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Original Research

Effects of Vegetation Cover and Slope Length on Nitrogen and Phosphorus Loss from a Sloping Land under Simulated Rainfall

Jing Qian, Li-Ping Zhang*, Wen-Yan Wang, Qiao Liu

Zhejiang Provincial Key Laboratory of Subtropical Soil and Plant Nutrition,
Key Laboratory of Polluted Environment Remediation and Ecological Health, Ministry of Education,
College of Environmental and Resource Sciences, Zhejiang University, Hangzhou-310058, China

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Abstract

In order to evaluate the effects of different slope lengths (1, 2, 3, 4, and 5 m) and different vegetation coverage ratios (20%, 45%, 60%, and 90%) on the mechanisms of nutrient loss and runoff producing processes, we have conducted 14 simulated rainfall experiments. The results show that N and P loss are decided by the concentration and the runoff volume, but when the amounts of N and P in topsoil are small, their loss content mostly depends on runoff volume. Dissolved nitrogen is the main form in the nitrogen loss, while nitrate nitrogen is the main component in dissolved nitrogen, but the proportion in the total nitrogen gradually decreases with slope length increasing or with the increase of vegetation cover; the main form of phosphorus losses is particulate phosphorus, and the excessive sediment-bound nutrient loss released into water might cause secondary pollution of an aquatic environment.

Keywords: artificial simulated rainfall, nitrogen loss, phosphorus loss, slope length, vegetation cover ratio

Introduction

The easier transformation of nitrogen and phosphorus from agricultural soils to freshwater bodies contributes to their accelerated eutrophication, which limits water use for drinking, recreation, and industry. Nitrogen (N) and phosphorus (P) are two of the major components of all comprehensive nutrient management plans. Managing these two nutrients involves integrating physical attributes (soil, water, and climate) with the dynamics of biological systems (soil organisms, plants, and animals) influenced by cultural practices in the pursuit of agricultural production [1]. Rainfall should be the driving force of soil erosion and nutrient loss, the surface runoff produced by the rainfall carried away soil nutrient in particulate state and dissolved state. This not only reduced soil fertility and fertilizer-use efficiency, but also led to the non-point source pollution and accelerated water eutrophication that had been identified as the main problem of water quality deterioration.

Nutrient loss caused by runoff is mostly influenced by topography, precipitation (intensity and duration), soil moisture content, land use, and land management practices [2], etc. Many studies about the effects of rainfall on nutrient loss are mainly related to the influence of rainfall intensity on the slope [3-5], different land use patterns [6], and original soil characters on nutrient loss [7]. This research is mostly combined with soil and water loss on the loess plateau [8-10].

Vegetation cover is an effective measure to improve water and soil conservation and nutrient loss [3, 11, 12].

*e-mail: lpzhang@zju.edu.cn

Table 1. Selected physicochemical properties of the surface soil (0-10 cm) in the test plots.

PH**	Organic carbon ($g{\cdot}kg^{-1}$)	Total nitrogen ($g{\cdot}kg^{-1}$)	Total phosphorus ($g{\cdot}kg^{-1}$)	sand %*	silt %*	clay %*
4.50	10.76	0.97	0.21	25.06	49.10	25.84

*By weight
**Soil water ratio (1:2.5)

Much research has focused on this issue, and the importance of vegetation cover has been fully confirmed [13, 14]. These studies focused on the effects of vegetation cover on soil erodibility in the process of soil and water loss, especially explaining the roles of rainfall interception from both macroscopic and microcosmic prospectives, most of which was about the relationship of soil erosion between forest and grassland. Other comparative experimental studies were done about the different vegetation cover types and the relationship between different vegetation cover types and soil erosion in farmland or bare land. But few current studies have been done in integrated effects of vegetation cover and slope length on N and P loss. Based on a variety of environmental factors affecting soil erosion and nutrient loss, the present study takes plant coverage ratio and slope length as variable factors, draws on the experience of some relevant theories and methods of artificial rainfall, investigates the mechanism and characteristics of these factors affecting runoff volume, nitrogen, and phosphorus loss, and the dynamic changing law in the hope of providing powerful scientific evidence for controlling non-point sources of environmental pollution.

Experimental Procedures

Artificial Simulated Rainfall Experiment

The simulated rainfall experiment was conducted in a glass greenhouse in Zhejiang University, China. The plot is composed of five pairs of earth troughs. Each plot is deliberately set with a 20º slope gradient, 0.5 m in width, 0.5 m in depth. Each trough is in duplicate. And each trough has different lengths such as one, two, three, four and five meters. Chinese cabbage (zhebai No. 6) was planted in each plot. The cabbage is commonly planted in local fields. With the growth of Chinese cabbage, the vegetation coverage of the experimental plots was 20%, 45%, 60%, and 90%. The vegetation coverage was measured by vertical and aerial photographs taken with a high-resolution digital camera and empirical estimation of visual inspection.

Simulated rainfalls were generated by the four side-sprinkle rainfall simulators set on both sides of each trough with a rainfall height of six meters. Fourteen simulated rainfalls were conducted during the whole experimental process for all five pairs of troughs. The time interval of each rainfall was determined according to the initial condition of the plot, particularly the initial soil moisture. Usually seven days was set for the interval, that is, the soil water content in each plot restored to the same level as the first simulated rainfall was given. And the process was repeated for each simulated rainfall.

