Bangladesh J. Bot. **52**(2): 487-493, 2023 (June) Special DOI: https://doi.org/10.3329/bjb.v52i20.68199

EFFECTS OF ADDING LOOSE MATERIALS ON IMPROVEMENT OF THE PHYSICAL PROPERTIES OF SEDIMENT AND GROWTH OF GREEN PLANTS

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Keywords: Loose materials, Sediment, Ryegrass, Physical properties

Abstract

Effects of different loose materials on the growth of green plants in the sediment and the improvement of the physical properties of the sediment were studied in pot experiments. Two types of loose materials, vermiculite and shale, were chosen. The addition ratio of loose materials and sediment were set to 1:1, 1:2, 1:5. Results showed that, the sediment after adding vermiculite was more conducive to the growth of ryegrass, and when the addition ratio was 1:1 and 1:2, the growth conditions of ryegrass were the best. The fresh weight of ryegrass in the treatment with the ratio of vermiculite and sediment at 1:1 increased by 43.94% compared to that in pure sediment; In the treatment with the ratio of 1:2, the plant height increased the most, which was 6 cm higher than that in pure sediment; When large amount of loose materials were added, the moisture content of the sediment increased compared to the pure sediment treatment; after the addition of loose materials, the bulk density of the sediment decreased, and the addition of too large amount would easily lead to a low bulk density, which was not conducive to water and fertilizer retention; The addition of vermiculite can reduce the bottom sediment.

Introduction

The resource utilization of river sediment is the fundamental measure to solve the problem of sediment outlet (Li 2017, Yan 2017, Chen 2018, Feng 2018, Lu 2018). Addition of sediment to soil for resource utilization is a positive and effective method for sediment disposal. The method is to use the macronutrient elements and rich organic matter contained in the sediment for improving the soil structure and supply plant nutrients (Yang 2008). The eutrophic nature of the sediment containing organic matter, nitrogen and phosphorus and other nutrients, is a fertilizer resource that can meet the nutrients required for plant growth. Its components including a large amount of clay lost from the land surface and abundant secondary minerals, is a good renewable resource (Zhao and Wang 2008, Jiang 2015). However, existing studies have shown that when the bulk density of the sediment is relatively large, the porosity is small, and the clay content is high, and there is a disadvantage of poor water permeability and ventilation. This condition is not conducive to the normal growth of plants to a certain extent, and has formed a great impact on the development of sediment resource utilization causing big hindrance. For example, Hu (2005) studied the physical properties of the sediment in a certain reservoir, and the results showed that the bulk density, porosity and texture of the sediment did not meet the soil physical properties standards that are

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conducive to crop growth in the dryland ploughing layer. Wang *et al.* (2019) measured the physical properties of sediment samples from the upper, middle and lower reaches of the Wuyuan River in Haikou City and showed that the porosity of the upper and lower sediments was low, resulting in compact sediment and low water holding capacity, which was not conducive to the development of plant roots; Xie (2017) determined the basic physical and chemical properties of the sediment in a river channel in Ma'anshan City where the results showed that the bulk density of the sediment in the river section with high flow velocity is 1.20g/ml, which is more than double that of other river sections, and the relative water holding rate of the sediment remains at 91%. It is about 41% higher than the 50% water holding rate of ordinary soil, and it needs to undergo preliminary drying treatment to meet the requirements of planting green plants. Therefore, measures should be taken to effectively improve the texture of the sediment, reduce the bulk density, and increase the porosity in the agricultural utilization of the sediment, so as to improve its air permeability and water permeability to meet the needs of plant growth.

Thus in the present study the commonly used loose materials were used as additives to improve the physical properties of sediment. Through pot experiments, the type and amount of loose materials that are most suitable for plant growth were studied, and the mechanism of loose materials to improve the physical properties of sediment was also explored. The problem of resource utilization provides a scientific basis.

Materials and Methods

In the present experiment polyethylene plastic flower pots of uniform size were used. The planting soil structure used in the experiment were the bottom 10 cm is loess, and the upper 10 cm is the bottom mud of the Shichuan River in Shaanxi with different loose materials. There are three types of vermiculite, shale, and mixture (vermiculite and shale are evenly mixed), of which shale is gray or black shale with high organic matter content. The planting soil and bottom mud were naturally air-dried, ground, and passed through a 2 mm sieve for use. The particle sizes of three types of loose materials were all 2-5 mm. The growth cycle and characteristics were considered comprehensively. The grass ryegrass was used as an indicator plant, and the amount of water and fertilizer were kept the same for each treatment during the growth of potted plants.

