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USLE/RUSLE Factors for National Scale Soil Loss Estimation Based on the Digital Detailed Soil Map

Kang-Ho Jung*, Won-Tae Kim, Seung-Oh Hur, Sang-Keon Ha, Pil-Kyun Jung and Yeong-Sang Jung[1]

National Institute of Agricultural Science and Technology, Suwon 441-707, Korea
[1]Kangwon National University, Chuncheon 200-701, Korea

Factors of universal soil loss equation, USLE, and its revised version, RUSLE for Korean soils were reevaluated to estimate the national scale of soil loss based on digital soil maps. Rainfall erosivity factor, R, of 158 locations of cities and counties were spacially interpolated by the inverse distance weight method. Soil erodibility factor, K, of 1321 soil phases of 390 soil series were calculated using the data of soil survey and agri-environmental quality monitoring. Topographic factor, LS, was estimated using soil map of 1:25,000 scale with soil phase and land use type. Cover management factor, C, of major crops and support practice factor, P, were summarized by analyzing the data of lysimeter and field experiments for 27 years (1975-2001) in the National Institute of Agricultural Science and Technology. R factor varied between 2322 and 6408 MJ mm ha^{-1} yr^{-1} hr^{-1} and the average value was 4276 MJ mm ha^{-1} yr^{-1} hr^{-1}. The average K value was evaluated as 0.027 MT hr MJ^{-1} mm^{-1}. The highest K factor was found in paddy rice fields, 0.034 MT hr MJ^{-1} mm^{-1}, and K factors in upland fields, grassland, and forest were 0.026, 0.019, and 0.020 MT hr MJ^{-1} mm^{-1}, respectively. C factors of upland crops ranged from 0.06 to 0.45 and that of grassland was 0.003. P factor varied between 0.01 and 0.85.

Key words : Soil erosion, Soil loss, USLE, RULSE.

Introduction

Since soil loss leads to soil degradation and accompanies nutrient and pesticide movement of non-point pollution sources (OECD, 1982), protection of soil loss is crucial for environmentally sound sustainable agriculture. Soil loss is one of the major agri-environmental problems, and it has been intensively dealt with by international organizations such as FAO and OECD.

Estimation of soil loss must be undertaken before implementing the best management practice. Soil loss has been estimated by the model as it was difficult to measure soil loss directly. The Universal Soil Loss Equation (USLE) has been the most widely accepted and utilized soil loss equation for over 30 years (Wischmeier and Smith, 1965 and 1978; Laflan and Moldenhauer, 2003). Since Shin et al. (1976), Jung et al. (1976), and Park (1976) introduced this model in Korea, many researches have been performed to put USLE to practical use for the past 30 years. This model became the basis for predicting the national scale soil loss.

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*Corresponding author: Phone : +82312900272, Fax: +82312900207, E-mail : stealea@rda.go.kr

In the USLE and its revised version RUSLE, 5 major factors are used to calculate the soil loss for a given site : rainfall and runoff erosivity (R), soil erodibility (K), slope length and steepness (LS), cover management (C), and support practice (P). Each factor is the numerical estimate of a specific condition that affects the severity of soil erosion at a particular location. Jung et al. (1983) and Park et al. (2000) calculated from the rainfall data obtained from the Korea Meteorological Administration (KMA). Jung et al. (1976) evaluated K factors of 83 soil conditions applicable in Korea and Jung et al. (1999) corrected K factors considering gravel coverage. The soil characteristics used for K factor estimation were obtained from the Introduction of Korean Soil (IKS) (NIAST, 1992) which reported the characteristics of 1285 soil phases of 378 soil series. Moreover the Taxonomical Classification of Korean Soils (TCKS) (NIAST, 2000) recorded the soil physical and chemical properties of representative soils of 390 soil series. Factors C and P in Korea were also reported by Shin et al. (1980), Jung et al. (1985), Oh, et al. (1987), Oh et al. (1991), Kim et al. (1991), and Oh et al. (1995). However, still no attempt has been made to integrate those research data systematically and to estimate soil loss on the national scale.

This study, therefore, was performed to integrate existing research products with the five factors of USLE and RUSLE in Korea for practical purposes. Soil type and land use type were used to predict the soil loss for cities and counties. Furthermore, OECD soil loss erosion grade (OECD, 2001) would be used to determine the potential erosion area in Korea.

