Cutting Propagation Technique of *Pennisetum purpureum* Schum

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Abstract [**Objectives**] The paper was to study the cutting propagation technique of *Pennisetum purpureum* Schum and to provide a technical reference for establishing an efficient cutting propagation method. [**Methods**] Six treatments were set up using *P. purpureum* cv. Guiminyin and *P. purpureum* cv. Guimu-1 as test materials, including 1-node oblique insertion, 1-node oblique insertion + rooting powder, 1-node transverse burial, 2-node oblique insertion, 2-node oblique insertion + rooting powder and 2-node transverse burial. The following indices were observed and determined for *P. purpureum* cuttings: emergence rate, rooting rate, root number, longest root length, fresh root weight, plant height, number of tillers, number of leaves, and fresh stem and leaf weight. [**Results**] In the 2-node cutting + rooting powder treatment, Guiminyin and Guimu-1 exhibited the highest survival rate, root growth indices, and stem and leaf growth indices, with the emergence rates of 94.29% and 90.26%, respectively. The 2-node cutting treatment followed closely behind, while the 1-node cutting treatment had the lowest indices. Under the same treatment, Guimuyin exhibited higher mean values for plant height, number of leaves, fresh stem and leaf weight, longest root length, and fresh root weight compared to Guimu-1. However, it had lower mean number of tillers, and emergence rate and rooting rate of the 1-node cutting treatment compared to Guimu-1. [**Conclusions**] The *P. purpureum* cuttings thrived in the 2-node cutting + rooting powder treatment, and the overall cutting effect of Guiminyin was superior to that of Guimu-1.

Key words *Pennisetum purpureum* Schum; Cutting; Propagation; Emergence rate

1 Introduction

Pennisetum purpureum Schum is a perennial tufted herb in the genus *Pennisetum* of the family Gramineae, native to the African tropics, and has been widely cultivated in tropical and subtropical regions of Africa, Asia, the Americas, and Oceania[1]. It has been grown for decades in Guangdong, Guangxi, Sichuan, Yunnan, Guizhou, Fujian, Hunan, Hubei, Jiangxi, Taiwan and other parts of China. The *P. purpureum* plant is tall, resistant to high temperatures, drought, barrenness and biotic stress, with a high biological yield and a wide range of uses. It can be used as fodder for cattle, sheep, rabbits and fish[2], and can also be used for soil and water conservation[1], bioenergy, papermaking, *etc.*[3]. Most research on *P. purpureum* has focused on silage processing, livestock and poultry feeding, and soil remediation of heavy metals.

P. purpureum seeds have very low fruiting and germination rates, with inconsistent maturity periods, and are easily dispersed[4]. Currently, stem cutting and root division are the main propagation methods used in production. Root division is not suitable for large-scale production, and stem cutting is more widely used. However, stem cutting also has some drawbacks, such as easy water loss, high water requirement during drying, slow rooting of cuttings, difficulties in guaranteeing the storage quality of cuttings, and seed stem planting largely limited by time, which affect the popularization and use of *P. purpureum*. Currently, Guizhou Province has developed local standards to standardize and guide production in response to the problem of high demand for *P. purpureum* seedlings and low survival rate of cuttings[5]. By using different culture solutions or hormones, scientists at home and abroad found that the germination rate of *P. purpureum* stems in hydroponic culture treatment (85.7%) was better than those in biogas solution (66.9%) and compound fertilizer treatments (less than 30%)[6]; 200 mg/L proanthocyanidin treatment promoted the rapid rooting of *P. purpureum*[7]; the survival rate of *P. purpureum* nodes immersed in 20% goat urine for 30 min was up to 97.78%, with the root number up to 38.33[8]. The survival rate of *P. purpureum* stem cuttings was not related to seed stem parts[4-9], but was related to the number of nodes in the stem cuttings, with the highest survival rate (94.2%) at one node[4]. Currently, the most commonly used cultivars in Southwest China are *P. purpureum* cv. Guiminyin and *P. purpureum* cv. Guimu-1. To increase the reproduction coefficient of *P. purpureum* and make efficient use of the seed stem, we researched the cutting propagation technique of *P. purpureum*. This technique is significant in addressing the low survival rate of direct planting and insufficient seedlings in production. Additionally, it provides technical references for establishing an efficient cutting propagation method of *P. purpureum*.

