Notice

DESCRIPTION CN119422779A

Methods for inducing spore formation in duckweed

绿萍结孢的诱导方法

[0001]

Technical Field

技术领域

[n0001]

This invention relates to the field of duckweed cultivation technology, and in particular to a method for inducing duckweed spore formation.

本发明涉及绿萍培养技术领域，尤其涉及一种绿萍结孢的诱导方法。

[0003]

Background Technology

背景技术

[n0002]

Duckweed is an aquatic plant that lives in a fern-algae symbiosis, and the cyanobacteria that live in its leaf cavity have a strong nitrogen-fixing ability.

绿萍是一种蕨-藻共生的水生植物，在其叶腔中共生的蓝藻具有很强的固氮能力。

This enables it to rapidly expand its biomass through asexual reproduction in nutrient-deficient freshwater environments and play an important role in the nitrogen cycle of freshwater ecosystems.

这使其能够在营养缺乏的淡水环境中通过无性繁殖，迅速扩大生物量，并在淡水生态体系的氮循环中起到重要作用。

In addition to asexual reproduction, duckweed can also reproduce sexually under certain conditions, forming spore fruits.

除了无性繁殖外，绿萍在满足特定条件下也能够进行有性繁殖，形成孢子果。

[n0003]

Currently, most seedlings are propagated asexually, and duckweed's suitable growth temperature is 20-35 degrees Celsius. It is difficult for duckweed to grow above 40 degrees Celsius or below 5 degrees Celsius. Under natural conditions, duckweed is difficult to survive the summer and winter.

目前由于种苗多采用无性营养繁殖体，而绿萍的适宜生长温度在20-35摄氏度，即高于40摄氏度或低于5摄氏度都难于生长，在自然条件下，绿萍难以越夏及越冬。

Therefore, a large number of asexual vegetative propagules are needed for production applications after duckweed dies in summer and winter. However, the required vegetative propagules can only be propagated artificially in summer and winter, resulting in high costs for seedling propagation and long-distance transportation to different locations.

因此夏天和冬天绿萍死亡后再进行生产上应用需要大量的无性营养繁殖体，而所需的营养繁殖体在夏天和冬天时只有采取人工措施才能繁殖，导致种苗繁殖成本及异地长距离运输成本较高。

Using spore fruits eliminates the need for artificial propagation in summer and winter, and their small size and ease of transportation effectively reduce propagation and transportation costs. However, since the conditions required for the production of spore fruits vary among different strains of duckweed, the number of duckweed strains that can produce spores in a given region is limited.

而采用孢子果则不需要进行夏天和冬天的人工繁殖，且孢子果体积小，运输方便，能够有效降低繁殖和运输成本。 但由于绿萍各个品系产生的孢子果所需条件各不相同，会导致一个地区能结孢的绿萍品系有限。

[n0004]

Therefore, providing an efficient method for inducing spore formation in duckweed and promoting its spore formation is an urgent problem to be solved.

因此，提供一种对于绿萍结孢的高效诱导方法，促进绿萍结孢，是目前亟待解决的问题。

[0007]

Summary of the Invention

发明内容

[n0005]

In view of this, embodiments of this application provide a method for inducing spore formation in duckweed to solve the above-mentioned problems.

有鉴于此，本申请实施例提供了一种绿萍结孢的诱导方法，以解决上述问题。

[n0006]

In a first aspect, embodiments of this application provide a method for inducing spore formation in duckweed, comprising the following steps:

第一方面，本申请实施例提供了一种绿萍结孢的诱导方法，包括如下步骤：

[n0007]

Pre-treatment of duckweed plants yields duckweed ready for cultivation;

对绿萍植株进行预处理，得到待培养绿萍；

[n0008]

The duckweed to be cultivated was sprayed with gibberellin solution according to a preset cycle. When the duckweed to be cultivated showed signs of spore formation, the spraying was stopped, and the cultivated duckweed was obtained.

采用赤霉素溶液按照预设周期对所述待培养绿萍进行喷施处理，当所述待培养绿萍出现结孢时，停止喷施，得到培养后的绿萍。

[n0009]

In some embodiments, the pretreatment of duckweed plants to obtain duckweed to be cultivated includes:

在其中一些实施例中，所述对绿萍植株进行预处理，得到待培养绿萍，包括：

[n0010]

After rinsing the duckweed plants in clean water, select those that meet the size requirements and remove any impurities.

将绿萍植株在清水中冲洗后，挑选规格大小符合要求的绿萍植株，并进行除杂处理；

[n0011]

The impurity-removed duckweed plants were purified to obtain duckweed for cultivation.

将除杂后的绿萍植株进行纯化处理，得到待培养绿萍。

[n0012]

In some embodiments, when purifying the impurity-removed duckweed plants, the impurity-removed duckweed plants are cultured in soil for one week.

在其中一些实施例中，在将除杂后的绿萍植株进行纯化处理时，将除杂后的绿萍植株进行土培培养一周。

[n0013]

In some embodiments, the gibberellin solution is obtained by diluting a gibberellin stock solution, wherein the preparation process of the gibberellin stock solution includes:

在其中一些实施例中，所述赤霉素溶液由赤霉素母液稀释得到，其中，所述赤霉素母液的配置过程包括：

[n0014]

Mix gibberellin crystals and anhydrous ethanol in a certain proportion, stir until completely dissolved, and obtain an alcoholic solution containing gibberellin.

按比例将赤霉素晶体和无水乙醇混合，搅拌，直至完全溶解，得到含有赤霉素的酒精溶液；

[n0015]

Deionized water was added to an alcoholic solution containing gibberellin and stirred until homogeneous to obtain a gibberellin stock solution; wherein the concentration of the gibberellin stock solution was 500 μg・mL⁻¹.

在含有赤霉素的酒精溶液中加入去离子水，搅拌均匀后得到赤霉素母液；其中所述赤霉素母液的浓度为500μg・mL⁻¹。

[n0016]

In some embodiments, the treatment concentration of the gibberellin solution is 1-7 μg・mL⁻¹.

在其中一些实施例中，所述赤霉素溶液的处理浓度为1-7μg・mL⁻¹。

[n0017]

In some embodiments, the treatment concentration of the gibberellin solution is 7 μg・mL⁻¹.

在其中一些实施例中，所述赤霉素溶液的处理浓度为7μg・mL⁻¹。

[n0018]

In some embodiments, the gibberellin solution is a GA3 solution.

在其中一些实施例中，所述赤霉素溶液为GA3溶液。

[n0019]

In some embodiments, the process of spraying the duckweed to be cultivated with gibberellin solution at a preset cycle, stopping the spraying when the duckweed begins to spore, and obtaining the cultivated duckweed includes:

在其中一些实施例中，所述采用赤霉素溶液按照预设周期对所述待培养绿萍进行喷施处理，当所述待培养绿萍出现结孢时，停止喷施，得到培养后的绿萍，包括：

[n0020]

Place the duckweed to be cultivated in a cultivation pot, cover the bottom of the pot with sterilized paddy soil, and fill it with clean water;

将所述待培养绿萍置于培养盆中，且盆底覆盖经灭菌处理的水稻土，并加满清水；

[n0021]

The duckweed to be cultivated was sprayed with the gibberellin solution under preset culture conditions, and the spraying frequency was once a week;

在预设培养条件下对所述待培养绿萍采用所述赤霉素溶液进行喷施处理，其中喷施的频次为每周一次；

[n0022]

When the duckweed to be cultivated begins to form spores, stop spraying to obtain the cultured duckweed.

当所述待培养绿萍出现结孢时，停止喷施，得到培养后的绿萍。

[n0023]

In some embodiments, the culture conditions include:

在其中一些实施例中，所述培养条件，包括：

[n0024]

The temperature is 20-25°C, and the air humidity is 85-90%.

温度为20-25°C，空气湿度为85-90%。

[n0025]

In some embodiments, the duckweed is any one of Mexican duckweed, triangular duckweed, and small-leaved duckweed.

在其中一些实施例中，所述绿萍为墨西哥萍、三角萍和小叶萍中的任意一种。

[n0026]

Technical effects of the present invention:

本发明的技术效果：

[n0027]

Regularly spraying duckweed with gibberellin can effectively induce spore formation without adversely affecting the duckweed plants.

