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UDC 55

The Effect of Integrated Grasses in Controlling Soil, Nutrient and Organic Matter in Loess Plateau, China

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ABSTRACT. Soil and nutrient loss is one of a serious problem in Loess plateau china. The eroded materials are directly transported to the lakes and rivers specifically yellow river in China, this might lead to eutrophication if no prevention measures will be taken. The experiment was conducted on soil, and nutrient loss from 5⁰ slope. Individual grasses plots for rye grass(Lolium), white clover(Trifolium repens) and integrated grass (rye + white clover) plots were prepared with a percentage cover of 25, 50, 80 and 100 in each treatment. Bare land was used as a reference plot. The results show that, the sediment loss in a bare land reported to be 1.5, 3, 2.7 and 1.3, 2.1, 1.9 in 100 % and 80 % cover plots. The runoff rate as compared to bare land, shown to be about 2 times less for white clover and rye grass plots, while more than 2 times less for integrated grasses plots. The total nitrogen and organic matter loss the results were in the order bare land white clover rye grasses and integrated grasses in which 100 %, 80 % and 50 % vegetative cover shown to perform better. On average enrichment ratio range was 40 % to 90 % for nutrient loss, and 50 % to 85 % for organic matter for all plots in comparison with soil origin. The enrichment ration significantly shown to be high from bare land> rye and white clover plots> integrated grasses plot. It has been concluded that integrated grasses is more effective measure over others in controlling both soil, nutrient and organic matter loss in the soil. This study contributed some information on the erosion modeling and improvement of soil and grassland conservation techniques for better land use for sustainable development.

Keywords: Integrated grasses; White clover; Rye grass; Sediment loss; Loess Plateua; Nutrient loss; Soil erosion.

INTRODUCTION

Intensive agriculture activities which practiced and established on a sloping land has been a critical problem for land degradation in the region. The increasing the need of food production in the past 50 year, lead to clearing of forestland and grassland [1], force urban and suburban to be encroached into prime agriculture land [2]. The loess plateau is located in the middle reaches of Yellow River. As one of the most serious soil and water loss areas in the world, it has been said that over 60 % of the land in the loess plateau in China has been suffering from soil erosion as a result of irrational land use and poor vegetation coverage and this erosion has seriously destroyed land resources and degraded the eco-environments ([3], [4] and [5]). Annual agricultural activities in this area along the steep slopes are exposed to soil, nutrient and organic matter (OM) loss through runoff and erosion. The loss of nutrient from the soil is one of the important feature of erosion, since nutrient mainly concentrates on the surface of the soil for plant use. Plant organic matter and nutrients in the soil mostly are highly eroded as sediments since they are closely associated with fine particles of the soil and largely minimize the soil cover [6]. Most of nutrients and organic carbon in surface runoff can lead to eutrophication [7], also the effect of excessive nitrate in drinking water is linked to methemoglobinemia (or blue baby syndrome) which affects the fetus and young children and non-Hodgkin's lymphoma ([8] and [9]).

Various measures were applied to study and explain different erosion situations and processes in the field. Chaudhry and Shafiq (1986) in their research said that crop management as the easiest and most effective tool of the soil conservation. Studies on erosion and soil loss has been made in different areas around the world ([11]; [12]). The purpose of this study was to compare the effect of rye grasses, white clover and rye+white clover strip integration plots in controlling erosion of both soils, nitrogen and organic matter. In the past very few studies have been made in this part of the country on the effect of integration of these types of grasses in controlling soil, nutrient and organic matter loss.This study will provide enough information on the erosion modeling and improvement of soil and grassland conservation techniques for better land use for sustainable development.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Institute of soil and water conservation in the state Laboratory of Soil erosion and Dryland Farming on Loess plateau from July-September.The soil to be worked on were collected from Zhifangguo village in Ansai city. The field where soil was taken is situated on a sloping land. The soil was analyzed for nitrogen by Kjeldahl digestion method [13] and organic matter [14]. Mean annual precipitation of this area is 530 mm with approximately 60%–80% of the precipitation falling during the summer wet season (July–September). Erosion in this region is concentrated mainly after storm rain and is often with high sediment concentration. Some physical characteristics are shown in the table below.