The loose materials used in this experiment were 3 types: vermiculite, shale, and mixture (the vermiculite and shale are evenly mixed). For each treatment, the control treatment was set to be 10 cm of loess at the bottom + 10 cm of bottom mud at the upper part, and each treatment was repeated 3 times, with a total of 30 potted plants. The experimental design is shown in Table 1.

Table 1. Experimental design.

Treatment number	Loose material type	Loose material to sediment volume ratio	Treatment number	Loose material type	Loose material to sediment volume ratio
1	Vermiculite	1:1	6	Shale	1:5
2	Vermiculite	1:2	7	Mixture	1:1
3	Vermiculite	1:5	8	Mixture	1:2
4	Shale	1:1	9	Mixture	1:5
5	Shale	1:2	Ck	/	0:1

CK = Pure sediment.

In order to compare the experimental treatments that are most suitable for plant growth, the plant growth status index was used as the evaluation object, the plant height was regularly monitored after emergence. The plant biomass was measured after harvest to comprehensively evaluate the plant growth status. For the sediment added with loose materials, the measured physical indicators include bulk density, water content, and texture to comprehensively evaluate its physical properties. All data were sorted by EXCEL 2010, and SPSS 19.0 was used for analysis of variance and multiple comparisons, and EXCEL 2010 was used to draw graphs.

Results and Discussion

Figure 1 showed the results of the fresh weight of ryegrass under different treatments when the loose material and the bottom mud were evenly mixed. It can be seen from the figure that after planting with pure bottom mud, the fresh weight of ryegrass was 29.56g. After the addition of 3 kinds of loose materials to the bottom mud, mixing them evenly and planting ryegrass, the fresh weight of ryegrass increased significantly, and the greater the amount of addition, the greater the increase. Under the treatment of vermiculite: sediment = 1:1, the fresh weight of ryegrass (42.55 g) increased by 43.94 % compared to that of ryegrass planted with pure sediment. Under the treatment of vermiculite: sediment = 1:2, the fresh weight of ryegrass (41.05 g) increased by 38.87 compared to the control treatment. Under the treatment of vermiculite: sediment = 1:5, the fresh weight of ryegrass (38.26 g) increased by 29.43 % compared to the control treatment. The increase in fresh weight of ryegrass under the treatment of adding vermiculite was greater than those of under the treatments of adding shale, and the increase of fresh weight of ryegrass under the treatment of adding the two mixtures is middle. The fresh weight of ryegrass increased by 43.94% under the shale treatment, the fresh weight of ryegrass (36.44g) increased by 23.27%, and the fresh weight of ryegrass (38.25g) increased by 29.40 % under the two mixture treatments. From the analysis of the significant difference results, it may be concluded that under the treatments with the ratio of loose material and sediment at 1:1 and 1:2, there were no significant differences in the fresh weight results. Wang (2017) showed that when the bottom mud and sawdust in different proportions was mixed to plant tall fescue, there was increase of sediment content. The dry weight and fresh weight of *Festuca arundinacea* were generally promoted first and then inhibited, and reached the maximum value in the experimental group with 40% sludge content.

Figure 2 showed results of the last measurement of the plant height of ryegrass under different treatments when the loose materials and the sediment were evenly mixed. It can be seen from the figure that the plant height of ryegrass after planting ryegrass with pure sediment was 28 cm, and the plant height of ryegrass increased with the addition of vermiculite, and the plant height (34 cm) increased maximum when the ratio of vermiculite to sediment was 1:2, which was 6 cm higher than that of pure sediment. Under the addition of shale, the plant height of ryegrass increased by 2 cm compared to the control under the shale and sediment ratios of 1:1 and 1:2, but the plant height of ryegrass decreased in the 1:5 treatment. The plant height of ryegrass did not change much under the two mixture treatments. Wang (2017) reported that the experimental group with sludge content of 10 - 40% had a significant effect on the seedling height of *Festuca arundinace*a.