通过对待培养绿萍进行定期赤霉素喷施处理，能够有效的诱导绿萍结孢，且不会对绿萍植株造成不良影响。

Furthermore, during the cultivation process, the spore formation of duckweed plants should be observed regularly. When spore formation occurs, the application of gibberellin solution should be stopped immediately to avoid excessive treatment from adversely affecting the spore formation quality of duckweed, thereby improving the spore formation rate and number of spore fruits of duckweed plants.

并且，在培养过程中，定期观察绿萍植株结孢，当结孢出现时立即停止赤霉素溶液的喷施，避免过度处理对绿萍结孢质量产生不良影响，由此提高绿萍植株孢子果结孢率和孢子果数量。

The overall cultivation method is simple and can effectively improve the quality of duckweed conservation and reduce labor.

整体培养方式简单，能够有效提高绿萍资源保种质量，减少劳动量。

[n0028]

Other features and aspects of this disclosure will become clear from the following detailed description of exemplary embodiments with reference to the accompanying drawings.

根据下面参考附图对示例性实施例的详细说明，本公开的其它特征及方面将变得清楚。

[0032]

Attached Figure Description

附图说明

[n0029]

The accompanying drawings, which are included in and form part of this specification, illustrate exemplary embodiments, features, and aspects of this disclosure together with the specification and serve to explain the principles of this disclosure.

包含在说明书中并且构成说明书的一部分的附图与说明书一起示出了本公开的示例性实施例、特征和方面，并且用于解释本公开的原理。

[n0030]

Figure 1 shows a flowchart of a method for inducing spore formation in duckweed according to an embodiment of this application.

图1示出为本申请实施例的绿萍结孢的诱导方法的流程图。

[0035]

Detailed Implementation

具体实施方式

[n0031]

Various exemplary embodiments, features, and aspects of this disclosure will now be described in detail with reference to the accompanying drawings.

以下将参考附图详细说明本公开的各种示例性实施例、特征和方面。

The same reference numerals in the accompanying drawings indicate elements that have the same or similar functions.

附图中相同的附图标记表示功能相同或相似的元件。

Although various aspects of the embodiments are shown in the accompanying drawings, the drawings are not necessarily drawn to scale unless otherwise specified.

尽管在附图中示出了实施例的各种方面，但是除非特别指出，不必按比例绘制附图。

[n0032]

The term “exemplary” as used here means “used as an example, embodiment or illustration”.

在这里专用的词“示例性”意为“用作例子、实施例或说明性”。

Any embodiment illustrated herein as “exemplary” should not be construed as superior to or better than other embodiments.

这里作为“示例性”所说明的任何实施例不必解释为优于或好于其它实施例。

[n0033]

Furthermore, numerous specific details are provided in the following detailed description of the embodiments to better illustrate this disclosure.

另外，为了更好的说明本公开，在下文的具体实施方式中给出了众多的具体细节。

Those skilled in the art will understand that this disclosure can be practiced even without certain specific details.

本领域技术人员应当理解，没有某些具体细节，本公开同样可以实施。

In some instances, methods, means, components, and circuits well known to those skilled in the art have not been described in detail in order to highlight the spirit of this disclosure.

在一些实例中，对于本领域技术人员熟知的方法、手段、元件和电路未作详细描述，以便于凸显本公开的主旨。

[n0034]

This application provides a method for inducing spore formation in duckweed. Figure 1 is a flowchart of the steps of the method for inducing spore formation in duckweed according to this application. As shown in Figure 1, the method includes the following steps:

本申请实施例提供了一种绿萍结孢的诱导方法，图1是根据本申请实施例的绿萍结孢的诱导方法的步骤流程图，如图1所示，该方法包括以下步骤：

[n0035]

S100. Pre-treat the duckweed plants to obtain duckweed to be cultivated;

S100、对绿萍植株进行预处理，得到待培养绿萍；

[n0036]

This step is carried out under natural conditions in the net greenhouse.

本步骤中，在网室大棚自然条件下进行。

Specifically, before formally inducing spore formation in duckweed, it is necessary to purify the duckweed to ensure that there is no contamination from other duckweed species during the subsequent induction process, which could affect the induction effect.

具体的，在正式对绿萍进行结孢诱导前，需要先进行绿萍的纯化处理，也即保证后续诱导过程中无杂萍污染，影响诱导效果。

Among them, the net-house cultivation can effectively solve the problem of insects, branches and other fallen objects falling into the cultivation container, which is common in outdoor net-house cultivation, and ensure that the growth and purity of duckweed are not affected by the outside world.

其中，网室大棚培养能干有效解决目前常见的室外网室培养所带来的昆虫、枝条等凋落物掉入培养容器中的问题，保障绿萍生长、纯度不受外界影响。

[n0037]

S200. Spray the duckweed to be cultured with gibberellin solution according to a preset cycle. Stop spraying when the duckweed to be cultured shows signs of spore formation, and the cultured duckweed is obtained.

S200、采用赤霉素溶液按照预设周期对待培养绿萍进行喷施处理，当待培养绿萍出现结孢时，停止喷施，得到培养后的绿萍。

[n0038]

In this step, sporulation is induced in the pretreated duckweed to be cultivated. Specifically, gibberellin solution is sprayed onto the duckweed to be cultivated within a certain period of time.

本步骤中，针对经过预处理的待培养绿萍进行结孢诱导，具体的，需采用赤霉素溶液在一定周期内对待培养绿萍进行喷施处理。

It should be noted that gibberellins (GAS) are a class of tetracyclic diterpenoid carboxylic acid compounds produced by green plants, fungi, and bacteria.

需要说明的是，赤霉素(GAS)是一类四环双萜羧酸化合物，由绿色植物、真菌以及细菌产生。

Regularly spraying duckweed with gibberellin can effectively induce spore formation without adversely affecting the duckweed plants.

通过对待培养绿萍进行定期赤霉素喷施处理，能够有效的诱导绿萍结孢，且不会对绿萍植株造成不良影响。

Furthermore, during the cultivation process, it is necessary to regularly observe the growth of the duckweed plants. In particular, when spore formation occurs, the application of gibberellin solution should be stopped immediately to avoid excessive treatment from adversely affecting the spore formation quality of the duckweed, thereby improving the spore formation rate and the number of spore fruits of the duckweed plants.

并且，在培养过程中，需要定期观察绿萍植株的生长情况，尤其是结孢现象出现时，需要立即停止赤霉素溶液的喷施，避免过度处理对绿萍结孢质量产生不良影响，由此提高绿萍植株孢子果结孢率和孢子果数量。

[n0039]

In some embodiments, the duckweed is any one of the following: Mexican duckweed, triangular duckweed, and small-leaved duckweed.

在其中一些实施例中，绿萍为墨西哥萍、三角萍和小叶萍中的任意一种。

[n0040]

In this embodiment, Mexican amaranth has the characteristics of strong cold resistance, high yield, strong nitrogen fixation ability, high sporulation rate, rich nutrition and strong salt tolerance, but poor heat resistance.

本实施例中，墨西哥萍具有抗寒性强、丰产性好、固氮能力强、结孢率高、营养丰富、耐盐性强等特点，但是抗热性较差。

Smallleaf water lily has the characteristics of strong heat resistance, stable sporulation performance, high sporulation rate and many female spores, but its cold resistance is poor.

小叶萍具有抗热性强、结孢性能稳定、结孢率高、雌孢子多等特点，但是抗寒性较差。

Spirogyra has strong nitrogen-fixing ability, fast growth rate, high nutritional value, and strong environmental adaptability, making it a good feed ingredient for livestock and poultry.

三角萍具有固氮能力强、生长速度快、营养价值高，环境适应能力强，是畜禽良好的饲料原料。

Therefore, this embodiment uses Mexican duckweed, triangular duckweed, and small-leaved duckweed as culture objects to provide research methods for cultivating duckweed varieties that are resistant to high and low temperatures, grow quickly, and have high nutritional value.

因此，本实施例以墨西哥萍、三角萍和小叶萍为培养对象，为培育耐高温、耐低温、长速快和营养价值高的绿萍品种提供研究方法。

[n0041]

In some embodiments, the duckweed plants are pretreated to obtain duckweed to be cultivated, including: rinsing the duckweed plants in clean water, selecting duckweed plants that meet the size requirements, and removing impurities; and purifying the impurity-removed duckweed plants to obtain duckweed to be cultivated.