Table 1. Soil physical characteristics of the research site

Characteristics	Values
<0.002mm	11.5
0.002-0.02mm	25.95
0.02-0.2mm	62.56
0.2-2mm	0.4
Texture class	Sandy loam
Bulk density	1.39g/cm^3
Organic matter (OM)	2.85g/Kg

Plot characteristics, experimental design and measurements.

13 experimental plots pans of 1m long, 0,2m and 0.2m deep were prepared for this experiment. In each plot the soil of 55.6kg was filled with it which will make the bulk density to be1.39g/cc which is commonly used for the soil of this area. The soil was well packed 13.9kg for every 5cm to make sure the weight is evenly distributed. The three vegetation cover, mixed grasses, rye grasses and white clover grasses were planted in strip lines and percentage wise.

The treatments were as follows; (1) Bare land (2) 100% integrated grasses (3) 100% rye grasses (4) 100% white clover (5) 80% integrated grasses (6) 80% rye grasses (7) 80% white clover (8) 50% integrated grasses (9) 50% rye grasses (10) 50% white clover (11) 25% integrated grasses (12) 25% rye grass (13) 25% white clover.

The rate of water application in all these plots during growing was similar to that of the bare land. Soil erosion simulation experiments were conducted after maintaining the soil moisture at 20 %. Then, rain simulations were conducted for whole cover plots at the maintained slopes of 5°gradient with rainfall maintained at an intensity of 90mm/h for an hour. Runoff and sediments were collected by flume which was linked at the bottom outlet of every plot and directly collected in buckets. After the rain simulation finishes, all buckets were weighed then the sediment water was allowed to settle. The remaining water in the buckets was discharged and the remaining was siphoned out and the sediment soil transferred to the aluminum dishes and oven–dried at 80°c for 24hrs before the weighing process carried out on the sediment.

In the laboratory, runoff water samples were filtered through 0.45μm filters. The N in the runoff included particulate N and dissolved N. The filtered runoff water were analyzed for nitrate nitrogen (NO3-N), and ammonium nitrogen (NH4-N). The sediment and original surface soil was analyzed for total N. Total N was measured using Foss 2300 semi-micro Kjeldahl method. Both NO3-N and NH4-N were measured with a continuous flow analyzer. N values in the simulated rainfall water was subtracted from the runoff data.

Nutrient loss was calculated as follows:

Nutrient loss in the soil= concentration of nutrient × sediment loss.

The enrichment ratios (ER) were calculated with the aim of assessing the risks of soil nutrient losses in the site using the following formula [15].

$$ER = \frac{\text{Average soil nutrient concentration in suspensions sediment}}{\text{Soil nutrient in topsoil (0-5cm)}}$$

Statistical analysis

Differences in runoff, sediment among the plots were evaluated by use of analysis of variance (ANOVA). Also the mean of different plots was distinguished by applying post hoc for least significant difference (LSD) interaction between vegetation covers. All statistical analyses were conducted using SPSS 11.5.

RESULTS AND DISCUSSION

Runoff and sediment losses

Runoff and sediment losses always go together in many events. The runoff and sediment loss in this research shown to decrease with vegetation cover in order bare land>low> high vegetation cover. In Table. 2 below show that the 100% and 80% cover plots show no significant difference between them with less sediment loss compared to other covers. The sediment loss in a bare land reported to be 1.5, 3, 2.7 and 1.3, 2.1, 1.9 times higher in 100, and 80 cover plots for white clover, rye grass and integrated grass plot respectively. The sediment losses were significantly higher in white clover plots than in rye grasses and integrated grass plots, but less compared to bare land.