2 Materials and methods

2.1 Materials *P. purpureum* cv. Guiminyin and *P. purpureum* cv. Guimu-1 were planted as cuttings in the autumn of 2019 in the fodder grass test base of Baitou Town, Chongzhou City, and had not been mowed or grazed in 2021, with more than 120 d of growth. Among them, the *P. purpureum* cv. Guimu-1 plant was about 3.8 m tall, with a mean stem diameter (second stem node above the ground) of 16.44 mm, and a mean number of stem nodes per plant of 21.7; the *P. purpureum* cv. Guiminyin plant was about 4 m tall, with a mean stem diameter (second stem node above the ground) of

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18.45 mm, and a mean number of stem nodes per plant of 18.7. The rooting powder was 2% indolebutyric acid · naphthylacetic acid (Zhengzhou Zhengshi Chemical Co., Ltd.).

2.2 Experimental site The test was conducted in the fodder grass test base of Baitou Town, Chongzhou City (30°63′ N, 103°60′ E), with an altitude of 560 m. The region belongs to the subtropical humid monsoon climate, with a mean annual temperature of 16.5 ℃, mean temperature of hottest month (August) of 26 ℃, mean temperature of coldest month (January) of 5.5 ℃, extreme high temperature of 36 ℃, extreme low temperature of −4.0 ℃, annual sunshine duration of 1 125 h, annual rainfall of 1 013.5 mm, frost-free period of 284 d, and ≥10 ℃ annual cumulative temperature of 5 548.0 ℃. The soil was an improved paddy soil with pH 6.5, organic matter content of 2.42%, and available N, P, and K contents of 54.1, 11.78, and 89.27 mg/kg, respectively. The experiment was conducted from August 13, 2021 to September 18, 2021.

2.3 Experimental design Six treatments were set up for *P. purpureum* cv. Guiminyin and *P. purpureum* cv. Guimu-1, namely 1-node oblique insertion, 1-node oblique insertion + rooting powder, 1-node transverse burial, 2-node oblique insertion, 2-node oblique insertion + rooting powder and 2-node transverse burial, and there were 3 replications of 20 stem nodes in each treatment group. The soil was plowed and crushed prior to cutting, and the seed stem socket was cut at an oblique angle. A stem node was inserted obliquely into the soil at an angle of 45° to the soil surface, and the soil was pressed tightly by hand. The stem nodes were planted with a plant spacing of 10 cm and a row spacing of 20 cm. The measures should be strictly implemented, such as thoroughly watering the cuttings, paying close attention to watering and moisturizing before seedling emergence, and promptly removing weeds after seedling emergence. The relevant indices were determined uniformly after 36 d of cutting.