在其中一些实施例中，对绿萍植株进行预处理，得到待培养绿萍，包括：将绿萍植株在清水中冲洗后，挑选规格大小符合要求的绿萍植株，并进行除杂处理；将除杂后的绿萍植株进行纯化处理，得到待培养绿萍。

[n0042]

In this embodiment, it is first necessary to select duckweed of uniform size and place it in a culture pot, and remove any duckweed and impurities that may affect the cultivation of duckweed.

本实施例中，首先需要挑选出大小规格均一的绿萍置于培养盆中，并去除影响绿萍培养的杂萍和杂质。

This involves removing other algae besides duckweed to prevent them from mixing with duckweed and competing for nutrients and space.

其中，通过去除绿萍以外的其他杂萍防止其他藻类与绿萍混合在一起竞争营养物质和空间。

During the induction of sporulation, duckweed needs sufficient nutrients to support its physiological changes, while the presence of other duckweed species can affect the sporulation effect of duckweed.

在诱导结孢过程中，绿萍需要足够的养分来支持其生理变化，而杂萍的存在会影响绿萍的结孢效果。

[n0043]

Furthermore, since duckweed may carry various microorganisms, such as bacteria and fungi, it is also necessary to remove these biological pollutants during the cleaning process to prevent duckweed diseases.

不仅如此，由于绿萍还可能携带各种微生物，如细菌、真菌等，因此除杂过程中还需要去除这些生物污染物，防止引发绿萍病害。

Especially during the subsequent induction of sporulation, the physiological state of duckweed will change, and its own defense mechanism may be affected to a certain extent. Removing the interference of biological pollutants in advance can effectively ensure the normal sporulation of duckweed.

尤其是在后续诱导结孢过程中，绿萍的生理状态会发生变化，其自身防御机制可能受到一定程度的影响，通过提前去除生物污染物的干扰能够有效保障绿萍结孢的正常进行。

Meanwhile, since gibberellins are produced by green plants, fungi, and bacteria, if impurities are not removed, some microorganisms may decompose the gibberellins and change the subsequent induction environment, thereby interfering with the induction of spore formation in duckweed.

同时，由于赤霉素是由绿色植物、真菌以及细菌产生，若不进行除杂处理，部分微生物很可能会分解赤霉素改变后续诱导环境，从而对绿萍结孢诱导产生干扰。

[n0044]

It should also be noted that after removing impurities from the duckweed plants, further purification is required. That is, there is a purification process before the gibberellin spray treatment.

还需要说明的是，在对绿萍植株进行除杂处理之后，还需对除杂后的绿萍进行进一步纯化，即在正式利用赤霉素喷施处理前，还存在一个纯化前置过程。

The reason is that after the impurity removal treatment, the duckweed plants may have physical or physiological damage. Purifying the duckweed plants again after impurity removal to ensure that they restore normal physiological function is an important prerequisite for effectively inducing conidia, so that they can better absorb and utilize gibberellin in the future.

原因在于经过除杂处理之后的绿萍植株可能存在物理或生理性损伤，将除杂后的绿萍植株再次纯化处理保障其恢复正常生理机能是有效诱导结孢的重要前提，在后续能够更好地吸收和利用赤霉素。

[n0045]

In some embodiments, when purifying the impurity-removed duckweed plants, the impurity-removed duckweed plants are cultured in soil for one week.

在其中一些实施例中，在将除杂后的绿萍植株进行纯化处理时，将除杂后的绿萍植株进行土培培养一周。

[n0046]

Specifically, in this embodiment, before formally cultivating duckweed, it is necessary to pre-cultivate it for one week using the normal soil cultivation method.

具体的，本实施例在正式培养绿萍之前，需要采用正常土培培养方法预培养一周。

During the week of pre-culture, the roots of duckweed can gradually adapt to the new soil environment, and the root cells damaged during the weeding process can regenerate, providing sufficient material support for the growth and spore formation of duckweed during the gibberellin treatment stage.

在预培养的一周内，绿萍的根系能够逐渐适应新的土壤环境，并且在这一周内，除杂时所受损的根系细胞能够再生，为绿萍在赤霉素处理阶段的生长和结孢提供充足的物质支持。

Meanwhile, after a week of pre-cultivation, the growth progress of individual duckweed plants will gradually become more synchronized, and the growth rate of leaves and the root development process will be relatively similar, which is more conducive to the synchronous development of the spore formation process.

同时，经过一周的预培养，绿萍个体之间的生长进度会逐渐趋于同步，叶片的生长速度、根系发育程序会相对接近，更有利于结孢过程的同步展开。

[n0047]

In some embodiments, the gibberellin solution is obtained by diluting gibberellin stock solution. The preparation process of gibberellin stock solution includes: mixing gibberellin crystals and anhydrous ethanol in proportion, stirring until completely dissolved to obtain an alcoholic solution containing gibberellin; adding deionized water to the alcoholic solution containing gibberellin, stirring evenly to obtain gibberellin stock solution; wherein the concentration of gibberellin stock solution is 500 μg・mL⁻¹.

在其中一些实施例中，赤霉素溶液由赤霉素母液稀释得到，其中，赤霉素母液的配置过程包括：按比例将赤霉素晶体和无水乙醇混合，搅拌，直至完全溶解，得到含有赤霉素的酒精溶液；在含有赤霉素的酒精溶液中加入去离子水，搅拌均匀后得到赤霉素母液；其中赤霉素母液的浓度为500μg・mL⁻¹。

[n0048]

In this embodiment, a gibberellin solution for spore formation in duckweed needs to be prepared in advance.

本实施例中，需要预先配置用于绿萍结孢的赤霉素溶液。

The gibberellin solution is obtained by diluting the gibberellin mother liquor according to actual needs.

其中，赤霉素溶液由赤霉素母液按实际需求稀释得到。

Specifically, gibberellin crystals are mixed with anhydrous ethanol in a specific ratio, preferably 1 g of gibberellin crystals per 25 ml of anhydrous ethanol, and stirred thoroughly until completely dissolved to obtain an alcoholic solution containing gibberellin. Subsequently, 2 L of deionized water is added to the alcoholic solution containing gibberellin and stirred evenly to obtain a gibberellin stock solution with a concentration of 500 μg・mL⁻¹. In subsequent cultivation of *Lysimachia christinae*, the gibberellin stock solution can be diluted to the required concentration, i.e., 1-7 μg・mL⁻¹, according to actual requirements.

具体的，将赤霉素晶体与无水乙醇按比例混合，其中优选比例为每25ml的无水乙醇中加入1g赤霉素晶体，并充分搅拌直至完全溶解，从而得到含有赤霉素的酒精溶液；随后，将含有赤霉素的酒精溶液中加入2L去离子水，搅拌均匀，得到浓度为500μg・mL⁻¹的赤霉素母液，后续在绿萍培养过程中可根据实际要求将赤霉素母液稀释至所需浓度，即1-7μg・mL⁻¹。

[n0049]

In some of these embodiments, the gibberellin solution is a GA3 solution.

在其中一些实施例中，赤霉素溶液为GA3溶液。

[n0050]

It should be noted that GA3, as an active compound in gibberellins, can accelerate the elongation of duckweed cells, making the duckweed plants larger and the leaf area larger. A larger leaf area means that duckweed can carry out more photosynthesis, providing energy and material basis for its own growth.

需要说明的是，GA3作为赤霉素中一种具有活性的化合物，能够加速绿萍细胞的伸长，使绿萍的植株个体增大、叶面积增大，而更大的叶面积意味着绿萍可以进行更多的光合作用，为自身生长提供能量和物质基础。

It is particularly noteworthy that GA3 can stimulate the reproductive growth of duckweed, increase the number of spores formed, and thus improve the reproductive efficiency of duckweed.

尤其需要说明的是，GA3能够刺激绿萍的生殖生长，增加绿萍的结孢数量，从而提高绿萍的繁殖效率。

[n0051]

In some of these embodiments, the treatment concentration of the gibberellin solution was 1-7 μg・mL⁻¹.

在其中一些实施例中，赤霉素溶液的处理浓度为1-7μg・mL⁻¹。

[n0052]

In this embodiment, when the gibberellin solution is used to spray the cultured duckweed, the concentration of the gibberellin solution is preferably 1-7 μg・mL⁻¹. At this concentration, the spore formation effect of the cultured duckweed is significantly improved compared with that without the use of gibberellin solution.

