The characteristics of soil and water loss in Pinus Massoniana forest in Quaternary red soil area of south China

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Abstract. The soil and water loss in Pinus massoniana forests is an urgent environmental problem in the red soil region of southern China. Using the method of field monitoring, by analogy and statistical analysis, the characteristics of soil and water loss of Pinus massoniana forests in Quaternary red soil region under 30 rainfall were analyzed, the results show that the relationship models of rainfall, runoff and sediment of pure Pinus massoniana plot were slightly different from the naked control plot, were all the univariate quadratic linear regression models. The contribution of runoff and sediment in different rain types were different, and the water and soil loss in Pinus massoniana forest was most prominent under moderate rain. The merging effect of sparse Pinus massoniana forest on raindrop, aggravated the degree of soil and water loss to some extent.

1. Introduction
Jiangxi province is one of the provinces where soil erosion is most serious in China, and the area of soil erosion is 2.65 million square kilometers, accounting for 15.87% of the land area of Jiangxi province. The forms of soil and water loss are not optimistic, especially the unreasonable development of slope farmland [1~3], Collapsing Erosion [4~5] and soil erosion under forest [6~8] are the main sources of soil erosion of Jiangxi province. Pinus massoniana, as a common tree species for soil and water conservation of south China, has been widely popularized since the first soil and water conservation project in Jiangxi province in 1980. However, Pinus massoniana will aggravate soil acidification, resulting in difficult survival of other plants, in addition to artificial damage to its underground vegetation, the soil and water loss under Pinus massoniana forests is extremely serious. “far from looking at green hills, near view of water and soil loss” has become a relatively prominent problem of the soil and water loss control in the red soil hilly region of southern China [7].

The study found that rainfall is the main driving factor of soil and water loss [8], surface vegetation degradation [9] and soil fertility and quality degradation [10], which further aggravated the degree of soil and water loss in forests, and soil and water loss under the forest has become an urgent problem to be solved in red soil hilly region in south China. In the southern red soil region, the correlation study was carried out by the field observation of standard runoff plots and the artificial rainfall experiment in the red soil region, and the research object mainly concentrated in the red soil region of granite with 15 ~ 25° slope [10], the research on the characteristics of soil and water loss in Pinus massoniana forest in Quaternary red soil region was less.

This study uses the method of field observation of Pinus massoniana pure forest plot, through the collection of runoff and sediment data of different plots in rainfall conditions, using statistical analysis,
to find out the relationship between rainfall, runoff and sediment, so as to clarify the characteristics of soil and water loss in Pinus massoniana forest, provide relevant technical reference and basis for controlling Pinus massoniana forest soil and water loss in southern red soil region China.

2. Study area
The study area is located in tiger mountain small watershed of Taihe county in Jiangxi province. The geographical position is E114°52’ ~ E114°54’, N26°50’ ~26 °51’, it belongs to middle subtropical monsoon climate. The multi-year mean rainfall is 1363mm. The mean temperature is 18.6 ℃, the extreme highest and the lowest temperature are 40.4 ℃ and -6 ℃ respectively. The small watershed of tiger mountain is a hilly region of plain, with elevation of 80 ~ 200 m, the slope of the hill is gentle, the slope is about 5°, the soil is red soil formed by Quaternary red clay, the thickness of soil is 3 ~ 40 m, and the vegetation coverage was close to 60 %. The main vegetation types include Pinus massoniana, Pinus elliottii, Liquidambar formosana, Schima superba and Lespedeza.

3. Experimental Methods

3.1. Test design and method
In the small watershed of tiger mountain, four types of natural plots were built according to the natural landform, namely, the naked control plot(CK), the pure tree (PT) plot of Pinus massoniana, respectively. Runoff and sediment collection devices were installed at the outlets of each plot. Basic configuration of each plot is shown in table 1 and figure 1.

![Figure 1](image)

(a) The naked control plot(CK)  (b) The pure tree (PT) plot of Pinus massoniana

| NO | Treatment | Slope | Canopy density | Area (m²) | Configuration description |
|----|-----------|-------|----------------|---------|--------------------------|
| I  | CK        | 9.3°  | 0%             | 344.6   | The surface was bare and without any vegetation cover |
| II | PT        | 6.7°  | 30%            | 313.0   | The surface is pure Pinus massoniana forest, and there is no vegetation under the forest |

3.2. Data observation
The 30 field rainfall, runoff and sediment data of the field monitoring plots in the study area from 2010 to 2011 were collected.

