Vetiver for Mine Tail Re-vegetation of Mofu Mountain in Nanjing of China

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Abstract The authors studied the basic chemical and physical properties of different materials that came from the mining of dolomite and vetiver growth behavior on Mofu Mountain of Nanjing, China. It showed that vetiver is a pioneer plant for mine tail re-vegetation.

Key words vetiver grass, mine tail re-vegetation, and quarry

Along the Yangtze River, Mofu Mountain is situated in northern part of Nanjing city of China with highest peak for 199.3m above sea level after mining for decades of years. The mountain protects Nanjing city from northern sandstorm cold snap attack. Since 1950's there were over ten companies involving in dolomite mining, that caused 2 000 000 m2 waste mountain area that is very difficult for re-vegetation. Following economy development the Mofu Mountain became part of the Nanjing City and effected the city's scenery. Since 1998 the Nanjing Horticulture Bureau has started to plant some trees to re-vegetate the mountain. However, due to the poor ecological environment it was not very successful. Large area still remains barren.

In 2002, the city mayor heard of vetiver grass and suggested the Horticulture Bureau to contact China Vetiver Network to use the grass to quickly re-vegetate the mountain. This paper described the basic properties of different mine tails and the function of vetiver on re-vegetate the mountains.

1 Materials and method

1.1 Soils

The soils came from the mine tail. It includes: coarse materials from carbonized shale, dolomite slag, Xiashu Loess, and earthy material from a lake.

1.2 Field tests

Vetiver tillers were planted along the contour spacing 150 x 10 cm on 26-29 June 2002. Each clump contained 3-5 tillers. Before planting all tillers were dipped with clay paste. Watering was provided after planting. Altogether 4 000 m2 slope area was planted. On 14 July urea was scattered for 200 kg/ha. The grass was pruned at a height of 40 cm above ground.

1.2.1：The effect of different mine tail materials on vetiver growth

Three plots (each with 200 m 2) were designed for each of the materials: carbonized shale, dolomite slag, Xiashu Loess, and earthy material from a lake. Three tillers were used at random at each of plot to determine vetiver growth every 16 days.

1.2.2 Effect of vetiver on micro-ecological environment

Small plots (1 x 1 m2) were used at random to determine the effect of vetiver grass on vegetation recovery after vetiver planting.

2.Results and analysis

2.1 Chemical and physical properties of different materials

The mechanical analysis is shown in table 1. Of several mine tail material, carbonized shale material contained the highest fragment over 2 mm in diameter for 49% and also the coarse sand over 70%. But it contained a little of fine sand and silt sand and the least clay for only 3.0-3.8%. It means that the material can retain very little moisture for plant use. On the contrary, the Xiashu loess contained the highest clay for 35%, without any fragments. Therefore, it can retain much moisture. The dolomite slag contained about 1/4 fragments. Besides, it contained much find sand and silt san. The earth from the lake contained the highest content of find sand. Since the carbonized shale had high fragment content and therefore could retain little moisture, about 1 kg Xiashu Loess was added to the planting hole.

Table 1 Mechanical analysis of different materials

Mine tails	Content of different particles (%)					texture
	>2mm fragment	2-0.2mm coarse sand	0.2-0.02mmfifine sand	0.02-0.002mm silt sand	〈0.002mm clay	
Carbonized shale	49.1 49.9	73.4 70.5	16.9 20.2	5.9 6.3	3.8 3.0	Sand or loamy sand
Dolomite slag	24.5 22.7	18.0 16.3	35.4 32.3	29.0 35.9	17.6 15.5	Clayey loam
Xiashu loess	0 0	0.5 0.7	32.8 29.5	32.1 34.6	34.6 35.2	Loamy clay
Earth from a lake	3.8 1.6	1.5 1.9	79.5 77.3	10.3 11.5	8.7 9.3	Sandy loam

Table 2 shows the basic chemical properties. It indicated that the carbonized shale contained the highest content of organic matter, total N, and available P and N. It came from its mineral origin. However, because it contained highest content of fragments, these elements may not be used by plants. Similar situation also exists for dolomite material. Table 2 also shown that different materials had different pH value from 4.13 to 8.85. Some materials had $CaCO_3$ for 328.3g/kg。All of these factors could affect the growth of plants.

Table 2 Chemical properties of different mine tail materials

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Mine tails	Organic matter (gkg^{-1})	Total N (gkg^{-1})	Available K ($mgkg^{-1}$)	AvailableP ($mgkg^{-1}$)	Available N ($mgkg^{-1}$)	pH (water) (1:2.5)	$CaCO_3$ (gkg^{-1})	CEC ($C_{mol}(+)kg^{-1}$)
Carbonized shale	57.0	1.43	22.8	121.3	148.3	4.13	0	8.04
	62.1	1.50	38.4	104.8	153.2	5.30	0	8.65
Dolomite slag	22.7	0.92	97.5	8.7	32.4	7.90	314.9	4.98
	13.9	0.64	77.8	5.2	29.3	7.84	328.3	4.95
Xiashu loess	5.7	0.47	89.2	16.3	36.1	7.42	6.4	11.82
	5.2	0.44	78.8	19.1	26.2	7.09	3.9	11.72
Earth from a lake	6.4	0.28	60.2	13.2	22.5	8.45	54.4	3.46
	6.1	0.31	54.9	14.6	23.7	8.85	56.9	3.30

