USER MANUAL

Soil Nutrient Tester

LMSNT-A100

www.labmate.com | info@labmate.com

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1. Introduction

Soil Nutrient Tester LMSNT-A100 offers measurement range of 0.001 to 9999. Its multi-nutrient detection feature, measures macro, secondary, micronutrients, including N, P, K, pH, and trace elements. It incorporates microcomputer control with programmable settings for stable, and automated operation. Its built-in thermal printer enables instant one-touch printing of test results. Our Soil Nutrient Tester supports agricultural research, soil fertility assessment, fertilizer optimization, and environmental monitoring.

2. Features

- LCD Display
- Touch Key Operation
- Stable Light Source
- Real-Time Data Transmission
- Memory Storage
- Dual Power Support

3. Specifications

Model No.	LMSNT-A100
Measurement Range	0.001 to 9999
Resolution	0.001
Soil Moisture Range	0 to 100% (g/100g)
Element Detection	N, P, K, Organic Matter, pH, Ca, Mg, S, Fe, Mn, B, Zn, Cu, Cl, Si
Fertilizer Types Tested	Chemical, Organic (foliar, water-soluble, spraying)
Heavy Metal Detection	Pb, Cr, Cd, Hg, As
Water Quality Test	pH, Ca, Mg, S, Fe, Mn, B, Zn, Cu, Cl, Si
pH Measurement	1 to 14
Salt Content (Conductivity)	0.01% to 1.00%
Wavelength Range	Red: 680 ± 2 nm, Blue: 420 ± 2 nm, Green: 510 ± 2 nm, Orange: 590 ± 4 nm
Sensitivity	Red: Greater than or equal to 4.5×10^{-5}, Blue: Greater than or equal to 3.17×10^{-3}, Green: Greater than or equal to 2.35×10^{-3}, Orange: Greater than or equal to 2.13×10^{-3}
Repeatability Error	Less than or equal to 0.05%
Stability Drift	Less than or equal to 0.2% within 30 mins, less than or equal to 0.3%/0.001 within 1 hr, less than or equal to 0.5% within 2 hrs
Linear Error	Less than or equal to 0.2%
Test Speed (1 sample)	Less than or equal to 30 minutes
Test Speed (8 samples)	Less than or equal to 1 hour
Power Consumption	Less than or equal to 5W
Power Supply	AC 220V, DC 12V (vehicle power or built-in lithium battery)
Dimension	550 × 390 × 370 mm
Weight	5 kg

4. Applications

Soil Nutrient Tester LMSNT-A100 is ideal for agricultural research, soil health analysis, fertilizer management, and environmental monitoring across farming fields, research labs, nurseries, and soil testing agencies.

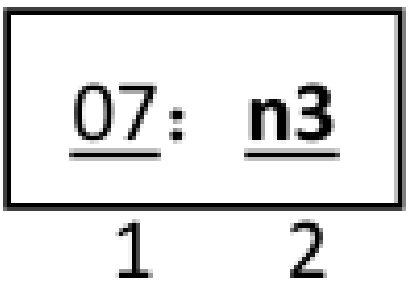
5. Operations

5.1 Operating instructions

1) **Warm up the instrument**
   The instrument will turn automatically into **"photoelectric colorimetric transmittance measurement"** state after it's turned on. For photoelectric colorimetric measurement, the instrument needs 20 minutes to warm up. For pH and moisture measurement, the instrument needs 5 minutes to warm up.
2) **Blank calibration**

- First, turn the front wheel of the filter, select the appropriate filter number according to test items (select according to the instructions), then put the blank solution in the light path, close the light-shielding cover, and press the "**colorimetric**" button to switch the function number to "1".
- Press the "adjust +" key, the LCD displays 100.0.
- Press the "Adjust-" button, the LCD displays 100.0. If not, press this button again until it displays 100.0 (until the "E" disappears completely, proceeding to the next step).

3) **Standard solution calibration**
   Press the "**colorimetric**" key to switch the function number to 3, put the standard liquid in the light path, close the shading cover, if the displayed value is greater than the standard value given in the manual, press the "adjust-" key; if the displayed value is less than the standard value, press the "adjust +" key until the displayed value is consistent with the standard value.
   Note: Don't start the next step until the "E" disappears completely.
4) **Solution to be tested**
   Place the test solution in the light path, close the light-shielding cover, and the value displayed at this time is the test solution concentration (mg/kg).
5) **Temperature test (when the temperature of the environment is required)**
   Press the "**Temperature/pH**" key to switch the function number to 4. The instrument will test the working environment temperature automatically and show it in Celsius.
6) **Save and print**
   If data needs to be retained for printing, you need to press the **"Save"** button after completing the test.
   For example, display



1) Number inside the machine
2) Storage state

21 kinds of storage status and their meanings:

n1	Alkaline hydrolysis of nitrogen
n2	Nitrate
n3	Ammonium Nitrogen
P	Available phosphorus
L	Available potassium
F	Organic matter
Fn1	Acid Decomposition of Nitrogen in Fertilizers
Fn2	Nitrate nitrogen of fertilizer
Fn3	Ammonium Nitrogen of Fertilizer
Fn4	Urea Nitrogen
Fn5	Urea Biuret
Fn6	Total nitrogen of the fertilizer
FP1	Available phosphorus of fertilizer
FP2	Water-soluble phosphorus of fertilizer
FP3	Total phosphorus of fertilizer
FF1	Humic acid of fertilizer
FF2	Organic matter of fertilizer
FL1	The available potassium of the fertilizer
FL2	Total potassium in the fertilizer
pH	pH value
H2O	Water content

At this time, "adjust +" and "adjust-" keys can be used to switch storage status. If you press the "Store" button again, test results in the solution will be stored in the cache of the instrument, and will not disappear even if the instrument is turned off. The data will not be deleted from the cache until it is printed out. If you press any key other than "adjust +", "adjust-", and "store", it means to give up storing and exit.
Press the **"Print"** key, and the instrument displays "LP". At this time, if you press any key except the "Print" key, it will exit the printing state. If you press the "Print" button again, the printer starts printing from the last test number; the display does not display the test number of this sample, and deletes its data from the buffer. After a datum is printed, the second and third from the bottom will be printed until the first one. (Up to 60 sets of data can be cached in the machine. If you need to continue storing, print out the previously stored data before storing.)
During printing, if you press any key other than the "**print"** key and hold it down, the printing state will quit after printing the current sample data.
Note:

- The cuvette should be cleaned before colorimetric analysis. Whether it is clean or not will directly affect the colorimetric result. Do not touch the optical surface of the cuvette with your hands or wipe the optical surface with hard paper or cloth. If the light-transmitting surface of the cuvette is dirty or not clear, it should be soaked and washed with a washing detergent. The used cuvette can be wiped with lens cleaning paper and then placed in the box.