Runoff results as presented in the table 2 below, it shows that there is no significant difference between 100% and 80% which shows to have less runoff. The results show that 100 and 80 percent covers are more efficient in controlling runoff. The runoff rate as compared to bare land, shown to be about 2 times less for white clover and rye grass plots, while more than 2 times less for integrated grasses plots. This might be contributed by vegetation covers which has been reported to reduce both runoff and sediment loss. When there is direct contact of raindrops to the soil surface this increase the soil erosion, but increases of vegetation cover always reduce the impact on the soil surface hence less erosion. The roots of the vegetation cover also have the function of holding the soil aggregates against the runoff and sediment loss.These results show that it is necessary to protect the soil surface by the effective vegetations with good canopy. In some research reports explains that the canopy reduces the surface of the soil from the rain drops impact, but maintain higher infiltration rate hence less runoff [16] According to the results it shows that rye and integrated grasses were good in controlling sediment loss, while only integrated grasses plots show to be best in controlling runoff compared to other plots.The good performance obtained in integrated grass plots for both runoff and sediment loss reductions may be due to two reasons. First reason it might be caused by the high and strong cover, ability to facilitate the leaching process in their plots, or second might be caused by the several characteristics of these two grasses rye and white clover on the runoff and sediment yield reduction.

Table 2. Runoff and Sediment yield in different vegetation type and cover plots.

Vegetation	Sediment Loss($Kg.h^{-1}$)				Runoff ($L.h^{-1}$)			
Cover %	100	80	50	25	100	80	50	25
Bare land	0.27A	0.27A	0.27A	0.27A	15.6A	15.6A	15.6A	15.6A
White clover	0.18Bb	0.21Bab	0.22Ba	0.23Ba	8.47Bb	9.14 Bbc	10.13Bab	10.58Ba
Rye grass	0.09Cb	0.13Cab	0.14Ca	0.15Ca	9.02Bb	9.54Bbc	9.6Bab	10.87Ba
Rye + clover	0.1Cb	0.14Cab	0.15Ca	0.16Ca	5.2Cb	6.01Cbc	7.15Cab	7.93Ca

Different capital letters (A, B and C) and small letters (a, b and c) represent the significance level within the type of vegetation and percentage covers respectively at $p<0.05$.

Nitrogen and Organic matter loss

The total nitrogen loss from the plots shown to be varied in different plots as reported in the table 3. The nitrogen and organic matter loss was in the order bare land> white clover> rye grasses and integrated grasses (Rye+ white clover). Integrated grasses and rye plot found to be more efficient than other plots in controlling nitrogen loss. The comparison of these results with bare land shows that, bare land was more than 3times higher in nitrogen loss than rye grasses and integrated grasses plot for 100%, 80% and 50% vegetative cover . Whereby in comparison with white clover plots, bare land shown to generate less or equal to 3 times more nitrogen loss. Statistically, in the results there was a big difference between 100% and 25% vegetation cover, but none of them can be differentiated from 80% and 50% cover plots.

No significant difference has been observed rye and integrated grass plots for all nutrient loss, but greater difference has been observed with white clover and bare land. These results show that rye and integrated grass are the best option among the rest in controlling nutrient losses. These results likely to have been caused by different reasons. For the different type of vegetation covers, rye and integrating grasses plots (rye+clover) shown to be more effective by having less nutrient loss compared with other plots. These results might be contributed by the interaction of two types of grasses growing together which has high influence in the nitrogen loss reduction through leaching or holding capacity. White clover as a leguminous plant, has the capacity of absorbing nitrogen from the atmosphere and soil when there is a competition of the other grasses. So the combination of two grasses influences the uptake of nutrients from the soil hence less nutrient loss. Also, since most of the nutrients tend to be incorporated into the sediments, then due to less sediment loss occurred in integrated grasses and rye plots then less nitrogen and organic matter will be lost. Zobisch et al. (1995) in his paper reported that total nutrient loss in the eroded soil totally depends on the amount of eroded soil and not because of nutrient concentration of the eroded soil. So, more organic matter and nitrogen loss observed to be from bare land and less cover plots as it has been supported above.

Percentage of vegetation cover is one of the factors that indirect has influence on the nutrient loss such as nitrogen and organic matter. Some other researchers have reported in their papers that vegetation cover reduces sediment loss ([18]; [19]; [20]; [21]), also [22] observed a highest plant cover and lowest soil losses from inter-cropping. Since sediment loss governs the nutrient loss [2] then, whenever there is an efficient vegetation cover then nutrient loss will be lower. These findings showed to be supported by the results in the Table 3, that in most of high covered plots less nutrient losses has been observed.