2.2 Vetiver growth on different mine tail materials

About 95% of the grasses survive. They started to grow around 15 days after planting. It grew at different speed. The grass grew fast on the lake earth. It reached 35 cm in 15 days (Fig.1). The daily growth reached 2.3 cm/per day. The grass on the other materials grew almost the same. Therefore in figure 1 there was one line to represent all the other materials and described as "mine tail". Staring from 15 July vetiver grew slowly caused by hot weather and high evaporation (Figure 2). The growth depended on temperature and soil moisture. When without irrigation facilities the growth depended on rainfall and soil properties including soil structure. Since the lake earth had large amount of fine sands （77.3-79.5%, table 1）, better soil structure that contained much moisture and possibly much available nutrients the grass grew better. Table 3 indicates that the lake earth contained 9.3% and 10.4% water for the soil of 0-20 cm and 20-40 cm respectively. The carbonized shale material contained less water because it contained too much of fragments. Even for same material, carbonized shale, the moisture differed possibly caused by different location on the slopes. Some material contained only 2.1% water where vetiver appeared wilt under high temperature. Field investigation showed that the growth of vetiver differed with landform. It grew better on the foot and middle of the mountain because soil there was thicker than the upper part (Fig.3). But general speaking vetiver grew much better than other plants. On 11-17 July when air temperature reached 39C (the highest temperature in the recent 10 years), only part of the vetiver shoots appeared yellow and wilt, while the whole plant of some *Jasminum mesnyi* and *photinia vagina* appeared yellow and even withered away.

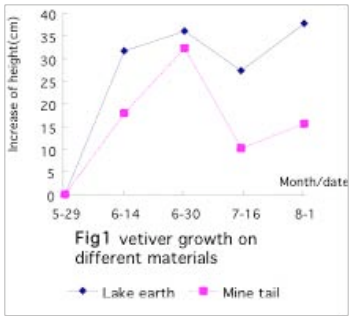

Fig1 vetiver growth on different materials

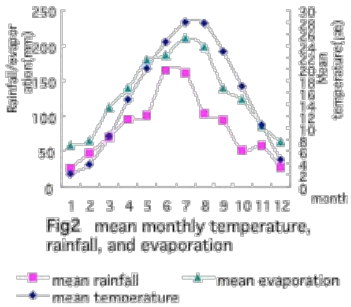

Fig2 mean monthly temperature, rainfall, and evaporation

Table 3 Soil moisture content in summer

Mine tails	depth （cm）	Wet weight （g）	Water content （g）	Water content （%）
Earth from lake	0-20	25.59	2.38	9.3
	20-40	57.58	5.99	10.4
Carbonized shale (no vetiver wilt)	0-20	36.84	2.26	6.1
	20-40	33.04	2.48	7.5
Carbonized shale (no vetiver wilt)	0-20	49.40	1.98	4.0
	20-40	42.70	3.02	7.1
Carbonized shale (some vetiver wilt)	0-20	71.78	1.5	2.1
	20-40	59.41	3.86	6.5

Samples collected on 5 August, 2002

2.3 Effect of vetiver on micro-ecology

Many study showed that vetiver hedge can improve micro-ecology and therefore can promote other plants to grow up [3]. It was

Many study showed that vetiver hedge can improve micro-ecology and therefore can promote other plants to grow up.[1,2] It was proved by present study. On the carbonized shale slope four 2x2㎡ plots were taken at random at both with and without vetiver hedges to measure vegetation coverage. It showed that with vetiver hedges the vegetation coverage reached 92%, while the ground without vetiver hedges was only 45%. In addition, the former contained multiple plant species, while the latter consisted of only wormwood. It is because vetiver hedges stopped fine earth and runoff and therefore improved soil moisture and other properties that were beneficial to other plants.

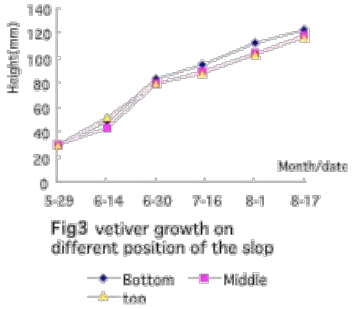

Fig3 vetiver growth on different position of the slop

3. Conclusion

(1) Although it was very difficult for plant to grow on the dolomite mine tails that had different mechanical and chemical properties, vetiver grew quite well on the different materials. There was little different on vetiver growth on different mine tail materials except for lake earth that was transported there from a lake. Just like on highway and railway embankment vetiver hedges formed in three months. It was proved again that vetiver is an excellent pioneer plant for waste mountain re-vegetation.
(2) Vetiver had wide tolerance and could improve ecological environment in short time in order that other plants can grew up the ground surface can be re-vegetated.
(3) Vetiver had high adaptability and can grow well on different materials. It is un-necessary to add soil to mine tails when planting. Although it grew better on lake earth, it grew even better than other plants on mine tail. Vetiver had well developed roots in just two months after planting and can fix soil solum from moving.
(4) Although vetiver is a heliophile it could grew well under young popular trees
(5) Based on this study and many other studies, vetiver can be planted in March, April, May, June, and September. The best time is March and April because within this period there is rainfall, weak sun shine, and low evaporation. Once the grass survived it can enter a fast growing period under higher temperature. I would grow slowly when the temperature near 40°C in July and possibly August. It can be planted without watering and can reach highest survival rate.

4. References

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Dolomite tailings on Mofu Mountain, Nanjing China. Before treatment with vetiver

Part of the slope after treatment

Well grown vetiver on mid-slope Note the steepness approx 60% plus

Root development in dolomite chip matrix

Other plants establishing between vetiver rows

Other creeping plants establishing between vetiver rows

A nice combination of vetiver and trees on the lower slopes of the tailings.