- The 4 cuvettes provided by this instrument are matched cuvettes. The reading error is ≯0.5 after being loaded with 2000μg/mL copper sulfate standard solution. If the user purchases the cuvettes, please check the matching cuvettes. Do not use unmatched cuvettes for color comparison.
- The light surface of the cuvette wall should face the light source when the cuvette is put in the light path.
- After adding one solution, shake it to mix well and then add the second one.
- If there is a solution outside the cuvette, it must be wiped dry with lens cleaning paper before testing; otherwise, it will cause light scattering and lead to larger test errors.
- Do not spill the colorimetric solution into the colorimetric tank. Once it is spilled, absorb the solution with absorbent paper immediately.
- If the pH electrode is not used, the cap must be worn; otherwise, abnormal phenomena may occur during the test.
- When connecting the printer, the communication line should be connected before the printer's power supply.
- When shutting down, the AC power cord must be unplugged, and check whether the cuvette in the cuvette tank is taken out to prevent the chemical solution from spilling into the tank and causing circuit corrosion damage.
- To prevent acid and alkali liquids from burning clothes and skin, do not spill the solution on the clothes during the measurement. Wash your hands after the measurement work to prevent the taking of certain poisonous solutions by mouth.
- Keep solutions out of the reach of children. The solution box should be locked to prevent children from taking it out and playing.

5.2 Determination method of soil nutrients

5.2.1 Collection and processing of soil samples

To make sure the samples represent the nutrient status of the field, samples should be taken at multiple points. Avoid sampling at the edge of fields, roadsides, ditch sides, manure piles, or wherever chemical fertilizers are placed. The sampling method can adopt the diagonal method, five-point sampling method, checkerboard sampling method, etc. Generally, at least five sampling points should be taken for each plot, and more samples can be taken for a large plot. The sampling depth is generally based on the cultivated layer (0-20cm). Samples taken from multiple points should be mixed thoroughly, discard the excess part according to the quarter method, keep about 250g, and remove the litter, residual roots, and other impurities. If there are clouds, they should be crushed. As the sample to be tested for analysis and testing. Generally, fresh soil samples are suitable for the rapid determination of soil nutrients.

5.2.2 Determination of soil water content

Weighing method:

Soil water content not only affects the growth and development of crops, but also needs to be used for nutrient content calculations in the process of soil nutrient determination. The operation steps are:

- After cleaning the aluminum box, weigh it on the balance and record it as W1.
- Put about 5g of the fresh soil sample into the aluminum box, and record it as W2.

- Add 5-10mL of burning alcohol (over the upper level of wet soil) into the aluminum box, mix it with the soil and ignite it, and then add 5mL of alcohol to ignite after the flame is extinguished. After the flame is extinguished, weigh it after cooling slightly, and record as W3.
- **Result calculation:**

  Soil water content (%) = (W2-W3)/(W3-W1) ×100%

5.2.3 Determination of soil pH

1) **Soil sample preparation**

   Remove large clods from the soil sample (air-drying is not necessary), weigh 25g, and put it in a small beaker. Add distilled water to the weight of the air-dried soil at a ratio of 1:1 (2:1 for acid soil) according to the soil water content. Stir to make the soil fully dispersed and allow it to stand for half an hour for determination.

2) **pH test paper measurement method**

   Dip the pH 5-9 precision test paper into the clear solution of the soil sample, take it out after half a minute, and observe the color of the test paper in comparison with the colorimetric plate.

   pH 7.0 is neutral, pH 6.5-7.0 is slightly acidic, pH 6.0-6.5 is weakly acidic, pH 5.5-6.0 is acidic, pH<5.5 is strongly acidic; pH 7.0-7.5 is slightly alkaline, pH 7.5-8.0 is weakly alkaline, pH 8.0-8.5 is alkaline, and pH above 8.5 is strongly alkaline.

3) **pH electrode measurement method**

   Preparation of standard buffer solutions of pH 4.01 and 9.18 (for use with pH electrodes):

   Take a small bag of standard buffer solution (powder) in a 100mL volumetric flask (the drug adhering in the plastic bag needs to be rinsed off), dilute the volume to 100mL with prepared decarbonated distilled water (boiling and cooling), and shake it well to make the corresponding Standard buffer with the right pH value.

➢ **Calibration**

- **Calibration before measurement:** Press the "temperature/PH" key to switch the function number to 5, rinse the pH electrode probe with distilled water and absorb the water with filter paper, then put it into the standard buffer solution of PH4.01, press "adjust +" key, wait until the "E" disappears and the displayed value (not necessarily 4.01, which is related to temperature) stabilizes, this calibration is completed. (The calibration must be performed before each measurement.)
- **Regular calibration:** After pH4.01 calibration of the electrode, rinse the probe with distilled water and absorb the water with filter paper, then put it into the pH9.18 standard buffer solution, press the "adjust-" button, and wait until "E" disappears. The calibration is completed as the value (not necessarily 9.18, which is related to temperature) is stable. (This calibration can be calibrated once a week.

➢ **Determination of pH**

Rinse the calibrated pH electrode with distilled water and absorb the water with filter paper, then put it in the depth solution to be measured, wait for 2-3 minutes, and after the displayed value is stable, the displayed value is the pH of the solution.

Note: After each use of the pH electrode, the probe needs to be rinsed with distilled water and absorb the water with filter paper, then soak it in saturated potassium chloride solution, and install a 50Ω terminator on the electrode interface to prevent electrostatic interference.

5.2.4 Determination of soil organic matter

1) **Preparation of the solution**

- **Organic reagent A:** Weigh 8 g of organic reagent A(powder), put it in a conical flask, and add an appropriate amount of distilled water (about 50 ml, the medicine on the plastic bag needs to be rinsed off as well). After it is completely dissolved, transfer it to a 100 mL volumetric flask, add distilled water to the mark, and shake well.
- **Organic reagent B:** Take a bag of organic reagent B powder, put in a conical flask (the powder adhered in the plastic bag need to be rinsed off), add 40 mL of distilled water, 1.0 mL of concentrated sulfuric acid, and transfer it to a 100 mL volumetric flask(the remaining liquid in the triangular flask should be rinsed). Make the volume up to the mark with distilled water and shake it well.