本实施例中，在利用赤霉素溶液对待培养绿萍进行喷施处理时，赤霉素溶液浓度优选为1-7μg・mL⁻¹，在此浓度下，待培养绿萍的结孢效果相较于未使用赤霉素溶液而言存在明显改善。

Specifically, the spore formation rate ranged from 4.67% to 15.12%, and the number of spores ranged from 3.75 to 6.32.

具体的，结孢率在4.67%-15.12%，结孢数量在3.75-6.32个。

[n0053]

In some of these embodiments, the treatment concentration of the gibberellin solution was 7 μg・mL⁻¹.

在其中一些实施例中，赤霉素溶液的处理浓度为7μg・mL⁻¹。

[n0054]

In this embodiment, the sporulation effect of duckweed was optimal when the treatment concentration of gibberellin solution was 7 μg・mL⁻¹.

本实施例中，当赤霉素溶液的处理浓度在7μg・mL⁻¹时，绿萍的结孢效果最优。

Specifically, the spore formation rate was 14.07%-15.12%, and the number of spores was 6.23-6.32.

具体的，结孢率在14.07%-15.12%，结孢数量在6.23-6.32个。

There was a highly significant difference between it and the duckweed treated without gibberellin.

与未添加赤霉素喷施处理的绿萍存在极显著差异。

[n0055]

In some embodiments, gibberellin solution is used to spray the duckweed to be cultivated at a preset cycle. When the duckweed to be cultivated shows signs of spore formation, the spraying is stopped, and the cultivated duckweed is obtained. The process includes: placing the duckweed to be cultivated in a cultivation pot, covering the bottom of the pot with sterilized paddy soil, and filling it with clean water; spraying the duckweed to be cultivated with gibberellin solution under preset cultivation conditions, wherein the spraying frequency is once a week; and stopping the spraying when the duckweed to be cultivated shows signs of spore formation, thereby obtaining the cultivated duckweed.

在其中一些实施例中，采用赤霉素溶液按照预设周期对待培养绿萍喷施处理，当待培养绿萍出现结孢时，停止喷施，得到培养后的绿萍，包括：将待培养绿萍置于培养盆中，且盆底覆盖经灭菌处理的水稻土，并加满清水；在预设培养条件下对待培养绿萍采用赤霉素溶液进行喷施处理，其中喷施的频次为每周一次；当待培养绿萍出现结孢时，停止喷施，得到培养后的绿萍。

[n0056]

In this embodiment, the entire process of cultivating duckweed is carried out in the base greenhouse, and the paddy soil for cultivating duckweed needs to be sterilized to remove harmful microorganisms and other harmful substances, so as to provide a clean growth mechanism for duckweed cultivation.

本实施例中，对于绿萍培养的整个过程均在基地温室中进行，并且对于培养绿萍的水稻土需要经过灭菌处理，去除其中的有害微生物等，为绿萍培养提供一个干净的生长机制。

The sterilization of paddy soil is achieved by high temperature and high pressure, and the appropriate temperature and pressure can be selected according to the actual sterilization requirements. This invention will not be elaborated here.

其中，对于水稻土的灭菌处理采用高温高压实现，且具体可根据实际灭菌需求选择合适的温度与压强，本发明在此处不再赘述。

After the paddy soil that has undergone high temperature and high pressure sterilization is placed at the bottom of the cultivation pot, it is filled with clean water to simulate the growth environment of duckweed in paddy fields.

将经过高温高压灭菌处理的水稻土置于培养盆的盆底后，加满清水，模拟绿萍水田生长环境。

Subsequently, under the preset culture conditions, the cultured duckweed was sprayed with the prepared gibberellin solution, and its spore formation was observed until spore formation occurred, at which point the spraying was stopped.

随后在预设的培养条件下利用配置好的赤霉素溶液对待培养绿萍进行喷施处理，并观察其结孢情况，直至结孢出现时停止喷施。

[n0057]

Furthermore, when starting gibberellin treatment, gibberellin spraying needs to be carried out according to a preset cycle. The standard for spraying is that the entire duckweed can be evenly sprayed with gibberellin solution, and specifically, gibberellin spraying treatment should be carried out once a week on Mondays.

不仅如此，在开始进行赤霉素处理时，需要按照预设周期进行赤霉素喷施，其中喷施的标准是整个绿萍能够均匀的喷到赤霉素溶液，且具体在每周的周一进行1次赤霉素喷施处理。

The growth and physiological activities of duckweed have a certain periodicity. Weekly treatment can realize the process of duckweed from absorption and response to adjustment of its own physiological state. This can avoid the stimulation and damage to duckweed caused by frequent treatment, and also prevent the duckweed from having an insignificant response to gibberellin due to too long an interval.

绿萍的生长和生理活动具有一定的周期性，每周一次的处理效率能够实现绿萍从吸收、响应到自身生理状态调整的过程，既能避免频繁处理对绿萍造成刺激伤害，又不会因为间隔时间过长而使绿萍对赤霉素的反应不明显。

[n0058]

In some embodiments, the culture conditions include a temperature of 20-25°C and an air humidity of 85-90%.

在其中一些实施例中，培养条件，包括：温度为20-25°C，空气湿度为85-90%。

[n0059]

In this embodiment, in order to provide the most suitable growth conditions for duckweed, it is preferred to cultivate duckweed at a temperature of 20-25°C and an air humidity of 85-90%.

本实施例中，为了能够给绿萍提供最适宜的生长条件，优选在温度为20-25°C，空气湿度为85-90%的条件下培养绿萍。

Within this temperature and humidity range, the growth rate and physiological state of duckweed can be effectively guaranteed. In particular, the 85%-90% humidity environment is conducive to the formation and maturation of duckweed spores, and the spores are more easily spread and germinate.

其中，在此温度区间和湿度区间下能够有效保证绿萍的生长速度及生理状态，尤其是85%-90%的湿度环境下有利于绿萍孢子的形成与成熟，孢子更容易传播和萌发。

[n0060]

The following examples and comparative studies will provide detailed descriptions of the induction of sporulation in *Lysimachia nummularia*, *Lysimachia triangularis*, and *Lysimachia nummularia*.

下面将分别针对墨西哥萍、三角萍和小叶萍的诱导结孢情况提供实施例和对比例进行详细说明。

[n0061]

It should be noted that the culture of each set of examples and comparative examples was carried out under natural conditions in a netted greenhouse, and the amount of duckweed was the same. After culture, the induction effect of each set of duckweed was measured, namely the sporangium setting rate, the number of duckweed sporangia and the male-female ratio of sporangia, as well as the size of duckweed and the C/N ratio of duckweed.

需要说明的是，每组实施例与对比例培养在网室大棚自然条件下进行，且放萍量一致，并在培养后分别针对各组萍体的诱导效果，即孢子果结孢率、绿萍孢子果数量和孢子果雌雄比，以及萍体大小和萍体C/N比进行测定。

[n0062]

Speciation rate of spore fruits: The spore formation of each duckweed pod was calculated as a unit. The spore formation of 100 duckweed pods was randomly counted in each replicate, and the average value of the three replicates was the final value.

孢子果结孢率：以每朵萍体为计算单位，每个重复随机统计100个萍体结孢情况，3个重复平均值为最终值；

[n0063]

Number of spore fruits: The number of spore fruits per sporozoite is calculated. A total of 100 spore fruits with sporozoite are counted per pot. The average value of 3 pots is the final value.

孢子果数量：以每个结孢萍体的孢子果数量来计算，每盆共统计100个有结孢萍体的孢子果数量情况，3盆重复平均值为最终值；

[n0064]

Male-female ratio of spore fruits: calculated based on the number of male and female spore fruits per spore-forming body. A total of 100 spore-forming bodies were counted per pot, and the average value of 3 replicates was taken as the final value.

孢子果雌雄比：以每个结孢萍体的孢子果雌雄数来计算，每盆共统计100个萍体结孢雌雄比情况，3盆重复平均值为最终值；

[n0065]

Duckweed size: Measure the length and width of the duckweed body. The length of the duckweed body is measured using the longest length of each duckweed body. 30 duckweed bodies are randomly measured in each replicate, and the average of the 3 replicates is the final measurement result. The width of the duckweed body is measured in the same way as the length, and the final average value is taken as the measurement result.