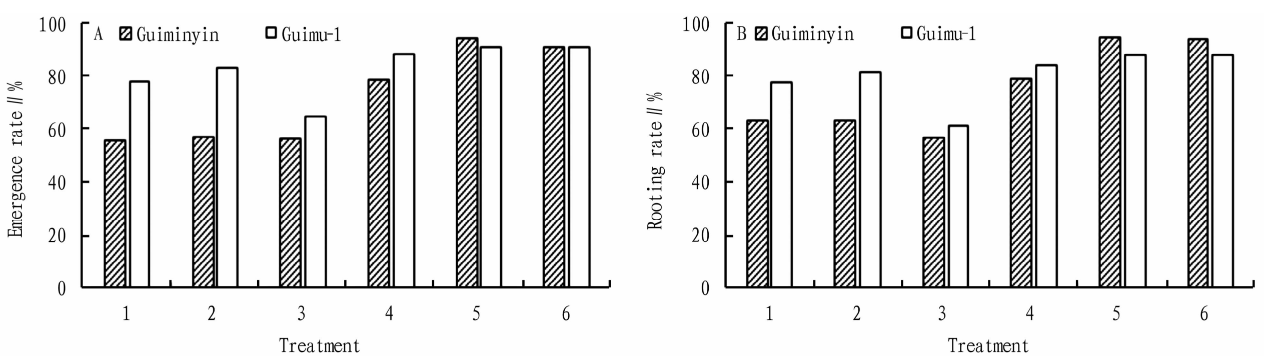
2.4 Index measurement Survival and rooting rates were determined by counting the number of surviving and rooted cuttings in each treatment. Plant height, number of leaves and number of tillers of 20 cuttings in each treatment were randomly measured, and mean values for plant height and number of tillers were calculated. Root number and longest root length of 10 cuttings were randomly examined from surviving plants in each treatment, and mean values for root number and longest root length were calculated. Fresh stem and leaf weight and fresh root weight were measured, and mean values for fresh stem and leaf weight and fresh root weight were calculated.

2.5 Data analysis Excel 2010 was used for data statistics and mapping.

3 Results and analysis

3.1 Effects of different treatments on the survival rate of *P. purpureum* For the same material, different treatments had different effects on the emergence rate of cuttings (Fig. 1A). For Guiminyin, the effects of treatments were in the following order: treatment 5 > treatment 6 > treatment 4 > treatment 2 > treatment 3 > treatment 1, and the emergence rate of treatment 5 was 1.69 times that of treatment 1. For Guimu-1, the effects of treatments were in the following order: treatment 5 > treatment 6 > treatment 4 > treatment 2 > treatment 1 > treatment 3, and the emergence rate of treatment 5 was 1.4 times that of treatment 3. The same treatment had different effects on the emergence rate of different species of *P. purpureum*. Except for treatment 5, the emergence rates of Guimu-1 in the remaining 5 treatments were higher than those of Guiminyin, with the emergence rate of Guimu-1 in treatment 2 being 45.78% higher than that of Guiminyin. Both cultivars had higher seedling emergence rates from the 2-node cutting treatments (treatments 4 − 6) than from the 1-node cutting treatments (treatments 1 − 3), and the treatments with rooting powder added (treatments 2 and 5) outperformed the other treatments with the same number of obliquely inserted nodes.

The effects of different treatments on the rooting rate of Guiminyin and Guimu-1 were basically consistent with the emergence rate, and the rooting rates were 56.67% − 94.29% (Fig. 1B). For different treatments, the rooting rates of both Guiminyin and Guimu-1 were successively treatment 5 > treatment 6 > treatment 4 > treatment 2 > treatment 1 > treatment 3, and the rooting rates of treatment 5 were 1.66 and 1.43 times that of treatment 3, respectively. The rooting rates of the 2-node treatments were higher than



Note: A. Emergence rate; B. Rooting rate. Treatments 1 − 6 are 1-node oblique insertion, 1-node oblique insertion + rooting powder, 1-node transverse burial, 2-node oblique insertion, 2-node oblique insertion + rooting powder, and 2-node transverse burial, respectively. The same below.

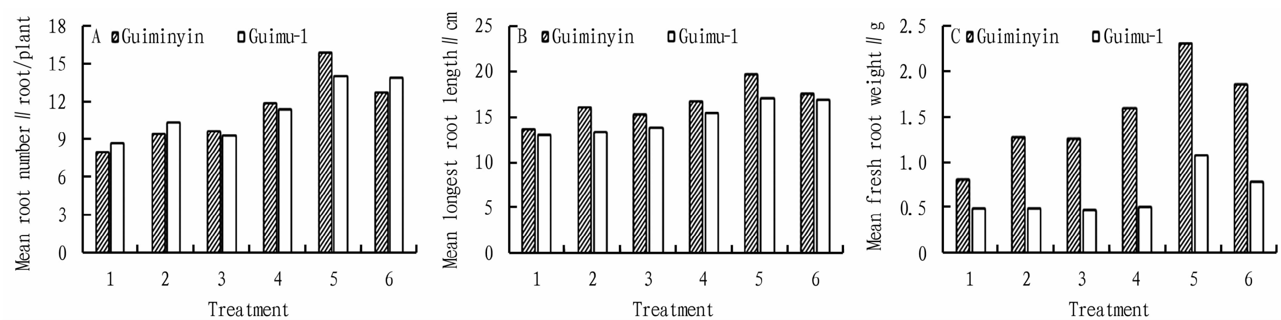
Fig. 1 Effects of different treatments on the survival rate of *Pennisetum purpureum*