Considering the rainfall characteristics, especially their intensity and duration in the local areas, the high intensity was designed at 2.0 $mm{\cdot}min^{-1}$. and the time caused the runoff to last 30 min for each simulated rainfall given. The rainfall intensity was adjusted by adjusting the aperture of the nozzles of the sprinklers and water pressure. Twenty rain gages were located along the sides of the plots in order to monitor the rainfall intensity in the process of the simulated rainfall. Based on these measures the equal raindrop distribution of the rainfall was also carefully calculated. Through the joint efforts and the adjustments, the simulated rainfall could approximately reach 90% of the natural rainfall in the following aspects: rainfall intensity, raindrop distribution, kinetic energy, and raindrop sizes.

Experimental Soil

The soil used in the experiment was classified as a typical yellow-red loam collected from Lin'an County in the western part of Zhejiang province, which is also the most common soil type in the province. Some physicochemical properties of the collected soil in the test plots were listed below in Table 1.

Sampling and Analytical Methods

In the process of each rainfall the time of the initial runoff was recorded. Runoff flew into a triangle metal trough at the bottom of each plot and then out from the outlet point. The runoff was collected at the same intervals (120 s) and stored in 1,000 ml clean polyethylene bottles. The water samples were collected from the supernatant using polyethylene bottles and then stored in the refrigerator at low temperature (4ºC) and the runoff volume was recorded.

Water samples were filtered through 0.45 μm filters to determine nitrate N (NO_3^--N), ammonia N (NH_4^+-N), and dissolved phosphorus (DP) in runoff. Ammonia N (NH_4^+-N) was analyzed by means of indophenol blue colorimetry, and nitrate N (NO_3^--N) by means of ultraviolet spectrophotometry. Determination of total nitrogen (TN) in runoff was done by means of alkaline potassium persulfate digestion using an unfiltered sample. Undissolved N was subtracted NH_4^+-N, NO_3^--N. Both dissolved phosphorus (DP) and total phosphorus (TP) were analyzed by ammonium molybdate spectrophotometric method [15].

Results and Discussion

The Effects of Different Plant Coverage Ratio and Different Slope Length on Runoff Characteristics

Soil water content mostly depended on the slope length and vegetation coverage, and showed significant differences. In general cases, the occurring time of surface runoff was earlier with increasing slope length, or later with increasing vegetation cover ratio. The runoff volume gradually increased with the duration time of rainfall, and finally got to a steady-state. Each runoff intensity per 2 min was depicted in Fig. 1. Under the conditions of the same coverage but different slope lengths, the order of the surface runoff intensity was as follows: 5 m > 4 m > 3 m > 2 m > 1 m, and under the conditions of the same slope lengths but different coverage, the order of the surface runoff intensity was as follows: 20% > 45% > 60% > 90%.

From results of the test, the total of surface runoff of different slope lengths such as 2, 3, 4, 5 m, compared to the slope length of 1m, was increased by 2.47, 3.05, 4.73, and 5.33 times, respectively. As Fig. 1A showed, runoff intensity of slope lengths of 1, 2, and 3 m changed gently with producing time, while increasing more abruptly for slope lengths of 4 m and 5 m from initiation of producing runoff, This is possibly related to the effect of increased area of rainfall coverage. Under the conditions of a certain rain intensity, the component force in the direction of slope surface, which was one part of the runoff gravity, was increased while the runoff velocity was increased and slash raindrop fell farther along the slope surface, the runoff velocity was increased as was runoff intensity. Therefore, the difference of runoff intensity on different time stages was even more obvious.

The total of surface runoff under the conditions of vegetation cover ratio: 20%, 45%, 60% compared to 90% was increased by 1.81, 2.13, 2.88 times, respectively. The runoff intensity decreased proportionally with the increasing vegetation cover ratio (Fig. 1B), which might be due to the vegetative cover that reduced the kinetic energy of rain-drops, prevented surface soil sealing, and reduced sediment yield; the slope field covered with vegetation leaves intercepted raindrops, impeded runoff, and increased infiltration time, and vegetation root improved the soil infiltration capacity, etc. [16, 17].

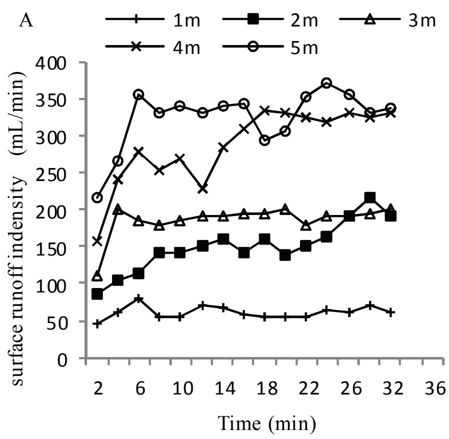
Total nitrogen (TN) in the runoff consisted of particulate nitrogen (PN) and dissolved nitrogen (DN), and dissolved nitrogen of the two major components: NO_3^--N and NH_4^+-N [18]. Total phosphorus (TP) was composed of dissolved phosphorus (DP) and particulate phosphorus (PP), namely TP=DP+PP [19]. There are three ways of soil nutrient loss processes because of the runoff in the soil-water erosion:

a) Soluble nutrients in soil liquid phase dissolved in runoff
b) Soil nutrients absorbed by soil particles released to runoff
c) Soil nutrient with soil particles carried away by runoff on the slope surface and transferred to water body [20].