3.2.1 Rainfall data. The rainfall was measured mainly through the collected rain gauges installed in the study area, where rainfall is set as a rainfall event with an interval of more than 6 hours, and the rainfall data mainly adopts rainfall, and the unit is mm.
3.2.2 Runoff data. Using runoff depth (unit: mm) to indicate the runoff, the acquisition method is as follows: First, the volume of runoff in each experimental plot is measured by volume method, and the runoff depth (mm) is obtained through unit conversion.

3.2.3 Sediment data. For better comparative analysis, it needs to be converted to the sediment yield on the unit area, mainly expressed by sediment yield per unit area (t/km²), the method is as follows: by measuring the sediment concentration of runoff generated by each rainfall, the sediment yield is calculated by multiplying the runoff volume, and then the sediment yield data on the unit area is obtained through unit conversion, i.e. sediment yield per unit area (t/km²).

3.3. Data analysis
All the data are processed and analyzed by Microsoft excel software.

4. Results and analysis

4.1. Rainfall characteristics analysis
As Table 2 showed, the total rainfall was 599.5 mm, among which the minimum rainfall was 7.8 mm, the maximum rainfall was 50 mm, and the average rainfall was 19.89 mm. According to the meteorological bureau's classification standard [2], as shown in Table 2, there were 9 drizzles in 30 rainfall, the rainfall of which was 81.2 mm, accounting for 13.54% of the total rainfall, there were 12 Moderate rain, the rainfall of which was 195.1 mm, accounting for 32.54% of the total rainfall, there were 9 Heavy rain and above, the rainfall of which was 323.2 mm, accounting for 53.92% of the total rainfall, whose rainfall amounted to more than half of the total rainfall. The standard deviation of 30 rainfall was 12.16, the coefficient of variation was 0.61, and the variability of the observed rainfall was significant.

| Rain type               | Frequency (Times) | Rainfall (mm) | Percentage of times of total rainfall (%) | Percentage of total rainfall (%) |
|------------------------|-------------------|---------------|-------------------------------------------|---------------------------------|
| Light rain             | 9                 | 81.2          | 30                                        | 13.54                           |
| Moderate rain          | 12                | 195.1         | 40                                        | 32.54                           |
| Heavy rain and above   | 9                 | 323.2         | 30                                        | 53.92                           |

4.2. Characteristics of total runoff and sediment yield
The Rainfall is the main driving force of runoff and sediment yield [8], Through the arrangement and analysis of 30 rainfall runoff and sediment yield data of PT plot, the total runoff depth was 209.36 mm, the runoff coefficient was 34.92%, compared with CK plot, the total runoff depth of the plot was 262.28 mm and the runoff coefficient was 43.75%, only by 52.92 mm and 8.83%, the difference was not obvious. The total sediment yield per unit area of the PT plot is 1721.28 t/km², and the total sediment yield per unit area of the CK plot was 970.91 t/km², and the difference was significant.

4.3. Characteristics of runoff and sediment in single field rainfall
As shown in figure 2 and figure 3, the rainfall is consistent with runoff and sediment yield, the correlation coefficients of rainfall and runoff in PT and CK plots were respectively 0.95 and 0.98 respectively (p<0.01), and the correlation coefficients of rainfall and sediment in PT and CK plots were 0.92 and 0.94 respectively (p<0.01), and the correlation coefficient of PT was slightly lower than that of CK. Runoff is the secondary driving force of sediment generation and migration [2], through the statistical analysis of runoff and sediment yield of PT and CK plots, the correlation coefficients of runoff and sediment were 0.92 and 0.93, all showed significant correlation (p<0.01).
4.4. Characteristics of runoff and sediment in different rain types
Under different rain types, the PT plot was slightly different from the CK plot, the proportion of runoff and sediment of moderate rain was higher than the CK plot, and the effect of reduction of runoff and sediment of light rain was the highest, close to 50 %, followed by heavy rain and above, respectively, 20.91 % and 37.50 %, the lowest was moderate rain, was 14.55 % and 30.22 %, respectively. Obviously, in moderate rain, the water and soil loss of Pinus massoniana forest is the most prominent.
5. Conclusion

(1) Compared with the CK plot, there was no significant difference in runoff and sediment of single rain (p < 0.01). The proportion of runoff and sediment in total runoff and sediment under different rain types were different, among which, the proportion of runoff and sediment under moderate rain type were the largest, the different contribution of runoff and sediment in different rain types also existed, and the water and soil loss in Pinus massoniana forest was most prominent under moderate rain.

(2) The relationship model between rainfall, runoff and sediment of PT plot were slightly different from that of the CK plot, the relationship models were all the univariate quadratic linear regression models.

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