Deep High-moisture Soil pH Test Equipment and Method

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Abstract. Excessive use of chemical fertilizers in the soil will cause excessive residues of heavy metals, soil hardening and high soil alkalinity. A soil pH tester is generally used to test the soil pH scale to ensure the normal growth of crops. However, the tester cannot be used directly in the case of soil hardening and the soil should be moistened before measurement. In addition, existing soil pH testers can only perform single-point tests, and multiple tests are generally required in order to obtain accurate experimental data. Common deep soil pH test devices are difficult to use and have the problem of inaccurate measurement results due to excessive impurities in the soil in the process of use, resulting in errors in soil analysis which require secondary revision to improve the soil environment. To make up for the defects of existing technologies, this study designs a deep high-moisture soil pH tester, which has the advantage of high soil impurity filtering performance and addresses the problem of inaccurate measurement results due to excessive impurities in the soil.

1 Introduction

This study discusses a piece of deep high-moisture soil pH tester and its test method, which can be applied to soil pH tests. From technical perspective, the tester includes a bottom plate, a base fixedly connected with the top surface of the bottom plate, a slag discharge mechanism fixedly installed on the top surface of the base, a stirring mechanism fixedly installed on the top surface of the bottom plate, a transmission mechanism fixedly installed below the stirring mechanism, and a clamping mechanism fixedly installed on the right side of the transmission mechanism. With the slag discharge mechanism, the deep high-moisture soil pH tester and method can effectively prevent garbage in the soil from entering the test process and improve its measurement accuracy. [1] The handle and the sealing plug in conjunction with the slag discharge port can make it more convenient to discharge the garbage inside the containing box and avoid the difficulty in the falling of the soil due to the accumulation of garbage in the containing box. The anti-skid pad can effectively prevent the entire device from sideslip during processing.

2 Soil pH testing

Soil pH includes the acid strength and the number of acidity, or the active acidity and the potential acidity. The acid strength refers to the concentration of H+ in the soil solution that is in equilibrium with the solid phase of the soil, expressed by pH. The number of acidity refers to the total amount of acid and buffer performance, representing the total amount of exchangeable hydrogen and aluminum in the soil, generally expressed by the amount of exchangeable acids.

The pH scale of the soil has great influence on soil fertility and plant growth. A lot of soil in northwestern and northern regions of China has a high pH value, and the red soil in the south has a low pH value. Therefore, crops and plants compatible with the soil pH can be planted. For example, acid-loving tea trees can be planted in red soil areas, while alfalfa has strong alkali resistance. The soil pH scale also affects the nutrient availability greatly. For example, phosphorus has high availability in neutral soil, while trace elements such as manganese, copper and zinc have poor availability in alkaline soil. In agricultural production, attention shall be paid to soil pH and measures shall be taken actively for its adjustment. The impact of pH on plants is multifaceted, roughly divided into the impact on the external environment and the impact on the plant itself. Each plant has the most suitable growth environment, and the soil too acid or too alkaline will both affect the growth and harvest of plants. Therefore, it is of great significance to test the soil pH scale. [2]

3 Precautions in soil pH test

The pH measuring electrode and the calomel electrode have different electrode potentials for different hydrogen ion activities in the measured solution, which are converted into digital values through pre-amplification and A/D, directly showing the pH value of the solution. The pH value of aqueous solution is generally measured with a glass electrode as the measuring electrode and a calomel electrode as the reference electrode. [3]

The head bulb of the glass electrode, as the main part of the electrode, is made of a special sensitive film and is only sensitive to hydrogen ions. When it is immersed in the test solution, the hydrogen ions in the test solution

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exchange ions with the hydration layer on the bulb surface. The hydrogen ions in the outer layer change since those in the inner layer of the bulb remain unchanged. Therefore, the potential difference generated also changes, which is then converted, showing a different pH value.

The instrument must be calibrated before measurement of the pH value of the solution. Generally, it is calibrated once a day during normal continuous use but shall be re-calibrated when the test solution is likely to damage the hydration layer of the electrode bulb or if there is any doubt about the test result. When the electrode plug is inserted, the option switch button should be pressed to make it in the pH position. The slope knob, if any, shall be placed at the corresponding position of the known electrode slope. Improper slope will result in the distortion of the test result. Before measurement, it is required to power on the instrument and hold for 30 minutes, adjust the null point of the potentiometer so that the reading is within 0, and then insert the plug of the glass electrode, which must be inserted in place; otherwise, the electrode potential will not show the value.

