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Evaluation of the vegetable mulch produced from Eremurus spectabilis on soil erosion control

A. Amraei* , B. Dahrazma

Department of Civil Engineering, Shahrood University of Technology, Shahrood, Iran

ABSTRACT: One of the main challenges of arid and desert regions is to control wind erosion that can cause significant economic and environmental damage. The present study aimed to stabilize erosion-prone soil using a vegetable mulch prepared from Eremurus spectabilis root powder. The effects of concentration and amount of mulch spraying on the soil erosion were investigated. Also, the penetration and reduction of the thickness of the fixed layer against wind speeds of 6, 9, 12 and 15 m/s for 5 minutes were studied in the wind tunnel. Finally, EC, pH, salinity and other soil elements were tested to evaluate the environmental impact of mulching. The results showed that increasing the amount of mulch spraying results in more mulch penetration in the soil and increasing the mulch concentration, despite reducing the depth of its penetration into the soil due to increasing the amount of adhesion between the soil particles, its greater resistance to wind erosion. In addition, based on the results, mulches with concentrations of 0.2, 0.6 and 0.7% can stabilize the soil against the wind stream, up to a maximum of 9, 12 and 15 m/s, respectively. Generally, the mulch is environmentally friendly and is an appropriate option for controlling the erosion of wind erosion-prone soil.

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1. INTRODUCTION

Today, arid and semi-arid areas account for about one-third of the Earth's surface, and more than a quarter of the world's drylands are affected by the phenomenon of desertification. Wind erosion and the formation of dust from it are an important indicator of the occurrence of desertification and a serious threat to arid areas [1-3].

One of the most important causes of wind erosion is wind speed and soil texture in an area [4, 5]. Dust storms usually occur in areas with high volumes of sand and gravel. These types of soil are easily displaced by wind due to low adhesion between particles and low specific gravity. Therefore, to prevent wind erosion, it is necessary to increase the friction between the particles of the soil by creating adhesion between them [6]. To stabilize the soil, various physical methods (such as plowing of the earth), chemical (such as oil and polymer mulch) and bio (such as planting and using natural mulches) are used, which have advantages and disadvantages [1, 7, 8].

The purpose of this study was to evaluate the performance of a vegetable mulch made from Eremurus spectabilis root powder for fixing and bonding particulate matter susceptible to wind erosion. For this purpose, by providing different concentrations of mulch and spraying it on the soil, its ability to control the amount of soil erosion at various wind speeds by the wind tunnel has been investigated.

*Corresponding author's email: Amir.engineer1994@gmail.com

2. METHODOLOGY

The soil used in this study was a fine-grained soil, which was prepared from the depth of 0-10 cm of the soil surface of the border regions of Iran and Turkmenistan.

The amount of powder required for the preparation of mulch in each test was weighed using a scale and placed into a beaker. Then each of the beakers was placed on the styrene and the amount of water required at 25 °C was added gradually and simultaneously by mixing the sample to produce mulches at a concentration of 0.1 to 0.7%. The sample was stirred for 1 minute at 500 rpm. The resulting mulch was put on standstill for 1 minute.

The soil was poured from the sieve No. 10 into a tray measuring 20×30 cm^2 and a depth of 2 cm. And its surface is perfectly flattened [9]. Then the desired mulch with a different amount of spraying was 15 and 25 mL (equivalent to 250 and 420 mL/m^2, respectively), at the height of 50 cm [1] on the surface of the soil inside the tray using a fully uniform spray Was split [7]. The mulching samples were immersed in the oven for 48 hours at 50°C (proportional to the maximum absolute temperature of the study area) so that the added water evaporated and the moisture content of the sample reached the initial moisture content of the soil [7, 8]. To obtain sample and laboratory temperature uniformity, the sample was placed in the laboratory for 3 hours.