Based on the understanding that both the slope length and vegetation coverage are the two important factors that affect soil nutrient loss processes, the objective of this paper was to study the effects of vegetation coverage and slope length on nutrient loss and investigate the nutrient transportation mechanism under artificial simulated rainfall conditions. The main results of the experiment are given below.

Loss of N and P in Runoff from Different Slope Lengths

N and P loss were decided by two factors: concentration (Fig. 2) and runoff volume (Fig. 1). In order to understand the changing trends of TN, NO_3^--N, and NH_4^+-N with rainfall duration and evaluate the influences of slope length on TN, NO_3^--N, NH_4^+-N, we chose the results of 2 m and 5 m, as presented in Fig. 3, and showed that under precipitation density of 2.0 mm·min^{-1} and vegetation coverage of 45%, the changes of TN, NO_3^--N, and NH_4^+-N loss were similar to each other at 2 m and 5 m slope lengths. The figures indicated that their loss volume of N in various forms were fluctuations with increasing rainfall time. In the 5-m long sloping field the loss was greater and more abrupt than that of the 2 m, while loss volume of the 2 m slope length was rel-



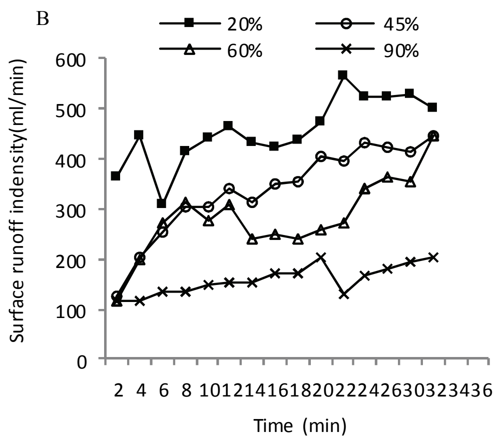


Fig. 1. (A) Surface runoff volume with increasing rainfall time on different slope lengths and 45% coverage; (B) Surface runoff volume with increasing rainfall time on different vegetation coverage and 4 m slope lengths.

atively smooth. Under the same conditions, the TP loss volume increased slightly and changed unstably with increasing rainfall duration at the 5 m-long sloping field, but varied a little in the 2 m-long sloping field within a certain small range (Fig. 3B).

With different slope lengths, because the amounts of N and P in topsoil were small, their loss content mostly depended on runoff volume. Surface runoff was less if the slope length was 2 m long, thus the differences of N and P loss were not obvious. However, when slope length was increased to 5 m long, the process of producing surface runoff was accelerated, so the runoff volume was also increased at different times. The differences of N and P loss were even more obvious. With the increase of runoff velocity, more sediment particles were carried away by runoff, therefore P loss tended to gradually increase mainly in sediment forms.

While each form of N and P concentrations in runoff at different slope lengths had differences, the changing trends of their concentrations of TN, NH_4^+-N, and NO_3^--N were similar. The concentrations were high at the early stage, and then reduced with the rainfall duration, or gradually stabled in the final rainfall phase. In view of the impact of slope length and rainfall time on N and P loss concentration, the results of the experiment were fitted by Statistical Software SPSS 18.0 system, and the fitting equation is as follows: Y_{SL} is the N or P loss concentration (mg·L^{-1}), X_1, slope length (m), and X_2, the producing runoff time (min). Table 2 showed N loss models have high determination coefficients (R^2>0.7) and are proved to provide sufficient accuracy.

The study selected the changes of average loss concentration of various forms of N and P under the conditions of the entire rainfall duration with vegetation coverage of 45% and different slope lengths (2, 3, 4, 5 m), and calculated their proportion of NO_3^--N, NH_4^+-N, and DP in their corresponding TN and TP, respectively (Table 3). The purpose was to further analyze the morphology of nutrient loss in runoff, the changing trends, and evaluate whether the potential possibility of nutrient loss of excessive sediment bound would cause the secondary pollution of an aquatic environment.

