

Research and Design of Ecological Restoration Machinery for Rock Desertification--Multifunctional Mountain Seeder

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Abstract. A grassland carbon sink is a grassland planting activity with special requirements to implement carbon sink measurement and monitoring of the growth process of forage grasses on the land where the baseline has been determined, with the main purpose of increasing carbon sink. The development of grassland carbon sink is extremely beneficial to achieve the two important deployments of carbon peaking and carbon neutrality. Grasslands with one-fourth area in the south are limited by the rugged topography of the karst landscape and thin soil layer, and the efficiency of pasture planting is low. For the above problems, our team proposes a design around mountain pasture cultivation to reduce carbon emissions and apply it to increase carbon sinks in grasslands of stone desertification areas. The design can provide a concrete solution for restoring the ecological environment and enhancing the carbon sink capacity of grassland in stone desertification areas, and also provide a technical guarantee for local herders to increase their income and productivity. This work has the advantages of high market potential, low cost, composite multi-functional automatic operation, and high planting efficiency with a small size, which has good promotion value. It effectively reduces carbon emissions while improving vegetation cover and establishes a new model of combining green restoration and agricultural production in mountainous areas.

1. Introduction

On September 22, 2021, the "Opinions of the Central Committee of the Communist Party of China (CPC) and the State Council on the Complete and Accurate Implementation of the New Development Concept for Carbon Neutrality" clearly pointed out that "the incremental amount of carbon sinks in the ecosystem should be enhanced. At the National People's Congress in 2022, Wang Zhaoming, a member of the National Committee of the Chinese People's Political Consultative Conference (CPPCC), suggested building a national grassland carbon sink standard system to account for the value of grassland carbon sinks and support the development and utilization of grassland carbon sinks[1-3].

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With the full implementation of the rural revitalization policy, consolidating the results of poverty eradication in vast rural areas is getting more and more attention[4]. The problem of stone desertification in the rural karst areas of southwest China, where agricultural income is the main source of income, is becoming more and more serious and has seriously affected the local

agricultural production and the living environment of residents. China has nearly 400 million hm^2 of natural grasslands, accounting for 41.7% of the country's land area, which is the largest carbon reservoir in China; one hectare of grassland can sequester 1.5 tons of carbon and release 2.8 tons of oxygen, which plays a pivotal role in the construction of national ecological security.

The carbon sequestration rate of artificially planted grassland in the IPCC report is $0.54\text{t C}/(\text{hm}^2/\text{year})$ [5,6]. However, the grasslands in the stone desertification areas of southwest China are limited by the rugged topography of the karst landscape and thin soil layer, and the planting rate of forage grass is extremely low.

In summary, this work designs a multifunctional forage seeder for the stone desertification terrain of Guangxi mountains to improve the forage planting rate, effectively neutralize carbon emission, and strive to enhance the carbon sink capacity of grassland to help achieve the goal of "double carbon".

2. Field Research

Based on the research results, we analyzed the stone desertification areas by using the AHP statistical method. Since the "carbon neutral" policy is a top-level design based on the overall environment, but there are great differences in geographic environment and industrial base in different regions, the specific implementation under the general direction is different, which also leads to the direct perception of the environment on the

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effectiveness of the policy implementation and the expectations of the outside world. Therefore, the team adopts the AHP hierarchical analysis method to objectively reflect the actual perceptions of different policy effectiveness at different levels of society, and to provide practical references for regionalized and customized policy formulation and implementation of "carbon neutral" strategies in the future. Combined with the research results of the Huanjiang Karst Research Institute of the Chinese Academy of Sciences, the following conclusions were drawn: first, the rate of manual carbon sink management of rocky desertification is slow and far from suitable for the environmental management of rocky desertification; second, the potential of grassland carbon sink is huge, and each hectare of grassland can reduce 3 tons of carbon emissions, which has a huge prospect of carbon sink.