To determine the resistance of treated and untreated samples against wind erosion, each of the samples was placed in

Fig. 1. Wind tunnel used

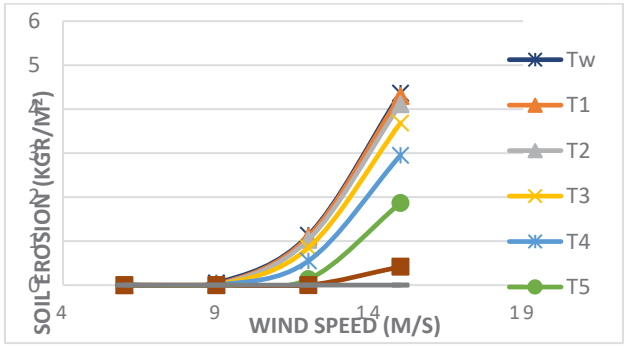

Fig. 2. The amount of erosion of treated soils in the amount of spraying of 25 mL, the sample was placed for 5 minutes against different wind speeds.

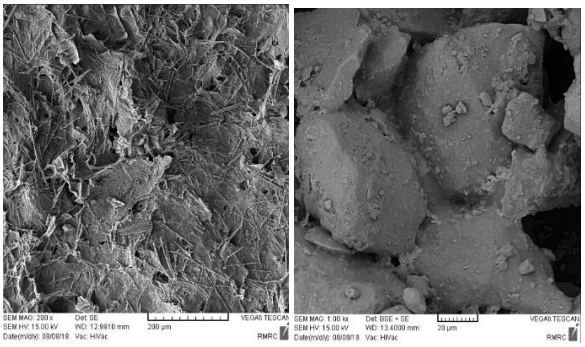

Fig. 3. SEM analysis results left picture. The sample treated with selected mulch (concentration 0.7%); the right picture. Control sample treated with water

the wind tunnel for 5 minutes against each of the wind speeds of 6, 9, 12 and 15 m/s [6-8]. To determine the amount of eroded soil, each sample was weighted before and after being placed in a tunnel. The difference in sample weight before and after the wind erosion test indicates the amount of soil erosion during the test [1, 7]. Figure 1 shows the wind tunnel used.

In addition to the above mentioned, environmental experiments and XRD[1] and SEM[2] analyses were performed on soil samples before and after mulch spraying.

3. RESULTS AND DISCUSSION

Based on the results of soil mechanics experiments, the studied soil has a low Plastic Limit and it is a silty soil with low organic matter content, the specific gravity of 2.69 and moisture content of less than 1 percent.

Based on the results of soil erosion experiments, mulch with a concentration of 0.2% can be used to prevent soil erosion against wind speed of 9 m/s. With increasing wind speed to 12 m/s, mulches with a concentration of 0.2-0.5% do not have sufficient durability and to avoid soil erosion requires the use of mulch at a concentration of 0.6%. In spite of the acceptable resistance of mulch made at 0.6% vs. wind speeds of 12 m/s, the mulch lost some of its resistance to winds at a speed of 15 m/s and some soil erosion occurred at this speed. Mulch with a concentration of 0.7% was selected and a spray amount of 25 mL could reduce the amount of wind erosion in front of the winds with the velocity up to 15 m/s. Accordingly, the amount of dust produced was also zero in the sample treated with the selected mulch. These results showed the effectiveness of the vegetable mulch with different concentrations in controlling wind erosion. The results of these experiments were shown in Figure 2.

The results of XRD analysis have shown that the addition of mulch to soil increases the amount of SiO_2 in the soil and thus increases the shear strength of the soil, yields higher in the stabilization process and helps to solidify the soil. Also, the mulch had the least negative effect on the soil structure and did not produce any toxic substances in it. Additionally, the amounts of pH, EC and soil salinity did not change after the mulching process. The results showed that the used mulch was completely environmentally friendly.

The results of the SEM analysis revealed the formation of a coating layer on the surface of the soil and the creation of adhesion and bonding between soil particles through the use of vegetable mulch. It is worth noting that the effect of mulch on the formation of a stabilized layer on the surface of the soil was much greater than water (control sample). The SEM analysis results were shown in Figure 3.

4. CONCLUSIONS

In general, it can be stated that the vegetable mulch made from the root powder of the plant created a soil-resistant coating, therefore had a high ability to stabilize fine-grained soils against erosion. Environmental and economic considerations of the process including easy growth, resistance to dehydration, cheapness, and availability, as well as easy preparation of mulch, made the mulch more practical.

Considering the compatibility of the mulch with the environment, it is suggested that future research be carried out to optimize the conditions for the use of the mulch in areas with dust pollution.

1 X-ray diffraction
2 Scanning Electron Microscopy

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