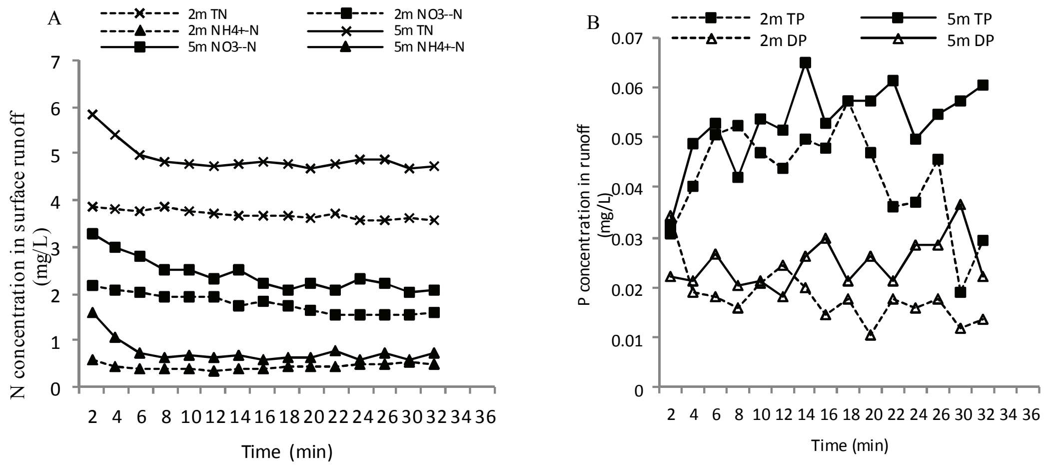


Fig. 2. (A) N concentration in the surface runoff with increasing rainfall time at different slope lengths and 45% coverage; (B) P concentration in the surface runoff with increasing rainfall time at different slope lengths and 45% coverage.

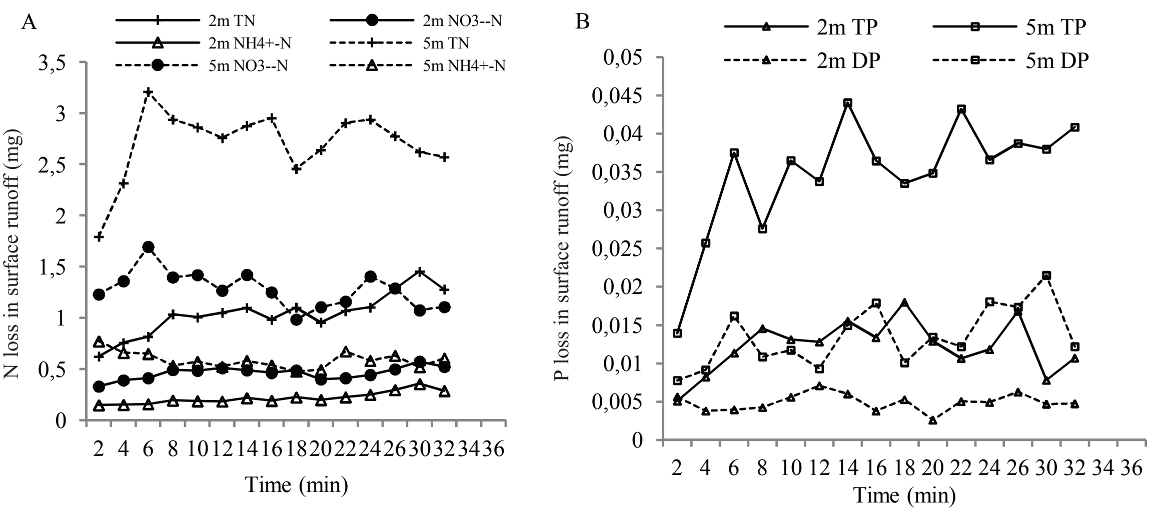


Fig. 3. (A) N loss content in the surface runoff with increasing rainfall time at different slope length and 45% coverage; (B)P loss content in the surface runoff with increasing rainfall time at different slope and 45% coverage.

Table 2. Correlation analysis between nutrient loss concentration (Y_{SL}), slope length (X_1), and rainfall time (X_2).

	Regression equations	R^2
TN	$Y_{SL}=2.6751 - 0.0706X_2+1.0611X_1+0.0043X_1X_2 - 0.1108X_1^2+0.0010X_2^2$	0.82
NO_3^--N	$Y_{SL}=1.2152+ 0.3886X_1 - 0.0092X_1X_2 + 0.0001X_2^2 - 0.0002X_1^2$	0.86
NH_4^+-N	$Y_{SL} = 0.2618 - 0.0290X_2 + 0.1945X_1 + 0.001260X_2^2 - 0.0056X_1X_2$	0.72
TP	$Y_{SL} =0.0404 + 0.0010X_2 - 0.0017X_1 - 6.2698e^{-5}X_2^2 + 0.0003X_1X_2$	0.68
DP	$Y_{SL} =0.0290 - 0.0013X_1 - 0.0012X_2+ 0.0002X_1X_2 + 1.0230e^{-5}X_2^2$	0.55

As Table 3 shows, TN concentration increased with increasing slope length. Dissolved nitrogen was the main form in the nitrogen loss (>50%), while NO_3^--N was the main component in dissolved nitrogen. But while the proportion in the TN gradually increased with increasing slope length, it mainly resulted from the increase of slope length and the extended time of runoff on slope surface under the conditions of the same coverage ratio. Although the velocity of runoff was quicker, it was beneficial to more soluble nitrogen dissolved into the runoff. And then due to the instability of NH_4^+-N of soil, it could easily be converted to NO_3^--N through nitrification, or could be lost to the atmosphere through the process of volatilization, NH_4^+-N loss in runoff was less than that of NO_3^--N.

As the amounts of DP and TP in topsoil were small, the differences of their average concentrations with different slope lengths were not obvious. The percentage of DP in TP also indicated that particulate phosphorus (PP) was the main form of P loss (>50%), the experimental results comply with much researches about measured P content in surface runoff, those researches also indicated that PP was the main form of P transportation [21, 22], even though the other studies in many other literatures, too, pointed out that the majority of N and P exported in runoff was usually in the dissolved faction, and nutrient loss might be related to soil moisture, topography, rainfall intensity, and soil texture [23].