those of the 1-node treatments, and for the same number of cuttings, the addition of rooting powder showed better performance than other treatments.

3.2 Effects of different treatments on the root growth indices of *P. purpureum* As shown in Fig. 2A, both Guiminyin and Guimu-1 exhibited the highest mean root number in treatment 5 (16 and 13.97), followed by treatment 6, while the lowest mean root number was observed in treatment 1 (8.13 and 8.71). In general, the mean root number was better in the 2-node treatments (treatments 4 – 6) than in the 1-node treatments (treatments 1 – 3).

As depicted in Fig. 2B, Guiminyin had the largest mean longest root length in treatment 5 (up to 19.67 cm), followed by treatment 6 (17.57 cm), while the shortest was observed in treatment 1 (13.77 cm). The trend of changes among the different treatments of Guimu-1 was the same as that of Guiminyin, where the mean root length of treatment 5 increased by 31.96% compared to treatment 1. The mean longest root length of the 2-node treatments was better than that of the 1-node treatments. In the same treatment, the mean root length of Guiminyin was longer than that of Guimu-1, with the mean root length of Guiminyin in treatment 2 increasing the most compared to that of Guimu-1, which was 21.23%.

As illustrated in Fig. 2C, Guiminyin had the largest mean fresh root weight in treatment 5 (2.31 g), followed by treatment 6 (1.85 g), while the smallest was observed in treatment 1 (0.81 g); Guimu-1 also had the largest mean fresh root weight in treatment 5 (1.07 g), followed by treatment 6 (0.78 g), and the smallest was observed in treatment 3 (0.47 g). The mean fresh root weight of the 2-node treatments was better than that of the 1-node treatments. In the same treatment, the mean fresh root weight of Guiminyin was significantly better than that of Guimu-1. Except for treatment 1, the mean fresh root weight of Guiminyin in the other treatments was 2.20 – 3.14 times that of Guimu-1.



Note: A. Mean root number; B. Mean longest root length; C. Mean fresh root weight.

Fig. 2 Effects of different treatments on the root growth indices of *Pennisetum purpureum*

3.3 Effect of different treatments on the stem and leaf growth indices of *P. purpureum* The mean plant heights of Guiminyin and Guimu-1 were highest in treatment 5 (89.94 and 83.11 cm), followed by treatment 6 (83.11 and 74.88 cm), and smallest in treatment 1 (57.74 and 46.35 cm). Plant height increased with the increasing number of cutting nodes. For the 1-node treatments, the mean plant heights of Guiminyin were successively treatment 2 > treatment 3 > treatment 1, while those of Guimu-1 were treatment 3 > treatment 2 > treatment 1 (Fig. 3A).

