Vegetation recovery in Loess Plateau in China

N. Ichizen

Center for Research on Wild Plants, Utsunomiya University, 350 Minemachi, Utsunomiya 321-8505, Japan

In hilly land of the Loess Plateau in China, bare ground has expanded due to crop cultivation and overgrazing. Field experiments were carried out to analyze the vegetation, soil loss and surface runoff and to identify perennial gramineous plants for vegetation recovery in the degraded southern slope. As a result of the prohibition of cultivation and grazing by sheep during twenty five years, dominant species changed from annual herbs to perennial herbs, the vegetation cover rate increased, and the amount of soil loss and surface runoff decreased. Plantation of switchgrass (*Panicum virgatum*) during six years reduced soil loss and surface runoff remarkably. One hundred fifty nine perennial weed species were introduced from foreign countries, and twenty species among these weeds such as smooth bromegrass (*Bromus inermis*) and switchgrass have grown very well.

Keywords: Loess Plateau, vegetation recovery, wild plants, switchgrass, smooth bromegrass

1. INTRODUCTION

Loess Plateau is the vast plateau which extends around midstream of the Yellow River (Hwang Ho River), occupying about 580,000 square kilometers, equivalent to approximately 1/16 of whole China and 1.5 times of whole Japan.

There live over 60 million people but fairly large numbers of people are obliged to live in the caves commonly called “Yaodong” in extreme poverty.

Loess Plateau is considered to have been formed by the accumulation of huge volume of the loess in thickness of 50 to100 meters brought to this semi-arid region from northwestern desert by strong winds 1.2 million years ago. The plateau was covered with rich vegetation in pre-historic age but the increases in population since 11th century promoted deforestation and development of grasslands on a large scale. As the results, the balance of ecosystem in this region was completely lost, giving birth to the barren plateau without a single tree as we see today.

The problems facing the agriculture in Loess Plateau are of grave nature. Loess Plateau lies roughly 1,000 to 2,000 meters above sea level, with annual mean temperature of 4 to 7°C and annual rainfall of 300 to 450 mm. Sixty to seventy percent of the rainfall takes place mostly from July to September like torrential rains, which, coupled with the characteristics of the loess, causes serious soil erosion. As the matter of fact, the annual mean soil erosion in Loess Plateau is said to amount to as much as 1,100 to 9,600 tons per square kilometer.

Farmers grow mostly wheat. Due to lack of sufficient rainfall, however, yields are extremely low ranging 500 to 1,000 kg/ha and in order to make up deficiencies, farmers cultivate terraced fields all over the slopes of the plateau reaching up to the peaks. Moreover, farmers graze sheep rather excessively on the steep slopes where farming is difficult. Such activities of the farmers contribute to accelerate the outflows of soil and water from the slopes of the plateau. This seems to indicate that, for the recovery of vegetation in Loess Plateau and cattle grazing as soon as possible and try to alter it to grasslands or forests (Figure 1).

Under the circumstances, we Japan-China joint research group established the experimental fields at Guyuan prefecture of Ningxia Hui Autonomous Region and at Ansai prefecture of Shaanxi

province, which are relatively center part of Loess Plateau, and have conducted extensive researches for 15 years from 1988 on such versatile subjects as climate, geology, soil, crop, ecology, afforestation, etc.

This report covers investigations on the current vegetation in the grazing land and researches on the adaptability of the introduced plants and further, studies on the influence of the difference in vegetation on the outflows of sand and water and finally, studies on the possibility of vegetation recovery in the semi-arid area in Loess plateau (Ichizen, 1999; Ichizen et al., 1993 a, b, 1994, 1997, 1998, 2000, 2001, 2002; Nishio et al., 2000; Tamura, 2000).