萍体大小：测量绿萍萍体的长度和宽度，萍体长度以每朵萍体最长的长度进行测量，每个重复随机测量30朵绿萍，3个重复的平均值为最终测量结果；萍体宽度测量方法同长度测量方法，取最终平均值为测量结果。

[n0066]

Mexican Ping:

墨西哥萍：

[n0067]

Example 1

实施例1

[n0068]

S1. Using normal soil culture methods, select Mexican duckweed of uniform size and specifications, remove impurities, and pre-culture for 1 week;

S1、采用正常土培培养方法，挑选大小规格均一的墨西哥萍，除杂后预培养1周；

[n0069]

S2. Treat with gibberellin at a concentration of 1 μg・mL⁻¹. Spray with gibberellin once a week on Monday and observe the spore formation. Stop spraying when spores appear.

S2、利用处理浓度为1μg・mL⁻¹的赤霉素进行处理，每周的周一进行1次赤霉素喷施处理，并观察其结孢情况，至结孢出现时停止喷施。

[n0070]

Example 2

实施例2

[n0071]

Unlike Example 1, the gibberellin treatment concentration was 3 μg・mL⁻¹.

与实施例1不同的是，赤霉素的处理浓度为3μg・mL⁻¹。

[n0072]

Example 3

实施例3

[n0073]

Unlike Example 1, the gibberellin treatment concentration was 7 μg・mL⁻¹.

与实施例1不同的是，赤霉素的处理浓度为7μg・mL⁻¹。

[n0074]

Comparative Example 1

对比例1

[n0075]

Unlike Example 1, gibberellin was not used.

与实施例1不同的是，未使用赤霉素。

[n0076]

Comparative Example 2

对比例2

[n0077]

Unlike Example 1, the gibberellin treatment concentration was 15 μg・mL⁻¹.

与实施例1不同的是，赤霉素的处理浓度为15μg・mL⁻¹。

[n0078]

Comparative Example 3

对比例3

[n0079]

Unlike Example 1, the gibberellin treatment concentration was 25 μg・mL⁻¹.

与实施例1不同的是，赤霉素的处理浓度为25μg・mL⁻¹。

[n0080]

The measurement results are as follows:

测定结果如下：

[n0081]

1. Induction effect:

1、诱导效果：

[n0082]

(1) Sporulation rate (%)

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(1)结孢率(%)

[n0083]

As shown in Table 1, the sporulation rate of Example 3 with a gibberellin treatment concentration of 7 μg・mL⁻¹ was 15.07%, the sporulation rate of Example 2 with a gibberellin treatment concentration of 3 μg・mL⁻¹ was 6.32%, and the sporulation rate of Example 1 with a gibberellin treatment concentration of 1 μg・mL⁻¹ was 4.69%.

如表1所示，实施例3在赤霉素处理质量浓度为7μg・mL⁻¹的结孢率为15.07%，实施例2在赤霉素处理浓度为3μg・mL⁻¹的结孢率为6.32%，实施例1在赤霉素处理浓度为1μg・mL⁻¹结孢率为4.69%；

[n0084]

Comparative Examples 1-3, i.e., gibberellin treatments at concentrations of 0 μg・mL⁻¹, 15 μg・mL⁻¹, and 25 μg・mL⁻¹, all showed a spore formation rate of 0%.

对比例1-3，即赤霉素处理浓度为0μg・mL⁻¹、15μg・mL⁻¹和25μg・mL⁻¹的结孢率都为0%。

[n0085]

Therefore, the sporulation rate was highest when the gibberellin treatment concentration was 7 μg・mL⁻¹, which was significantly different from other examples and comparative examples; the sporulation rates of the treatment concentrations of 1 μg・mL⁻¹ and 3 μg・mL⁻¹ were next; while the sporulation rates of comparative examples 1-3, i.e., the treatment concentrations of 0 μg・mL⁻¹, 15 μg・mL⁻¹, and 25 μg・mL⁻¹, were all 0%, and no sporulation occurred.

因此，当赤霉素处理质量浓度为7μg・mL⁻¹时的结孢率最高，与其他实施例及对比例均有极显著差异；处理质量浓度为1μg・mL⁻¹的结孢率与处理质量浓度为

3μg・mL⁻¹的结孢率次之；而对比例1-3即处理质量浓度为0μg・mL⁻¹、15μg・mL⁻¹和25μg・mL⁻¹的结孢率都为0%，都未能结孢。

[n0086]

(2) Number of spores

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(2)结孢数量(个)

[n0087]

The number of spores formed by gibberellin treatment of Mexican clover was 6.32 at 7 μg・mL⁻¹, 4.15 at 3 μg・mL⁻¹, 3.87 at 1 μg・mL⁻¹, and 0 at 0 μg・mL⁻¹, 15 μg・mL⁻¹, and 25 μg・mL⁻¹.

墨西哥萍在赤霉素处理7μg・mL⁻¹的结孢数量为6.32个，3μg・mL⁻¹的结孢数量为4.15个，1μg・mL⁻¹结孢数量为3.87个，0μg・mL⁻¹、15μg・mL⁻¹和25μg・mL⁻¹的结孢数量都为0个。

[n0088]

Therefore, in Example 3, the treatment with a mass concentration of 7 μg・mL⁻¹ produced the highest number of spores, which was significantly different from other

examples and comparative examples; the treatments with mass concentrations of 1 μg・mL⁻¹ and 3 μg・mL⁻¹ produced the next highest number of spores.

因此，实施例3中处理质量浓度为7μg・mL⁻¹的结孢数量最多，与其他实施例及对比例都有极显著差异；处理质量浓度为1μg・mL⁻¹和3μg・mL⁻¹的结孢数量次之。

[n0089]

(3) Female-to-male ratio

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(3)雌雄比例

[n0090]

In Mexican clover treated with gibberellin at concentrations of 7 μg・mL⁻¹, the male-to-female ratio of sporocarps was 0.59:1; at 3 μg・mL⁻¹, the male-to-female ratio of sporocarps <img file="BDA00051571292100000093.JPG" frnum="0001" he="62" id="0002" img-content="drawing" img-format="tif" inline="yes" orientation="portrait" pgnum="

0002" wi="58"/> was 0.52:1; at 1 μg・mL⁻¹, the male-to-female ratio of sporocarps was 0.49:1; and at 0 μg・mL⁻¹, 15 μg・mL⁻¹, and 20 μg・mL⁻¹, the male-to-female ratio of sporocarps was 0:0.

墨西哥萍在赤霉素处理质量浓度7μg・mL⁻¹的孢子果 雄比为0.59：1，3μg・mL⁻¹的孢子果 雄比为0.52：1，1μg・mL⁻¹的孢子果 雄比为0.49：1，0μg・mL⁻¹、15μg・mL⁻¹和20μg・mL⁻¹的的孢子果 雄比为0：0。

[n0091]

Therefore, the highest proportion of male spores (NER48) was observed in the treatment with a concentration of 7 μg・mL⁻¹, showing a highly significant difference compared to the control group; the proportion of male spores (NER50) was observed in the treatments with concentrations of 1 and 3 μg・mL⁻¹, with no significant difference between the two treatments, but both showing highly significant differences compared to the control group.

因此，处理质量浓度为7μg・mL⁻¹的孢子果 雄比例最高，与对比例有极显著差异；处理质量浓度为1和3μg・mL⁻¹的孢子果 雄比次之，且两者之间无显著差异，与对比例均有极显著差异。

[n0094]

Table 1. Induction Effects of Gibberellin Concentration on Mexican Pepper in Examples 1-3 and Comparative Examples 1-3

表1实施例1-3及对比例1-3赤霉素浓度对墨西哥萍的诱导效果表

[n0095]

2. Size of the duckweed

2、萍体大小

[n0096]

As shown in Table 2, the length and width of the Mexican water lily in Examples 1-3 were enhanced. Among them, the length and width of the water lily treated with gibberellin at a concentration of 7 μg・mL⁻¹ in Example 3 were the largest, increasing by about 40% compared with Comparative Example 1 without gibberellin, and the difference from Examples 1 and 2 was also significant. The length and width of the water lily in Examples 1 and 2 were also relatively increased compared with Comparative Example 1, but the difference was small.