2) **Steps**

Add 3 mL of distilled water into the first 100 mL conical flask as a blank; pipette 3 mL of the organic matter reagent B solution into the second 100 mL conical flask as a standard; weigh 1 g of air-dried soil sample into the conical flask, or use fresh soil (1+Water content) g is added to the third 100mL conical flask and evaporated to dryness in a boiling water bath, and 3 mL of distilled water is added to shake the soil sample to be tested. Add to the three conical flasks one by one: Organic reagent A solution 10 mL, concentrated sulfuric acid 10mL. After shaking for half a minute, immediately place it in a boiling water bath and heat for 15 minutes, then add 25 mL of distilled water, shake well, filter, and set aside.

3) **Testing methods**

Pipette 2.5 mL each of the blank solution, standard solution, and test solution into three cuvettes.

- Turn the left wheel of the filter to “4", place the blank in the light path, press the "colorimetric" key in turn, the function number will be switched to 1, press the "adjust +" key, the instrument displays ≤100%; press the "adjust-" key to make the instrument display 100%.
- Press the "colorimetric" key, switch the function number to 3, put the standard solution in the light path, and press the adjustment key to make the instrument display a value of 26.
- Put the solution to be tested in the light path, and the value shown by the instrument at this time is the soil organic matter content (%).

Note: Water bath heating is not necessary when the room temperature is above 20℃, but it should be left for 15-20 minutes before adding 25 mL of distilled water.

5.2.5 Determination of soil available nutrients

1) **Preparation of the solution**

- **Preparation of soil extractant:** Add 1 bag of soil extractant powder into a 500mL volumetric flask, and add distilled water to the volume mark.

- **Preparation of soil mixed standard solution:** Add 1.0 mL of the soil nutrient mixed standard stock solution into a 100mL volumetric flask, and then add the soil extractant to the mark. Make sure the cover of the soil standard solution is always sealed.

2) **Preparation of soil nutrient test solution**
Weigh 1.0 gram of air-dried soil sample or 1.0 gram of fresh soil sample (1+water content), and put it in a soil extraction bottle (conical flask or plastic bottle), add 20 mL of soil extractant into the extraction bottle, add 1 spoonful of soil decolorizing agent into the extraction bottle, keep the temperature between 20-25℃, vigorously shake for 3 minutes (a reciprocating shaker of 280 times per minute is recommended), filter it and transfer to a dry conical flask. The solution is ready for use as a test of soil available nutrients. This solution can be used to determine ammonium nitrogen, nitrate nitrogen, available phosphorus, and available potassium in soil.

3) **Determination of soil ammonium nitrogen**
Add 2 mL of the soil extractant and place it in a test tube as a blank. Take 2 mL of the soil standard solution in another test tube, add 2 mL of the soil test solution to the third test tube, and add:
4 drops of soil ammonium nitrogen reagent No. 1
4 drops of soil ammonium nitrogen reagent No. 2
2 drops of soil ammonium nitrogen reagent No. 3
Shake well, keep for 10 minutes, and transfer to three cuvettes for measurement:

- Turn the left wheel of the filter to set the value to 1, place the blank solution in the light path, press the "**colorimetric**" key, the function number will switch to 1, press the "adjust +" key, the instrument will show ≤100%; press the "adjust-" key to make the instrument display 100%.
- Press the "**colorimetric**" key, switch the function number to 3, put the standard solution in the light path, and press the adjustment key to make the instrument display a value of 48.0.
- Put the test solution in the light path, and the instrument will show the ammonium nitrogen content (mg/kg) in the soil.

4) **Determination of soil nitrate nitrogen**
Add 2mL of the soil extractant into one test tube as a blank solution, add 2mL of the soil standard solution into another test tube as a standard solution, add 2mL of the soil test solution into the third test tube as the test solution, and add in sequence:
4 drops of Nitrate Nitrogen Reagent No. 1 (Gradually add and shake)
10 drops of Nitrate Reagent No. 2
1 drop of nitrate No. 3 reagent (shake vigorously before use or heat 3 minutes in a hot water bath at about 70℃ and shake a few times to fully suspend the sediment before use)
Shake for one minute, let it stand for 15 minutes, and transfer to three cuvettes for measurement.

- Turn the left wheel of the filter to set the value to 2, place the blank solution in the light path, press the "**colorimetric**" key, the function number will switch to 1, press the "adjust +" key, the instrument displays ≤100%; press the "adjust-" Key to make the instrument display 100%.

- Press the "**colorimetric**" key to switch the function number to 3, put the standard solution in the light path, and press the adjustment key to make the instrument display a value of 48.0.
- Put the test solution in the light path, and the instrument shows the nitrate nitrogen content (mg/kg) in the soil.

Note: Nitrate nitrogen rises and falls with water and is mainly distributed in the 0-40 cm soil layer. To make the test results correspond to reality, it is recommended that the soil be sampled at a depth of 0-40 cm, and the soil weight coefficient (0.15) should change to 0.3 during calculation.

Note: For those who add a reducing agent when measuring soil hydrolyzed nitrogen, there is no need to measure nitrate nitrogen separately.

5) **Determination of soil available phosphorus**

Add 2mLofsoil extractant (for blank use), 2 mL of soil standard solution (for standard use), and 2 mL of soil filtrate (for testing) into three test tubes in sequence:

4 drops of Soil Available Phosphorus Reagent No. 1 (slowly and carefully, shake until there are no bubbles).

4 drops of Soil Available Phosphorus No. 2 Reagent, shake well until there are no bubbles.

1 drop of Soil Available Phosphorus No. 3 Reagent, shake well.

Shake well, let stand for 10 minutes, and transfer to three cuvettes, respectively, and measure them.

- Turn the left wheel of the filter to set the value to 6, place the blank solution in the light path, press the "**colorimetric**" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" key to make the instrument show 100%.
- Press the "**colorimetric**" key, the function number will switch to 3, put the standard solution in the light path, and press the adjustment key to make the instrument show a value of 48.0.
- Put the solution to be tested in the light path, and the reading of the instrument is the content of P_2O_5 in the soil (mg/kg).

Note: When the room temperature is lower than 20°C, it is recommended to extend the side-front reaction time appropriately until the color of the solution is stable before measuring. The indicator of stable color is when the reading is stable after standard adjustment, and there are no air bubbles attached to the cuvette wall.