The total loss content of various forms of N with different slope lengths was shown in Fig. 4. With the extendibility of slope lengths the total loss content of various forms of N was increased linearly, which was mainly influenced by the runoff volume. As compared to 5 m-long slope length, the total lost content of TN with the slope lengths of 2, 3, and 4 m was 42%, 49%, 82%, respectively. The total lost content of NO_3^--N was 42%, 46%, 93%, while the total lost content of NH_4^+-N was 23%, 53%, 62%, which was relatively not obvious. The total loss content of various forms of N did not show its proportional increase with the extension of slope lengths. The changing trends of total loss content of both TP and DP were similar with that of N with different slope lengths, while the percentage of DP in TP reduced with increasing slope lengths; in contrast PP increased. Then the fact further explained that sediments production were increased as slope length and rain intensity increased, the content of N and P carried by sediments went up.

Loss of N and P in Runoff from Different Vegetation Cover Ratios

Under the conditions of different vegetation coverage ratios, the mechanism of producing runoff in the sloping fields would change. The plot with vegetation coverage could increase producing subsurface flow compared to bare

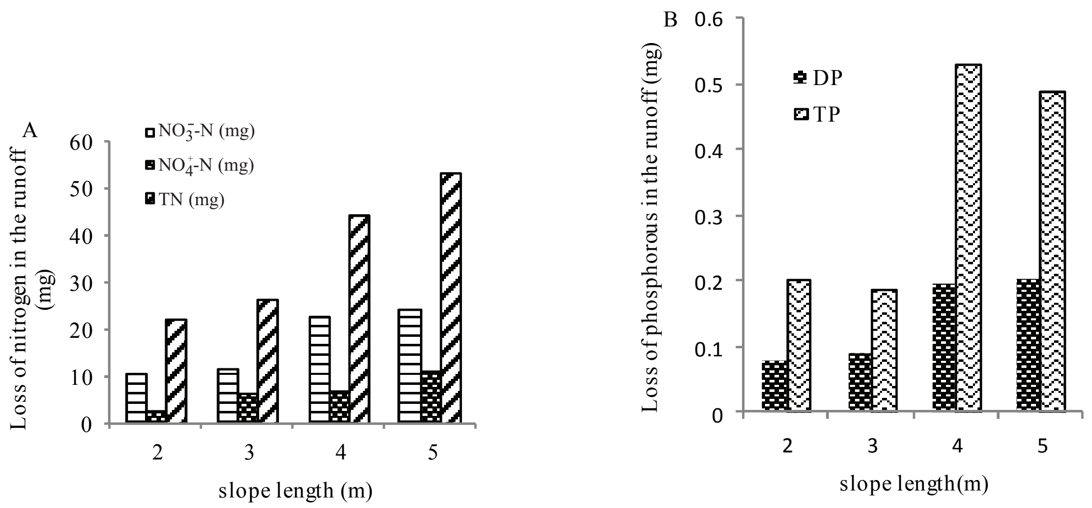


Fig. 4. N and P total loss content on different slope lengths with 45% coverage.

Table 3.With different slope lengths and 45% coverage, every form of N and P in the proportion of TN, TP, and their average concentration.

Slope length (m)	$C_{NO_3^--N}$ ($mg \cdot L^{-1}$)	$C_{NH_4^+-N}$ ($mg \cdot L^{-1}$)	C_{TN} ($mg \cdot L^{-1}$)	$C_{NO_3^--N}/C_{TN}$ (%)	$C_{NH_4^+-N}/C_{TN}$ (%)	C_{DP} ($mg \cdot L^{-1}$)	C_{TP} ($mg \cdot L^{-1}$)	C_{DP}/C_{TP} (%)
2	1.77	0.43	3.70	47.84	11.62	0.02	0.05	35
3	1.85	0.87	4.30	43.00	20.00	0.02	0.05	34
4	2.33	0.70	4.58	48.68	15.28	0.02	0.05	35
5	2.40	0.73	4.78	50.00	15.27	0.02	0.05	32

plot, resulting in reducing N and P transformation. During the stimulated rainfall, high vegetation cover could significantly affect the changes in N and P concentrations in surface runoff such as reducing the direct impact of raindrops on the slope surface, lessoning soil aggregate disintegration, accelerating infiltration speed, and slowing down the surface runoff velocity, etc.

If different vegetation cover ratios were given, the loss volume of N and P was also influenced by the concentration (Fig. 5) and the runoff volume (Fig. 1). As Fig. 6 showed, N and P loss in wavy trend increased with rainfall duration with low vegetation cover ratio, while the change of N and P loss were gentle with high vegetation cover ratio. This result is mainly due to the increase of runoff identity and sediment production rate. The production of Infiltration-excess runoff was formed prior to soil internal voids saturated with low vegetation cover ratio or bare soil, which led to the extraction process of N and P with time lag effect. They were abounded in soil surface layer and deep layer before producing runoff [24], with high vegetation cover ratio on the slope, vegetation isolation layer protected soil surface layer from the direct impact of raindrops, and vegetation roots could improve the soil infiltration capacity. Stored full runoff was not produced until soil internal voids were saturated; therefore N and P concentration were relatively stable.