Materials and Methods

For the estimation of soil loss, USLE was expressed as following equation (Eq. 1).

$$A = R \cdot K \cdot LS \cdot C \cdot P \tag{1}$$

A : annual soil loss (MT ha^{-1} yr^{-1})
R : rainfall and runoff erosivity (MJ mm ha^{-1} yr^{-1} hr^{-1})
K : soil erodibility (=A/R, MT hr MJ^{-1} mm^{-1})
LS : slope length and steepness (dimensionless)
C : cover-management (dimensionless)
P : support practice (dimensionless)

R factor The average R factors of 158 locations of cities and counties were calculated using the inverse distance weight method based on 1 km spatial unit TM coordinates from ΣEI_{30} of Jung et al. (1983) and Park et al. (2000), where E was the total kinetic energy of rainfall and I_{30} was the 30-minute maximum rainfall intensity. The former was analyzed using the rainfall data in 69 observation stations of KMA from 1969 to 1978 and the latter was done in 53 sites from 1973 to 1996 to calculate ΣEI_{30}. The unit of ΣEI_{30} is the MJ mm ha^{-1} yr^{-1} hr^{-1}.

K factor The K factors were calculated with the equation modified by Box (1981) which originally were developed by Wischmeier and Smith (1978).

$$K = [\{2.1 \times 10^{-4}(12\text{-}OM)M^{1.14} + 3.25(S\text{-}2) + 2.5(P\text{-}3)\} / 100] \tag{2}$$

$$K_m = K \times [1.0977 \times 10^{-0.0111x}] \tag{3}$$

where M is the product of the primary particle size fractions: (% very fine sand + % silt) × (% silt + % sand), S is the structure code (1-4), P is the permeability code (1-6), x is the gravel coverage (%), and K_m is the modified K considering gravel coverage.

Soil phase, as a mapping unit, was used to estimate the K factor. Soil phase was analyzed using texture, gravel content, slope, etc. in the same soil series. The contents of very fine sand, silt, clay, and organic matter, soil structure code and permeability code were derived from TCKS (NIAST, 2000) which described the characteristics pertaining to the different features of each soil series. Since the soil texture of a soil phase is different from that of representative soil of the series, the particle contents of geologically associated soil series were used for the K factor calculation. The gravel coverage was determined with the gravel content grade divided into 3 groups of none (0-10%), gravelly (10-35%), and skeletal (35%<) in IKS (NIAST, 1992) and the representative value of group was assumed to be 5, 22.5 and 40%, respectively.

In addition, the K factors in upland were corrected taking into account changes in organic matter content by employing various cultivation method using regressive curve of organic matter contents from Monitoring Project on Agri-Environment Quality in Korea (MPAEQ) (NIAST, 2003) surveyed in 2001 and those from TCKS (NIAST, 2000) in 1969 to 1980.

LS factor The slope length factor L was dependent on slope length and steepness (Wischmeir and Smith, 1978; Foster et al., 1977; McCool et al., 1989)

$$L = (\lambda/22.1)^m \tag{4}$$

where m is the slope length exponent: $m = \beta / (1+\beta)$.

$$\beta = (\sin\theta/0.0896) / [3.0(\sin\theta)0.8 + 0.56] \tag{5}$$

where θ = slope angle.

The slope steepness factor S was evaluated from the following equation (McCool et al., 1987).

$$S = 10.8 \sin\theta + 0.03 \text{ (steepness} < 9\%) \tag{6}$$

$$S = 16.8 \sin\theta + 0.50 \text{ (steepness} \geq 9\%) \tag{7}$$

For LS factor, the median value (%) of slope grade of soil phase was converted into slope angle and slope length was determined as the representative value with land use type using soil map (1:25,000).

C factor To evaluate the C factor with covered crop, the experimental results from 1977 to 2001 conducted by the Soil Conservation Laboratory in the NIAST on field lysimeter pots were collected. The C factor was calculated and it was applied on a national scale to yield an estimation. The average C factor for a province was estimated by averaging over cultivated area and C factor of major crops.

P factor The P factors for crop lands were determined using the results of NIAST from 1976 to 1999 by lysimeter study. The P factors for grassland and forests assigned the value 1.0 in this study.

