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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences, 2 (4): 1536-1539, 1999 Research Article

Soil Loss Prediction (Using Rusle) and Comparison With Measured Soil Loss

Almas, M. and T. Jamal*
Department of Agriculture, Muzaffarabad, Azad Kashmir, Pakistan
*Department of Soil Science, Faculty of Agriculture, University Putra, Malaysia

bstract
ne main objective of this study was to predict soil loss from various field experiments and to compare the results with easured soil loss from the field to see the performance of Revised Universal Soil Loss Equation (RUSLE) in predicting the il loss. The results of this study showed that there was no significant difference in measured and predicted soil loss with e exception of few bare plots. Therefore it can be concluded that the RUSLE model has a potential to be used for edicting soil loss under different treatments and management practices in Malaysia. Its results are more accurate at high vels of erosivity. Only the improvement need is to estimate factor values for different annual crops, fruit crops and fferent crop and soil management practices used under Malaysian condition. Soil loss computed with RUSLE will be the st available estimates to be used for soil conservation planning.

troduction
il erosion prediction is a powerful tool used by soil nservationists for soil conservation planning and to guide rmer =s choice of conservation practices that best fit eir needs and interests in specific fields. According to ischmeier and Smith (1978), prediction of the effect of ferent land use systems on soil erosion is necessary to able the best combination of land use and management actices to be selected, in order to minimise soil erosion d maintain soil productivity.
e most widely used soil loss prediction model is the iversal Soil Loss Equation (USLE). The Revised Universal il Loss Equation (RUSLE) is the revision and update of LE. RUSLE, like its predecessor, is an erosion model signed to predict the long-term average annual soil loss m specific field slope in specified land-use and inagement system.
e RUSLE retain much of the equation structure of the LE but several concepts from other process based sion modeling have been used in RUSLE to significantly prove erosion prediction. These concepts are practically ed to estimate factor values for slope length, slope epness and supporting practice effects.

aterials and Methods
e soil loss data from various experiments and under ferent treatments was used for prediction of soil loss by SLE model. The locations of the experiments were at rdang and Puchong, Selangor, Malaysia conducted during period from 1978 to 1994. The treatments for different periments were annual crops (maize, sugar cane, undnut, mungbean cowpea, chilli and sweet potato) and ferent management practices along with bare plots.
e factor values of R, K, LS, C and P were calculated lividually for each treatment of all the four experiments. e method of calculating the factor values is described as lowing.

R-factor value: The R-factor is the sum of individual storm erosivity values, EI, for erosive storms over a time period which is usually average annual or an average crop stage (Wischmeier and Smith, 1978).
EI_{30} for experimental period was calculated in metric units of $J.m^{-2}$ cm. h^{-1} from Soil Physics annual Reports for the years 1979, 1980 & 1981.These units were converted to SI units of $MJ.mm.ha^{-1}.h^{-1}$ and then to US customary units by dividing with a conversion factor of 17.02 (Foster *at al.*, 1981) to hundreds of $ft.tonf.in.ac.^{-1}.h.^{-1}.yr.^{-1}$ which are the units acceptable by RUSLE model for calculating R-factor value.

K -factor value: The soil erodibility factor (K) is the rate of soil loss per unit of R or EI for a specific soil as measured on a unit plot, which is 72.6 foot (22.1 m) length of uniform 9 percent slope continuously in clean-tilled fallow (Wischmeier and Smith, 1978). Therefore it has a units of mass per area per erosivity unit.
The value of K was calculated by RUSLE model using nomograph method from the available data of soil texture of the experimental area and was used for soil prediction. K-factor value was same for all other experiments, which were conducted on the same plots because the yearly data for texture was not available separately for each experiment.

LS-factor value: The factor L and S for effect of slope length and steepness are dimension less ratios of soil loss from a given slope to that from a unit plot with all other factors equal. The LS-factor value was calculated by RUSLE keeping in view the length and slope of each plot and the *susceptibility of soil to rill erosion relative to interrill* erosion. This factor value was also same for all the experiments conducted on the same plots and was used for soil prediction.

C-factor value: In RUSLE the sub factor method is used to compute soil loss ratios as a function of three sub factors:

canopy, ground cover and with in soil effects. Sub factor values for the within soil effect are calculated from amount of biomass in the soil which accumulates from roots and incorporation of crop residue. RUSLE computes decomposition of biomass on and in the soil. This factor value was predicted by RUSLE model after calculating the values for percent canopy cover, percent ground cover, root mass in top 4 inches of soil, average fall height of rain drop, number of years since last soil disturbance and roughness condition of the soil. This value was than used for soil prediction from the treatments of each experiment.