6) **Determination of soil available potassium**

Add 2 mL of soil extractant into one test tube as a blank; add 2 mL of soil standard solution into another test tube as a standard; add 2 mL of soil nutrient filtrate into the third test tube as a test solution; add in sequence:

4 drops of soil available potassium reagent No. 1.

4 drops of soil available potassium reagent No. 2.

Shake well, transfer to three cuvettes, and measure on the machine immediately:

- Turn the left wheel of the filter to set the value to 6, place the blank solution in the light path, press the "**colorimetric**" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" key to make the instrument show 100%.

- Press the "**colorimetric**" key to switch the function number to 3, put the standard solution in the light path, and press the adjustment key to make the instrument display a value of 200.0.
- Put the test solution in the light path, and the reading of the instrument is the K2O content (mg/kg) in the soil.

7) **Determination of soil hydrolyzed nitrogen**

➢ **Upland soil**

Preparation of test solution, blank solution, and standard solution

Add 25mL of distilled water to the 100 mL conical flask, add 12 drops of hydrolysis agent, 2 drops of stabilizer, and then weigh 1.0 g of air-dried soil sample or 1.0 g of fresh soil sample (1+water content) and 1 g of reducing agent. Mix well and add it to the above-mentioned conical flask, and then quickly seal it with a rubber stopper with a distillation tube. Hang a bottle containing 2-5 mL of distilled water at the outlet of the distillation tube (make sure the liquid level is just over the mouth of the distillation tube). Add 3 drops of absorbent to left and right distilled water bottle (show in the pictured) in the water bottle. Place the conical flask with the distillation tube on the asbestos net and heat it to medium boiling (with an electric stove or alcohol lamp). Shake the conical flask intermittently before boiling to prevent bubbles from rushing up. After the boiling is stable, keep the distillation for 7 minutes, and remove it from the electric furnace. After cooling, pour the absorption solution into the vial together with the liquid that enters the distillation tube, and transfer it to a 100mL volumetric flask without loss (repeated three times of rinsing and transfer it into the volumetric flask), add distilled water to make the volume up to complete the hydrolyzed nitrogen test solution.

Use distilled water as a blank solution when measuring hydrolyzed nitrogen.

Note: Preparation of hydrolyzed nitrogen reducing agent: Weigh 10 g of ferrous sulfate and 2 g of zinc powder with a balance, mix well, seal and cover, and store in a moisture-proof container for further use.

The standard solution is prepared by diluting the soil mixed standard stock solution 100 times with distilled water; that is, use 1 mL of the soil nutrient mixed standard stock solution, put it into a 100mL volumetric flask, and then dilute to the mark with distilled water.

➢ **Measurement method**

Add 2 mL each of the hydrolyzed nitrogen test solution, standard solution, and blank solution, and transfer them into three test tubes. To these three test tubes, add:

4 drops of soil ammonium nitrogen reagent No. 1.

4 drops of soil ammonium nitrogen reagent No. 2.

2 drops of soil ammonium nitrogen reagent No. 3.

Shake well, transfer to three cuvettes after 10 minutes, and measure on the machine:

- Turn the left wheel of the filter to set the value to 1, put the blank solution in the light path, press the "**colorimetric**" key, the function number will switch to 1, press the "adjust +" key, the instrument displays ≤100%; press the "adjust-" key to make the instrument display 100%.
- Press the "**colorimetric**" key, the function number will switch to 3, put the standard solution in the light path, and press the adjustment key to make the instrument display a value of 240.

- Put the test solution in the light path, and the instrument reading is the hydrolyzed nitrogen content (mg/kg) in the soil.
  The hydrolyzed nitrogen in this determination is available nitrogen, including nitrate nitrogen, ammonium nitrogen, and easily hydrolyzed organic nitrogen.
  Note 1: When there is no need to measure nitrate nitrogen, no reducing agent needs to be added. At the same time, only 8 drops of hydrolyzing agent should be added, and the other steps remain unchanged.
  Note 2: The reducing agent is easy to absorb moisture and reduce performance, so it must be sealed and always stored.

➢ **Paddy soil**
Same as upland soil, but only 10 drops of hydrolyzed nitrogen hydrolysis agent are needed. Do not use a reducing agent.
Note: The soil nutrient content applicable to the determination method described in this manual is:

Item	Ammonium nitrogen	Nitrate	Hydrolyzed nitrogen	Available phosphorous	Available potassium	Organic matter	Total nitrogen
Content (mg/kg)	10-240	20-100	30-500	10-96	40-300	5%-45%	0.5%-6%

When the measured value exceeds the upper limit in the table, it is the test solution with the corresponding extractant and dilute the adjustment value of the standard solution as well.
If the measured result is greater than the maximum content in the table, it is recommended to dilute the filtrate and measure it according to the above method, and then multiply the measured value by the dilution factor to obtain the soil nutrient content. When it is necessary to dilute the test solution, dilute it with an extractant. Do not dilute the standard solution.

8) **Conversion of the test value between this quick test method and the conventional method**
Although the measurement methods recommended in this manual are all from classic methods, they are rapid measurement methods, and their results are somewhat different from conventional methods. After testing, there is a very significant correlation between the two. Under certain soil conditions, it can be converted into routine measurement values. The following conversion coefficients are obtained from soils in several provinces through a large number of tests and can be used in most areas. However, due to the complexity of soil conditions, local soil conversion coefficients can be set by themselves if possible.
Table - Conversion between the quick measurement method and the conventional method

Item	Hydrolyzed Nitrogen	Ammonium Nitrogen	Nitrate	Available phosphorus	Available Potassium	Organic matter	Total Nitrogen
Conversion ratio	1.0—1.3	1.0	1.0	1.0	1.0	1.0-1.2	1.0

Methods recommended by this manual	Alkali-hydrolyzed distillation method	Nessler's colorimetric method	Nitric acid test powder method	Molybdenum blue colorimetry	Titration method with sodium tetraphenyl boron solution	Potassium Dichromate	Acidolysis Colorimetry
Corresponding conventional method	Alkaline Diffusion Method	Nessler's colorimetric method	Nitric acid test powder method	Mo-Sb colorimetric method	Flame photometry	Tyurin's method (×1.1)	Acid hydrolysis titration
Corresponding extraction method	-	Potassium Chloride (KCl)	Distilled water	Olsen method	Ammonium acetate	-	-

Note 1: Multiplying the measurement result of this rapid measurement method by the conversion factor is roughly equivalent to the conventional measurement value.
Note 2: The conversion factor of 1.0 indicates that the result of this quick test is roughly equivalent to 95-105% of the measured value of the control.
Note 3: The coefficients in this table are for reference only. It is recommended that users in various places conduct a comparison of actual measurements for specific local soils and find the local conversion coefficient.