Results and Discussion

R factor The R factors of 158 locations of cities and counties calculated in this study showed that the average R factor in Korea was 4210 MJ mm ha^{-1} yr^{-1} hr^{-1} and the maximum and minimum values were 2332 MJ mm ha^{-1} yr^{-1} hr^{-1} in Donghae and 6408 MJ mm ha^{-1} yr^{-1} hr^{-1} in Namhae, respectively (Jung et al., 1983). And the average, the maximum, and minimum R factor was 4276 MJ mm ha^{-1} yr^{-1} hr^{-1}, 2669 MJ mm ha^{-1} yr^{-1} hr^{-1} in Yeongdeog and 7268 MJ mm ha^{-1} yr^{-1} hr^{-1} in Namhae

Table 1. Average R factors of the cities and counties in Korea (1973-1996).†

City/County	R factor‡	City/County	R factor	City/County	R factor	City/County	R factor
Seoul	5152	Anyang	4996	Bonghwa	3431	Muju	3792
Busan	5496	Yangju	5103	Sangju	3186	Buan	4111
Daegu	3062	Yangpyeong	4956	Seongju	3223	Sunchang	4245
Incheon	5557	Yeoju	4777	Andong	3054	Wanju	4186
Gwangju	4615	Yeoncheon	4923	Yeongdeog	2668	Igsan	4439
Daejeon	4509	Osan	4906	Yeongyang	2918	Imsil	3861
Ulsan	4276	Yongin	4863	Yeongju	3752	Jangsu	4045
Gangneung	4111	Euiwang	4951	Yeongcheon	2723	Jeonju	4259
Goseong	4629	Euijeongbu	5077	Yecheon	3351	Jeongeub	4245
Donghae	3975	Icheon	4762	Ulreung	3357	Jinan	3988
Samcheog	3693	Paju	5301	Uljin	3027	Namjeju†	5470
Sogcho	3784	Pyeongtaeg	4891	Euiseong	2814	Bugjeju†	4841
Yanggu	3509	Pocheon	4742	Cheongdo	3555	Seoguipo†	6035
Yangyang	3830	Hanam	5011	Cheongsong	2827	Jeju†	4348
Yeongwol	4032	Hwaseong	4928	Chilgog	2826	Gongju	4777
Wonju	4429	Geoje	7076	Pohang	2778	Geumsan	3934
Inje	3367	Geochang	3807	Gangjin	5381	Nonsan	4562
Jeongseon	3991	Goseong	5716	Goheung	6076	Dangjin	4953
Cheolwon	4440	Gimhae	4909	Gogseong	4583	Boryeong	5230
Chuncheon	4242	Namhae	7268	Gwangyang	5540	Buyeo	5104
Taebaeg	3662	Masan	5417	Gurye	4711	Seosan	4982
Pyeongchang	4126	Milyang	3843	Naju	4689	Seocheon	4525
Hongcheon	4323	Sacheon	5719	Damyang	4487	Asan	4835
Hwacheon	4145	Sancheong	5106	Mogpo	3557	Yeongi	4561
Hoingseong	4442	Yangsan	4469	Muan	4024	Yesan	4910
Gapyeong	4631	Euiryeong	4646	Boseong	5464	Cheonan	4646
Goyang	5236	Jinju	5238	Suncheon	5067	Cheongyang	5005
Gwacheon	5041	Jinhae	5584	Sinan	4213	Taean	5008
Gwangmyeong	5016	Changnyeong	4090	Yeosu	5799	Hongseong	4970
Gwangju	4956	Changwon	4770	Yeonggwang	4422	Goisan	3919
(Gyeonggi)		Tongyeong	5527	Yeongam	4667	Danyang	3936
Guri	5089	Hadong	5411	Wando	5281	Boeun	3875
Gunpo	4939	Haman	4888	Jangseong	4451	Yeongdong	3401
Gimpo	5757	Hamyang	4364	Jangheung	5691	Ogcheon	3903
Namyangju	4973	Habcheon	4145	Jindo	4674	Eumseong	4357
Dongducheon	4976	Gyeongsan	3020	Hampyeong	4431	Jecheon	4128
Bucheon	4945	Gyeongju	3296	Haenam	4785	Jincheon	4442
Seongnam	4975	Goryeong	3638	Hwasun	4892	Cheongwon	4297
Suwon	4913	Gumi	2728	Gochang	4343	Cheongju	4389
Siheung	4899	Gunwi	2794	Gunsan	4190	Chungju	4091
Ansan	4938	Gimcheon	3088	Gimje	4196		
Anseong	4704	Mungyeong	3278	Namwon	4279		

† The data from Park et al. (2000) were used in the estimation of R factor. For Jeju province, the data from Jung et al. (1983) were used.

