16.2	94.3	113.1	19.9
6-6 to 6-8-90	188	145.9	148.1	1.5	139.7	150.0	7.4
6-24-93	62	23.0	25.0	8.7	25.5	29.3	14.9
7-7-93	102	49.3	44.3	(10.1)	57.8	59.0	2.1

* ( ) Indicate negative values.

during the 11-yr period. One event that occurred on 6 June 1990 accounted for 55 and 52% of the total measured from CCCT and BBCT plots, respectively. Cumulative predicted soil loss for CCCT and BBCT for the 11-yr period was 11.0 and 17.0 kg m^{-2}, respectively. The model underpredicted soil loss by 13% from CCCT and overpredicted soil loss by 28% from the BBCT plots. For the largest event that accounted for over 50% of the total measured soil loss, the model underpredicted by 6% from CCCT and overpredicted by 23% from BBCT.

SUMMARY

Runoff and soil loss predictions from the Water Erosion Prediction Project (WEPP) Hillslope Model (version 95.7) were compared to measured losses from seven cropping and management treatments that occurred over an 11-year period. The treatments were continuous cultivated fallow (FAL), conventionally tilled continuous corn (CCCT), chisel plowed continuous corn (CCCP), no-till continuous corn (CCNT), conventionally tilled continuous soybean (BBCT), chisel plowed continuous soybean (BBCP), and no-till continuous soybean (BBNT).

When averaged over tillage, runoff predictions of the model for continuous corn and continuous soybean were within 15% of those measured. Both measured and predicted runoff losses for continuous soybean were higher than those for continuous corn, probably due to the differences in canopy and residue cover. Measured and predicted runoff for continuous fallow were more than 70% higher than from continuous corn or continuous soybean. The model overpredicted soil loss from continuous corn and continuous soybean by 22 and 87%, respectively. Measured and predicted soil losses from continuous soybean were 12 and 74% higher than those from continuous corn. When averaged over crop, WEPP slightly overpredicted runoff from conventional, chisel plow, and no-till. The model did not show an appreciable difference in runoff prediction for the different tillage systems. The model overpredicted soil losses by 50, 67, and 29% for conventional, chisel, and no-till tillage systems, respectively.

Table 2. Measured and predicted soil loss for seven large events observed during the 1983 through 1993 period

		Soil Loss (Kg m^{-2})					
		Conventional Corn			Conventional Soybean		
Date	Rainfall (mm)	Measured	Predicted	(% Diff)	Measured	Predicted	(% Diff)
4-30-83	120	2.13	1.44	(32.4)	3.00	2.70	(10.0)
5-21 -83	58	0.42	0.75	78.6	0.57	1.00	75.4
6-17-85	49	0.55	0.58	5.5	0.38	0.50	31.6
5-11 to 5-15-90	159	1.93	0.74	(61.7)	1.19	1.38	16.0
6-6 to 6-8-90	188	7.00	6.58	(6.0)	6.97	8.61	23.5
6-24-93	62	0.21	0.48	128.6	0.43	0.92	114.0
7-7-93	102	0.47	0.51	8.5	0.76	1.94	155.0

* ( ) Indicate negative values.

On an annual basis, the model predicted reasonably well for the wet years with runoff >200 mm but greatly underpredicted for the dry years with runoff <100 mm. The model overpredicted annual soil loss for the years with low soil loss. For the high soil loss years, the model predicted soil losses reasonably well from continuous corn treatments but overpredicted from continuous soybean treatments.

Runoff and soil losses were also analyzed by cropstage. Each tillage year was divided into five periods based on uniform ground cover and management effects. The periods were rough fallow (F), seedbed (SB), rapid growth (P12), reproduction and maturation (P3), and residue (P4). The mean percent distribution of the measured and predicted runoff for the F, SB, P12, P3, and P4 stages was 12.7 and 11.6, 11.5 and 12.5, 8.7 and 13.6, 13.4 and 30.6, and 53.7 and 31.7% of the total tillage year runoff, respectively. The model prediction of runoff for the F and SB periods was quite satisfactory. The model overestimated runoff during the P12 and P3 periods and underestimated runoff for the P4 period. For both conventional and chisel tillage treatments, the model overpredicted soil loss for the SB, P12, P3, and P4 periods and underpredicted for the F period. More than 50% of the total soil loss occurred during the SB period and the model overpredicted by 24 and 43% for the conventional and chisel tillage systems, respectively. Because of residue cover and other soil conditions, measured and predicted soil losses during the P4 period were very small (< 0.04 kg m^{-2}).

The model was also tested for seven large erosion events that occurred during the 11-yr period from conventionally tilled continuous corn (CCCT) and continuous soybean (BBCT) cropping systems. These events accounted for more than 80% of the total measured soil loss during the study period. Except for one event, the differences between measured and predicted runoff were within 20%. The model overpredicted cumulative runoff from these events by 3.3% for CCCT and by 11.0% for BBCT. The model underpredicted cumulative soil loss by 13.0% from CCCT and overpredicted by 28% from BBCT. The model performed well for the largest event that accounted for more than 50% of the measured soil loss.

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