P-factor value: P-factor in RUSLE is the ratio of soil loss with a specific support practice to the corresponding loss with up slope and down slope tillage. These practices principally affect erosion by modifying the flow pattern, grade or direction of surface runoff and by reducing the amount and rate of runoff.
P-factor value by RUSLE was calculated after taking in account the sub-factor values of stripcropping, contouring, terracing and sub surface drainage condition of the soil.

Soil loss table: After calculating the individual factor values, they appeared on the soil loss table of RUSLE model. Soil loss was predicted as A in the equation, $R \times K \times LS \times C \times P = A$ in the units of tons per acre. These values were used to compare with measured soil loss values by statistical analysis for individual experiment and as an overall performance of RUSLE.

Results and Discussions

Experiment no. 1. Upm/se (1.1): This experiment was conducted for 11 months from Nov. 1, 1978 to Sept. 30, 1979 at Serdang farm, UPM. The treatments in this experiment were (1) Bare plot, (2) Maize, (3) Maize with mulch and (4) Groundnut.
There were three replications for each treatment. The mean soil losses of three replications from various treatments for actual field experiment as reported in Soil Physics annual report 1979 and as predicted by RUSLE is shown in Table 1. Total soil loss from the field experiment was 68 percent from bare plot followed by 17 percent from groundnut crop, 14 percent from maize crop and 1 percent from maize with mulch. The soil loss from the field experiment was in the order of, bare plot > groundnut crop > maize crop > maize crop with mulch. The total soil loss as predicted by RUSLE for the same experiment was 65 percent from bare plot followed by groundnut crop with 22 percent than from maize crop with 12 percent and 1 percent from maize with mulch. The order of soil loss was same as actual field experiment bare plot > groundnut > maize > maize with mulch. Paired sample t-test shows that the difference in measured soil loss and as predicted by RUSLE was not significantly different from each other at 0.05 level of significance ($t = 1.825$; $p < 0.1656$). Therefor it can be assumed that for this experiment RUSLE has predicted soil loss which is almost similar to actual field experiment with the exception of bare and groundnut crop for which the difference is more.

Experiment no. 2 upm/se (1.2): This experiment was conducted on the same plots of experiment 1, from Oct. 19, 1979 to Sept. 30, 1980 for a year. Mean soil losses from three replications of actual field experiment as reported in Soil Physics annual report 1980 and as predicted with RUSLE is shown in Table 2. The treatments under this experiment were (1) Bare plot, (2) Mungbean, (3) Cowpea and (4) Groundnut.
The total soil loss from the experiment was 57 percent from bare plot followed by mungbean with 21 percent than from groundnut plot with 12 percent and lowest was from cowpea with 10 percent. The order of soil loss from actual field experiment was, bare plot > mungbean > groundnut > cowpea crop. The total soil loss from the experiment as predicted by RUSLE was 50 percent from bare plot followed by mungbean with 25 percent than from groundnut with 13 percent and lowest from cowpea with 11 percent. The order of predicted soil loss was same as actual field experiment, bare plot > mungbean > groundnut > cowpea.
Paired sample t-test shows that the difference between measured soil loss from field experiment and soil loss as predicted by RUSLE was not significant at 0.05 level of significance ($t = -0.311$; $p < 0.776$). The difference between measured and predicted soil loss for bare plot was higher as compare to other treatments. Therefor it can be assumed that RUSLE has predicted soil loss that is close to actual field soil loss except for bare plot for which RUSLE has under estimated by 15 percent which may be due to roughness condition of the soil.