‡ Unit of the R factor is MJ mm ha^{-1} yr^{-1} hr^{-1}.

from Park et al. (2000) (Table 1).

Park et al. (2000) reported that erosivity in inland areas had been similar to that of Jung et al. (1983). To be precise the R factor in the coastal areas were higher than this calculation. In detail, the R factors were larger than 1000 MJ mm ha^{-1} yr^{-1} hr^{-1} in east coast areas in Kangwon province and south coast areas in Kyongnam province such as Gangneung, Goseong, Masan, and Haman, which means that the potential risk of soil loss and flooding would be high. It was presumed that this trend would persist considering the rainfall patterns thereafter, for example, typoon Rusa, and the analysis of R factor after 1997 and monitoring of the rainfall patterns in these areas are needed. R factors of Daegu and Kyoungbuk province were low ranging from 2669 to 3639 MJ mm ha^{-1} yr^{-1} hr^{-1}, and those of the south coastal areas including Geoje, Namhae, Yeosu and some part of east coastal areas such as Gimpo and Incheon were larger than 5500 MJ mm ha^{-1} yr^{-1} hr^{-1} (Table 1).

K factor The K factors in Korea were summarized in Table 2. It varied between 0.001 MT hr MJ^{-1} mm^{-1} (Jeogag and Pyeongdae series) and 0.102 MT hr MJ^{-1} mm^{-1} (Gwanghwal series). The average K factor in Korea was 0.027 MT hr MJ^{-1} mm^{-1}. As shown with the land use type in the table, the average K factor of paddy, cropland, grassland and forest was 0.036, 0.026, 0.019, and 0.020 MT hr MJ^{-1} mm^{-1}, respectively. The K factor in paddy

Table 2. K factors of major soil series in Korea.

Soil series	Soil code†	K factor‡	Soil series	Soil code	Soil series	Soil series	Soil code	Soil series
Anryong	Ar-, An-	0.025	Haengsan	Hp-	0.014	Pyeongtag	Pt	0.066
Asan	As-, AR-	0.019		Hz-	0.026	Sachon	Sc-	0.022
Baegsan	Be-	0.030	Hogye	Hg-	0.026		Sf-	0.030
	Bj-	0.028	Hwadong	Hd-	0.044	Samgag	Sg-	0.021
Bancheon	Bc-	0.035		Hj-	0.052		Sm-	0.013
Banho	Bh-	0.045	Hwangryong	Hr-	0.016		Sv-	0.008
	Bl-	0.022		Hl-	0.017	Sangju	SA-	0.025
	BL-	0.028		Hk-	0.026		Su-	0.016
Bongsan	Bx-	0.023		Hy-	0.027	Seogcheon	SE	0.065
Cheongsan	Ca-, Cm-	0.023	Isan	Is-, Ir-, Iv-	0.014		SV	0.045
	Cv-	0.013	Jangseong	Js-	0.016	Seogto	St-, Ss-	0.021
Cheongsim	Cc-, Cr-	0.032		JS-	0.009		Sb-	0.023
	Cs-		Jangwon	Jw-	0.022	Seongsan	Sz-	0.035
Chilgog	CG	0.026	Jeonbug	Jb-	0.070		SY-	0.044
Daegog	DK-, DL-	0.031	Jeonnam	Jn-	0.037	Songjeong	So-	0.019
Daegu	Df-, Dg-	0.010	Jigog	Jo-	0.003	Songsan	SN-, SR-	0.013
Daesan	Dv-	0.021	Jisan	Ji-	0.035	Suam	Sq-, SK-	0.016
Deogsan	Dp-	0.023	Jungdong	Jd-	0.040	Taehwa	Ta-, Tr-	0.036
	Db-	0.013	Maegog	Mo-	0.017		TB-, TG-	0.021
Dosan	Da-, Dj-	0.009	Mangyeong	Ma-	0.076		TM-	0.023
	Ds-	0.004		Mg-	0.041	Ugog	Uo	0.023
Gaghwa	Ga-	0.016	Masan	Mz-	0.022	Wolgog	Wo-	0.039
	Gb-, Gu	0.025	Nagdong	Nd	0.040		Wc-	0.054
	Gl-	0.022		Nn	0.050	Woljeong	Wj-	0.012
Goesan	KQ-, KD-,	0.025	Noegog	Nk-	0.025		WR-	0.006
	KX-	0.014	Odae	Od-	0.006	Wongog	Wa-, Wd-	0.048
Gopyeong	Gp-	0.023	Oesan	Os-, Oa-	0.022	Yeongog	Yg-	0.036
Gosan	Gx-	0.018	Ogcheon	Oc-	0.039		Yc-	0.044
Guisan	Kt-	0.006	Ora	Or-	0.037		YN-	0.048
Gujwa	Kq-, Kj-	0.009	Osan	On-	0.016	Yesan	Ya-	0.034
Gwanag	Gn-	0.010	Pungcheon	Px-	0.018		Yb-	0.021
	Ge-	0.006		Pu-	0.021	Yonggye	Ys, Yx	0.021
Habin	Hb-	0.027		Pz-	0.030		YxB	0.032
	Hk-	0.030	Pyeongtag	Pt	0.066	Yongji	Yj-	0.044