5.3 Determination method of fertilizer nutrients

5.3.1 Collection and processing of fertilizer samples

To make sure the measured samples represent the nutrient status of the field, it is required to sample at multiple points, discard the excess part according to the quarter method, and keep about 250 g; for block and granular elemental fertilizers and compound fertilizers, organic fertilizers (required Air-dried), reduce to 100 g by the quarter method. By crushing or grinding, sifting through a 1mmsieve (i.e., 20 mesh sieve), sealed and stored for further use.

5.3.2 Determination of water content of fertilizer

The low-temperature vacuum drying method or the aluminum box drying weighing method can be used (mainly suitable for organic fertilizers).

5.3.3 The preparation of the medicament

1) **Fertilizer nutrient standard solution:** Add 1.0mL of the reserve mixed fertilizer standard solution, put it in a 100mL volumetric flask, and add distilled water to the mark to be the mixed fertilizer standard solution. It should be sealed at any time during use.
2) **Fertilizer extractant:** Weigh 10 g of fertilizer extractant powder, put it into a 500 mL volumetric flask, and dissolve it with distilled water to the volume mark. (This powder can be prepared immediately or directly weighed 1 g+50 mL distilled water for each sample).

5.4 Determination of N, P, and K content of elementary fertilizer

5.4.1 Determination of N content in nitrogen fertilizer

1) Determination of N content of ammonium sulfate, ammonium chloride, ammonium nitrate, ammonium bicarbonate, and other ammonium nitrogen fertilizers.
   Preparation of the test solution:
   Weigh 0.5g (accurate to 0.01g) of a representative fertilizer sample that has been ground, add to a 100 mL conical flask, add about 50 mL of distilled water + 1 mL of concentrated sulfuric acid (or 50 mL of fertilizer extractant), and seal it with a rubber stopper. Keep it at about 25℃, shake until it is completely dissolved (or heat on the electric stove for 5 minutes), then transfer to a 100mL volumetric flask, add distilled water to make the volume, shake well, and then filter into a clean conical flask (no need to filter if the solution is clear. If the conical flask is wet, discard the first filtrate).
   Add 2.0mL of the filtrate into a 100mL volumetric flask, use distilled water to make the volume up to the mark, shake evenly to complete the ammonium nitrogen test solution.
2) **Measurement steps**
   Add 2.0 mL of distilled water (for blank solution), 2.0 mL of fertilizer standard solution, and 2.0 mL of fertilizer test solution into three small glass bottles, and add the following content sequentially:
   4 drops of fertilizer ammonium N reagent No. 1; 4 drops of fertilizer ammonium N reagent No. 2; 4 drops of fertilizer ammonium N reagent No. 3; 2 drops of fertilizer Ammonium N reagent No. 4.
   Shake well, let stand for 10 minutes, and transfer to three cuvettes respectively, and measure on the machine:

- Turn the left wheel of the filter to set the value to 1, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" key to make the LCD show 100%.
- Put the standard solution in the light path, press the "colorimetric" key to switch the function number to 3, and press the adjustment key to display the value in the table.
- Put the test solution in the light path, and the displayed value is the fertilizer's ammonium N content (%). For ammonium nitrate, the measured value × 2 is the fertilizer N content.

5.4.2 Determination of N content in Nitrate Nitrogen Fertilizer

1) Preparation of the test solution: Same as the test solution for ammonium nitrogen fertilizer.
2) **Measurement steps**
   Add 1.0 mL of distilled water, fertilizer standard solution, or test solution into three small glass bottles, add 2 mL of distilled water to the three small glass bottles, and then add the min sequence:
   Fertilizer Nitrate Nitrogen Reagent No. 1 2 drops.
   Fertilizer Nitrate Nitrogen No. 2 Reagent 4 drops.

Fertilizer nitrate nitrogen No. 3 reagent 1 drop (before dropping, it must be shaken vigorously or heated in a 70°C hot water bath for 3 minutes and shaken several times to fully suspend the sediment before adding it).
Shake well, let stand for 15 minutes, and transfer to three cuvettes for measurement on the machine.

- Turn the left wheel of the filter to set the value to 2, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" Key to make the LCD show 100%.
- Put the standard solution in the light path, press the "colorimetric" key to switch the function number to 3, and press the adjustment key to display the value as in the table.
- Put the test solution in the light path, and the displayed value is the fertilizer nitrate nitrogen content (%). If the fertilizer is ammonium nitrate, the measured value × 2 is the nitrogen content of the ammonium nitrate fertilizer.

5.4.3 Determination of the N content of urea

1) **Preparation of the test solution:**
Weigh 0.5g (accurate to 0.01g) of a representative fertilizer sample that has been ground, and place it in a 100mL conical flask. Add 5mL of water to moisten the sample, then add 2mL of concentrated sulfuric acid, heat it with a low flame, and shake it continuously. Stop heating when white smoke starts. After cooling, carefully add a little distilled water, transfer to a 100mL volumetric flask, dilute to the mark with distilled water, shake well, and filter (if the solution is clear, it is not necessary to filter), use a 1mL pipette to suck 0.5mL filtrate into a 100mL volumetric flask, and add distilled water to the content mark to complete the test solution.
2) **Determination procedure:**
Same as the procedure for the determination of nitrogen content of ammonium nitrogen fertilizers. Adjust the standard to the value in the table, and the display readings of the test solution are the nitrogen content of urea (%).

5.4.4 Determination of biuret content in urea

1) **Preparation of the test solution:**
Weigh 3.00g urea sample (accurate to 0.01g), transfer to a 100mL volumetric flask, add an appropriate amount of water to dissolve it, add distilled water to the mark, shake well to prepare the test solution.
2) **Measurement Procedure:**
Add 2.0 mL of distilled water (for blank solution), biuret standard solution, or test solution into three small glass bottles, and add them in sequence:
2 drops of Biuret masking agent; 4 drops of Biuret developer.
Shake well and keep the temperature at about 25°C. After 15 minutes, transfer to three cuvettes and test on the machine:

- Turn the left wheel of the filter to set the value to 2, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" Key to make the LCD show 100%.

- Put the standard solution in the light path, press the "colorimetric" key to switch the function number to 3, and press the adjustment key to show the value in the table.
- Place the test liquid in the light path, and the displayed value at this time is the biuret content (%) in urea.