如表2所示，实施例1-实施例3中的墨西哥萍萍体的长度和宽度均得到增强，其中实施例3赤霉素处理浓度为7μg・mL⁻¹的萍体长度和宽度最大，相较于对比例1未添加赤霉素而言，增加约40%，且与实施例1和实施例2的差异也较为显著；实施例1和2的萍体长度及宽度较对比例1而言也相对增加，但差异较小。

Therefore, it can be seen that when the Mexican duckweed forms spores, the duckweed body will relatively increase in size.

由此可知，墨西哥萍结孢时，萍体会相对增大。

Although the length and width of Comparative Examples 2-3 were also relatively increased, the results were only slightly different from those of Comparative Example 1, which did not use gibberellin.

对比例2-3虽长度和宽度也相对增大，但与未使用赤霉素的对比例1结果差异微小。

[n0098]

Table 2. Schematic diagram of the effect of gibberellin concentration on the size of duckweed in Examples 1-3 and Comparative Examples 1-3.

表2赤霉素浓度对实施例1-3及对比例1-3的萍体大小影响示意表

[n0099]

3. C/N ratio

3、C/N比例

[n0100]

As shown in Table 3, when the C/N ratio increases to a certain level, the Mexican clover can form spores, and the C/N ratio will increase when the Mexican clover forms spores.

如表3可知，C/N比增加到一定水平时墨西哥萍就可以结孢，且墨西哥萍结孢时C/N比会增加。

Compared with Comparative Examples 1-3, the C/N ratio of Examples 1-3 was significantly enhanced.

与对比例1-3相比，实施例1-3的C/N均得到显著增强。

Among them, Example 3 showed the highest C/N ratio at a gibberellin treatment concentration of 7 μg・mL⁻¹, which was significantly different from Comparative Examples 1-3. Examples 1 and 2 showed the second highest C/N ratios at gibberellin treatment concentrations of 1 and 3 μg・mL⁻¹, respectively, but were still significantly different from Comparative Examples 1-3.

其中，实施例3赤霉素处理浓度为7μg・mL⁻¹时的C/N最大，与对比例1-3差异巨大，实施例1和实施例2在赤霉素处理浓度分别为1和3μg・mL⁻¹时次之，但与对比例1-3相比也较为显著。

The C/N ratios of Comparative Examples 1-3 are averaged.

对比例1-3的C/N比较为平均。

[n0102]

Table 3. Schematic diagram of the effect of gibberellin concentration on the C/N ratio of Examples 1-3 and Comparative Examples 1-3.

表3赤霉素浓度对实施例1-3及对比例1-3的C/N比例大小影响示意表

[n0103]

Triangle duckweed:

三角萍：

[n0104]

Example 4

实施例4

[n0105]

S1. Using normal soil culture methods, select uniform-sized duckweed, remove impurities, and pre-culture for 1 week.

S1、采用正常土培培养方法，挑选大小规格均一的三角萍，除杂后预培养1周；

[n0106]

S2. Treat with gibberellin at a concentration of 1 μg・mL⁻¹. Spray with gibberellin once a week on Monday and observe the spore formation. Stop spraying when spores appear.

S2、利用处理浓度为1μg・mL⁻¹的赤霉素进行处理，每周的周一进行1次赤霉素喷施处理，并观察其结孢情况，至结孢出现时停止喷施。

[n0107]

Example 5

实施例5

[n0108]

Unlike Example 4, the gibberellin treatment concentration was 3 μg・mL⁻¹.

与实施例4不同的是，赤霉素的处理浓度为3μg・mL⁻¹。

[n0109]

Example 6

实施例6

[n0110]

Unlike Example 4, the gibberellin treatment concentration was 7 μg・mL⁻¹.

与实施例4不同的是，赤霉素的处理浓度为7μg・mL⁻¹。

[n0111]

Comparative Example 4

对比例4

[n0112]

Unlike Example 4, gibberellin was not used.

与实施例4不同的是，未使用赤霉素。

[n0113]

Comparative Example 5

对比例5

[n0114]

Unlike Example 4, the gibberellin treatment concentration was 15 μg・mL⁻¹.

与实施例4不同的是，赤霉素的处理浓度为15μg・mL⁻¹。

[n0115]

Comparative Example 6

对比例6

[n0116]

Unlike Example 4, the gibberellin treatment concentration was 25 μg・mL⁻¹.

与实施例4不同的是，赤霉素的处理浓度为25μg・mL⁻¹。

[n0117]

The measurement results are as follows:

测定结果如下：

[n0118]

1. Induction effect:

1、诱导效果：

[n0119]

(1) Sporulation rate (%)

---

(1)结孢率(%)

[n0120]

As shown in Table 4, the sporulation rate of Example 6 with a gibberellin treatment concentration of 7 μg・mL⁻¹ was 14.97%, the sporulation rate of Example 5 with a gibberellin treatment concentration of 3 μg・mL⁻¹ was 7.31%, and the sporulation rate of Example 4 with a gibberellin treatment concentration of 1 μg・mL⁻¹ was 4.67%.

如表4所示，实施例6在赤霉素处理质量浓度为7μg・mL⁻¹的结孢率为14.97%，实施例5在赤霉素处理浓度为3μg・mL⁻¹的结孢率为7.31%，实施例4在赤霉素处理浓度为1μg・mL⁻¹结孢率为4.67%；

[n0121]

Comparative Examples 4-6, i.e., gibberellin treatments at concentrations of 0 μg・mL⁻¹, 15 μg・mL⁻¹, and 25 μg・mL⁻¹, all showed a spore formation rate of 0%.

对比例4-6，即赤霉素处理浓度为0μg・mL⁻¹、15μg・mL⁻¹和25μg・mL⁻¹的结孢率都为0%。

[n0122]

Therefore, the sporulation rate was highest when the gibberellin treatment concentration was 7 μg・mL⁻¹, which was significantly different from other examples and comparative examples. The sporulation rates of the treatment concentrations of 1 μg・mL⁻¹ and 3 μg・mL⁻¹ were next. The sporulation rates of comparative examples 4-6, i.e., the treatment concentrations of 0 μg・mL⁻¹, 15 μg・mL⁻¹, and 25 μg・mL⁻¹, were all 0%, and no sporulation occurred.

因此，当赤霉素处理质量浓度为7μg・mL⁻¹时的结孢率最高，与其他实施例及对比例均有极显著差异；处理质量浓度为1μg・mL⁻¹的结孢率与处理质量浓度为

3μg・mL⁻¹的结孢率次之；而对比例4-6即处理质量浓度为0μg・mL⁻¹、15μg・mL⁻¹和25μg・mL⁻¹的结孢率都为0%，都未能结孢。

[n0123]

(2) Number of spores

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(2)结孢数量(个)

[n0124]

The number of spores formed by *Tripterygium wilfordii* treated with gibberellin was 6.27 at 7 μg・mL_NER71, 4.19 at 3 μg・mL_NER72, and 3.91 at 1 μg・mL_NER73. The number of spores formed at 0 μg・mL_NER74, 15 μg・mL_NER75, and 25 μg・mL_NER76 were all 0.

三角萍在赤霉素处理7μg・mL⁻¹的结孢数量为6.27个，3μg・mL⁻¹的结孢数量为4.19个，1μg・mL⁻¹结孢数量为3.91个，0μg・mL⁻¹、15μg・mL⁻¹和25μg・mL⁻¹的结孢数量都为0个。

[n0125]

Therefore, in Example 6, the treatment with a mass concentration of 7 μg・mL⁻¹ produced the highest number of spores, which was significantly different from other

examples and comparative examples; the treatments with mass concentrations of 1 μg・mL⁻¹ and 3 μg・mL⁻¹ produced the next highest number of spores.

因此，实施例6中处理质量浓度为7μg・mL⁻¹的结孢数量最多，与其他实施例及对比例都有极显著差异；处理质量浓度为1μg・mL⁻¹和3μg・mL⁻¹的结孢数量次之。

[n0126]

(3) Female-to-male ratio

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(3)雌雄比例

[n0127]

The male-to-female ratio of sporocarps of *Lysimachia christinae* treated with gibberellin at concentrations of 7 μg・mL⁻¹ was 0.61:1; the male-to-female ratio of sporocarps ...