† Codes for slope and erosivity class were emitted.

‡ Unit of the K factor is MT hr MJ^{-1} mm^{-1}.

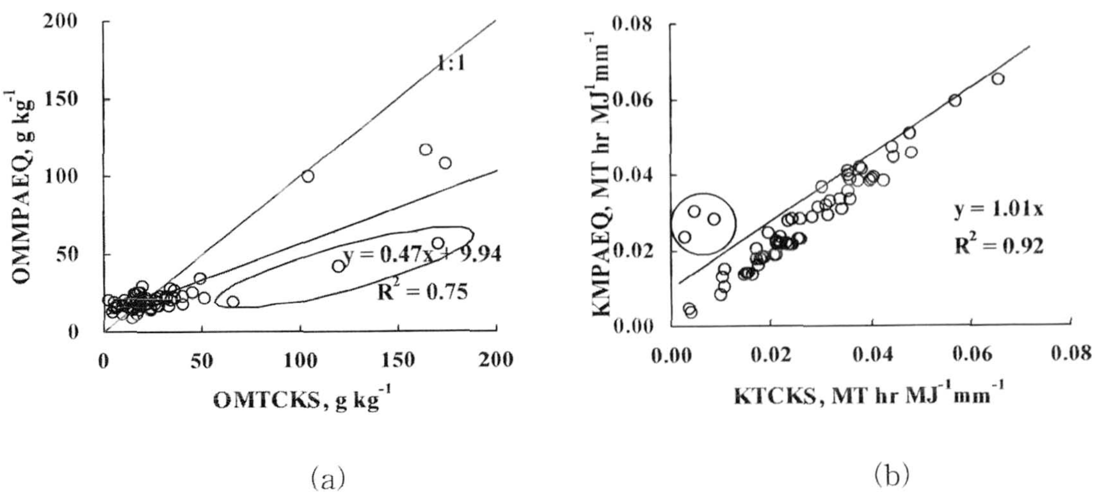

Fig. 1. Comparison of soil organic matter (a) and soil erodibility (b) between Taxonomical Classification of Korean Soils (TCKS, NIAST, 2000) and Monitoring Project on Agri-Environment Quality (MPAEQ, NIAST, 2003) in upland. The regression curve in (b) was calculated without data in dot circle. The data in TCKS and MPAEQ were surveyed from 1969 to 1981, and in 2001, respectively.

was the highest, since the proportion of silty textured soil was high with low gravel contents. Those of grass land and forest were low, because the organic matter contents were high. The average K factors of upland in the provinces such as Kyounggi and Chungnam, which are located on the lower reaches of a river and plain lands were higher 0.033-0.037 MT hr MJ^{-1} mm^{-1} than those of Chungbuk, Kyoungbuk, and Kangwon which are located on a hilly region and the upper parts of a river of 0.026-0.028 MT hr MJ^{-1} mm^{-1}.

