A Study on the Soil and Water Conservation Effect of *Larix kaernpferi* (Sieb. et Zucc.) Forest

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Abstract: The direct runoff and soil erosion was observed in the Larix kaernpferi forest that was man planted with two different site preparation methods for contrasting. The results showed that the hole or strip site preparation methods has obvious effects to decrease the direct runoff and soil erosion. The hole site preparation method has the best effect on decreasing direct runoff by 34% and soil erosion by 42%. The two different site preparation methods also had obvious effects on decreasing the washing of nutrient element by 79.75kg • hm^{-2} • a^{-1}—135.40kg • hm^{-2} • a^{-1}.
Keywords: soil and water conservation, site preparation, direct runoff, soil nutrient, Larix kaernpferi

Forest can not only affect soil physic and chemistry traits, but also regulate rainfall's distribution and water flow process. The study of forest ecology now put much emphasis on the forest effects on decreasing soil erosion and the change of soil characteristics. The study on these effects of man-planted *Larix kaernpferi* forest using two different site preparation methods was carried on in 1993—1995 in Longyuwan forestry center in Luanchuan county, Henan province. The amount of direct runoff, soil erosion and soil nutrient elements were observed in the fixed field.

1 Study site outlines

The study site is lying in the Longyuwan forestry center in Luanchuan county, Henan province, locating at 111° 35′ E and 33° 45′ . The altitude is 1 550m, having a northwest slope of 20° . The soil is brown with the depth of 50cm. The site's yearly average air temperature is 12℃, and the precipitation is 880mm.

Three runoff fields were setup in forest fields using hole site preparation, strip site preparation respectively and the check. Each field area is (20×15) m^2. The hole site preparation method uses (0.4×0.4×0.3) m^3 hole, while the strip site preparation uses (1.5×5) m×0.3 m—0.5 m. All of three runoff fields were planted with 2-year-old *Larix kaernpferi* seedlings.

2 Study method

2.1 The measurement of soil physic traits

The weight and ring cutting methods were used to measure the soil water content, unit weight, gravity, capillary porosity, non-capillary porosity, and maximum moisture capacity. The double ring casing tube and the circle infiltration measurement were used to measure soil permeable speed and amount [7].

2.2 The measurement of direct flow-off

The measurement was carried out in blocked field using bricks and cement lowly banked at the upper and two lateral sides; the bank being isolated with field belt. The lower side was dyked to have runoff channels and its collecting pool with asphalt felt on them to avoid rainfalls. The runoff was

measured when it appears after rainfall. The pool bottom was washed with clean water after the measurement for the later use.

The sediment method was used to measure the soil erosion amount. The silt in the pool bottom was disturbed and well mixed with upper water. 1,000ml mixture was immediately scooped out into plastic bucket. The upper water was poured out after natural settlement, while the silt was natural dried and weighted with a 1/100 mine scale. The unit is kg/m^3.

2.3 The analysis of the flow-off water sample

The water sample was collected at the entrance of the pool in each representative rainfall time with amount of 0.5 L—1.0 L. The analysis method was used according to the literature [7].

3 Results and discussion

3.1 The physic traits of soil

The change of soil physic traits will affect the soil ability to store, retain and efficiently utilize soil water, and so affect the development of forest, especially when it occurs in the surface layer. Therefore, it has an important function in water cycle. The site preparation obviously affected the physic traits of soil according to the observation (Table 1): The greatest soil gravity was of the check, while the smallest, of the hole site preparation one. The unit weight of soil varied in $0.92g/cm^3$—$2.38g/cm^3$, and kept the same change trend as that of soil gravity in different site preparation field. It also showed that the upper soil layer one > the lower soil layer one. The greatest of soil non-capillary porosity was in hole site preparation field, the second, in strip site preparation field, and the smallest, in check; while its changing value showed the inverse ratio to that of the soil unit weight. The capillary porosity and soil maximum moisture capacity showed the same trend. Contrasting to that of check, the hole and strip site preparation method lied a better foundation for water infiltration in soil, for the site preparation can increase the soil porosity and decrease the unit weight of soil. Therefore, the site preparation can promote water storage capacity of soil, which benefits to the soil and water conservation.

Table 1 Effect of different site preparation on soil physic traits

Prepa-ration	layer(cm)	Soil gravity ($g \cdot cm^{-3}$)	Unit weight of soil ($g \cdot cm^{-3}$)	Non-capillary porosity (%)	Capillary porosity (%)	Maximum moisture capacity (%)
Hole	0—10	1.75	0.92	15.1	42.5	167.3
	10—20	2.08	0.97	12.6	40.3	128.6
	20—30	2.19	1.02	9.7	36.7	82.5
	30—40	2.25	1.05	8.5	30.6	71.3
Strip	0—10	1.80	0.96	14.1	40.8	147.2
	10—20	2.09	1.03	11.3	38.4	120.4
	20—30	2.23	1.07	9.2	34.1	80.2
	30—40	2.28	1.10	8.2	28.4	69.4
check	0—10	2.04	1.03	12.3	36.5	119.8
	10—20	2.17	1.12	10.7	32.3	82.7
	20—30	2.24	1.25	9.0	27.5	73.6
	30—40	2.38	1.36	7.8	21.4	60.5