Table 2 showed the results of determining the moisture content and bulk density of the sediment after planting ryegrass under different treatments. The moisture content of the pure sediment after planting was 13.65%, and the bulk density was 1.356 $g \cdot cm^{-3}$. It is apparent from Table 2 that when the amount of loose material was huge, the water content of the sediment was higher than that of pure sediment. When the ratio of loose material and sediment was 1:1, the water content of vermiculite was higher than other materials. Adding loose materials can reduce

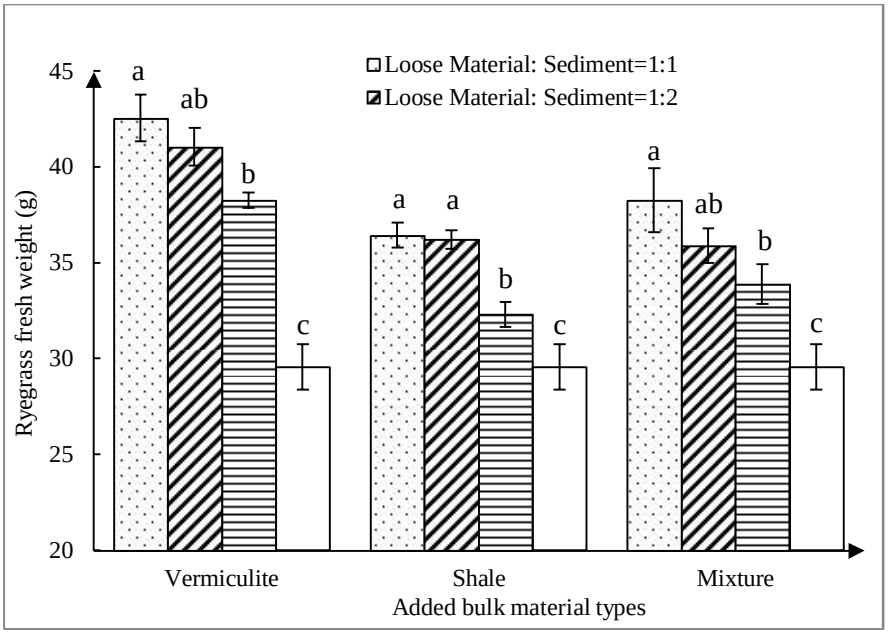

Fig. 1. Fresh weight of ryegrass under different treatments when loose materials and sediment were evenly mixed.

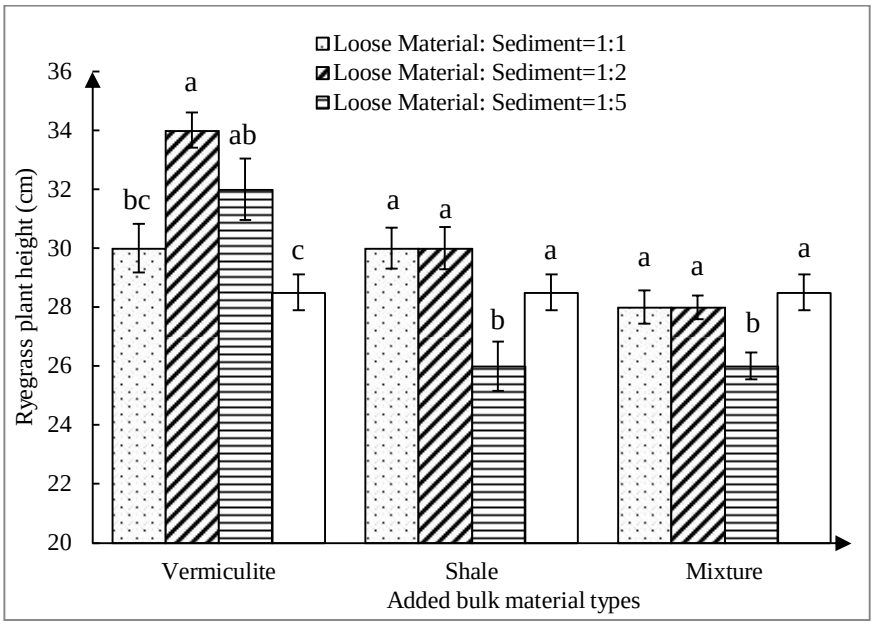

Fig. 2. Plant height of ryegrass under different treatments when loose materials and sediment were evenly mixed.