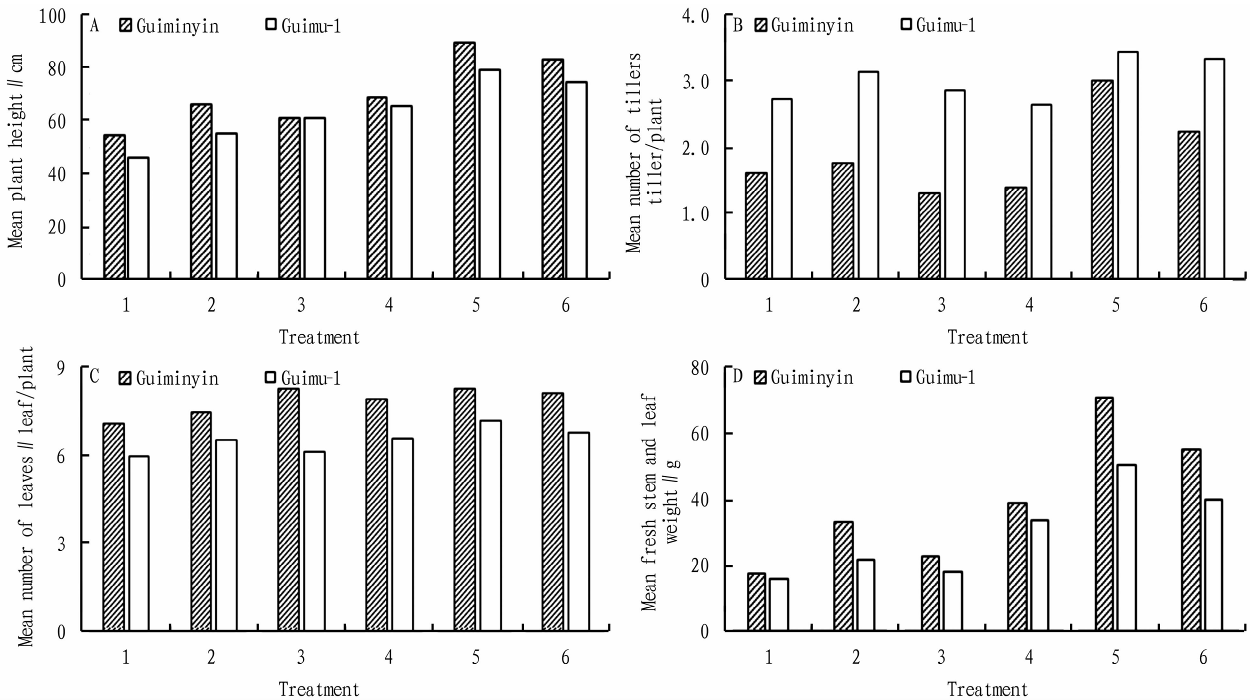
The mean numbers of tillers of Guiminyin and Guimu-1 in treatment 5 were highest with 3.01 and 3.42 tillers per plant, while those in treatment 3 were lowest with 1.32 and 2.37 tillers per plant, respectively. Except for treatment 4 of Guiminyin, the mean number of tillers increased with the increasing number of cutting nodes on the whole. Under the same treatment, the mean number of tillers of Guimu-1 was better than that of Guiminyin (Fig. 3B).

The mean numbers of leaves of Guiminyin and Guimu-1 were highest in treatment 5 (8.22 and 7.13 leaves/plant), and lowest in treatment 1 (7.06 and 5.95 leaves/plant). The mean number of leaves of Guiminyin increased with the increasing number of cutting nodes in all treatments except treatment 3. In the same treatment, the mean number of leaves of Guiminyin was higher than that of Guimu-1 (Fig. 3C).

The mean fresh stem and leaf weights of different treatments of Guiminyin and Guimu-1 were ranked from large to small as treatment 5 > treatment 6 > treatment 4 > treatment 2 > treatment 3 > treatment 1, among which the mean fresh weights of treatment 5 were 4.0 and 3.2 times that of treatment 1. In the same treatment, the mean fresh weight of Guiminyin was higher than that of Guimu-1, with the mean fresh weight of Guiminyin in treatment 2 increasing the most compared to that of Guimu-1, which was 54.95% (Fig. 3D).