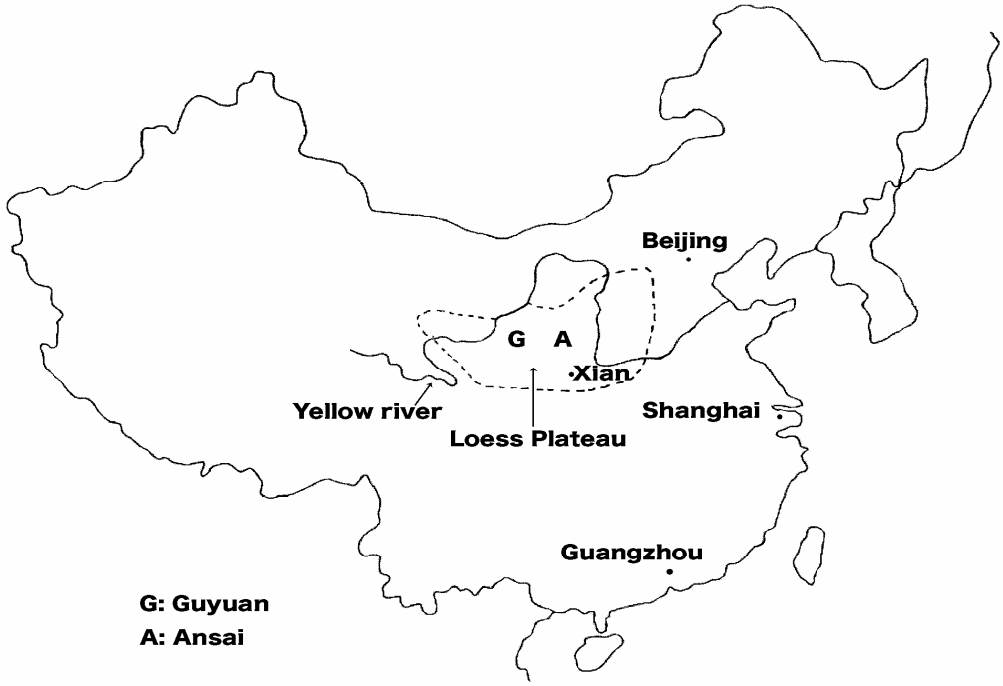

Figure 1. The location of Loess Plateau in China

2. OUTLINE OF OUR RESEARCH PROGRAM ON THE LOESS PLATEAU

1) To prevent soil erosion and destruction of land resources on the Loess Plateau, farming on steep slopes where farmers have constructed terraced fields should be suspended as soon as possible, and grasslands should be established there instead. To accomplish this object, it is important to introduce various kinds of herbage including pasture grasses that are drought- resistant, cold-hardy and palatable to domestic animals.
2) To stop the farming on steep slopes, it is essential to increase sharply the productivity of crops on flatlands and gentle slopes to secure the supply of foodstuffs. For the accomplishment of this purpose, various kinds or cultivars of crops should be introduced and be examined for their adaptability to the natural conditions of the plateau.

3. EFFECT OF GRAZING ON VEGETATION IN PASTURE

Results of investigations on vegetation are shown in Table 1. Species of emerged plants in grazed plot include *Compositae, Labiatae, Euphorbiaceae, Zygophyllaceae* and *Gramineae*, which are classified into 5 families, 6 genera and 7 species. In suspended grazing plot, the number of plant species increased to 7 families, 9 genera and 10 species, which include *Compositae, Labiatae, Euphorbiceae, Polygalaceae, Zygophyllaceae*, *Leguminosae* and *Gramineae*.

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recovery in the semi-arid area in Loess plateau (Ichizen, 1999; Ichizen et al., 1993 a, b, 1994, 1997, 1998, 2000, 2001, 2002; Nishio et al., 2000; Tamura, 2000).