The K factors were compared with the organic matter contents for 63 upland soil series collected in 1969-1981 from TCKS and in 2001 from MPAEQ. The organic matter contents more than 19 g kg^{-1} in 1969-1981 had tendency to decrease with time while those less than 19 g kg^{-1} had tendency to increase (Fig. 1a). The temporal variations of most soils were slight while those of some soils such as Gujwa, Sineom, and Ara, which had high organic matter contents were increased largely to maximum 0.026 (Fig. 1b). This implied that the potential risk of soil erosion might increased where grassland or forest which had high organic matter contents were turned into farmland. Figure 1 shows the relationship between organic matter contents (OMMPAEQ and OMTCKS) in 2001 and those in 1969-1981 by the following equation :

$$OM_{MPAEQ}\ (g\ kg^{-1}) = 0.47\ OM_{TCKS}\ (g\ kg^{-1}) + 9.94 \quad (8)$$

LS factor Soil phase in soil map was classified as 6 slope grade and the median value was chosen as the representative value. The slope length was also determined as the representative value with slope grade and land use type from the soil map (Table 3).

There is little difference in the predicted effect of slope on soil erosion between RUSLE and USLE up to slopes of about 20% but the data of high steepness in Wischmeier and Smith (1978) were much bigger than the data in McCool (1987). The effect of slope on soil erosion was researched in the range of 5 and 30% steepness in NIAST and LS factors calculated using USLE was regarded to be applicable in Korea. But it was judged to be more reasonable to use RUSLE for LS factor afterward to estimate soil loss in steep slope land. Furthermore, extra research should be performed more on severe soil erosion occurring on high-steepness slopes.

C factor Since the Korean peninsula is located in the Asian monsoon belt, more than half of the annual precipitation falls during the summer season and floods frequently occur due to torrential rains. So C factor of cropland was dependent on how much the cultivated crop could be covered in summer.

Table 4 shows C factors of major upland crops measured by the Soil Conservation Laboratory of NIAST in 1977-2001. C factors were high in chinese cabbage and maize of which fields were left a fallow or coverage were low in rainy season from June to Sep. On the contrary, peanut and Job's tears had low C factor. In grassland, soil loss was similar to maize cultivation in the first year of reclamation, but was reduced rapidly. The measured soil loss was 1/100 of the soil loss from the bare soil in the second year of reclamation.

Orchards were divided into two groups: the managed

Table 3. Steepness and slope length using soil map and LS factor by RUSLE.

Slope			Slope length (LS factor)					
Grade	Range	Median	Paddy field	Upland field	Orchard and grass land		Forest	
	%	%						
A	0-2	1.0	60 (0.13)	60 (0.13)	110	(0.14)	150	(0.15)
B	2-7	4.5	60 (0.58)	60 (0.58)		(0.71)		(0.79)
C	7-15	11.0	35 (1.19)	40 (1.27)		(2.10)		(2.45)
D	15-30	22.5	20 (2.31)	30 (3.50)		(6.43)		(7.74)
E	30-60	45.0	10 (3.12)	20 (4.98)		(15.8)		(19.5)
F	60-100	80.0	5 (4.47)	20 (8.94)		(21.0)		(24.5)

Table 4. C factors determined by lysimeter experiments.

Coverage crop	C factor	SD
Soybean	0.19	0.10
Red pepper	0.28	0.09
Maize	0.44	0.03
Upland rice	0.34	0.02
Yulmu†	0.18	
Peanut	0.06	0.03
Chinese cabbage	0.59	0.24
Orchard grass covered	0.01	0.001
Non covered	0.43	
Grass land	0.003	0.003
Grass land (1st year)	0.47	

† Yulmu is the Korean practical name of Coix lachrymajobi var. mayuen.

grass-covered and the uncovered. The C factor in the former was 0.01 but that in the latter was a high of 0.40. The standard deviation meaning the annual fluctuation was below 0.10 with exception of chinese cabbage.

The C factor in upland-crop fields of provinces varied between 0.31 and 0.43 (Table 5) and the average value was 0.34. Big cities such as Seoul and Pusan had a large value of C factor since green vegetable and condiment vegetable were cultivated mainly around urban area.

P factor Support practices could reduce soil loss by 50% to 90% compared to the up and down slope tillage (Table 6). It had been reported that the reduction effect on soil erosion of support practice varied by land slope (Laflen, 2003). However research results yielded from NIAST showed minor variation. Contour cultivation and vinyl mulching were known for popular conservation practices in Korea but there were no statistical data of practice-conducted land area, so the average value was difficult to evaluate.