3.2 The infiltration characteristic of soil

The soil infiltration mainly depends on soil porosity, especially on non-capillary porosity, but

porosity depends in a great content on soil physic traits, precipitation and its intensity. According to the soil infiltration observation in different site preparation field (Table 2), the greatest amount of soil beginning infiltration was in hole site preparation field (25mm/min), the second was in strip site preparation field (23mm/min), while the smallest, the check field (20mm/min). The change of amount of stable infiltration showed the same as that of the beginning one. The infiltration speeds varied among 6.2—14.4 mm/min. Therefore, according to local precipitation, much of the rainfall can be absorbed by soil, while only a little became direct runoff, especially in hole site preparation field. Therefore, the hole site preparation method has obvious effect on decreasing the surface runoff.

Table 2 Relationship between soil site preparation and soil infiltration

Preparation	Layer (cm)	Infiltration speed (mm/min)		Infiltration flowing speed (mm/min)
		Beginning	Stable	
Hole	0—10	25	9.6	12.4
	10—20	22	8.2	10.6
	20—30	20	7.3	9.7
	30—40	16	5.7	6.4
Strip	0—10	23	9.2	14.4
	10—20	21	7.5	10.6
	20—30	20	6.8	8.3
	30—40	16	5.3	7.2
Check	0—10	20	7.8	12.3
	10—20	18	6.5	6.2
	20—30	17	6.1	9.7
	30—40	14	4.4	10.3

3.3 The effect of site preparation on the runoff

3.3.1 The relationship between precipitation and runoff

There was much change of soil physic traits and soil infiltration characteristics because of the different site preparation. Therefore, the different site preparation has much difference in regulating direct runoff and decreasing soil erosion (Table 3).

Table 3 Runoff of runoff field with different site preparation

Month	Precipitation (mm)	Hole site preparation		Strip site preparation		Check	
		Runoff (mm)	Silt (kg)	Runoff (mm)	Silt (kg)	Runoff (mm)	Silt (kg)
6	71.2	3.70	8.4	4.1	11.2	11.0	15.6
7	186.3	27.5	52.5	37.9	63.4	42.1	76.7
8	157.9	23.4	47.4	34.2	45.0	38.4	64.4
9	152.7	14.1	36.9	16.5	52.5	23.5	58.5
10	70.2	3.1	5.3	5.7	10.4	13.3	24.6
Total	638.8	71.8	150.2	98.4	193.5	128.3	239.8

According to Table 3, the following principal can be seen:

(1) The amount of runoff and silt in it increased with the increasing of precipitation. In the growth season of *Larix kaernpferi*, the amount of runoff varied among 71.8mm—128.3mm in three runoff fields, while the amount of silt, 150.2kg—239.8 kg.

(2) Site preparation method has obvious regulation on direct runoff. In 5 months, the direct runoff in the hole site preparation field was 71.8mm, 11.2% of the yearly precipitation, while the silt amount was 150.2 kg; In the strip precipitation one, the value was 98.4mm, 15.4%, 87.5 kg, respectively. However, in the check one, the observation was 128.3mm, 20.1%, 239.8 kg, respectively. As discussed above, the hole site preparation method has the best effect on decreasing direct runoff and silt amount washed away, The strip site preparation method, the second, and the check does the least.

(3) The amount of runoff and silt varied greatly in different time. Precipitation concentrates in June, August and September in local area with large amount and great intensity. Therefore, in these three months, it has the greatest amount of runoff in forest and silt washed away, which are about 85% of all of the year.

3.3.2 The relationship between rainfall intensity and runoff

The amount of runoff and silt in it has a near relationship with the rainfall intensity, and as the precipitation keeps constant, its intensity will become the main factor. In this study, table 4 had showed this relationship (Table 4).

Table 4 Effect of rainfall intensity on the amount of runoff and soil erosion

Precipitation (mm)	Rainfall intensity ($mm.h^{-1}$)	Hole site preparation		Strip site preparation		check	
		Runoff (mm)	Silt (kg)	Runoff (mm)	Silt (kg)	Runoff (mm)	Silt (kg)
0.5	0.2	0	0	0	0	0	0
1.8	0.7	0	0	0	0	0	0
6.3	1.6	0.7	0.4	0.8	0.4	1.2	1.2
10.5	3.1	1.4	2.1	1.7	3.5	2.0	2.1
10.5	11.7	3.8	4.9	5.9	6.3	7.1	8.5
15.7	1.2	1.5	4.3	1.8	5.4	2.6	6.7
18.4	2.5	2.1	5.8	3.1	7.2	4.7	9.4
23.1	1.8	3.7	5.5	4.2	7.6	6.1	8.8
27.4	1.2	4.6	6.1	5.2	8.2	7.5	3.3
34.1	5.6	6.2	7.2	7.7	9.4	9.9	11.9
49.2	3.2	6.9	7.8	8.3	9.8	10.3	12.5

