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Use of RUSLE for Soil Loss Prediction During Different Growth Periods

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Abstract: Revised Universal Soil Loss Equation (RUSLE) was used for soil loss prediction from the standard erosion plots of banana, pineapple, intercrop of banana-pineapple and bare plot. The results were compared with the measured soil loss for each growth period and as an overall experimental period of nine months. The results showed that for individual periods the soil loss was over-estimated for some treatments and under-estimated for some except for banana plot. For overall experimental period the average percent deviation from measured soil loss was only 12 percent. The chi-square test showed that the difference in measured and predicted soil loss was not significant. On these basis it can be said that RUSLE model can be used for soil loss prediction from banana-pineapple intercropping system in Malaysia.

Key words: Soil loss, prediction, growth periods, erosion plots

Introduction

Revised Universal Soil Loss Equation (RUSLE) is the third revision and update of Universal Soil Loss Equation (USLE) published by U.S. Department of Agriculture, Washington D.C. in 1992. RUSLE retain much of the equation structure of USLE except several concepts from process based erosion modeling have been used to improve erosion prediction. RUSLE computes average annual sheet and rill erosion for a landscape profile. The soil loss value computed is the representative of that area (Renard *et al.*, 1991). More extensive database was used by Foster *et al.* (1993) to develop equations for computing P-Factor values for RUSLE than was used to develop P-Factor value for the USLE. The equation in RUSLE include adjustments for land slope, ridge height and storm severity and off grade contouring. Other improvements in RUSLE includes expanded information on soil erodibility, a slope length factor, a sub-factor method for computing values for the cover-management factor and improved factor values for the effect of contouring, terracing, strip cropping and management practices for range land (Renard *et al.*, 1991). The development of RUSLE computer program permits application to situations not possible with the USLE technology (Renard, 1992).

The purpose of this study was to examine the performance of RUSLE in Malaysia under different treatments of crop and soil management on standard erosion plots and also to compare the measured and predicted soil loss from upland intercropping system of banana-pineapple.

Materials and Methods

Soil loss data for three growth periods (pre-establishment, establishment and early maturity) and as an overall experimental period of nine months was taken for soil erosion prediction from the experiment conducted at Puchong, Selangor, Malaysia on standard erosion plots (Abbasi and Jamal, 1999). The treatments of the field experiment were banana crop, pineapple crop, intercrop of banana-pineapple and bare plot. The factor values of the RUSLE model (Fig. 1) were calculated separately from the available inputs by the following procedure.

R-factor: The R-factor is the sum of individual storm erosivity values (EI) for qualifying storms over a time period, usually average annual or an average crop stage (Wischmeier and Smith, 1978). EI_{30} index for experimental period was calculated in the units of $MJ.mm.ha^{-1}h^{-1}$ and were converted to US customary units by dividing with a conversion factor of 17.02 (Foster *et al.*, 1993) to hundreds of $ft.tonf.in.ac^{-1}h^{-1}y^{-1}$ which are the units acceptable by RUSLE model for calculating R-factor. The city code number was allocated to Puchong for identification and the calculated observations of EI_{30} for a period of nine months was used in the city database. All the information required by the model were provided for calculating EI_{30} value for Puchong.

K-factor: 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 feet (22.1 m) length of uniform 9 percent slope continuously in clean-tilled fallow (Wischmeier and Smith, 1978). Therefore it has a unit of mass per unit area per erosivity unit. The value of K was calculated by RUSLE using nomograph method from the available data of soil textural class and organic matter of the experimental plots.

LS-factor: 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 being equal. The LS-factor value was calculated by RUSLE keeping in view the length (22.1 m or 72.6 ft.) and slope (9%) of each plot.

C-factor: This factor value was calculated by RUSLE model by providing the input values from field measurement for

Table 1: Comparison of measured and predicted soil loss

Treatment	Pre-est. Period (Tons/ac)		Est-period (Tons/ac)		Early Mat. P. (Tons/ac)		Overall Exp. P. (Tons/ac)	
	Meas.	Pred.	Meas	Pred	Meas	Fired.	Meas	Pred.
Bare plot	25	35	102	100	133.0	65.0	260.0	240
Banana plot	26	26	38	38	37.0	24.0	101.0	100
Pineapple plot	42	39	18	26	1.5	3.9	61.5	61
Intercrop plot	34	38	28	19	3.2	1.7	65.2	61
Total	127.0	138.0	186.0	183.0	174.7	94.6	487.7	462.0
Mean	31.7	34.5	46.5	45.7	43.7	23.6	122 .0	115.5

