Loss of Soil and Nutrient from Different Soil Managements in Highland Agriculture

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Abstract
A lysimeter study was conducted to evaluate soil and nutrient loss from soil under different managements for highland agriculture in Korea. Two treatments, use of chemical fertilizer and use of compost, were compared together with three ploughing methods. For the soil management treatments: up and down ploughing, contour ploughing, and contour ploughing with mulching were compared. No relocation was designed due to the limitation of number of lysimeter plots. The mulching material was PE film. For chemical fertilizer treatment, urea for nitrogen fertilizer, super phosphate for phosphate fertilizer, and potassium chloride for potassium fertilizer were used. Contour cropping of Chinese cabbages and potatoes reduce runoff by one half, and soil loss by one third to one fifth in comparison with the up-and down cropping. The nutrient losses were significantly reduced. Mulching in reduced soil and nutrient loss more than cabbage cropping. Since less difference of nutrient concentrations in runoff between treatments was observed than differences in total soil and nutrient losses, major difference might be depend upon nutrient loss from the soil as in cabbage cropping.

Key words
Soil loss, nutrient loss, soil management, compost, chemical fertilizer, Highland agriculture.

Introduction
Highland agriculture in Korea is widespread in the mountainous area at high altitudes > 600 m elevation, however, due to poor soil management against soil erosion, the fertile surface soil has been largely lost (Jung *et al.* 1999). To get high yields, farmers apply heavy amounts of fertilizers. The excessive nutrients might be lost together with soil particles and runoff lost from the unprotected fields, and contaminate water bodies downstream (Park 2002; 2004). This study was to evaluate soil and nutrient loss from the soil with different soil management for two vegetable crops, cabbage and potato, through a lysimeter study. The treatments included chemical fertilizers and compost, with 3 different soil management practices: up and down ploughing, contour ploughing, and contour ploughing with straw mulching.

Methods
A lysimeter study was conducted in 2004 on a experimental farm with the 13 percent slope located on Hoenggye-Ri, Daegwallyeong-Myun, Pyeongchang-Gun, Gangwon-Do at an elevation of 750 m. Table 1 shows the precipitation during the growing period at Daegwallyeong. The width of the lysimeter was 3 m, and the length was 15 m. Chinese Cabbages (*Brassica caprestris subvar. napusvar. Perkinesis:* Gangta) and potatoes (*Solanum tuberrosum*; Sumi) were planted on May 25th by the standard method of crop planting (RDA 2003). Two treatments including use of chemical fertilizer and use of compost were compared with three ploughing methods. For soil management treatment, up and down ploughing, contour ploughing , and contour ploughing with mulching were compared. No relocation was designed due to the limitation of number of lysimeter plots. The mulching material was PE film. For chemical fertilizer treatment, urea for nitrogen fertilizer, super phosphate for phosphate fertilizer, and potassium chloride for potassium fertilizer were used.

Table 1. Precipitation during the growing period of 2004 at Daegwallyeong

Precipitation (mm)						
May	June	July	August	September	October	Total
82.6	281.7	552.5	471.9	215.8	4.0	1,608.5

The application amounts of chemical fertilizers for Chinese cabbages were 250N-78P_2O_5-130 K_2O kg/ha. Half of the urea was applied as basal fertilizer, and the remaining half was applied later as additional fertilizer. Phosphate and potassium fertilizers were applied as a basal fertilizer. For potatoes rates were

150N-158P_2O_5-130K_2O and all fertilizers were used as a basal fertilizer. For compost fertilizers, the mixed compost consisted of 40 % of poultry manure compost, 20 % of swine manure compost, and 40 % of swine manure-sawdust-bark mixture compost. Table 2 shows the composition of the mixed compost. The soil and runoff water through the growing season were collected at every rainfall event, and chemical properties were analysed by RDA standard methods (RDA 2003).

Table 2. Composition of the mixed compost

N(%)	P_2O_5(%)	K_2O(%)	pH(1:5)	NaCl(%)
1.25	1.79	1.05	7.8	0.13

Results

From the Chinese cabbage cropping (Table 3), the runoff from the lysimeter plot of contour cropping was one half that from the up and down cropping. The soil loss from contour cropping was one fourth of the soil loss from the up and down cropping. The total nitrogen loss from contour cropping was one thirds of the total nitrogen loss from the up and down cropping. Loss of total phosphate from contour cropping was one fifth of that for up and down cropping. Clearing, contour, cultivation + mulching reduces soil and nutrient loss

Table 3. Runoff and fertilizer loss from lysimeter plots of Chinese cabbage

Cropping		Runoff	Soil loss	Nutrient loss(kg/ha)				
Fertilizer	Plow	(m^3/ha)	(MT/ha)	T-N	T-P	K	Ca	Mg
Chemical fertilizer	Up and down	4,773	14.3	60.1	14.3	9.9	21.1	4.2
	Contour	2,086	3.8	19.5	2.9	3.6	14.1	1.2
	Contour + mulching	1,820	2.2	17.7	2.5	3.0	6.3	0.4
	Average	2,893	6.8	32.4	6.6	5.5	13.9	1.9
Compost	Up and down	4,514	15.2	65.1	12.4	9.4	14.9	3.4
	Contour	2,876	2.9	22.9	3.3	7.9	15.3	2.5
	Contour + mulching	1,613	2.5	13.5	1.9	2.1	10.2	1.1
	Average	3,001	6.9	33.8	5.8	6.5	13.5	2.3
Mean		2,947	6.8	33.1	6.2	6.0	13.7	2.1