soil bulk density, which is conducive to water permeability and ventilation. If the addition amount is too large, it will easily lead to low bulk density, which is not conducive to water and fertilizer retention. The bulk density of vermiculite: sediment = 1:5 treatment was 1.24 $g \cdot cm^{-3}$, and the bulk density of vermiculite: sediment = 1:1 treatment was less than 1. The bulk density of shale: sediment = 1:5 was 1.25 $g \cdot cm^{-3}$, and the bulk density of shale: sediment = 1:1 was only 1.07 $g \cdot cm^{-3}$. The law is consistent under treatment mixture. It was observed that addition of vermiculite can reduce the clay content of the sediment and increase the sand content of the sediment (Table 3).Wang *et al.* (2012) investigated effects of addition of different proportion of half-composting corn stalks fertilizer，rice husks and river sand on improving the soil permeability in coastal silty muddy soil. Results showed that the water infiltration rate and water leakage amount per unit time after the application of the river sand were not significant in comparison to the control. The water infiltration rate and water leakage amount per unit time after the application of the rice husks were significantly higher than the control，but far less than applied half-composting corn stalks fertilizer in soil.

Table 2. Moisture content and bulk density of sediment after planting ryegrass under different treatments.

Type of loose materials	Vermiculite		Shale		Mixture	
Loose materials and Sediment mixing ratio	Moisture content	Bulk density（g/cm^3）	Moisture content	Bulk density (g/cm^3)	Moisture content	Bulk density (g/cm^3)
1:1	22.15%	0.9658	17.33%	1.0742	19.34%	1.0309
1:2	10.78%	1.0373	14.52%	1.2345	17.63%	1.1508
1:5	13.95%	1.2376	11.98%	1.2505	10.51%	1.2594

Table 3. Mechanical composition of sediment after planting ryegrass under different treatments.

	Cosmid (<0.002 mm %)	Powder (0.02~0.002 mm %)	Grit (2~0.02mm %)	Texture
Pure bottom mud	12.29	73.04	14.67	silty loam
Vermiculite: Bottom mud = 1:1	5.04	42.44	52.52	sandy loam
Vermiculite: Bottom mud = 1:2	8.56	61.57	29.87	silty loam
Vermiculite: Bottom mud = 1:5	11.34	75.85	12.81	silty loam
Shale: sediment = 1:1	12.08	67.56	20.36	silty loam
Shale: sediment = 1:2	12.92	77.05	10.03	silty loam
Shale: sediment = 1:5	19.13	64.19	16.68	silty loam
Mixture: Sediment = 1:1	15.60	71.10	13.30	silty loam
Mixture: Sediment = 1:2	12.91	75.77	11.32	silty loam
Mixture: Sediment = 1:5	14.37	62.84	22.79	silty loam

From the present study it may be concluded that from the standpoint of plant height and fresh weight of ryegrass, addition vermiculite to the sediment was more conducive to the growth of ryegrass, and the growth conditions of ryegrass are the best when the addition ratio was 1:1 and

1:2. As a soil conditioner, vermiculite has great effects on the nutrition of the soil. It can loosen the soil, has good air permeability and strong water absorption. It is especially effective for the dense sediment.

It was also found that when the amount of loose material added was large, the water content of the sediment was higher than that of pure sediment. When the ratio of loose materials and sediment was 1:1, the water content of vermiculite was the highest compared to other materials. Addition of loose materials can reduce soil bulk density, which was conducive to water permeability and ventilation. If the addition amount was too large, it will easily lead to low bulk density, which was not conducive to water and fertilizer retention. The addition of vermiculite can reduce the clay content of the sediment and increase the sand content of the sediment.

Due to its eutrophication, sediment is one of the materials for improving urban greening soil. However, due to its large volume and small porosity, it has the disadvantage of poor water permeability and ventilation, which is not conducive to the normal growth of most plants. In the present study, by adding loose materials the physical properties of the sediment, the types and proportions of loose materials suitable for the growth of ryegrass were analyzed. Results provided a basis for scientific issues such as resource utilization of sediment and utilization of sediment for improving urban greening soil. The clay content of the mud can increase the sand content of the sediment and effectively improve the texture of the sediment. The research results can provide theoretical support for the scientific issues related to the improvement of urban greening soil by the sediment.

Acknowledgements

This study was financed by Shaanxi Provincial Science and Technology Plan Project，Key R&D projects (2022ZDLSF06-04), Innovation Capability Support Program of Shaanxi，Construction of Shaanxi soil mass quality detection and evaluation sharing platform (2021PT-053)，Technology Innovation Center for Land Engineering and Human Settlements, Shaanxi Land Engineering Construction Group Co., Ltd. and Xi'an Jiaotong University (2021WHZ0090), and Shaanxi Provincial Land Engineering Construction Group internal research project (DJTD 2022-4).

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(Manuscript received on 01 June, 2022; revised on 10 June, 2022)