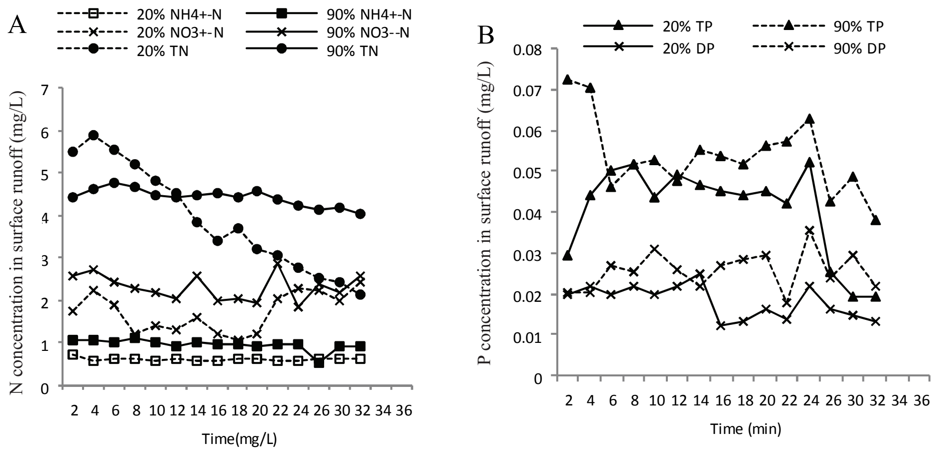


Fig. 5. (A) N concentration in the surface runoff with increasing rainfall time with different vegetation coverage ratio and 5 m slope length; (B) P concentration in the surface runoff with increasing rainfall time with different vegetation coverage ratio and 5 m slope length.

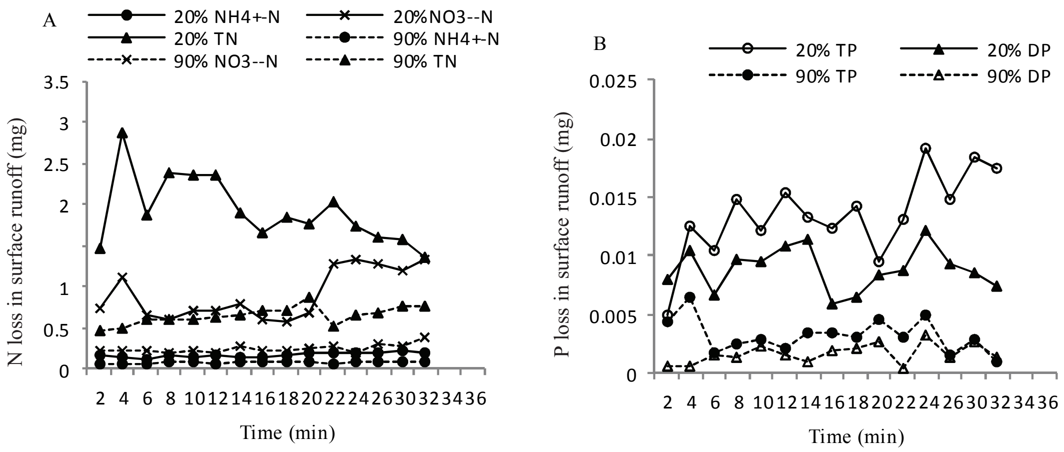


Fig. 6. (A) N loss content in the surface runoff with increasing rainfall time with different coverage and 5 m slope length; (B) P loss content in the surface runoff with increasing rainfall time with different coverage and 5 m slope length.

Table 4. Correlation analysis based on nutrient loss concentration (Y_{VCR}), vegetation coverage (X_3) and rainfall time (X_2).

	Regression equations	R^2
TN	Y_{VCR}=6.5250 – 0.1819X_2 – 0.0189X_3 + 0.0016X_3X_2 + 0.0006X_2^2	0.95
NO_3^--N	Y_{VCR}=1.8057 – 0.0804X_2 + 0.0141X_3+0.0015X_2^2+0.0003X_2X_3 – 4.9653$e^{-5}X_3^2$	0.69
NH_4^+-N	Y_{VCR}=5.9698 – 0.0146X_3 – 0.1312X_2 – 0.0003X_2^2 + 0.0015X_3X_2 – 3.05928$e^{-5}X_3^2$	0.82
TP	Y_{VCR}=0.0383+ 0.0010X_2 + 0.0001X_1 – 5.1372$e^{-5}X_2^2$+3.7793$e^{-6}X_2X_3$	0.59
DP	Y_{VCR} = 0.0198 – 3.0216$e^{-5}X_2$+2.4002$e^{-5}X_3$+ 5.2341$e^{-6}X_2X_3$ – 1.0005$e^{-5}X_2^2$	0.57

Table 5. Various forms of N and P in the proportion of TN and TP, the average concentration of TN and TP with different vegetation cover ratio and 5 m slope.

