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Design and Application of Quantitative Adjustable Liquid Injection Device for Maize Stalk Center Borehole

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Abstract In view of the problems that the drilling depth can not be adjusted and the amount of liquid injection can not be accurately modulated in the local test device of maize variety breeding and disease resistance, combining the test technical requirements of drilling, liquid injection and sealing of the penultimate radial pitch of maize straw from the ground, a quantitative adjustable liquid injection device for maize stalk center borehole was designed. Its structure, working principle, key technical parameters and practical application effect were elaborated in detail. The field experiment demonstrated that the quantitative adjustable liquid injection device for maize stalk center borehole could meet the requirements of the local test of maize stalk rot.

Key words Maize stalk , Center borehole, Quantitative adjustable liquid injection

0 Introduction

There are many scientific research units or experimental stations at the provincial, municipal and county levels engaged in propagation and cultivation in China, and the workload of field experiments on maize stalk resistance to stalk rot is large, but there are few studies on special devices for inoculation experiments of maize stalk rot in China. At present, only the electric trunk drilling and injecting machine developed by Greenman Machinery Group Co., Ltd. is used for tree treatment and disease prevention in China, but it is not suitable for maize stalk rot resistance experiment. Through searching the relevant information, it is found that there are no relevant products for maize stalk drilling, liquid injection and sealing available in China.

Maize stalk rot inoculation methods mainly include stem base inoculation method and root inoculation method[1-2], in which the drilling injection in stem base inoculation method has the advantages of simplicity and easy control of inoculation amount, but the stem base inoculation method still uses a large number of manual operation methods for testing[3], resulting in the accuracy and reliability of the test results of this method is not high, which directly affects the accuracy of the identification results. At present, the use of maize stalk drilling injection tools mainly depends on manual step-by-step operation. This method usually involves the steps of drilling with an electric hand drill, injecting bacterial solution with a medical hand-pressed injector, and smearing Vaseline with fingers, which has the advantages of portability and easy operation. However, it also has significant disadvantages, including high labor costs[4]. What is worse, it is difficult for operators to adjust the drilling depth and injection amount in time due to the difference in the diameter of the penultimate radial pitch of different maize varieties, which leads to a high damage rate of maize plants and a large waste of liquid medicine. As a result, the experiment often fails to achieve the desired goal, and it is easy to pollute the environment.

In view of the problems of manual drilling in the stem base of maize plant, the uncontrollability of the amount of bacteria injected and the incompleteness of Vaseline sealing holes, as well as the lack of related products in China, we designed a new type of integrated field test device. The device can realize the adjustable depth drilling of the corn straw, the adjustable liquid injection amount and the quantitative adjustment of the injection sealing Vaseline, and aims to serve the agricultural production and the scientific research work more effectively.

1 Overall structure and working principle

1.1 Overall structure The quantitative adjustable liquid injection device for maize stalk center borehole is mainly composed of a control box body, a harness part, and a hand-held drilling injection sealing part. Specifically, the control box body and the strap components mainly comprise a double-shoulder harness, a handle, a 24 V quick plug connector (female), a quick plug connector for connecting a bacterial solution bottle, a quick plug connector for connecting a Vaseline bottle, a six-core rear nut socket (waterproof aviation socket), a liquid infusion quick plug connector (female), a check valve, an electric hand drill power supply, a bacterial solution storage bottle, and a controller. The drilling liquid injection sealing part mainly comprises a depth limiting positioning ring, a bacterial liquid injection head, a Vaseline injection head, an injection head fixing bracket and the like. The overall structure of the drilling liquid injection device is shown in Fig. 1.

1.2 Working principle A drilling liquid injection seal component is held by a right hand to drill a hole obliquely below the maize stalk at the penultimate radial pitch of the maize stalk from the ground at an angle of 45 degrees, the drilling depth reaches the middle part of the maize stalk pith under the action of a depth-limiting positioning ring. After drilling, the bacterial solution injection head was inserted into the drilling hole, and 1 - 2 mL of the pathogen inoculum was injected into the stem pith of the maize

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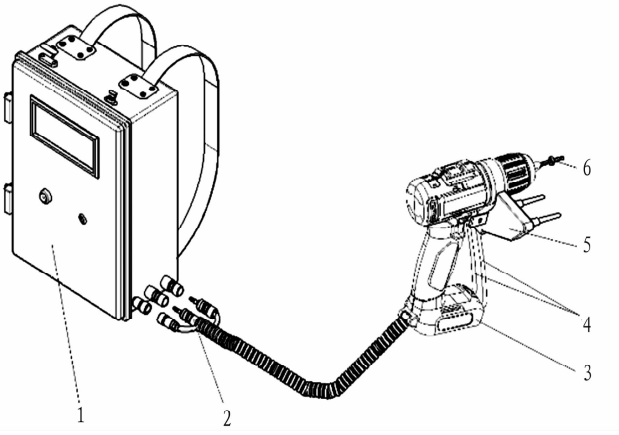
plant, and then the Vaseline injection head was used to aim at the solution hole, and a certain amount of Vaseline was injected to block the drilling hole to complete the operation process of a single maize plant. The required liquid injection amount can be set by adjusting the liquid injector, and the liquid injection speed can be adjusted by the control panel of the electric push rod.