5.4.5 Determination of phosphorus content in phosphate fertilizer

1) **Determination of available phosphorus (water-soluble, citric acid-soluble) in phosphate fertilizer.**

➢ **Preparation of the test solution**

Weigh 0.5g (accurate to 0.01g) of a representative sample that has been ground, and place it in a conical flask. Add about 50mL of distilled water and 1mL of concentrated sulfuric acid (or 50mL of fertilizer extractant), sealed with a rubber stopper, and keep the temperature at 25°C. Shake around, vortex until completely dissolved (or heat on the electric stove for 5 minutes), then transfer to a 100mL volumetric flask, add distilled water to make up, shake well, and then filter in a clean conical flask (if the solution is clear, do not filter; if the bottle is wet, discard the first filtrate).

Add 0.5mL of filter solution (if it is superphosphate, then 2mL of filtrate) into a 100mL volumetric flask, and add distilled water to the mark to complete the test solution.

➢ **Measurement procedure**

Add 2.0 mL of distilled water (for blank solution), fertilizer standard solution, and test solution into three small glass bottles, and add 7 drops of Fertilizer phosphorus reagent. Shake well, and after standing for 20 minutes, transfer to three cuvettes for measurement on the machine:

- Turn the left wheel of the filter to set the value to 1, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" Key to make the LCD show 100%.
- Put the standard solution in the light path, press the "colorimetric" key to switch the function number to 3, and press the adjustment key to display the value in the table.
- Put the liquid to be tested in the light path, and the displayed value at this time is the available phosphorus content (%) of the fertilizer.

2) Determination of water-soluble phosphorus content in phosphate fertilizers (including superphosphate, double superphosphate, monoammonium, diammonium, etc.)

➢ **Preparation of the test solution:**

Weigh 0.5g (accurate to 0.01g) of a representative sample that has been ground, put it in a conical flask, add 50mL of distilled water, seal it with a rubber stopper, keep the temperature at about 25℃, and shake until it is completely dissolved (or 30 minutes), transfer to a 100mL volumetric flask, make the volume with distilled water, shake well and filter in a clean Erlenmeyer flask (discard the initial filtrate if the bottle is wet).

Add 0.5mLfilter solution (2.0mL filtrate for superphosphate) into a 100mL volumetric flask, add distilled water to the mark to complete the fertilizer water-soluble phosphorus test solution.

➢ **Measurement procedure**

Add 2.0 mL of distilled water (for blank solution), fertilizer standard solution, or test solution into three small glass bottles, and add 7 drops of Fertilizer phosphorus reagent.

Shake well, and after standing for 20 minutes, transfer to three cuvettes for measurement on the machine:

- Turn the wheel of the filter to set the value to 1, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" Key to make the LCD show 100%.
- Put the standard solution in the light path, press the "colorimetric" key to switch the function number to 3, and press the adjustment key to display the value in the table.
- Place the test liquid in the light path, and the displayed value at this time is the water-soluble phosphorus content (%) of the fertilizer.

3) **Determination of potassium content in potassium fertilizer**

➢ **Preparation of test solution**

Weigh 0.5g of a representative fertilizer sample that has been ground and place it in a conical flask, add about 50mL of distilled water + 1mL of concentrated sulfuric acid (or 50mL of fertilizer extractant), seal it carefully with a rubber stopper, keep the temperature at about 25°C, and shake until it is completely dissolved (Or heat it on the electric stove for 5 minutes), then transfer to a 100mL volumetric flask, add distilled water to make the volume, shake well, and then filter into a clean Erlenmeyer flask (if the solution is clear, do not filter, if the Erlenmeyer flask is wet, discard the initial filtrate). Finally, use 0.5mL of the filtrate (when the potassium content is higher than 30%, it needs to be diluted 40,000 times) or 1mL of the filtrate (when the potassium content is less than 30%, it needs to be diluted 20,000 times) into a 100mL volumetric flask. Add distilled water to the volume mark to complete the test solution for available potassium in fertilizer.

➢ **Measurement procedure**

Add 2mL of distilled water (as blank solution), standard solution or test solution into three small glass bottles, and add them in sequence:

4 drops of fertilizer potassium reagent No. 1.

4 drops of fertilizer potassium No. 2 reagent.

4 drops of fertilizer potassium reagent No. 3.

After shaking well, transfer them to three cuvettes for measurement on the machine.

- Turn the left wheel of the filter to set the value to 6, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" Key to make the LCD show 100%.
- Press the "colorimetric" key, the function number is switched to 3, put the standard solution in the light path, and press the adjustment key to show the value in the table.
- Put the test solution in the light path, and the displayed value is the K2O content (%) in the fertilizer sample.

Note 1: For fully water-soluble fertilizers, distilled water can be used as an extractant. After complete dissolution, if the solution is very clear, it can be measured directly without filtering.
Note 2: The method for determining the available phosphorus and potassium content in the compound (mixed) fertilizer is the same as that of the elemental fertilizer (the amount of extractant is 50 mL or 1g extractant+50 mL distilled water).

5.5 Determination of nitrogen, phosphorus, and potassium content in compound (mixed) fertilizer

5.5.1 Preparation of the test solution

Weigh 0.5 g of a representative fertilizer sample that has been ground and place it in a 100 mL conical flask. Add 5 mL of water to moisten the fertilizer, and then add 2 mL of concentrated sulfuric acid, heat it with a low flame, and shake it continuously until no bubbles or smoke are emitted. Transfer to a 100mL volumetric flask after cooling, dilute to the mark with distilled water, after filtering, transfer 2.0 mL filtrate into a 100 mL volumetric flask, add distilled water to the volume mark to complete the test solution (this test solution can be used for the determination of nitrogen, phosphorus, and potassium content in compound fertilizers).

5.5.2 Measurement Steps

1) **Determination of total nitrogen content**

➢ **For nitrogen content that is less than 25%:**

Add 2mL of distilled water into a small glass bottle as a blank, add 2 mL of fertilizer standard solution into another small glass bottle, add 2 mL of fertilizer test solution into the third small glass bottle, add:
4 drops of fertilizer ammonium nitrogen No. 1 reagent.
4 drops of fertilizer ammonium nitrogen No. 2 reagent.
4 drops of fertilizer ammonium nitrogen No. 3 reagent.
2 drops of fertilizer Ammonium Nitrogen No. 4 Reagent.
Shake well, transfer to three cuvettes after 10 minutes, and measure on the machine:

- Turn the left wheel of the filter to set the value as 1, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" key to make the instrument show 100%.
- Press the "colorimetric" key, the function number is switched to 3, put the standard solution in the light path, and press the adjustment key to show the value in the table.
- Put the test solution in the light path, and the reading of the instrument is the content (%) of ammonium nitrogen in the fertilizer sample.