Table 1. plant cover of each species in pasture

Family	Species	Plant cover (%)	
		Grazed plot	Suspended grazing plot
Compositae	*Artemisia capillaris*	9.3	8.7
	Artemisia frigida	8.1	7.5
	Aster altaicus	0	0.3
Labiatae	*Thymus mongolicus*	2.1	2.6
Euphorbiaceae	*Euphorbia fischeriana*	0.4	0.5
Polygalaaceae	*Polygala tenuifolia*	0	0.4
Zygophyllaceae	*Peganum harmala*	0.6	0.8
Leguminosae	*Oxytropis ochrantha*		0.5
Gramineae	*Aneurolepidum dasystachys*	0.8	11.6
	Stipa bungeana	3.8	44.9

4. ADAPTABILITY OF INTRODUCED PLANTS

As the results of growth studies of 18,000 plant species collected inside and outside of China and seeded in the experimental field, possibilities were suggested that perennial gramineous plants could grow well. Therefore adaptability of 197 perennial gramineous species was investigated in pasture. Results of growth studies are as shown in Table 2. 20 species could grow for 5 years after seeding. *Panicum virgatum* showed highest plant cover and height.

Table 2. Plant cover and height of perennial gramineous plants

Species	Plant cover (%)	Plant height (cm)
Panicum virgatum	100	146
Bromus inermis	83	26
Stipa bungeana	78	22
Eremochloa ophihurodes	78	10
Stipa comata	77	20
Bothriochloa ischaemum	76	24
Bromus marginatus	44	18
Oryzopsis hymenoides	43	26
Bromus bielbersteinii	41	17
Elymus dahuricus	38	17
Elymus junceus	29	16
Agropyron intermedium	25	20
Agropyron repens	21	14
Agropyron elongatum	19	21
Agropyron sibiricum	19	13
Agropyron desertorum	16	19
Bromus carinatus	16	13
Eragrostis curvula	14	27
Festuca arundinacea	9	18
Fertuca ovina	9	16

5. EFFECT OF DIFFERENCE IN VEGETATION ON OUTFLOWS OF SOIL AND WATER

In Table 3 are shown the influence of suspended grazing and seeding on soil and water outflows and on degree of vegetational coverage. Outflows increased in the order of plowed plot > grazed plot > suspended grazing and *Stipa bungeana* seeding plot > suspended grazing and *Bromus inermis* seeding plot > suspended grazing and *Panicum virgatum* seeding plot. On the other hand, the vegetational coverage increased in the order of suspended grazing and seeding plots > grazed plot > plowed plot.

As the results, it has been confined that the increases in vegetational coverage of the slopes due to suspended grazing and *Panicum virgatum* seeding are effective in decreasing outflows of soil and water.

Table 3. Effect of suspended grazing and seeding on outflows of soil and water

Plot	Vegetation cover (%)	Soil outflow (t/km2)	Water outflows (m3/km2)
Panicum virgatum seeding	101.1	152	764
Bromus inermis seeding	100.8	317	1,653
Stipa bungeana seeding	103.7	589	2,695
Grazed	30.5	1,070	4,987
Plowed	0	1,438	5,616

6. TOWARD THE VEGETATION RECOVERY IN LOESS PLATEAU

Many grasses and trees have been planted in hilly land. *Panicum* spp., *Caragana* spp., *Hippophe* spp., *Pinus* spp., *Robinia* spp. And *Quercus* spp. showed good growth. It is the goal of our group to make a blueprint for vegetation recovery in hilly land in Loess Plateau.

Our experimental research which we conducted at Guyuan prefecture of Ningxia Hui Autonomous Region and Ansai prefecture of Shaanxi province during the period from 1988 to 2002 could be considered to be a model of systematic study on soil and water conservation on the Loess Plateau through biological means. Although we were able to obtain several good results in this study beyond our expectations, the scope of our activities is much too small, when compared with the vastness of the plateau.

However, that may be, if we allow the soil erosion at its current rate, the Loess Plateau will certainly become a devastated land in the comparatively near future. In my opinion, we should do our best on the plateau without delay to protect this part of our research group to lay down a tangible scheme at least, for the establishment of herbs and crops on the Loess Plateau at an early date, on the basis of our ideas as well as of our activities.

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