Experiment No. 3. upm/se (1.4): This experiment was als conducted on the same plots of experiment 1 and 2, Serdang UPM farm from March 24, 1981 to Dec.29, 198 for 10 months. Mean soil loss from three replications different treatments for actual field experiment as report in Soil Physics annual report, 1981 and as predicted w RUSLE is shown in Table 3. The treatments under th experiment were, (1) Bare plot, (2) Chilli, (3) Sugarca (Yellow variety) and (4) Sugarcane (Green variety).
Total soil loss from the field experiment was 47 perc from bare plot followed by sugarcane (G) with 19 perc than from sugarcane (Y) with 18 percent and from c with 16 percent. The order of soil loss from f experiment was, bare plot > sugarcane (G) > sugarcane >chilli crop. The total soil loss as predicted by RUSLE the same experiment was 45 percent from bare followed, by sugarcane (G) with 20 percent than f sugarcane (Y) with 19 percent and than from chilli wit percent. The order of predicted soil loss was same as a experiment, bare plot > sugarcane (G) > sugarcane (chilli plot. Paired sample t-test shows that the differen measured soil loss from field experiment to soil lo predicted by RUSLE is not significant at 0.05 lev significance ($t = -2.551$; $p < 0.084$). Therefor fro experiment also it can be assumed that RUSLE can be to predict soil loss, though all the results are estimated by an average of 30 tons/ac. that may be short period of the experiment. Due to which the E factor) was low which gave low values of soil loss.

able 1: Soil loss from field (measured) and as predicted by TUSLE (predicted)

reatments	Measured (Tons/ac)	Predicted (tons/ac)	Diff. (pred-Meas)
are plot	83.0	95.0	11.0
aize crop	16.9	17.0	0.0
aize with mulch	1.2	1.8	0.6
roundnut crop	21.3	31.0	9.7
ean	30.6	35.9	5.3
d.Dev	35.9	40.5	8.0

able 2: Soil loss from field (measured) and as predicted by TUSLE (predicted)

eatments	Measured (Tons/ac)	Predicted (tons/ac)	Diff. (pred-Meas)
ra plot	117.26	100.00	-17.26
ungbean crop	43.16	49.00	5.84
wpea crop	20.65	23.00	2.35
oundnut crop	24.48	27.00	2.52
ean	51.38	49.75	-1.63
d.Dev.	45.00	35.39	10.53

able 3: Soil loss from field (measured) and as predicted by TUSLE (predicted)

eatments	Measured (Tons/ac)	Predicted (tons/ac)	Diff. (pred-Meas)
are plot	119.75	54.00	-65.76
illi crop	40.00	23.00	-17.00
garcane(Y)	45.70	27.00	-18.70
garcane(G)	47.48	28.00	-19.480
ean	63.23	33.000	-30.23
d.Dev.	37.81	14.16	23.70

periment No. 4. Sweet potato: This experiment was nducted at Puchong farm of UPM from June 22, 1994 to v. 22, 1994 for 5 months (Lau, 1994). The total soil loss om bare plot and under sweet potato is shown in Table 4. tal soil loss from the field experiment was 82 per cent om bare plot and 18 percent from sweet potato crop here as the total soil loss as predicted with RUSLE was 8 percent from bare plot and 2 percent from sweet potato ot. The order of soil loss was same in both but there was fference in percentage loss of soil from plots this may be e to short period of experiment because RUSLE is sically meant to predict average annual soil loss.

ired sample t-test shows that the difference between easured soil loss and as predicted by RUSLE is not gnificantly different from each other ($t = 1.013$; $p <$ 495) at 0.05 level of significance. Therefor it can be sumed that RUSLE can be used for this experiment. The fference for bare plot is very high which is mainly due to ort period of the experiment. For which R-factor was very w which has predicted low soil loss for bare plot. It is well own that if all other factors are constant the soil loss is ectly proportional to the level of erosivity (Wischmeier *et* ., 1978).

Table 4: Soil loss from field (measured) and as predicted by TUSLE.

Treatments	Measured (Tons/ac)	Predicted (tons/ac)	Diff. (pred-Meas)
Bare plot	4.23	78.00	73.76
Sweet potato	0.91	1.40	0.48
Mean	2.57	39.70	37.125
Std.Dev.	2.34	57.62	51.82

Overall comparison of soil loss: Soil loss data from four experiments with different treatments were used for soil prediction using RUSLE. Three experiments were conducted on the same plots of Serdang farm but with different treatments and at different time. The other one experiment was conducted at Puchong farm with only two treatments for 5 months. Among the 14 treatments of the four experiments RUSLE under estimated 5 treatment (all treatments of exp.3 and bare plot of exp.2) and over estimated 4 treatments (groundnut, mungbean and bare plot of exp.1 and 4) where as the results of 5 treatments were almost same (maize, maize with mulch, cowpea, potato and groundnut crop of exp.2) with an average difference of 1.19 tons/ac. From the overall comparison of difference between actual and predicted (Fig. 1) it looks like from figure that at low levels of soil loss RUSLE predict more accurately as compared to high level of soil loss. When difference between measured and predicted soil loss was compared without bare plots (Fig. 2) both the lines of measured and predicted were very close to each other except for the treatments of sugarcane and chilli crop where the average difference was 18 tons/ac. Whereas when all the bare plots were compared they showed lot of variations except for the bare plot of exp. 1 for which the difference was only 11 tons/ac.