➢ **For the nitrogen content that is higher than 25%:**

Add 2mLofdistilled water into a small glass bottle as a blank, add 2 mL of fertilizer standard solution into another small glass bottle, add 1 mL of fertilizer test solution + 1 mL of distilled water into the third small glass bottle.

Set the standard solution value to 2 times higher, and other operations are the same as (1) the operation of determining the nitrogen content for the nitrogen content is less than 25%.

Note 1: If there's reddish-brown gas when adding concentrated sulfuric acid to the Erlenmeyer flask, there is nitrate nitrogen in the compound fertilizer. The nitrate nitrogen content needs to be determined separately according to the elemental nitrate nitrogen method and compared with the original method. The nitrogen content determined by the method is added together to obtain the total nitrogen content in the compound fertilizer.

Note 2: Ammonium phosphate compound fertilizer can be directly weighed, 0.5g dissolved, and diluted with distilled water without being digested for determination.

2) **Determination of total phosphorus content**

Add 2mL of distilled water into a small glass bottle as a blank, add 2 mL of fertilizer standard solution into another small glass bottle, and add 2 mL of fertilizer test solution into the third small glass bottle. Add 7 drops of fertilizer phosphorus reagent to each bottle, shake well, transfer to three cuvettes after 20 minutes, and measure on the machine:

- Turn the left wheel of the filter to set the value to 1, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" key to make the instrument show 100%.
- Press the "colorimetric" key, the function number will switch to 3, put the standard solution in the light path, and press the adjustment key to show the value as in the table.
- Place the test solution in the light path, and the reading of the instrument is the content (%) of P2O5 in the fertilizer sample.

3) **Determination of total potassium content**

Add 2mLofdistilled water into a small glass bottle as a blank solution, add 2 mL of fertilizer standard solution into another small glass bottle as a standard solution, add 2mL of fertilizer available potassium test solution into the third small glass bottle, add in sequence:

4 drops of fertilizer potassium reagent No. 1.

4 drops of fertilizer potassium No. 2 reagent.

4 drops of fertilizer potassium reagent No. 3.

After shaking well, transfer to three cuvettes and test on the machine:

- Turn the left wheel of the filter to set the value to 6, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" key to make the instrument show 100%.
- Press the "colorimetric" key, the function number is switched to 3, put the standard solution in the light path, and press the adjustment key to display the value as in the table.
- Put the test solution in the light path, and the reading of the instrument is the K2O content (%) in the fertilizer sample.

Note: For fully water-soluble fertilizers, distilled water can be used to replace the extractant. It can be determined after being completely dissolved in water. After dissolving, if the solution is clear, use it without filtering.

5.6 Measurement of heavy metals (lead, chromium, cadmium, mercury, and arsenic) in the soil

5.6.1 Preparation of solution

1) **Lead reagent**

- **Lead masking agent:** Weigh 40 grams of lead masking agent (solid) in a beaker, add 100 mL of distilled water, then 2 drops of lead indicator, and adjust the pH to 8.5 - 9.0 with concentrated ammonia. Transfer to a 250 mL separatory funnel, repeat extraction with heavy metal developer several times, 10-20 mL each time, discard the developer layer until the color developer remains green. Wash with 10 mL chloroform and repeat washing 2 times, to make the chloroform layer colorless, and discard the chloroform layer. Transfer the purified liquid to a 200 mL volumetric flask and use distilled water to bring up the volume.
- **Masking agent:** Weigh 10 grams of lead mask agent(solid), dissolve it with distilled water, transfer it to a 100 mL volumetric flask, and bring it up to the volume mark with distilled water.
- **Lead-reducing agent:** Weigh 20 grams of lead-reducing agent solid in a beaker, add 40 mL of distilled water, add 2 drops of lead indicator, and add concentrated ammonia to adjust the pH to 8.5-9.0. Transfer to a 250mL separatory funnel, use heavy metal developer to extract several times, 10-20 mL each time, discard the developer layer until the color developer remains green. Wash three times with chloroform, 10 mL each time, to make the chloroform layer colorless, and discard the chloroform layer. Adjust the pH of the purified liquid to acidity with concentrated hydrochloric acid, transfer it to a 100 mL volumetric flask, and use distilled water to bring the volume mark.
- **Lead acid and alkali regulator:** Weigh 50 grams of lead acid and alkali regulator into a 100 mL beaker, add 50 mL of distilled water, stir to dissolve it completely, and pour it into a 25 mL white plastic bottle after cooling.
- **Lead stabilizer:** Pipet 20 mL lead stabilizer concentrate into a 100 mL volumetric flask, and bring up to volume with distilled water.
- **Heavy metal developer (the same below):** Pour the heavy metal developer from a small black plastic bottle and dissolve it in 50 ml of chloroform. If not completely dissolved, filter it with quantitative filter paper in a 250 ml separatory funnel, and use (1+99) Ammonia for extraction(3 times), 100 ml each time, filter the extract with cotton into a 500 ml separatory funnel, adjust to acidity with (1+1) hydrochloric acid, and use 100 ml, 50 ml, 50 ml for extraction of the precipitated dithizone. The chloroform was used for three rounds of extraction, and the chloroform layers were combined into the stock solution of the dithizone solution.

  Take 1.0 ml of stock solution, add chloroform to 10 ml, and mix well. Use a 10 mm cuvette and use chloroform as a blank to measure the absorbance (A) at the wavelength of the No. 2 filter, and use formula (1) to calculate the dithizone needed to prepare 100 ml of color reagent (70% transmittance). The volume (V/ml) of the stock solution is then diluted with chloroform and shaken well. (About 1ml)

  V=1.55/A (1)
- **Lead standard solution:** Pipette 1 mL of Lead standard liquid parent liquid into a 100 mL volumetric flask, and use distilled water to bring to volume.