Vegetation cover ratio (%)	$C_{NO_3^-\text{-}N}$ (mg·L^{-1})	$C_{NH_4^+\text{-}N}$ (mg·L^{-1})	C_{TN} (mg·L^{-1})	$C_{NO_3^-\text{-}N}/C_{TN}$ (%)	$C_{NH_4^+\text{-}N}/C_{TN}$ (%)	C_{DP} (mg·L^{-1})	C_{TP} (mg·L^{-1})	C_{DP}/C_{TP} (%)
20	1.73	0.61	3.91	44.24	15.60	0.02	0.05	33
45	2.00	0.68	4.18	47.85	16.27	0.02	0.05	40
60	1.98	0.74	4.20	47.14	17.62	0.02	0.05	40
90	2.31	0.97	4.43	52.14	21.90	0.02	0.06	40

The changing conditions of various forms of N and P concentrations were similar, generally speaking. The results of the experiment at different vegetable coverage ratios were fitted by Statistical Software SPSS 18.0 system and the fitting equation was as follows: Y_{VCR} is the N or P loss concentration (mg·L^{-1}), X_3 is the coverage ratio (%), and X_2 is the producing runoff time (min). As Table 4 showed, N loss models have high determination coefficients (R^2>0.7), and these models are proved to provide sufficient accuracy, DP and TP loss concentrations have low determination coefficient, and P loss has big fluctuations depending on rainfall duration.

The average loss concentration of N and P on 5 m-long slope during the entire rainfall with different vegetation cover ratio (20%,45%,60%,90%) were selected and the proportion of NO_3^--N, NH_4^+-N calculated in their corresponding TN and DP in the TP Respectively (Table 5), the proportion of NO_3^--N and NH_4^+-N in the TN gradually increased with increasing vegetation coverage ratio, and the dissolved nitrogen was the main form in the N loss. When the proportion of undissolved N in TN was less than 35%, the proportion of DP in TP was also increased with increasing of coverage ratio. PP made up of the main part of P loss.

Under the conditions of the same rainfall intensity, the vegetation cover can obviously reduce the kinetic energy of raindrops so as to prevent surface soil sealing and reduce sediment yield. The plot covered with vegetation could increase surface roughness, reduce runoff velocity, and help the suspended sediments in the runoff to deposit and increase the action time between slope surface and runoff. Meanwhile, vegetation roots improved the soil infiltration capacity [15, 19], and these effects resulted in acceleration of N and P absorbed by the surface of soil particles to release into runoff [25].

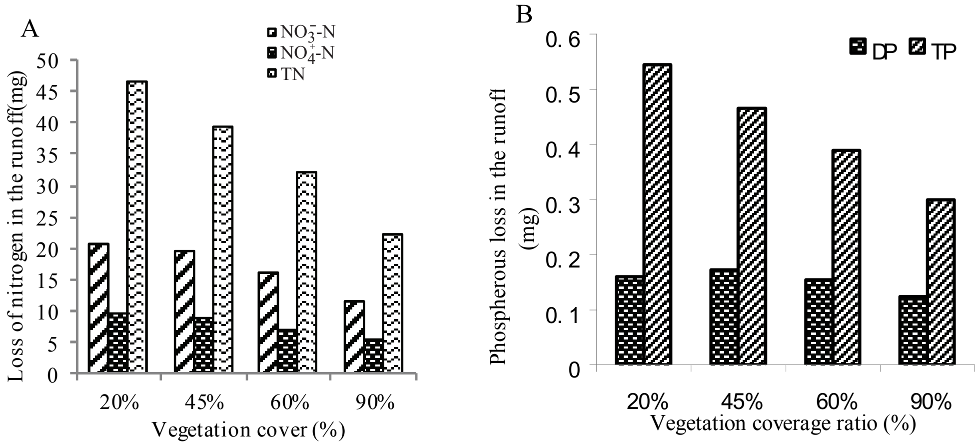


Fig. 7. N and P total loss content with different slopes with 5 m slope length.

As Fig. 7 showed, the total loss of TN and TP decreased almost linearly with increasing vegetation cover ratio, but the differences of the total loss contents of dissolved N and P was slight at different stages of vegetation cover. Therefore, the changes of TP and TN loss mostly depended on the content of N and P absorbed by sediment particles.

Analyses on the Co-Relation between Slope Length and Vegetation Coverage for Nutrient Loss of N and P

Linear regression analysis was made according to TN and TP concentrations, and surface runoff intensity, respectively. The conditions of different slope lengths, the obviously negative co-relation ($R^2>0.5$), was determined between the loss concentration of N and P and runoff intensity. It was proved that rainfall caused surface runoff, which was the main method of nutrient loss of both N and P with different slope lengths. Under the conditions of different vegetation coverage ratio, form the angle of the relationship between surface runoff intensity and TN and TP concentration, TP determination coefficient was relatively low ($R^2<0.5$), showing big fluctuations of both TN and TP concentration with entire rainfall duration (Fig. 8). In particular, when vegetation cover ratio was 20% and 45%, respectively, the determination coefficient of TP was 0.1254 and 0.1173, which indicated that P loss in the sloping field much depended on sediment yield rate and nutrient enrichment rate on sediment. Because of the low vegetation cover, the direct effects of raindrops on slope surface were enhanced, induced more aggregate disintegration, increased runoff velocity on slope surface, and more sediments were washed away by runoff, resulting in the instable TP concentration. But low nutrient content in the topsoil may be one of the reasons for a low coefficient of determination between surface runoff intensity and TP concentration.