The 68 precipitation observation in 3 years was arranged as intensity Ⅰ ($1mm \cdot h^{-1}$—$2mm \cdot h^{-1}$), intensity Ⅱ ($3mm \cdot h^{-1}$—$4mm \cdot h^{-1}$), intensity Ⅲ($5mm \cdot h^{-1}$—$6\ mm \cdot h^{-1}$), the corresponding direct runoff and silt observation of three different site preparation field was calculated. Then the relationship of runoff, silt amount, these figures showed that when the rainfall intensity increased (Ⅰ to Ⅲ), the amount of runoff and silt sharply increased.

3.4 The effect of site preparation method on the soil nutrient

When rain falls on soil surface, it can wash away not only the soil, but also the nutrient element in soil. According to the observation, there was great differentia of soil nutrient element amount in runoff in different site preparation fields (Table 5). The following conclusion can be obtained:

(1) There were many nutrient element in the runoff, the largest amount being K, N, Ca, and showing the characteristics of K>N>Ca>Mg. The amount of washed nutrient element was under $100kg \cdot hm^{-2}$. Among them, that in hole site preparation field is smallest in three runoff fields, washing about $54.7kg \cdot hm^{-2}$; the second is that in strip site preparation method, $76.10\ kg \cdot hm^{-2}$; while that in the check field is $99.21\ kg \cdot hm^{-2}$, the largest.

(2) Among the amount of nutrient element washed away, the K, Ca, N were the highest, P and Mg were smaller. In three different site preparation field, the amount in the hole site preparation was the

smallest (144.32kg • hm^{-2}), the largest was in the check field (235.19 kg • hm^{-2}).

(3) The amount of 5 elements washed away in runoff and silt in the hole site preparation field was 199.02 kg • hm^{-2}, that in the strip site preparation field was 254.65 kg • hm^{-2}, and in the check one, 334.43 kg • hm^{-2}. The observation showed that the hole site preparation has the best effect on water and soil conservation.

Table 5 Relationship between different soil site preparation and nutrient loss (kg • hm^{-2} • a^{-1})

Element	Amount in hole site preparation			Amount in strip site preparation			Amount in check		
	Runoff	Silt	Total	Runoff	Silt	Total	Runoff	Silt	Total
N	4.80	2.75	7.55	6.61	3.85	10.46	8.62	4.48	13.10
P	0.09	4.95	5.04	0.13	7.21	7.34	0.17	8.79	8.96
K	45.15	121.10	166.25	62.97	141.50	204.47	82.11	183.70	256.81
Ca	3.84	12.8	16.64	5.27	20.95	26.22	6.87	29.63	36.50
Mg	0.82	2.72	3.54	1.12	5.06	6.18	1.46	8.59	10.05
Total	54.7	144.32	199.02	76.10	178.57	254.65	99.21	235.19	334.42

4 Conclusions

(1) The site preparation has obvious effect on decreasing runoff, in which the hole method showed the greatest effect, the strip one, the second, and all of them are better than the check.

(2) The site preparation method has some effect on soil physic traits: the hole and the strip site preparation method can promote soil capillary porosity, and thus to soil infiltration obviously. Therefore, the beginning and stable infiltration speed in these two fields is higher than that of check. Therefore, a suitable site preparation method is benefit to decrease soil erosion.

(3) The site preparation method affects the amount of nutrient element in runoff and silt: The amount in prepared fields is lower than that of check field, in which that of hole site preparation is the lowest.

(4) Comprehensively analysis, the conclusion can be obtained that the hole site preparation is a suitable method. It has an obvious effect on decreasing runoff and silt, and so decreasing the nutrient element loss.

References

[1] Ma Xue-hua. 1993. the forest hydrology. Beijing: the forest publishing house of china. 90-140.
[2] Zhang Wan-ru. 1986. the forest soil for china. Beijing: the science publishing house. 57-165.
[3] Xu Wan-ren, 1994, Preliminary study on hydrological effect of major forests in Helan mountain area, Chinese journal of ecology, **13**(4): 55-60.
[4] Zhao Yong, Li Shu-ren, 1995, Study on hydrological effects of conservation forests in Nanwan reservoir regions of Xinyang City. Acta Agriculturae University Henanensis, **29**(2): 121-127.
[5] Wang Wei-hua, Zhu Jin-wei, 1993, The regulation effect of *Pinus tabulaeformis* forest on runoffs, Chinese journal of ecology, **12**(6): 17-20.
[6] Liang Yun-hua, 1988, Forest hydrology and its study method, Journal of northeast forestry university, (4): 1-9.