Table 3. Total Nitrogen and Organic matter loss

Vegetation	Total organic matter loss				Total Nitrogen Loss			
Cover %	100	80	50	25	100	80	50	25
Bare land	1.9A	1.9A	1.9A	1.9A	0.15A	0.15A	0.15A	0.15A
White clover	0.8Bb	1.1Bab	0.9Bab	1.2Ba	0.05Bb	0.1Bab	0.07Bab	0.09Ba
Rye grass	0.4BCb	0.6BCab	0.8BCab	0.9BCa	0.03Cb	0.04Cab	0.05Cab	0.06Ca
Rye + clover	0.4Cb	0.6Cab	0.9Cab	1Ca	0.03Cb	0.04Cab	0.04Cab	0.08Ca

Different capital letters (A, B and C) and small letters (a and b) represent the significance level within the type of vegetation and percentage covers respectively at $p<0.05$.

Nitrate and Ammonium loss in the runoff water.

The average concentration of NO3- N in the tested runoff water was very high compared to NH4- N for all vegetation cover plots during the entire rainfall as shown in Table 4. This observation might be caused by the stability of these two forms of nitrogen. In a relative steady system always NO3- N concentration is greater than NH4- N. So results tell us that water pollution is mainly contributed by NO4- N because NH4- N is very volatile and is ready to react at any time. In all plots show to have almost the same concentration, this show that neither vegetation cover nor percentage vegetation cover shows to reduce or control both NH4- N and NO3- N.

Table 4. Average Nitrate and ammonium concentration.

Vegetation	Average Nitrate Concentration (mg/l)				Average Ammonium Concentration(mg/l)			
Cover %	100	80	50	25	100	80	50	25
Bare land	8A	8A	8A	8A	0.4A	0.4A	0.4A	0.4A
White clover	8.5Aa	8.2Aa	8Aa	8Aa	0.21Ba	0.23Ba	0.16Ba	0.35Ba
Rye grass	8.6Aa	8Aa	8Aa	8.3Aa	0.23Ba	0.22Ba	0.2Ba	0.37Ba
Rye + clover	8.12Aa	7.8Aa	8.1Aa	8.1Aa	0.15Ba	0.18Ba	0.33Ba	0.28Ba

Different capital letters (A and B) and small letters (a) represent the significance level within the type of vegetation and percentage covers respectively at $p<0.05$.

Enrichment ratio

The enrichment ratio, eroded soil and the top soil (0-5 cm) data for both nitrogen and organic matter is shown in the Table 5. The data obtained show that there has been a different enrichment ratio among the plots. On the average range, the nutrient loss was 40% to 90% for organic matter, and 50% to 85% for nitrogen in all plots in comparison with soil origin.

In the table 5 below, the significant difference has been observed between integrated grasses plot and other two plots, however no significant difference has been observed between rye and white clover plots. These differences likely to have been caused by some other different reasons. For the different types of vegetation covers, integrating grasses plot rye+clover shown to be more effective by having less enrichment ration compared with others. These results might be contributed by the interaction of two types of grasses growing together which has high influence in the nutrients loss reduction, since fine particles are usually the first to be transported during the soil erosion process. As a result, sediment in the initial runoff is enriched in clay and the chemicals adsorbed on the surface of the clay particles ([23]; [24]). So, if the vegetation cover has the capability of reducing runoff then the enrichment ratio will be low. As it has been shown in the previous discussion that, integrated grass shown to be more effective in both runoff and sediment reduction, this also prove to enrich less compare to other plots in recent discussion. This also might be contributed by the holding and leaching capacity of the runoff which might be caused my these two combined grasses. Also, since most of the nutrients tend to be incorporated into the sediments, then due to less sediment loss occurred in integrated grasses plots then less nitrogen will be lost. In the enrichment results show some variations in results as vegetation cover increases, these variations might be caused by the size, soil, vegetation and other environmental factors of the plots.

Table 5. Enrichment ratio for both Nitrogen loss and Organic matter loss.