During the test, a standard buffer solution with the pH value close to that of the test solution shall be selected. In the meantime, the electrode shall be washed with distilled water and a small part of the standard buffer solution shall be taken to assimilate the electrode. Improper selection or non-standard preparation of the standard solution is an important factor that affects the test result. The closer the pH value of the standard solution is to that of the test solution, the more accurate the test result will be. In addition, the uniformity of the solution also affects the stability of the test. The more uniform the solution is, the more stable the electrode potential generated by the ion activity will be.

4 Deep high-moisture soil pH test equipment

To solve the technical problems above, this study invents a piece of deep high-moisture soil pH test equipment, including a bottom plate, a base, a slag discharge mechanism, a stirring mechanism, a transmission mechanism, and a clamping mechanism. The specific test equipment is introduced as follows:

4.1 Slag discharge mechanism

The slag discharge mechanism includes a feed port, a turnplate, a first rotating motor, a first bearing, a first rotating shaft, a crushing blade, a through hole, a containing box, a first sliding block and a first chute. A containing box is fixedly connected with the top surface of the base, the left side of which is fixedly connected with a feed port and the top surface of which is fixedly inlaid with a first bearing and connected with a first rotating motor. A first rotating shaft is fixedly connected with the output end of the first rotating motor, the bottom of which penetrates the first bearing and extends to the inside of the containing box and the outer surface of which is fixedly connected with the inner ring of the first bearing and a crushing blade. A turnplate is fixedly connected with the back surface of the first rotating shaft, the top surface of which is provided with a through hole. A full circle of a first chute is set up on the inner side wall of the containing box. The outer surface of the turnplate is fixedly connected with a first sliding block adaptive to the first chute which is clamped inside the first chute. [4]

4.2 Stirring mechanism

The stirring mechanism includes a second rotating motor, a water inlet pipe, a first valve, a second bearing, a stirring rod, a second rotating shaft, a scraper, a brush, a bushing plate, a partition plate, a water outlet pipe and a mixing box. The top surface of the bottom plate is fixedly connected with a mixing box which is located on the right side of the base. A connecting pipe is fixedly connected with the upper part of the left side of the mixing box, the left end of which is fixedly connected with the lower part of the right side of the containing box. The top surface of the mixing box is fixedly inlaid with a second bearing and fixedly connected with a second rotating motor. A second rotating shaft is fixedly connected with the output end of the second rotating motor, the bottom of which penetrates the second bearing and extends to the inside of the mixing box and the outer surface of which is fixedly connected with a stirring rod. A scraper is fixedly connected with the bottom surface of the second rotating shaft, the bottom surface of which is fixedly connected with a brush. A bushing plate adaptive to the mixing box is fixedly connected with the inner side wall of the mixing box, the top surface of which is in contact with the bottom surface of the brush. A partition plate adaptive to the mixing box is fixedly connected with the inner side wall of the mixing box, which is located below the bushing plate. The bottom surface of the partition plate is fixedly connected with a water outlet pipe. A water inlet pipe is fixedly connected with the top surface of the mixing box, which is located on the right side of the second rotating motor and the outer surface of which is fixedly connected with a first valve.

The technical solution above can make the mixing of soil and distilled water and the discharge of the solution more convenient.

4.3 Transmission mechanism

The transmission mechanism includes a second sliding block, a second chute, a sliding plate, a sliding rod, a forward and reverse rotation motor, a first threaded rod, an electric push rod, a slip ring, a first threaded tube and a baffle. A forward and reverse rotation motor is fixedly connected with the inner side wall of the mixing box. A sliding plate is placed inside the mixing box, which is located below the partition plate and the top surface of which is fixedly inlaid with a slip ring and a first threaded tube located on the right side of the slip ring. A first threaded rod is fixedly connected with the output end of the forward and reverse rotation motor, which is connected to the threads of the first threaded tube and the top end of which penetrates the first threaded tube and extends up above the sliding plate and is fixedly connected with a baffle. A sliding rod is fixedly connected with the bottom

surface of the partition plate, which is sleeved with the slip ring and the bottom end of which penetrates the slip ring and extends down below the sliding plate. The inner side wall of the mixing box is fixedly connected with the bottom end of the sliding rod, on which a second chute is provided. A second sliding block adaptive to the second chute is fixedly connected with the left side of the sliding plate, which is clamped inside the second chute. An electric push rod is fixedly connected with the right side of the sliding plate. [5]

The technical solution above can make it more convenient for the measuring cup to receive the solution and avoid the splashing of the solution due to the far distance between the measuring cup and the water outlet pipe.