Table 5. C factors estimated by considering the weight of cultivated area of each crop.

Province	C factor
Seoul	0.40
Pusan	0.43
Daegu	0.39
Incheon	0.33
Gwangju	0.42
Daejeon	0.32
Ulsan	0.33
Kyonggi	0.32
Kangwon	0.35
Chungbuk	0.31
Chungnam	0.33
Jeonbuk	0.33
Jeonnam	0.35
Kyongbuk	0.31
Kyongnam	0.34
Jeju	0.35
Average	0.34

Table 6. P factors of conservation practices in Korea.

			P factor
Contour	normal		0.54
	high ridge		0.25
	subsoiling		0.32
Mulching of furrow	contour	rice straw	0.14
		stump	0.21
	vertical	rice straw	0.32
Vinyl mulching of ridge	contour		0.29
	vertical		0.85
Contour terrace			0.08
Terrace channel			0.10
Gravel band			0.15
Grass band			0.16

Conclusion

The USLE factors were summarized using research products for the past 30 years. Rainfall erosivity varied between 2332-6408 MJ mm ha^{-1} yr^{-1} h^{-1} with region and the average value in Korea was 4210 MJ mm ha^{-1} yr^{-1} hr^{-1}. The high erosivity was shown in south coastal area and in parts of west coast area. Soil erodibility differed by region and land use type. The plain region and the lower parts of a river showed higher K factor than the hilly region and the upper parts of a river. With land use type, K factors were ranked in descending order as following; paddy field>upland-crop field>forest≒grassland. The average K factor was 0.027 MT hr MJ^{-1} mm^{-1}. The cover management factor was dependent on how much covered in the summer season. Moreover, C factors of crops which had low coverage in this season such as chinese cabbage and maize were larger than 0.4. The average C factor of province in upland-crop fields varied between 0.31 and 0.43 and the regional variation was no bigger than those of the other factors. Support practices were found to reduce soil loss by 50 to 90% compared to upslope and downslope tillage, but the average value of the region or the nation could not be estimated since no statistical data were available.

References

ASI. 1992. Introduction of soils in Korea. Agricultural Sciences Institute, Suwon, Korea.

Box. Jr. J. E. 1981. The effect of surface slaty fragment on soil erosion by water. Soil Sci. Soc. Am. J. 43:111-116.

Jung, P. K., M. H. Ko, and K. T. Um. 1985. Discussion of cropping management factor for estimating soil loss. J. Korean Soc. Soil Sci. Fert. 18:7-13.

Jung, P. K., M. H. Ko, J. N. Im, K. T. Um, and D. U. Choi. 1983. Rainfall erosion factor for estimating soil loss. J. Korean Soc. Soil Sci. Fert. 16:112-118.

Jung, Y. S., J. S. Shin, and Y. H. Shin. 1976. Erodibility of soils of Korea. J. Korean Soc. Soil Sci. Fert. 9:109-113.

Jung, Y. S., Y. K. Kwon, H. S. Lim, S. K. Ha, and J. E Yang. 1999. R and K factors for an application of RUSLE on the slope soils in Kangwon-Do, Korea. J. Korean Soc. Soil Sci. Fert. 32:31-38.

Kim. Y. H., P. K. Jung, and S. J. Oh. 1991. Effects on soil erosion control with different levels of barley straw mulches. Res. Rept. ORD(S&F) 33:29-33

Laflan, J. M., and W. C. Moldenhauer. 2003. Pioneering soil erosion prediction. p. 54. In The USLE Story. WASWC Special Publication No. 1. World Association of Soil and Water Conservation, IA, USA.

McCool, D. K., G. R. Foster, C. K. Mutchler, and L. D. Meyer. 1989. Revised slope length factor for the Universal Soil Loss Equation. Trans. Am. Soc. Agric. Eng. 32:1571-1576.

McCool, D. K., L. C. Brown, G. R. Foster, C. K. Mutchler, and L. D. Meyer. 1987. Revised slope steepness factor for the Universal Soil Loss Equation. Trans. Am. Soc. Agric. Eng. 30:1387-1396.

NIAST. 2003. Monitoring project on agri-environment quality in Korea. National Institute of Agricultural Science and Technology, Suwon, Korea.