Table 2: Soil erosion prediction with RUSLE

Growth periods	Treatment	R (ft.tonf.in/ac-h)	K	LS	C	P	Predicted soil loss ft/ac)
Pre-est.	Bare	347	0.129	1.003	0.786	1.00	35.0
	Banana	347	0.214	1.003	0.346	1.00	26.0
	Intercrop	347	0.190	1.003	0.536	1.00	38.0
	Pineapple	347	0.243	1.003	0.457	1.00	39.0
Estab.	Bare	471	0.269	1.003	0.786	1.00	100.0
	Banana	471	0.243	1.003	0.330	1.00	38.0
	Intercrop	471	0.212	1.003	0.298	1.00	26.0
	Pineapple	471	0.229	1.003	0.177	1.00	19.0
Early Mat.	Bare	290	0.283	1.003	0.786	1.00	65.0
	Banana	290	0.254	1.003	0.329	1.00	24.0
	Intercrop	290	0.187	1.003	0.071	1.00	3.9
	Pineapple	290	0.217	1.003	0.026	1.00	'1.7
Overall Exp.	Bare	1108	0.272	1.003	0.786	1.00	240.0
	Banana	1108	0.293	1.003	0.315	1.00	100.0
	Intercrop	1108	0.236	1.003	0.233	1.00	61.0
	Pineapple	1108	0.252	1.003	0.217	1.00	61.0

percent canopy cover, percent ground cover, root mass in top 4 inches of soil, average fall height, number of years since last soil disturbance and roughness condition of soil.

P-factor: P-factor value by RUSLE was calculated by providing information for calculating sub-factor values for strip cropping, contouring, terracing and ground water drainage.

Soil Loss Table: After calculating the individual factor values for R, K, LS, C and P they appeared on the soil loss table in the RUSLE model and soil loss was predicted as A value, which was in tons per acre per year. The difference in the measured and predicted soil loss under each treatment was calculated for every growth period and as an overall for the total experimental period. This difference was analysed statistically by chi-square test to see any significant difference in measured and predicted soil loss.

Results and Discussion

Pre-establishment Period: The soil loss measured during pre-establishment period from the field was compared to the predicted soil loss for this period (Table 1). The factor values of the model for R, LS and P were kept the same for all the plots due to same EI_{30}, degree of slope and length of the slope. P-factor was calculated as 1 for all the plots. Though pineapple plants were planted in strips but the number of plants per strip was very few therefore the effect of strips on soil erosion was negligible. The factor values for C was different for each plot due to difference in canopy cover, average fall height, ground cover and root biomass (Table 2).

The results of soil erosion prediction for the pre-establishment period showed that, RUSLE has predicted 28.6 percent more than measured soil loss for bare plot, 10.5 percent more for intercrop plot and 7.7 percent less for pineapple plot. Whereas for banana plot there was no difference in measured and predicted soil loss. The average deviation for all plots for this period was 11.7 percent, that was still less than 12 percent as reported by Wischmeier (1976).

Establishment Period: For the establishment period, the factor values for each plot were same as the pre-establishment period except for the R and C factor. As there was no significant change in texture and other inputs for the factor. R and C factors were different from pre-establishment period due to difference in EI_{30}, canopy cover, average fall height and root biomass for this period (Table 2).