There was, however, little difference between chemical fertilizer treatment plots and compost treatment plots. Since smaller differences in nutrient concentrations in runoff between treatments were observed than differences in total soil and nutrient loss, the major loss of nutrient may be in soil. Contour cropping of potatoes also reduced runoff by one half, and soil loss by one thirds in comparison with up-and down cropping (Table 5).

The nutrient losses were also reduced remarkably as for cabbage cropping. Mulching effects in reducing soil and nutrient loss were more distinct for potatoes than for cabbage cropping. Since there was less difference in nutrient concentrations

Table 4. Nutrient concentration in runoff for different soil management practices with cabbage cropping

Cropping		Nutrient concentration in runoff(mg/L)				
Fertilizers	Ploughing	T-N	T-P	K	Ca	Mg
Chemical Fertilizers	Up and down	4.11	0.17	1.50	2.87	0.63
	Contour	3.06	0.05	1.39	5.75	0.48
	Contour + mulching	5.32	0.11	1.42	2.80	0.16
	Average	4.16	0.11	1.44	3.81	0.42
Compost	Up and down	5.60	0.18	1.57	2.53	0.53
	Contour	4.52	0.14	2.50	4.42	0.73
	Contour + mulching	3.96	0.06	1.05	5.64	0.56
	Average	4.67	0.13	1.71	4.20	0.61
Mean		4.42	0.12	1.56	4.00	0.51

Table 5. Runoff and fertilizer loss from lysimeter plots of potatoes

Cropping		Runoff	Soil loss	Nutrient loss (kg/ha)				
Fertilizers	Ploughing	(㎥/ha)	(MT/ha)	T-N	T-P	K	Ca	Mg
Chemical fertilizer	Up and down	4,490	20.5	68.0	19.1	8.4	13.2	2.5
	Contour	2,520	6.8	23.3	5.8	4.6	5.7	1.3
	Contour + mulching	1,482	1.1	9.3	1.2	2.0	3.7	1.0
	Average	2,813	9.5	33.5	8.7	5.0	7.5	1.6
Compost fertilizer	Up and down	3,561	11.2	47.2	10.6	7.6	9.6	2.3
	Contour	1,960	4.3	20.5	4.0	3.2	4.6	1.2
	Contour + mulching	1,329	1.6	10.3	1.5	1.7	3.1	1.0
	Average	2,283	5.7	26.0	5.4	4.6	5.7	1.5
Mean		2,557	7.6	29.7	0.5	4.8	6.6	1.6

in runoff between treatments than the differences in total soil and nutrient losses, the major difference might depend upon nutrient loss in soil as in cabbage cropping.

Table 6. Nutrient concentration in runoff for different soil management practices with potato cropping

Fertilizers	Ploughing methods	Nutrient concentration (mg/L)				
		T-N	T-P	K	Ca	Mg
Chemical fertilizer	Up and down	2.96	0.24	1.09	1.11	0.27
	Contour	2.94	0.04	1.31	0.87	0.24
	Contour + mulching	3.51	0.13	1.21	2.09	0.61
	Average	3.14	0.14	1.20	1.36	0.37
Compost fertilizer	Up and down	3.99	0.14	1.51	1.23	0.42
	Contour	3.21	0.26	1.28	1.27	0.36
	Contour + mulching	3.99	0.18	1.05	0.92	0.60
	Average	3.73	0.19	1.28	1.14	0.46
Mean		3.44	0.17	1.24	1.25	0.42

From another monitoring survey carried by Park (2008), BOD loads from a catchment in the highland area during the rainy period in the cropping season were 3 times to the loads during the non-rainy period. The estimated T-N pollution loads were 0.290 ton/day and 0.298 ton/day for non-rainy periods and 1.180 ton/day and 1.033 ton/day for rainy periods. The estimated T-P pollution loads were 0.223 ton/day and 0.155 ton/day for non-rainy periods and 0.812 ton/day and 0.373 ton/day for rainy periods. The T-N and T-P loads were 4 times those in non-rainy periods. Proper management including contour cropping to reduce soil erosion and N and P loads are urgently needed for highland agriculture.

Conclusion

The experimental results showed that contour cropping could reduce soil erosion and nutrient loss, regardless of crops and fertilizer use pattern. Contour cropping of Chinese cabbages and potatoes reduced runoff by one half, and soil loss by one third to one fifth in comparison with the up-and down cropping. The nutrient losses were also reduced remarkably. Mulching reduced soil and nutrient loss especially for in potatoes cropping. Proper managements including contour cropping to reduce soil erosion and N and P loads is urgently needed for highland agriculture.

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