三角萍在赤霉素处理质量浓度7μg・mL⁻¹的孢子果 雄比为0.61：1，3μg・mL⁻¹的孢子果 雄比为0.56：1，1μg・mL⁻¹的孢子果 雄比为0.53:1，0μg・mL⁻¹、15μg・mL⁻¹和20μg・mL⁻¹的的孢子果 雄比为0：0。

[n0128]

Therefore, the highest proportion of male spores (NER91) treated with a concentration of 7 μg・mL⁻¹ was observed, showing a highly significant difference compared to the control group; the proportion of male spores (NER93) treated with concentrations of 1 and 3 μg・mL⁻¹ was the next highest, with no significant difference between the two groups, but both showing highly significant differences compared to the control group.

因此，处理质量浓度为7μg・mL⁻¹的孢子果 雄比例最高，与对比例有极显著差异；处理质量浓度为1和3μg・mL⁻¹的孢子果 雄比次之，且两者之间无显著差异，与对比例均有极显著差异。

[n0130]

Table 4. Induction effects of gibberellin concentration on *Tripterygium wilfordii* in Examples 4-6 and Comparative Examples 4-6.

表4实施例4-6及对比例4-6赤霉素浓度对三角萍的诱导效果表

[n0131]

2. Size of the duckweed

2、萍体大小

[n0132]

As shown in Table 5, the length and width of the duckweed bodies in Examples 4-6 were enhanced. Among them, the duckweed bodies treated with gibberellin at a concentration of 7 μg・mL⁻¹ in Example 6 had the largest length and width, which increased by about 40% compared with Comparative Example 1 without gibberellin, and the difference from Examples 4 and 5 was also significant. The length and width of the duckweed bodies in Examples 4 and 5 were also relatively increased compared with Comparative Example 1, but the difference was small.

如表5所示，实施例4-实施例6中的三角萍萍体的长度和宽度均得到增强，其中实施例6赤霉素处理浓度为7μg・mL⁻¹的萍体长度和宽度最大，相较于对比例1未添加赤霉素而言，增加约40%，且与实施例4和实施例5的差异也较为显著；实施例4和5的萍体长度及宽度较对比例1而言也相对增加，但差异较小。

Therefore, it can be seen that when duckweed forms spores, the duckweed body will relatively increase in size.

由此可知，三角萍结孢时，萍体会相对增大。

Although the length and width of Comparative Examples 5-6 were also relatively increased, the results were only slightly different from those of Comparative Example 4, which did not use gibberellin.

对比例5-6虽长度和宽度也相对增大，但与未使用赤霉素的对比例4结果差异微小。

[n0135]

Table 5. Schematic diagram of the effect of gibberellin concentration on the size of duckweed in Examples 4-6 and Comparative Examples 4-6.

表5赤霉素浓度对实施例4-6及对比例4-6的萍体大小影响示意表

[n0136]

3. C/N ratio

3、C/N比例

[n0137]

As shown in Table 6, when the C/N ratio increases to a certain level, duckweed can form spores, and the C/N ratio will increase when duckweed forms spores.

如表6可知，C/N比增加到一定水平时三角萍就可以结孢，且三角萍结孢时C/N比会增加。

Compared with Comparative Examples 4-6, the C/N ratios of Examples 4-6 were significantly enhanced.

与对比例4-6相比，实施例4-6的C/N均得到显著增强。

Among them, Example 6 showed the highest C/N ratio at a gibberellin treatment concentration of 7 μg・mL⁻¹, which was significantly different from Comparative Examples 4-6. Examples 4 and 5 showed the second highest C/N ratios at gibberellin treatment concentrations of 1 μg・mL⁻¹ and 3 μg・mL⁻¹, respectively, but were still significantly different from Comparative Examples 4-6.

其中，实施例6赤霉素处理浓度为7μg・mL⁻¹时的C/N最大，与对比例4-6差异巨大，实施例4和实施例5在赤霉素处理浓度分别为1和3μg・mL⁻¹时次之，但与对比例4-6相比也较为显著。

The C/N ratios of Comparative Examples 4-6 are averaged.

对比例4-6的C/N比较为平均。

[n0139]

Table 6. Schematic diagram of the effect of gibberellin concentration on the C/N ratio of Examples 4-6 and Comparative Examples 4-6.

表6赤霉素浓度对实施例4-6及对比例4-6的C/N比例大小影响示意表

[n0140]

Xiao Yeping:

小叶萍：

[n0141]

Example 7

实施例7

[n0142]

S1. Using normal soil culture methods, select small water lilies of uniform size and specifications, remove impurities, and pre-culture for 1 week;

S1、采用正常土培培养方法，挑选大小规格均一的小叶萍，除杂后预培养1周；

[n0143]

S2. Treat with gibberellin at a concentration of 1 μg・mL⁻¹. Spray with gibberellin once a week on Monday and observe the spore formation. Stop spraying when spores appear.

S2、利用处理浓度为1μg・mL⁻¹的赤霉素进行处理，每周的周一进行1次赤霉素喷施处理，并观察其结孢情况，至结孢出现时停止喷施。

[n0144]

Example 8

实施例8

[n0145]

Unlike Example 7, the gibberellin treatment concentration was 3 μg・mL⁻¹.

与实施例7不同的是，赤霉素的处理浓度为3μg・mL⁻¹。

[n0146]

Example 9

实施例9

[n0147]

Unlike Example 7, the gibberellin treatment concentration was 7 μg・mL⁻¹.

与实施例7不同的是，赤霉素的处理浓度为7μg・mL⁻¹。

[n0148]

Comparative Example 7

对比例7

[n0149]

Unlike Example 7, gibberellin was not used.

与实施例7不同的是，未使用赤霉素。

[n0150]

Comparative Example 8

对比例8

[n0151]

Unlike Example 7, the gibberellin treatment concentration was 15 μg・mL¹.

与实施例7不同的是，赤霉素的处理浓度为15μg・mL¹。

[n0152]

Comparative Example 9

对比例9

[n0153]

Unlike Example 7, the gibberellin treatment concentration was 25 μg・mL¹.

与实施例7不同的是，赤霉素的处理浓度为25μg・mL¹。

[n0154]

The measurement results are as follows:

测定结果如下：

[n0155]

1. Induction effect:

1、诱导效果：

[n0156]

(1) Sporulation rate (%)

---

(1)结孢率(%)

[n0157]

As shown in Table 7, the sporulation rate of Example 9 with a gibberellin treatment concentration of 7 μg・mL⁻¹ was 15.12%, the sporulation rate of Example 7 with a gibberellin treatment concentration of 3 μg・mL⁻¹ was 5.29%, and the sporulation rate of Example 6 with a gibberellin treatment concentration of 1 μg・mL⁻¹ was 4.83%.

如表7所示，实施例9在赤霉素处理质量浓度为7μg・mL⁻¹的结孢率为15.12%，实施例7在赤霉素处理浓度为3μg・mL⁻¹的结孢率为5.29%，实施例6在赤霉素处理浓度为1μg・mL⁻¹结孢率为4.83%；

[n0158]

Comparative Examples 7-9, i.e., gibberellin treatments at concentrations of 0 μg・mL⁻¹, 15 μg・mL⁻¹, and 25 μg・mL⁻¹, all showed a spore formation rate of 0%.

对比例7-9，即赤霉素处理浓度为0μg・mL⁻¹、15μg・mL⁻¹和25μg・mL⁻¹的结孢率都为0%。

[n0159]

Therefore, the sporulation rate was highest when the gibberellin treatment concentration was 7 μg・mL⁻¹, which was significantly different from other examples and comparative examples; the sporulation rates of the treatment concentrations of 1 μg・mL⁻¹ and 3 μg・mL⁻¹ were next; while the sporulation rates of comparative examples 7-9, i.e., the treatment concentrations of 0 μg・mL⁻¹, 15 μg・mL⁻¹, and 25 μg・mL⁻¹, were all 0%, and none of them sporulated.