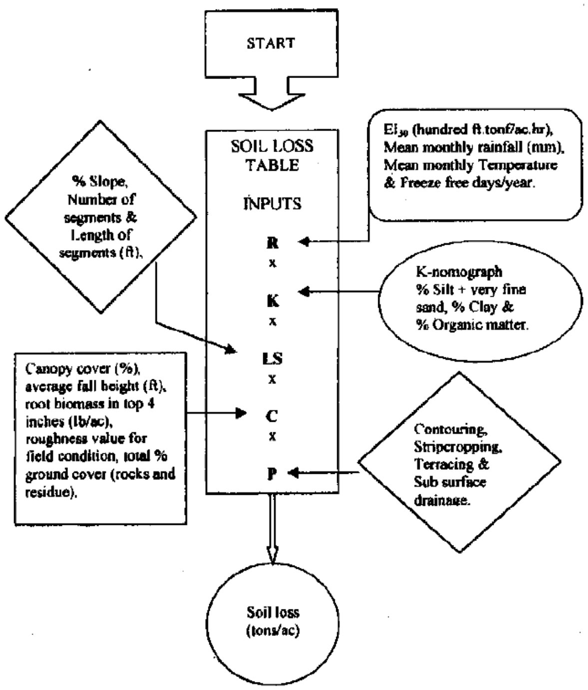

Fig. 1: Revised Universal Soil Loss Equation Model

The results of soil erosion prediction for establishment period showed that, RUSLE underestimated for bare and intercrop plot by 2 percent and 7.7 percent respectively. Soil loss from pineapple plot was overestimated by 5 percent and there was no difference in soil loss for banana plot (Table 1). The average deviation for all the plots from the measured soil loss was only 3.7 percent, which is much less than 12 percent as reported by Wischmeier (1976).

Early Maturity Period: For the early maturity period the factor values for R, K and C were different from the earlier two periods due to difference in EI_{30}, organic matter, percentage of canopy cover, percentage of average fall height, ground cover and root biomass for each crop during the third period. LS and P factors were same as the earlier two periods due to same degree and length of slope and also same soil conservation practices of the plots (Table 2).
The results during early maturity period were underestimated for bare and banana by an average of 79 percent and were overestimated for intercrop and pineapple plots by an average of 15 percent. The difference in measured and predicted soil loss was also high as compared to first two periods (Table 1). The average deviation for all plots from the measured soil loss was 46.9 percent, which is higher than the average limit of 12 percent as reported by Wischmeier (1976).

Overall Experimental Period: This period included overall study period of nine months. The factor values of K and C were different from the growth periods. These values were taken as an average value of the inputs required for each factor in calculating the sub-factor values for individual crop and bare plot. Whereas R-value was the total EI_{30} computed for the experimental period. LS and P were the same due to same degree of slope, length and soil conservation practices (Table 2).
When soil loss during overall experimental period was predicted it showed an underestimation for bare, intercrop and pineapple by 7.7, 6.4 and 0.8 percent respectively, whereas there was almost no difference in predicted and measured soil loss for banana plot (Table 1). The average deviation from the measured soil loss during the overall experimental period was only 4.05 percent which was much less than the average deviation of 12 percent as reported by Wischmeier (1976).
These results indicated that for short period (growth period) there was more difference between predicted and measured soil losses as compared to longer period (overall experimental period). The Chi-square test for non-parametric paired analysis showed that the differences between measured and predicted soil loss for the experimental period was not significant at 0.05 probability level (X_2 = 2.25, p>19.67). If all other factors are constant soil loss from the field is directly proportional to the erosivity of the rainfall. Therefore the higher the EI_{30}, index the more will be the soil loss.
The results of present study were 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 22 different sites. They found that on the sites where soil loss was less than 9 mt/ha (22.23 tons/ac) 80 percent loss was over estimated. Whereas for the sites with soil loss greater than 20 tons/ha (49.4 tons/ac) 22 percent loss was over estimated. That means USLE usually over estimates at sites with relatively low erosion rates. Van Vliet and Wall (1979),

while predicting soil erosion by USLE in Southern Ontario on corn crop from two different stations with the data of 4 to 6 years, found that the difference in measured and predicted soil loss was not significantly different from each other. Renard *et al*. (1991) reported the differences of 5.0 tons/ac of soil loss when they compared soil loss between USLE and RUSLE from cornfield in Indianapolis, USA.

The accuracy of a predicted soil loss will depend on how accurately the physical and management conditions on the particular piece of land are described by the parameters values used for sub-factor calculations. An error in the selection of a factor value will produce an equivalent percentage error in soil loss estimates. The specific storm or the specific year soil losses and short term average will differ substantially from the longtime average prediction by RUSLE for the specified physical and managemental conditions (Wischmeier and Smith, 1978). They will generally be most accurate for medium textured soils, slope length of less than 400 ft, gradients of 3 to 18 percent and consistent cropping and management systems that have been represented in erosion plots studies. The farther these limits are exceeded, the greater will be the probability of significant extrapolation error (Wischmeier and Smith, 1978).

On the basis of these results it can be concluded that RUSLE can be used successfully to estimate average annual field soil losses from the sloping agricultural lands in Malaysia. Soil losses computed with the RUSLE are the best available estimates and therefore can be used in soil conservation planning. The results of soil erosion prediction would be more reliable if they are averaged for a longer period and less reliable if they are averaged for a shorter period.

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