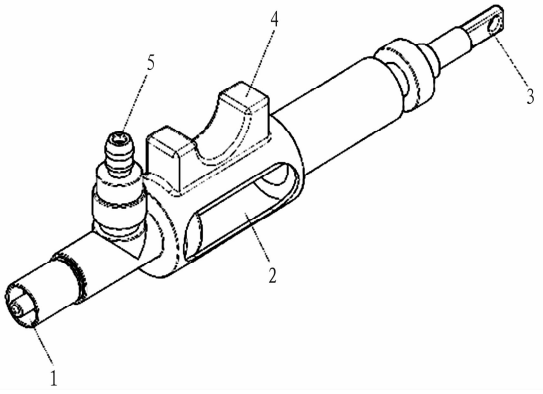


NOTE 1. Control box and harness; 2. Quick connector; 3. Pipeline holder; 4. Liquid tube and Vaseline tube; 5. Injection head fixing bracket; 6. Depth limit positioning ring and drill bit.

Fig. 1 Overall structural diagram of drilling and liquid injection device

2 Structural parameter design of key components

The adjustable quantitative liquid injection device is the core component of the quantitative adjustable liquid injection device for maize stalk center borehole. It is mainly used for quantitative output of bacterial solution and Vaseline liquid. It plays a decisive role in the results of vaccination identification and the success of the experiment. Therefore, according to the requirements of maize stalk rot resistance inoculation experiment, an integrated field experiment device for maize stalk rot was designed, which could drill holes with adjustable depth, inject liquid with adjustable amount, and inject Vaseline with adjustable sealing amount, as shown in Fig. 2.

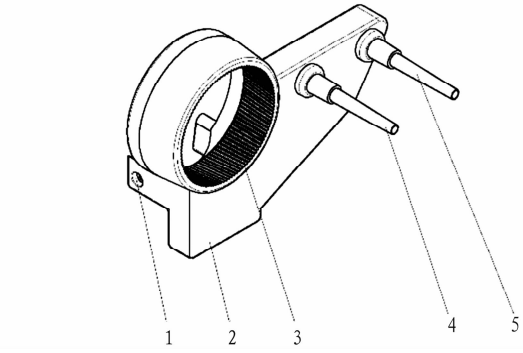


NOTE 1. Bacterial solution outlet; 2. Glass cover (both sides); 3. Push rod; 4. Fixing bracket; 5. Solution inlet.

Fig. 2 Schematic diagram for structure of adjustable quantitative injection device

2.1 Structural design of adjustable quantitative liquid injection device When the injection volume is set to 2 mL, the injection volume can be accurately controlled by the calibrated injection device, so as to ensure the consistency of each injection volume. The adjustable quantitative liquid injection device mainly comprises a hose connector, a fixing bracket, a stretched spring, a 0 – 5 mL adjusting nut, a piston rod, a threaded rod, a 0 – 5 mL scale (solution cavity), a spring, a Luer taper, a check valve ball and a glass cover (on both sides). The structure of the adjustable quantitative liquid injection is shown in Fig. 2.

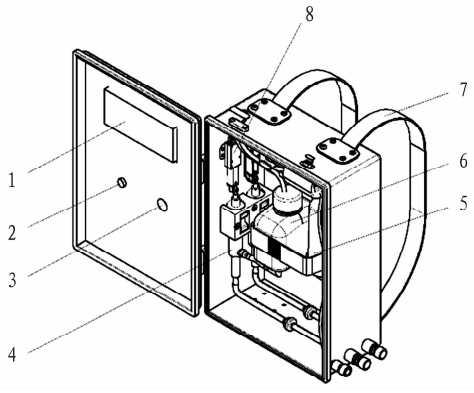
2.2 Structural design of injection head fixing bracket The inside of the injection head fixing bracket is a passage component for independent liquid flow of the two liquid injection channels. These two liquid injection channel can separately output different bacterial solutions to the bacterial solution outlet, so that the liquid injection efficiency can be improved, the influence on the experiment effect caused by chemical reaction generate by mutual mixing can be avoided, different liquid medicines can be accurately conveyed to the maize stalk action part in sequence and according to the amount, and the accuracy and the safety of the experiment are improved. The structure of injection head fixing bracket is shown in Fig. 3.



NOTE 1. Fixing bracket connecting hole; 2. Bacterial solution inlet; 3. Fixing; 4. Push rod; 5. Fixing seat.