3. Theoretical calculation

China's grassland vegetation biomass accounts for 10.3% of the total national biomass and grassland soil carbon storage accounts for 36.5% of the total national soil carbon storage[7-9]. Under the current scenario, China's 392.8 million hectares of natural grasslands can sequester about 520 million tons of carbon per year, equivalent to an annual reduction of 2,710.3 million tons of carbon dioxide. Under the planning scenario, if the combined grassland coverage increases to 57% in the 14th and 15th Five-Year Plans, the amount of carbon sequestered by grasslands increases This is equivalent to a reduction of 3.775 billion tons of CO₂. The potential of grassland carbon sinks in rocky desertification areas is huge.

Table 1. Grading criteria of stone desertification intensity in pure carbonate karst area.

strength grade	Evaluation factor	
	The average thickness of soil layer /cm	Agricultural utilization value
Moderate desertification	<10	Difficult to use
High desertification	<5	Difficult to use
Extreme desertification	<3	Unusable value

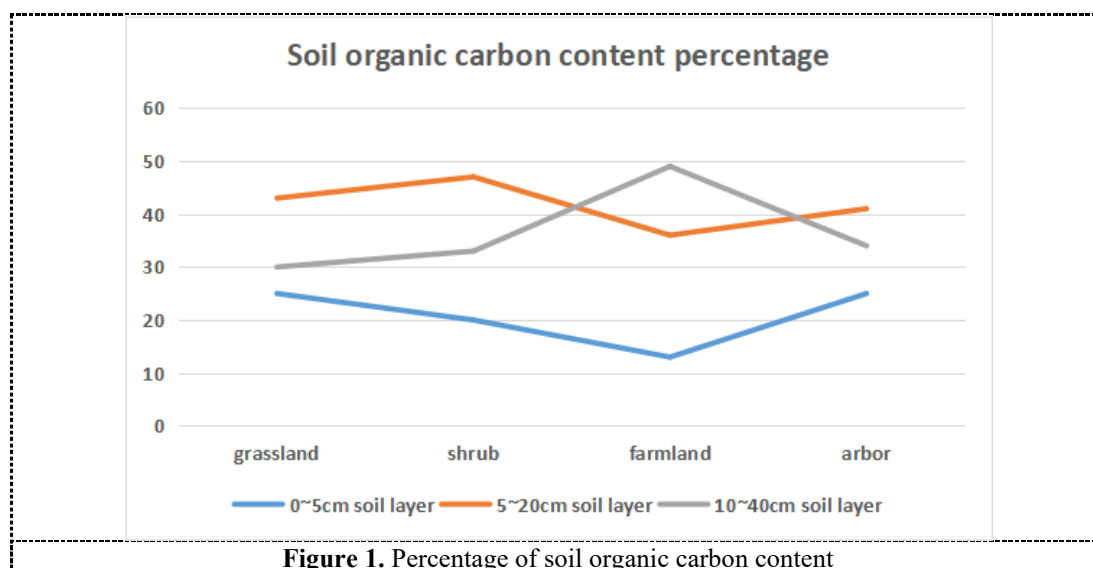


Figure 1. Percentage of soil organic carbon content

3.1. Forage selection

According to the literature[10], *Gordonia* can be sown when the topsoil temperature reaches 12-16°C and has a longer nutritional growth period. After the research, the local climatic conditions and the climatic conditions required for the growth of various forage types of grass, such as alfalfa and other grasses cannot adapt to the growth environment of rocky desertification areas, and finally, choose Gaodan grass as the grass species.

3.2. Program test

The terrain was prepared outdoors, limited to a fixed 10*10m area with 37 large stones and several small

stones, with a slope of about 18° and sandy soil. The actual results of the field experiment (late June, 34° C, sunny, southern Qinling Mountains) were as follows: the number of holes was stable at 350-360, the average speed was about 18s, and the number of pits avoided was stable at 34-36.

The team conducted several field experiments to simulate the typical working conditions of the seeder outdoors, based on a simulated terrain with sandy soil of 10m*10m and a slope of about 18 degrees, and calculated the efficiency of the seeder based on the simulated data. It was measured that the seeder could complete a complete sowing operation every 18 seconds on average, and 34-36 effective forage units could be completed in a 10m*10m area on average, while the carbon sequestration per unit leaf area of *Gordonia* spp.