4.4 Clamping mechanism

Further, the clamping mechanism includes a positioning plate, a third chute, a third sliding block, a third bearing, a fixed plate, a clutch base, a second threaded rod, a second threaded tube, a moving plate and a handle. A positioning plate is fixedly connected with the flexible end of the electric push rod, the back of which is fixedly connected with a fixed plate. The right side of the fixed plate is fixedly inlaid with a third bearing. A moving plate is placed on the right side of the fixed plate, the right side of which is fixedly inlaid with a second threaded tube. A second threaded rod is placed on the right side of the moving plate, the left end of which penetrates the second threaded tube and extends to the left side of the movable plate. The second threaded tube is threadedly connected with the second threaded rod. The outer surface of the left end of the second threaded rod is fixedly connected with the inner ring of the third bearing. The right end of the second threaded rod is fixedly connected with a handle. Side faces of both the fixed plate and the moving plate close to each other are fixedly connected with a clutch base. A third chute is provided on the side face of the positioning plate close to the moving plate. A third sliding block adaptive to the third chute is provided on the side face of the moving plate close to the positioning plate, which is clamped inside the third chute. A measuring cup is placed between the two clutch bases, the outer surface of which is in contact with the inner ring of the clutch base. The lower part of the right side of the mixing box is provided with a discharge port and fixedly connected with a support plate located below the discharge port.

The technical solution above can effectively avoid the shaking of the measuring cup when it is moved so that it is more convenient for the staff to take the measuring cup for detection.

5 Deep high-moisture soil pH test method

The test method includes the following steps:

The first rotating motor is electrically connected to the municipal power supply. The operator puts the soil sample into the containing box from the feed port. The first rotating motor is energized and started to drive the first rotating shaft, the crushing blade, and the turnplate to rotate. Under the action of the through hole, the soil sample falls and is discharged into the mixing box through the connecting pipe;

The second rotating motor is electrically connected to the municipal power supply and started to drive the stirring rod, the second rotating shaft, the scraper, and the brush to rotate to stir the soil. The operator opens the first valve and pours the distilled water through the water inlet pipe, draining the solution into the inside of the measuring cup through the water outlet pipe.

The forward and reverse rotation motor and the electric push rod are electrically connected to the municipal power supply. The motor is energized and started. Under the action of the first threaded tube, the sliding plate drives the electric push rod down. The electric push rod is energized and started to drive the clamping mechanism to push out from the discharge port. The operator twists the handle to move the moving plate under the action of the second threaded tube, and then takes out the measuring cup to carry out the pH test.

6 Conclusion

Compared with the existing technologies, the deep high-moisture soil pH tester and method have the following advantages:

1) The slag discharge mechanism in the present invention can effectively prevent the garbage in the soil from entering the test process and improve the measurement accuracy of the device. The handle and the sealing plug in combination with the slag discharge port make it more convenient to discharge the garbage in the containing box and avoid the difficulty in the falling of the soil due to the accumulation of garbage in the containing box.

2) The stirring mechanism in the present invention can make the mixing of soil and distilled water and the discharge of the solution more convenient. The transmission mechanism can make it more convenient for the measuring cup to receive the solution and avoid the splashing of the solution due to the far distance between the measuring cup and the water outlet pipe.

3) The clamping mechanism in the present invention can effectively avoid the shaking of the measuring cup when it is moved so that it is more convenient for the staff to take the measuring cup for detection. The anti-skid pad can effectively prevent the entire device from sideslip during processing, improving its stability.

4) The present invention is provided with a guide plate which can effectively avoid the accumulation of soil samples in the containing box and make it easy to use. The slag discharge pipe in conjunction with the second valve can make the discharge of residues in the mixing box more convenient and avoid the accumulation of residues in the box. The support plate is provided to effectively prevent the operator from colliding with the clamping mechanism inadvertently.

References

1. Gao F. (2014) Discussion on Soil pH Test Method [C]//2014 Beijing Science and Technology Paper Exchange Conference for Soil and Fertilizer System. Beijing Soil and Fertilizer Workstation.
2. Ji Tw. (2020) Discussion on Fertilizer and Soil pH Test Methods. Zhejiang Agricultural Sciences, v.61(04):146-148.
3. Chen J. (2020) Soil pH Test Method and Application Analysis. Chemical Engineering Design Communications, v.46; No.214(04): 238+268.
4. Liu Q, Mu X.M, Gao. P, Zhao G.j, Sun W Y, Zhang W,Gao Y, Yang S.Y., Qiu T.Y. (2020) Study on the Effect of Soil Hydraulic Erosion on Physical and Chemical Indicators of Soil Quality. Study on soil and water conservation, 27(06): 386-392.
5. Li Y, Li M.H, Yue X (2020) Distribution characteristics and changing trend of soil pH in Taihu Lake area. Resource Environmentand Engineering, 34(03): 363-365+431.