Fig. 3 Structural diagram of injection head fixing bracket

2.3 Structural design of control box body The interior of the control box body is connected with a push rod of the adjustable quantitative liquid injection device by two miniature electric push rods, and the length of the push rod at the rear end of the liquid injection device is adjusted by an adjusting nut so as to adjust the liquid injection amount of the liquid injection each time. The injection speed is adjusted by the parameter setting of the controller panel of the electric push rod to adapt to the characteristics of different solutions and the absorption capacity of maize stalk. The liquid injection tube is a soft medical silicone tube with certain strength. The control box cover is provided with a display screen, a power switch and an alarm buzzer, which are used for switching the device, setting the liquid injection amount, alarming the parameters. The structure of the control box and harness is shown in Fig. 4.



NOTE 1. Display screen; 2. Power switch; 3. Alarm buzzer; 4. Adjustable quantitative liquid injection device; 5. Vaseline liquid storage bottle; 6. Bacterial solution storage bottle; 7. Shoulder harness; 8. Electric push rod.

Fig. 4 Schematic diagram of control box and harness structure

3 Field experiment

3.1 Experimental conditions To further study the operation effect of the quantitative adjustable liquid injection device for maize stalk center borehole, we conducted the experiment at the experimental base of Heilongjiang Academy of Agricultural Machinery Sciences on July 11, 2024. We set the injection volume of the device to 2 mL and the injection rate to 1 mL/sec to test the prototype device.

3.2 Experiment results We used the device to test different varieties of maize stalk, and realized the adjustable amount of liquid injection, the precise control of liquid injection speed and drilling depth. In the test process, the device can quickly and accurately complete the drilling, liquid injection and sealing operations, effectively improve the test efficiency of stalk rot resistance, and reduce the waste of liquid medicine and solution and the pollution to the environment. Compared with that traditional liquid injection method, the operation efficiency of the device is effectively improved.

At the beginning of October 2024, we began to dissect the maize stalk tested with the device to evaluate the effect of the experiment. The experimental results show that the device can accurately deliver bacterial liquid and Vaseline solution to the designated location, which significantly improves the accuracy and credibility of the experimental data. Compared with the traditional manual step-by-step operation mode, the device integrates drilling, liquid injection and sealing operations into a continuous process, realizes single-person operation instead of multi-person step-by-step operation, simplifies the operation process, and improves the efficiency of the experimental operation. The performance of the device fully meets the needs of the test. Fig. 5 shows the experimental results of maize stalk center borehole for injection of bacterial solution.

3.3 Application fields The quantitative adjustable liquid injection device for maize stalk center borehole is a local test technology specially designed for maize variety breeding and improving disease resistance. In this technology, the bacterial liquid (pathogenic microorganism) is precisely introduced into the central part of maize stalk by artificial or mechanical means, and then the disease degree of maize stalk infected by pathogenic microorganism can be observed. The device met a number of experimental requirements including maize stalk center borehole, adjustable injection volume, Vaseline sealing, and subsequent split processing. Its "one-button" adjustable quantitative automatic injection function not only improves production efficiency, but also effectively reduces labor costs. The field experiment of quantitative adjustable liquid injection device for maize stalk center borehole is shown in Fig. 6.

Fig. 5 Experimental results of injecting bacterial solution into the center borehole of maize stalks

Fig. 6 Field experiment

4 Conclusions

(i) The device is mainly applied to a maize variety breeding experimental base, and is a novel full-automatic maize stalk "stalk rot resistance" test device which is light, simple and easy to operate by one button.

(ii) It improves productivity and reduces costs. In the past, three workers operated step by step, but one worker can complete the workload of three workers using this device and the test efficiency and quality are significantly improved.

(iii) Through precise control and operation, the new device can improve the quality stability of the experiment, reduce the error of manual operation, and further guarantee the safety of operators and the ecological environment.

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7 Workshop doors and windows

It is necessary to set up one-way doors in the production workshop as much as possible, so as to ensure that personnel can only flow from high cleanliness area to low cleanliness area. People, like air, cannot flow against the current. Non-toxic, corrosion-resistant and easy-to-clean materials, such as aluminum alloy and tempered glass, should be selected to ensure food safety and easy maintenance. Windows should be fitted with easy-to-clean insect screens to prevent pests from entering the workshop and contaminating food. At the same time, the edges of doors and windows should be well sealed to avoid dust entry[14].

The microbial control of frozen drinks is very important, especially after *L. monocytogenes* is listed in the national standard. Enterprises should be the first responsible person for food safety and strictly control the quality. Therefore, it is necessary to consider how to reduce food safety risks in project design. This paper focuses on the main controlling factors of microorganisms, water and air. Microbial control needs to be considered from many aspects, not only involving quality, supply, research and development, and procurement, but also closely related to project management. Only by doing well in every link can the microbial risks in frozen drinks be effectively controlled[15-16].

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