Three alternative crops to reduce soil erosion for mountain agriculture in Gangwondo, Korea

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Abstract
Alternative cropping that might reduce soil erosion and could ensure farm income in this mountainous highland agricultural region was tried. Three edible wild plants; goatsbeard, Korean thistle, and aster, were selected to test as alternative crops to reduce soil erosion in mountain agriculture of highland area in Gangwondo, Korea. The soil losses from the alternative cropping were 28 to 61 percent of the soil loss from summer radish cultivated by conservation tillage with contour and plastic film mulching. The relative soil losses in the second year ranged from 2.8 to 5.5 percent in comparison with radish cultivation. Rapid surface coverage by these alternative crops resulted in continuous soil loss protection. Greater residue, no-till, and vigorous root growth also contributed the reduced soil loss. Farm net profit of these crops was greater than for radish. At least three year cultivation, however, might be necessary for economic cultivation of goatsbeard or aster due to low or no yield in the first year.

Key Words
Soil loss, alternative crops, edible perennial plants, mountain agriculture, highland.

Introduction

Mountain agriculture of highland area in Korea has been mostly depended upon vegetable crop production such as Chinese cabbages and radish ensuring high income, but involves management problems due to severe erosion. One half of the highland agricultural lands of South Korea are distributed in Ganwondo (Jung *et al*. 1998, 2006). The eroded soils and runoff have caused pollution problems in running water. For an example, muddy water caused by heavy rain in the 2006 summer growing season in the upper stream area of the Soyang River Basin in Gangwondo lasted for more than 9 months until late March of 2007 increasing turbidity of running water from 3.1 NTU in 2005 to 55.8 NTU in 2006 (Gangwondo 2008), and thus protecting measures to reduce soil erosion are urgently need (Jung *et al*. 2006, Lee 2006). This research is to develop an alternative crop that might reduce soil erosion and could ensure farm income in this mountainous highland agricultural region. Edible wild plants could be alternative cover crops for this purpose. Three edible wild plants; goatsbeard, Korean thistle, and aster, were selected to test as alternative cropping to reduce soil erosion in mountain agriculture of this highland area in Korea.

Methods

Planting

Three edible wild perennial plants including goatsbeard (*Aruncus diocicus var. kamrschaticus* H. Hara), Korean thistle (*Cirsium setidens* Nakai), and aster (*Aster scaber* Thunb), were selected to test as alternative crops comparing effectives with radish (*Raphanus sativus*) in the experimental farm located on Jawoonri, Hongcheon, Gangwondo, from 2006 to 2009. Table 1 shows surface soil characteristics of the experimental farm.

Table 1. Surface soil characteristics of the experimental farm.

pH (1:5)	EC (dS/ m)	OM (g/kg)	Av-P_2O_5 (mg/kg)	Exchangeable cations ($cmol^+/kg$)			Particle size distribution (%)		
				Ca	Mg	K	Sand	Silt	Clay
5.5	0.13	18.5	409	2.9	0.8	0.9	59	25	16

The 8 plots with 18 m length and 3 m width were formulated on 18.5 % slope, partitioned by the plastic board of 30 cm height. Three alternative crops, goatsbeard, Korean thistle, and aster were panted compared with radish with two replications. The goatsbeard was transplanted on May 11 2007 at the planting density of 60-cm X 30-cm. The seedlings were grown up by seedling box. The Korean thistle and aster were

transplanted at the planting density of 50-cm X 20-cm on the same date. The seedlings were grown up by pot raising. The compost fertilizers were applied at 7 MT/ha and NPK fertilizers at the rate of 336 kg/ha of nitrogen by urea, 50 kg/ha of phosphate as super phosphate, and 276 kg/ha of potassium as potassium chloride were used before transplanting. Radish were seeded on June 5 2007, and June 24, 2008 at the planting density of 70-cm X 25-cm by contour planting with plastic film mulching as conservation farmers used to take to do.

Soil loss and runoff monitoring

Soil loss and runoff during the growing periods were monitored at each rain events by simple runoff collector (Pinson *et al*. 2004) installed in each plot (Figure 1). The amounts of soil loss and runoff were weighed in laboratory.

Figure 1. Simple soil loss and runoff collector installed in the plots.

Crop growth, coverage and yield

Growth of crops and canopy coverage were measured seasonally. The lengths of stem and leaves were measured. Surface coverage of canopy was measured indirectly through pixel analysis of photographs taken at the 2 m above the canopy taking green pixel number 75 to 85 being plant cover. Yield of crops were measured after harvest.

Results

Effect of alternative crops on soil loss

Table 2 and 3 show cumulative soil loss during the cropping period in 2007 and 2008 comparing that from radish cultivated by conservation tillage with contour cropping and plastic mulching. The cumulative soil loss from radish in 2007 was 6 MT/ha. The relative soil loss from the Korean thistle plot was 28 percent of that from radish plots, 36 percent from goatsbeard plots, 61 percent from aster plots. In 2008, the cumulative soil loss from radish was 12 t/ha. The relative soil loss from the Korean thistle, goatsbeard, and aster ranged from 2.8 to 5.5 percent of the soil loss from radish cultivation. Changes in crop coverage (Figure 2) show the surface crop coverage in 2007 and 2008. Crop coverage of the three alternative crops increased rapidly as plant stands expanded. Since these alternative crops were perennial plants, the surface coverage in 2008, the second year of cultivation, rapidly increased to over 80 percent before heavy rainy season begun, and reached almost 100 percent in July. This successful coverage reduced soil erosion by 95 percent. Additionally, greater plant residue remained in the following spring from the three wild crops compared with radish. Moreover, little soil disturbance from no-till for the wild crops resulted in less soil loss. Goatsbeard showed vigorous root growth and effectively retained soil particles, resulting in enhanced soil erosion protection.