Conclusions

Our study provides theoretical guidance for vegetation coverage and slope length aimed at soil and nutrient conservation, with the help of rainfall simulators to study the effects of slope length and vegetation cover on nutrient loss

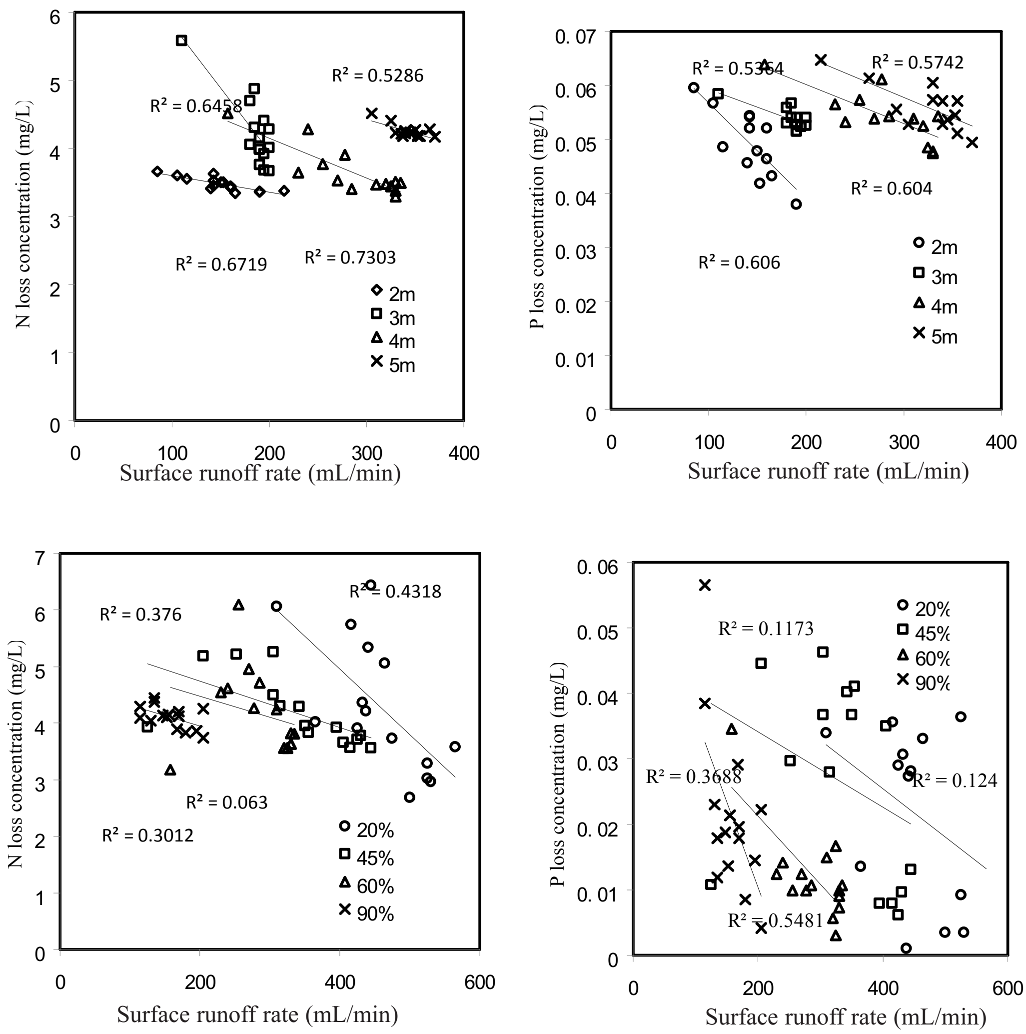


Fig. 8. Under the conditions of different slope lengths: (A) relation of surface runoff rate and N loss concentration, (B) surface runoff rate and P loss concentration. Under the conditions of different vegetation coverage: (C) relation of surface runoff rate and N loss concentration, (D) surface runoff rate and P loss concentration.

in experimental plots. The results indicated: firstly, to reduce slope length or increase plant cover was an effective approach to prevent nutrient loss. Under the conditions of the given experiment, the occurring time of surface runoff was earlier for longer slope length than the shorter one or later for the high vegetation coverage than the low one. Secondly, the surface runoff and nutrient loss increased with increasing slope length or decreased with increasing vegetation coverage. The changing trends of the N concentration in runoff were high at an early stage, and then reduced with increasing time, and gradually became stable in the final rainfall phase. P concentration was varied within a certain range; thirdly, dissolved nitrogen was the main form in the nitrogen loss, while NO_3^--N was the main component in dissolved nitrogen, but the proportion in the total nitrogen gradually decreased with increasing slope length or with decreasing vegetation cover, and the main form of phosphorus losses was PP. Slope length had a positive correlation with the loss amounts of nitrogen and phosphorus, while vegetation coverage negatively correlated with nitrogen and phosphorus loss. The study also demonstrates that an intercepting ditch could effectively reduce non-point pollution caused by N and P loss.

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