NIAST. 2000. Taxonomical classification of Korean soils. National Institute of Agricultural Science and Technology, Suwon, Korea.

OECD. 1982. Agricultural and environmental policies, Opportunities for integration. OECD, Paris, France.

OECD. 2001. Environmental indicators for agriculture. V. 3: Soil quality. OECD, Paris, France.

Oh, S. J., and P. K. Jung. 1995. Effect of soil erosion control with different grass species on slope land. RDA. J. Agri. Sci. 37:246-250.

Oh, S. J., P. K. Jung, and Y. H. Kim. 1991. Studies on soil erosion control with soil management in sloped farming land. Res. Rept. ORD(S). 33:68-72.

Oh, S. J., P. K. Jung, M. H. Ko, Y. H. Kim, and S. H. Kim. 1987. Effect of erosion control with slope length and subsoiling in apple orchard. Res. Rept. ORD(SPM&U) 29:66-70.

Park, S. W. 1976. A study on point storm energy influencing to the soil erosion. Korean J. Hydrol. 9:47-54

Park, J, H., H. S. Woo, C. K. Pyun, and K. K. Kim. 2000. A study of distribution of rainfall erosivity in USLE/RUSLE for estimation of soil loss. J. Korea Water Res. Assoc. 33:603-610.

Park. C. S. 2002. Soil management practices to reduce water erosion from the sloped farmland in highland. Ph. D. Thesis, Kangwon National University, Chuncheon, Korea.

Shin, J. S., and Y. H. Shin. 1980. The effect of erosion control practices factor value on soil loss. Res. Rept. ORD(SP&M). 22:36-41.

Shin, J. S., Y. S. Jung, and Y. H. Shin. 1976. Soil loss prediction for uplands. Res. Rept. ORD(S). 18:1-8.

Wischmeier, W. H., and D. D. Smith. 1965 Predicting rainfall-erosion losses from cropland east of the Rocky Mountains: Guide for selection of practices for soil and water conservation. Agric. Handbook No. 282. US Dep. Agric., Washington, DC, USA.

Wischmeier, W. H., and D. D. Smith. 1978 Predicting rainfall-erosion losses: A guide to conservation planning. Agric. Handbook No. 537. US Dep. Agric., Washington, DC, USA.

수치 정밀토양도에 기초한 전국 토양유실량의 평가를 위한 USLE/RUSLE 인자의 산정

정강호* · 김원태 · 허승오 · 하상건 · 정필균 · 정영상[1]

농업과학기술원, [1]강원대학교

국가 전체의 토양유실량을 산정하기 위하여 범용토양유실예측공식 (USLE)과 개정 범용토양유실예측공식 (RUSLE)의 각 인자를 재평가하였다. 정 외 (1983)과 박 외 (2000)의 연구결과를 거리역산가중치법으로 계산하여 전국 158개 시군의 강우유출인자 (R)를 평가하였고, 한국토양총설 (1992), Taxonomical Classification of Korean Soils (2000), 농업환경변동조사사업 보고서 (2003)에 수록되어 있는 정보를 이용하여 390개 토양통, 1321개 토양상에 대한 토양침식성인자 (K)를 산출하였다. 지형인자 (LS)는 1:25,000 토양도를 이용하여 경사도, 경사장, 토지이용에 따른 대표 값을 산정하였으며 식생피복인자 (C)와 침식조절인자 (P)는 지난 27년간 농업과학기술원 토양보전분야의 연구결과를 종합하여 정리하였다. 강우유출인자는 시군에 따라 2322-6408 MJ mm ha^{-1} yr^{-1} hr^{-1}이었으며 전체평균은 4276 MJ mm ha^{-1} yr^{-1} hr^{-1}이었다. 우리나라의 평균 토양침식성인자는 0.027 MT hr MJ^{-1} mm^{-1}이었으며 강 상류 및 내륙에 위치한 충북, 경북, 강원 등에서 낮았고, 경기, 충남, 전남 등에서 높았다. 토지이용별로 보면 논이 0.034 MT hr MJ^{-1} mm^{-1}로 가장 컸고 밭, 임지, 초지가 각각 0.026, 0.019, 0.020 MT hr MJ^{-1} mm^{-1}이었다. 밭의 작물인자는 0.06-0.45였으며 초지는 0.003이었다. 침식조절인자는 토양보전농법에 따라 0.01-0.85로 평가되었다.