Table 2. Effect of alternative cropping to reduce soil loss in mountain agriculture in 2007.

Precipitation event			Soil loss (kg/ha)			
Date of collection	Period	Rainfall (mm)	Goats-beards	Korean thistle	Aster	Radish[1)]
Jul 20, ’07	Jul 10~Jul 19	101.7	88	74	136	226
Aug 2, ’07	Jul 24~Aug. 1	90.6	517	422	591	1,306
Aug 9, ’07	Aug. 2~Aug 8	150.6	766	552	1,470	2,415
Aug11, ’07	Aug 9~Aug 10	165.1	645	498	1,568	206.6
Cumulative		508.0	2,026	1,546	3,765	6,006
Relative soil loss (%)			35.5	28.0	60.6	100

[1)] Summer radish were cultivated

Table 3. Effect of alternative cropping to reduce soil loss in mountain agriculture in 2008.

		Precipitation event			Soil loss (kg/ha)	
Date of collection	Period	Rainfall (mm)	Goats- beards	Korean Thistle	Aster	Radish
Jul 21, '08	Jul 13~Jul 21	113.4	35	25	30	343
Jul 26, '08	Jul 22~Jul 26	195.2	141	185	211	2,923
Aug 3, '08	Jul 30~Aug 3	63.1	138	90	37	2,507
Aug 23, '08	Aug 9~Aug 23	169.5	358	169	75	6,496
Cumulative		541.2	672	469	354	12,269
Relative soil loss (%)			5.5	3.9	2.8	100

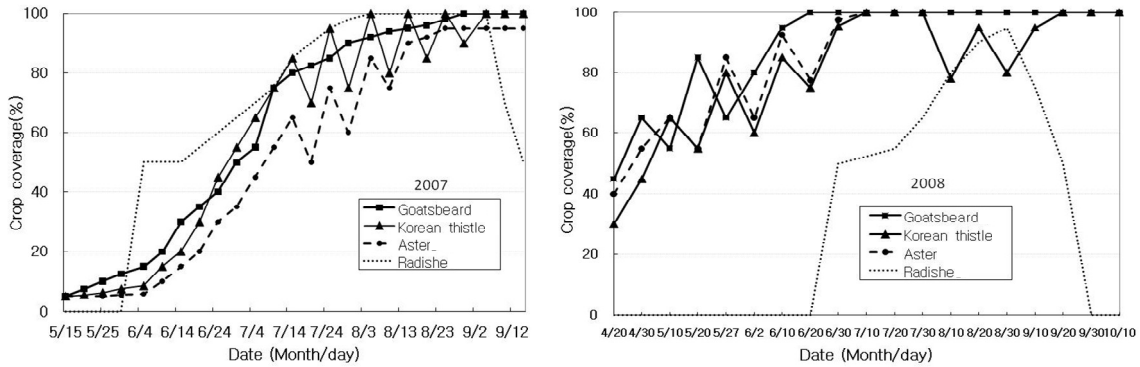

Figure 2. Changes in crop coverage during the cropping period in 2007 (left) and 2008 (right).

Yield and economic feasibility of alternative crops

Table 4 shows yield of three alternative crops, and their net profit from cultivating the crops in comparison with summer radish. Average yield of goatsbeard in 2007 and 2008 was 4.4 t/ha, and the farm net profit was 13.1 thousand US$ per ha. No economic value of yield was observed in the first year of cultivation. The average farm net profit of Korean thistle and aster for three years was 14.8 and 9.3 thousand US$ per ha, respectively. These values were greater than that of the summer radish. For goatsbeard and aster, it is necessary to cultivate for at least three years to get profit due to low or no yield in the first year. The yield of Korean thistle, however, decreased substantially from 16.0 t/ha in the second year to 6.3 t/ha in the third year.

Table 4. Fresh yields of the crops and their economic value.

Crops	Yield (t/ha fw)				Farm profit (X 1000 US$)			
	2007	2008	2009	Average	2007	2008	2009	Average
Goatsbeard	-	4.21	4.60	4.41	- 7.65 [1)]	22.31	24.56	13.07
Korean thistle	14.47	15.96	6.30	12.24	14.63	23.36	6.46	14.81
Aster	4.72	11.80	11.09	9.20	- 3.39 [2)]	16.29	15.06	9.32
Radish	41.86	41.91	43.79	42.52	9.25	8.39	4.98	7.54

[1)] Cost only due to no crop yield. [2)] Greater cost than income.

Conclusion

Three perennial wild edible plants goatsbeard, Korean thistle, and aster could be cultivated as alternative crops to reduce soil loss from the mountain agricultural area in highland of Korea. The soil losses from these alternative plants were 28 to 60 percent of the soil loss from summer radish cultivated by conservation tillage with contour and plastic film mulching. The relative soil losses in the second year ranged from 2.8 to 5.5 percent in comparison with radish cultivation. Successive soil loss protection by these alternative crops was due to rapid surface coverage. Farm income values of these crops were higher than that of radish. However, a three year rotation might be necessary for economic cultivation of Korean thistle or aster due to decrease in yield caused by continuous production.

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