Paired sample t-test for overall comparison between measured and predicted soil loss showed that they were not significantly different from each other at 0.05 level of significance ($t = -0.290$; $p < 0.078$). When the data of soil loss of one bare plot (65.760) was removed (as it was outlier) the regression analysis gave an better coefficient of determination (R^2) of 0.87 (including the bare plot $R^2 = 0.75$) When 1:1 regression line was compared with the regression line of the data it showed that all the points were very close to 1:1 line (Fig. 3). This also shows the performance of RUSLE in predicting soil loss for these experiments.

When EI_{30} (R-factor) for the different experiments was compared with the difference of measured and predicted soil loss, it showed that at high EI_{30}, the difference between actual and predicted is less and as the values of EI_{30} decreases the difference also increases with the exception of sweet potato crop. This exception may be due to short period of experiment (5 month). Van and Wall (1979) also reported the similar results while predicting soil erosion in Southern Ontario on corn crop from two different stations

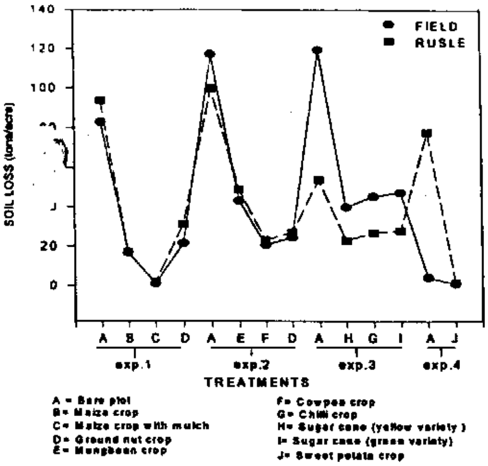

Fig. 1: Comparison of Soil Loss

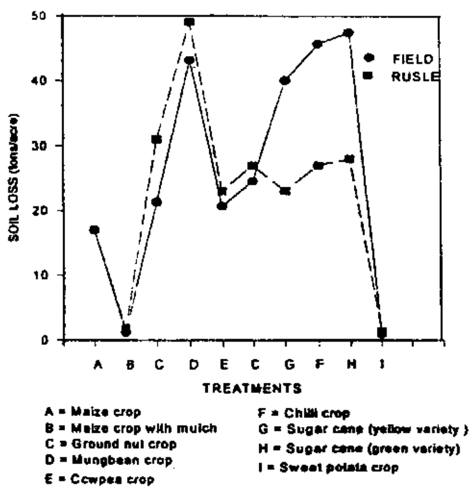

Fig. 2: Comparison of Soilloss from crop plots

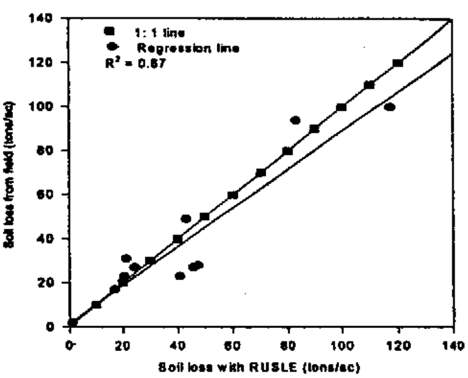

Fig. 3: Comparison of results with 1:1 line.

with a data of 4 to 6 years. The data for all field experiments were less than one year. The results of the present study were also consistent with the findings of Risse *et al.* (1993), when they compared average annual measured soil loss with average annual predicted soil loss from more than 220 plots of different sites. RUSLE is basically ment for predicting annual sheet and rill erosion. Therefore its results for a shorter period may not be so accurate. RUSLE can be used in Malaysia for predicting soil loss by determining the appropriate values for equation factors dealing with climate, topography, landuse and crop management factors. But before its wide spread use it should be tested for other crops and in different locations in Malaysia.

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