Vegetation	Top soil OM (g/Kg)				OM loss(g/Kg)				Enrichment ratio(E_R)			
Cover %	100	80	50	25	100	80	50	25	100	80	50	25
Bare land	4.3	4.3	4.3	4.3	3.8	3.8	3.8	3.8	0.9	0.9	0.9	0.9
White clover	6.3	6.7	5.3	6.6	4.4	5.3	4.3	5.6	0.7Ab	0.8Aab	0.8Aa	0.85Aa
Rye grass	8.3	7.6	6.3	6.6	4.9	5.12	5.4	6	0.6Ab	0.68Aab	0.85Aa	0.9Aa
Rye + clover	10.9	8.6	9.3	9.8	4.35	4.31	6.04	6.37	0.4Bb	0.5Bab	0.65Ba	0.65Ba
	Top soil Nitrogen(%)				Nitrogen loss (%)							
Bare land	0.4	0.4	0.4	0.4	0.34	0.34	0.34	0.34	0.85	0.85	0.85	0.85
White clover	0.45	0.7	0.4	0.54	0.31	0.56	0.31	0.41	0.7Ab	0.8Aab	0.8Aa	0.76Aa
Rye grass	0.55	0.4	0.45	0.57	0.33	0.27	0.33	0.43	0.6Ab	0.7Aab	0.75Aa	0.76Aa
Rye + clover	0.64	0.56	0.45	0.7	0.32	0.31	0.29	0.51	0.5Bb	0.55Bab	0.65Ba	0.65Ba

Different capital letters (A and B) and small letters (a and b) represent the significance level within the type of vegetation and percentage covers respectively at $p<0.05$.

CONCLUSION

The study has been done and come out with some conclusion on soil, nitrogen and organic matter losses. The significant difference was observed in runoff and sediment loss vegetation cover plots and bare land. The integrated grasses plot shows greater significant differences with bare land, rye and white clover plot in controlling runoff. Rye and integrated grasses were very effective in holding soil sediment loss. Lastly integrated grasses plot has been concluded to be the best in both runoff and sediment loss reduction.

Runoff, sediment loss, nutrient and organic matter loss seem to be affected by the Percentage of vegetation cover, low loss shown in the order 100% cover> 80%> 50%>25> bare land. However the vegetation cover doesn't seem to work in controlling nitrate nitrogen and ammonium nitrogen. Nitrate nitrogen concentration shown to be higher than ammonium nitrate.

The enrichment ration significantly shown to be high from bare land> rye and white clover plots> integrated grasses plot.

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УДК 55

Эффект от посадки комплексных трав в регулировании почв, питательных и органических веществ Лессового плато, Китай

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Аннотация. Деградация почв и питательных веществ – одна из серьезных проблем Лессового плато Китая. Эродированные материалы попадают непосредственно в озера и реки, особенно в Желтую реку в Китае, что может привести к эвтрофикации, если не принять соответствующих мер. Эксперимент был проведен на почвах и питательных веществах 5° склона. Индивидуальные газоны для плевела (Lolium), клевера ползучего (Trifolium repens) и газоны из комплекса трав (плевел + клевер ползучий) были подготовлены с процентом покрытия 25, 50, 80 и 100 при каждой обработке. В качестве экспериментального участка использовалась земля, лишенная растительности. Результаты показали, что потеря осадка на участке, лишенном растительности составила 1.5, 3, 2.7 и 1.3, 2.1, 1.9 в 100 % и 80 % на участке с растительностью. Уровень стока с участка, лишенного растительности составил примерно в 2 раза больше, чем с участков, засаженных клевером ползучим и плевелом и в 2 раза меньше для участков, засаженных комплексными травами. Общая потеря азота и питательных веществ с голой почвы клевером ползучим и плевелом и с комплексом трав, из которых растительный покров 100 %, 80 % и 50 % выполнили свою функцию лучше. Норма среднего коэффициента обогащения составила от 40 % до 90 % для потери питательных веществ и от 50 % до 85 % для органических веществ для всех участков в сравнении с почвенным происхождением. Коэффициент обогащения значительно превысил на участке с растительностью плевел и клевер ползучий участки с комплексом трав. Было сделано заключение, что комплекс трав – наиболее эффективная мера для контроля деградации почв, питательных и органических веществ. Данное исследование содержит информацию о моделировании эрозии и технике улучшения консервации почвы и лугов для наилучшего использования земли в целях обеспечения устойчивого развития.

Ключевые слова: комплекс трав; клевер ползучий; плевел; потери осадков; Лессовое плато; потеря питательных веществ; эрозия почв.