The amount of carbon sequestered per unit leaf area of *Gordonia* spp. selected according to the suitable forage type in rocky desertification areas was 23.79 kg/m² -day.

Let the amount of carbon sequestered per hectare be *W*, the time to complete a single sowing action be *t*, the number of effective units of forage planted be *S*, and the amount of carbon sequestered per unit leaf area be *a*. Assuming that each effective forage unit can produce an effective leaf area of 1 m², the theoretical calculation of carbon sequestration based on 1 hectare is as follows:

$$W=(10000 \times S \times a \times t) / 100$$

The estimated amount of carbon sequestered per hectare of grassland planted by the seeder working in the rocky desertification area is calculated to be about 3.04 tons

4. Benefit analysis

4.1. Application Prospects

First of all, this work has a wide application prospect. In Guangxi Province, for example, the rocky desertification

Table 2. Comparison of sowing efficiency between manual seeding and seeder.

	artificial seeding	sowing machine
Seeded area		1 acre
Number of seeding points		2640
Seeding time	7.5 hours	5.87 hours
Seeding efficiency	352 /hour	450 /hour

5. Mechanical design

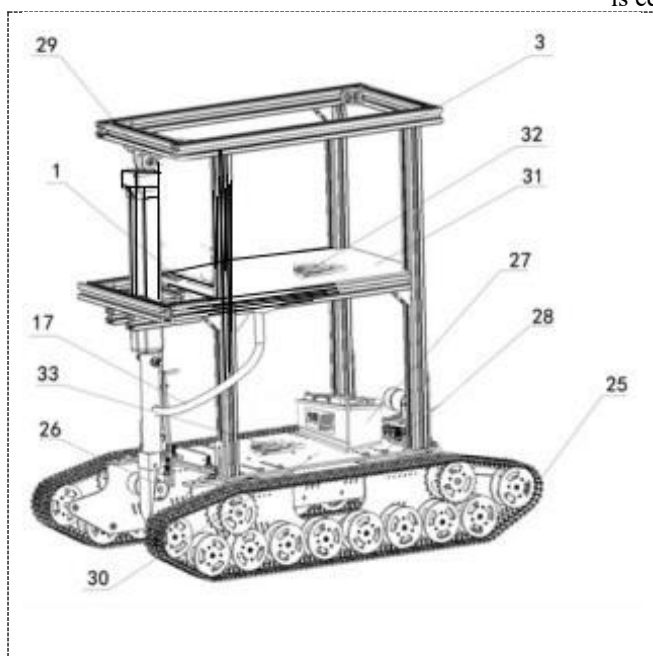


Figure 2. Overall Model

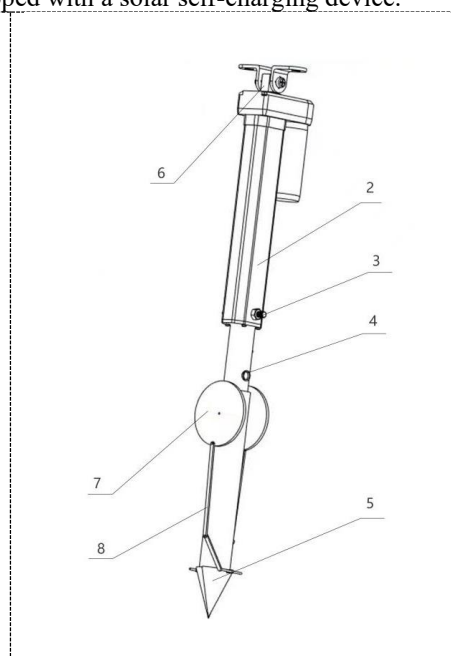


Figure 3. Ecological restoration machine trencher

The specific process of realizing the seeding function is as follows: while the machine is driving in the stone desert area, the digging device is controlled to sink vertically by the fully automatic electric control device such as an infrared transmitter to complete the pit

land in the region is 1.5330 million h m², accounting for 6.5% of the total land area. This part of the land cannot be planted with crops such as rice and corn for a long time (frequent plowing will intensify soil erosion and further expand the area of rocky desertification), and it is not practical to leave a large area unused. According to experience and literature, only pasture or shallow-rooted shrubs can be planted in areas with serious stone desertification. The forage itself can be used as silage for animal husbandry and can keep soil and water, so local farmers in Guangxi mostly choose to plant large forage grasses (affected by the rainy climate, the plants grow vigorously and are large).