4 Discussion and conclusions

4.1 Discussion Due to low seed set and germination rates, *P. purpureum* is mostly propagated asexually in production by stem node cuttings. Survival of *P. purpureum* cuttings and seedling growth and development are affected by several factors. In this experiment, two types of cutting methods were set up: oblique insertion and transverse burial. Under the same treatment, obliquely inserted *P. purpureum* had a higher survival and rooting rate compared to transversely buried *P. purpureum*. Additionally, obliquely inserted *P. purpureum* had better indices for root length, plant height, and fresh stem and leaf weight. This means that under appropriate temperature, oblique insertion of *P. purpureum* stem nodes has a high success rate, but in the actual production, it is necessary to consider the factors such as nursery substrate, cutting season, environmental temperature and humidity. Yuan Jinfu *et al.* [10]



Note: A. Mean plant height; B. Mean number of tillers; C. Mean number of leaves; D. Mean fresh stem and leaf weight.

Fig. 3 Effects of different treatments on the stem and leaf growth indices of *Pennisetum purpureum*

found that the survival rate of *P. purpureum* inserted obliquely (90%) was slightly higher than that of *P. purpureum* buried transversely (87%), but the difference was not statistically significant. Nevertheless, transverse burial is relatively time-consuming in the production, while oblique insertion is easier and more convenient. From the perspective of planting efficiency, oblique insertion is more appropriate, but in case of high temperature, large soil moisture evaporation and insufficient irrigation, transverse burial could be a preferred choice for seedling propagation.

In this study, 2-node stem cuttings were superior to 1-node stem cuttings in terms of survival rate, root growth and leaf growth, which may be attributed to the fact that *P. purpureum* cuttings are usually rooted from spores at the internodes of the stem, and an appropriate increase in the number of spores facilitates the colonization of *P. purpureum*. However, this is different from the study of Luo Fucheng *et al.* [4], which found that *P. purpureum* cuttings had the highest survival rate (94.2%) in the 1-node treatment, and when the stem nodes were increased to 4, the survival rate was only 74.3%. It is speculated to be due to the fact that when new shoots of *P. purpureum* sprout from the incision, it is difficult for the cuttings to maintain their bright green state if the stem segments are too long, and their survival rate will be significantly reduced in case of water imbalance. The differences in the experimental results may be related to the height of the stem nodes in the soil at the time of cutting or different field management. In addition, it has been shown that under soil substrate conditions, *P. purpureum* tends to emerge faster from proximal node stems than from distal node stems, *i. e.*, the more mature the stems, the earlier their axillary buds germinated[6].

Studies have shown that rooting powder can induce the formation of adventitious roots, shorten the rooting time, and increase the survival rate of seedlings by regulating the levels of endogenous hormones as well as the activities of important enzymes in plants[11], which has been reported in many woody and herbaceous plants[11-13]. In this study, the addition of rooting powder significantly increased the survival and rooting rates of Guiminyin and Guimu-1 cuttings and effectively promoted the growth of seedling roots and aerial parts. This was also confirmed by Ge Peiling *et al.* [14] in their study on *Eremochloa ophiuroides*, where the use of rooting agents favored the survival and rooting rates of asexual propagation of stem segments. There are differences in the appropriate concentration, application time and application method of rooting agents for different plants, and further research is needed in practical application.

4.2 Conclusions The results of the cutting propagation experiment for *P. purpureum* cv. Guiminyin and *P. purpureum* cv. Guimu-1 indicate that both cultivars had the best survival rate, root growth indices and stem and leaf growth indices in the 2-node cutting + rooting powder treatment (emergence rate of 94.29% and 90.26%), followed by the 2-node cutting treatment, while the 1-node cutting treatment had the lowest indices. Under the same treatment, Guiminyin exhibited higher mean values for plant height, number of leaves, fresh stem and leaf weight, longest root length, and fresh root weight compared to Guimu-1. However, it had lower mean number of tillers, and emergence rate and rooting rate of the 1-node cutting treatment compared to Guimu-1. Therefore, the cuttings of *P. purpureum* treated with 2-node cutting + rooting powder had the best effect. Additionally, the overall cutting effect of Guiminyin was better than that of Guimu-1.

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