因此，当赤霉素处理质量浓度为7μg・mL⁻¹时的结孢率最高，与其他实施例及对比例均有极显著差异；处理质量浓度为1μg・mL⁻¹的结孢率与处理质量浓度为3μg・mL⁻¹的结孢率次之；而对比例7-9即处理质量浓度为0μg・mL⁻¹、15μg・mL⁻¹和25μg・mL⁻¹的结孢率都为0%，都未能结孢。

[n0160]

(2) Number of spores

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(2)结孢数量(个)

[n0161]

The number of spores formed by *Phyllostachys edulis* treated with gibberellin was 6.23 at 7 μg・mL_NER114, 4.07 at 3 μg・mL_NER115, and 3.75 at 1 μg・mL_NER116. The number of spores formed by 0 μg・mL_NER117, 15 μg・mL_NER118, and 25 μg・mL_NER119 was 0.

小叶萍在赤霉素处理7μg・mL⁻¹的结孢数量为6.23个，3μg・mL⁻¹的结孢数量为4.07个，1μg・mL⁻¹结孢数量为3.75个，0μg・mL⁻¹、15μg・mL⁻¹和25μg・mL⁻¹的结孢数量都为0个。

[n0162]

Therefore, in Example 9, the treatment with a mass concentration of 7 μg・mL⁻¹ produced the highest number of spores, which was significantly different from other examples and comparative examples; the treatments with mass concentrations of 1 μg・mL⁻¹ and 3 μg・mL⁻¹ produced the next highest number of spores.

因此，实施例9中处理质量浓度为7μg・mL⁻¹的结孢数量最多，与其他实施例及对比例都有极显著差异；处理质量浓度为1μg・mL⁻¹和3μg・mL⁻¹的结孢数量次之。

[n0163]

(3) Female-to-male ratio

---

(3)雌雄比例

[n0164]

The sporocarp male-to-spore ratio of *Solanum nigrum* treated with gibberellin at a concentration of 7 μg・mL_NER123 was 0.58:1, at 3 μg・mL_NER124 it was 0.49:1, at 1 μg・mL_NER125 it was 0.49:1, and at 0 μg・mL_NER126, 15 μg・mL_NER127 and 20 μg・mL_NER128 it was 0:0.

小叶萍在赤霉素处理质量浓度7μg・mL⁻¹的孢子果雄比为0.58：1，3μg・mL⁻¹的孢子果雄比为0.49：1，1μg・mL⁻¹的孢子果雄比为0.49:1，0μg・mL⁻¹、15μg・mL⁻¹和20μg・mL⁻¹的的孢子果雄比为0：0。

[n0165]

Therefore, the treatment with a mass concentration of 7 μg・mL⁻¹ had the highest proportion of male and female spore fruits, which was significantly different from the

control group; the treatments with mass concentrations of 1 and 3 μg・mL⁻¹ had the next highest proportions of male and female spore fruits, and there was no significant difference between the two, but both were significantly different from the control group.

因此，处理质量浓度为7μg・mL⁻¹的孢子果雄比例最高，与对比例有极显著差异；处理质量浓度为1和3μg・mL⁻¹的孢子果雄比次之，且两者之间无显著差异，与对比例均有极显著差异。

[n0167]

Table 7. Induction Effects of Gibberellin Concentration on *Lysimachia christinae* in Examples 7-9 and Comparative Examples 7-9

表7实施例7-9及对比例7-9赤霉素浓度对小叶萍的诱导效果表

[n0168]

2. Size of the duckweed

2、萍体大小

[n0169]

As shown in Table 8, the length and width of the *Nymphaea pulcherrima* bodies in Examples 7-9 were all enhanced. Among them, the length and width of the *Nymphaea pulcherrima* bodies treated with gibberellin at a concentration of 7 μg・mL⁻¹ in Example 9 were the largest, increasing by about 40% compared to Comparative Example 7 without gibberellin, and the difference from Examples 7 and 8 was also significant. The length and width of the *Nymphaea pulcherrima* bodies in Examples 7 and 8 were also relatively increased compared to Comparative Example 7, but the difference was small.

如表8所示，实施例7-实施例9中的小叶萍萍体的长度和宽度均得到增强，其中实施例9赤霉素处理浓度为7μg・mL⁻¹的萍体长度和宽度最大，相较于对比例7未添加赤霉素而言，增加约40%，且与实施例7和实施例8的差异也较为显著；实施例7和8的萍体长度及宽度较对比例7而言也相对增加，但差异较小。

Therefore, it can be seen that when duckweed forms spores, the duckweed body will relatively increase in size.

由此可知，小叶萍结孢时，萍体会相对增大。

Although the length and width of Comparative Examples 8-9 were also relatively increased, the results were only slightly different from those of Comparative Example 7, which did not use gibberellin.

对比例8-9虽长度和宽度也相对增大，但与未使用赤霉素的对比例7结果差异微小。

[n0171]

Table 8. Schematic diagram of the effect of gibberellin concentration on the size of duckweed in Examples 7-9 and Comparative Examples 7-9.

表8赤霉素浓度对实施例7-9及对比例7-9的萍体大小影响示意表

[n0172]

3. C/N ratio

3、C/N比例

[n0173]

As shown in Table 9, when the C/N ratio increases to a certain level, *Leptochloa chinensis* can form spores, and the C/N ratio will increase when *Leptochloa chinensis* forms spores.

如表9可知，C/N比增加到一定水平时小叶萍就可以结孢，且小叶萍结孢时C/N比会增加。

Compared with Comparative Examples 7-9, the C/N ratio of Examples 7-9 was significantly enhanced.

与对比例7-9相比，实施例7-9的C/N均得到显著增强。

Among them, Example 9 showed the highest C/N ratio at a gibberellin treatment concentration of 7 μg・mL⁻¹, which was significantly different from Comparative Examples 7-9. Examples 7 and 8 showed the second highest C/N ratios at gibberellin treatment concentrations of 1 and 3 μg・mL⁻¹, respectively, but were still significantly different from Comparative Examples 7-9.

其中，实施例9赤霉素处理浓度为7μg・mL⁻¹时的C/N最大，与对比例7-9差异巨大，实施例7和实施例8在赤霉素处理浓度分别为1和3μg・mL⁻¹时次之，但与对比例7-9相比也较为显著。

The C/N ratios of Comparative Examples 7-9 are averaged.

对比例7-9的C/N比较为平均。

[n0176]

Table 6. Schematic diagram of the effect of gibberellin concentration on the C/N ratio of Examples 7-9 and Comparative Examples 7-9.

表6赤霉素浓度对实施例7-9及对比例7-9的C/N比例大小影响示意表

[n0177]

In summary, the culture effect was best when the gibberellin concentration was 7 μg・mL⁻¹, with optimal results in terms of sporulation rate, number of sporulations, male-to-female ratio, body size, and C/N ratio.

综上所述，当赤霉素浓度为7μg・mL⁻¹的培养效果最好，无论是结孢率、结孢数、雌雄比例、萍体大小、C/N比例，均为最优。

Furthermore, as shown in Table 1-9, higher gibberellin concentrations are not necessarily better. When gibberellin concentrations rise to a certain level, they can affect the spore formation of duckweed and inhibit its growth.

并且，表1-9可知，赤霉素浓度并非越高越好，当赤霉素浓度升高到一定程度后，会影响绿萍结孢，抑制绿萍生长。

By controlling the gibberellin concentration using the method described in this application, we can not only effectively improve the quality of Duckweed conservation resources, bringing significant benefits to the cultivation of superior Duckweed quality and the reduction of conservation costs, but also effectively solve the problem of breeding new hybrid varieties and overcome difficulties in production applications.

通过本申请的方法控制赤霉素浓度，不仅能够有效提高绿萍资源保种质量，为培育优异的绿萍品质和降低保种成本带来显著效果，还能有效解决杂交新品种选育问题，解决生产上的应用困难。

[n0178]

The above embodiments only illustrate several implementation methods of this application. The descriptions are relatively specific and detailed, but they should not be construed as limiting the scope of the invention patent.

以上实施例仅表达了本申请的几种实施方式，其描述较为具体和详细，但并不能因此而理解对发明专利范围的限制。

It should be noted that those skilled in the art can make several modifications or improvements without departing from the concept of this application, and these all fall within the scope of protection of this application.

应当指出的是，对于本领域的普通技术人员来说，在不脱离本申请构思的前提下，还可以做出若干变形或改进，这些都属于本申请的保护范围。

Therefore, the scope of protection of this patent application shall be determined by the appended claims.

因此，本申请专利的保护范围应以所附权利要求为准。