4.2. Carbon sink efficiency

The design is fully functional, excellent product, simple operation, multi-functional and automatic operation, more suitable for stone desert rugged terrain than other seeders, and can improve forage planting efficiency 1.277 times than manual.

The multifunctional seeding machine is mainly able to realize the function of digging pits and sowing seeds and is equipped with a solar self-charging device.

opening function; when the expansion shovel expands to the maximum in the pit, the conveyor belt at the bottom of the seed storage bin runs and the grass seed is transferred to the electrically controlled seed rower. Among them, the direct driving of the turntable by the

motor enables stable work in the mountainous area. The grass seed is quantitatively transported along the hose from the seed storage bin to the seeding conduit and falls into the surface pit, completing the entire seeding process. Meanwhile, the seeder contains a solar self-charging module, which uses solar energy for self-charging and assists a self-light-seeking device to improve the efficiency of solar energy utilization and realize partial self-supply of energy.

1) Track structure (Figure 2) Our tracks can travel smoothly in karst terrain, and the track structure adopted can be applied to carry out operations in rocky desertification areas with small stones, which can better meet the movement of rugged roads and ensure the smoothness and reliability of Gaodan grass planting. The track structure is suitable for operation in the rocky desertification area with small stones.

2) Trencher (Figure 3). The trencher is capable of being inserted into shallow soil layers, and the tip casing is tightly wrapped to ensure that seeds do not leak out of the cylindrical conduit when not in operation. When running, the whole seeder is driven by the push rod in a vertical motion, and its deep penetration into the soil layer opens the shell for seed dispersal. Finally, through field research and simulation, it is found that the depth of the soil pit can meet the requirements for planting *Gordonia* seeds

3) Solar self-charging module. Using the head, Esp8266-Nona, and photoresistor to achieve light source tracking, the machine does not work using the head to track the strongest light source, always faces the sun to maintain the charging state, and can provide the maximum power for the power supply, effective use of solar energy, and through the solar self-tracking collection device for each auxiliary system charging energy, a certain degree of energy saving, to achieve the reduction of carbon emissions. The upper limit of theoretical photoelectric conversion efficiency of common silicon solar cells is about 33%, and our team uses commercial silicon solar cells, whose light/electric conversion efficiency is generally 12% to 15%, which can be used as a backup energy source to charge the machine on sunny days. After measurement, the machine can be fully charged in about 60h, which can effectively reduce the use of electricity and reduce the burden of carbon emission.

6. conclusion

Grassland carbon sink is a grass planting activity with special requirements to implement carbon sink measurement and monitoring of the forage growth process on the land with a defined baseline and with the main purpose of increasing carbon sink. Taking grassland carbon sink as an entry point, a new concept of carbon reduction and neutralization in stone desertification areas is proposed by seeking a new method of carbon neutralization and increasing carbon sink in stone desertification areas.

The statistical method of AHP was adopted to analyze the stone desertification area. Based on the AHP hierarchical analysis method, we can objectively reflect the actual feelings of different levels of society on the effectiveness of different policies and then provide a practical reference for regionalized and customized policy formulation and implementation of "carbon neutral" strategies in the future.

Crawlers can cope with rugged terrain and landslides and other unexpected situations. To adapt the product to the rugged terrain of mountainous areas with mixed gravel and soil, we use the track structure for the base drive, which can fully meet the road surface of rocky desertification areas and has advantages in cost and electronic control. Self-charging and self-light-seeking tracking module. As a component of carbon neutrality and carbon emission reduction, it uses reasonable cooperative movement between the rudder and the photoresistor to continuously adjust the solar panel to light movement and maximize the energy utilization of the machine. The machine reduces carbon emissions through the solar module, which realizes the absorption of solar energy during the movement of the machine to provide energy for the machine.

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