2) **Arsenic reagent**

- **Arsenic standard solution:** Pipette 10mL arsenic standard solution stock solution into a 100 mL volumetric flask, and use distilled water to bring to the volume.
- **Arsenic acid and alkali regulator A:** Weigh 50 grams of arsenic acid and alkali regulator A (solid) in a 100 mL beaker, add 50 mL of distilled water, stir to completely dissolve it, and pour it into a 25 mL white plastic bottle after cooling.
- **Acid-base regulator B:** Use 34 mL of concentrated hydrochloric acid in a 100 mL volumetric flask, and add distilled water to make the volume constant. (When dropping, use a 25 mL white plastic bottle).
- **Arsenic masking agent:** Weigh 45 grams of arsenic masking agent(solids) in a beaker, add about 50 mL of distilled water to dissolve, transfer to a 100 mL volumetric flask, and use distilled water to bring to volume.
- **Arsenic co-masking agent:** Weigh 20 grams of Arsenic co-masking agent solid in a beaker, add distilled water to dissolve (heating to aid solubility when the temperature is low), transfer it to a 100 mL volumetric flask, and use distilled water to bring to volume.
- **Arsenic absorption solution:** A. Dissolve the Arsenic absorption liquid raw material A of the arsenic absorption solution in 80 mL of water, add 5 mL of concentrated nitric acid, and dilute to 100 mL with water. B. Put the arsenic absorption liquid raw material B of the arsenic absorbing solution in a beaker containing 100 mL of water, cover with a watch glass, boil for 5 minutes, and cool. Mix A solution, B solution, and absolute ethanol in a ratio of 1:1:2, and store in the dark.

3) **Cadmium reagent**

- **Cadmium standard solution:** Pipette 1 mL of cadmium standard solution stock solution into a 100 mL volumetric flask, and use distilled water to bring to the volume.
- **Cadmium acid-base regulator:** Weigh 35 grams of cadmium acid-base regulator solid into a beaker, add 65 mL of distilled water, stir to make it completely dissolved, and then cool.
- **Cadmium masking agent:** Weigh 20 grams of cadmium masking agent solid in a beaker, add 40 mL of distilled water, and add concentrated ammonia water to adjust the pH value to 8.5-9.0. Transfer to a 250mL separatory funnel, use heavy metal developer to extract several times, 10-20 mL each time, discard the developer layer, until the color of the developer does not change green. Wash three times with chloroform (10 mL each time) to make the chloroform layer colorless, and discard the chloroform layer. Adjust the pH of the purified solution to acidity with concentrated hydrochloric acid, transfer it to a 100 mL volumetric flask, and use distilled water to bring it to the volume.
- **Cadmium co-masking agent:** Weigh 100 grams of cadmium co-masking agent solids and dissolve them in a 500 mL beaker containing about 200 mL of distilled water, then add 250 mL of concentrated ammonia, and transfer to a 500 mL volumetric flask after the dissolution is complete, and use distilled water to bring to the volume.
- **Heavy metal chromogenic agent:** The same as the heavy metal chromogenic agent in lead.

4) **Chromium reagent**

- **Chromium standard solution:** Pipette 1mL of chromium standard solution stock solution into a 100 mL volumetric flask, and use distilled water to make the volume constant.
- **Chromium developer:** Pour out all the chromium developer solids in the small black plastic bottle, dissolve them with acetone, dilute to 100 ml, shake it well, and pour it into the small black plastic bottle for further use.

5) **Mercury reagent**

- **Mercury standard solution:** Pipette 1mL of mercury standard solution stock solution into a 100 mL volumetric flask, and use distilled water to bring to the volume.
- **Mercury masking agent:** Weigh 20 grams of mercury masking agent solids into a beaker, add 40 mL of distilled water, and add concentrated ammonia to adjust the pH to 8.5-9.0. Transfer to a 250 mL separatory funnel, and extract several times with heavy metal developer (10-20 mL each time), discarding the developer layer until the color developer remains green. Wash three times with chloroform, 10 mL each time, to make the chloroform layer colorless, and discard the chloroform layer. Adjust the pH of the purified solution to acidity with concentrated hydrochloric acid, transfer it to a 100 mL volumetric flask, and use distilled water to bring it to the volume. (It can be put into a small plastic bottle when using.)
- **Mercuryco-masking agent:** Weigh 20 grams of mercury co-masking agent solids in a beaker, add distilled water to dissolve it (heating to aid volume when the temperature is low), transfer it to a 100 mL volumetric flask, and use distilled water to bring to the volume.
- **Heavy metal chromogenic agent:** Same as the heavy metal chromogenic agent in lead.

5.6.2 Measurement method

1) **Combined digestion and determination of lead, arsenic, chromium, and cadmium**

Preparation of test solution:

Use three clean 100 mL conical flasks, label as No. 1 (for blank), No. 2 (for standard), and No. 3 (for sample). Put several glass balls into them (soaked in 10% Nitric acid overnight and rinsed with tap water and distilled water). Add 2.00 mL of lead standard solution, 2.00 mL of arsenic standard solution, 2.00 mL of chromium standard solution, and 2.00 mL of cadmium standard solution to bottle 2, and add soil sample (1.0g) to bottle 3. and then add mixed acid A (perchloric acid: nitric acid = 1:4, volume ratio) 10mL and concentrated sulfuric acid 2.5 mL to bottles 1, 2, and 3 respectively, (if you do two samples at a time, add more A conical flask). Then place the three conical flasks on an electric stove lined with asbestos nets and heat until there is about 2.5 mL of solution left, and the solution is colorless or light yellow, and no bubbles are generated. Remove the flask when a large amount of white smoke is generated in the flask. cool down. After cooling slightly, add about 20 mL of distilled water to the three conical flasks along the wall of the bottle with a washing bottle. Place them on the electric stove and heat again until white smoke is generated

in the bottle and about 2.5 mL of solution remains in the bottle. Remove the flask and cool down. Finally, use distilled water to transfer all the solutions to three 50 mL volumetric flasks carefully, and bring the volume to the mark. After shaking, they are the blanks, standards, and samples for the four heavy metals of lead, arsenic, chromium, and cadmium.

2) **Determination of lead, arsenic, chromium, and cadmium**

➢ **Determination of lead**

Use 5.00 mL each of the blank, standard, and test solution into three 50 mL colorimetric tubes, add 15mL distilled water each, shake well, and add 1.0 mL soil lead masking agent and 2.0 mL soil lead masking agent, respectively. 1.0 mL of soil lead reducing agent, 1 drop of soil lead color aid, 2 drops of soil lead indicator, shake well (after adding one kind, add the next agent after shaking up). Add dropwise (shaking while adding) the soil lead acid-base regulator until the solution is yellow-green, then add 2.0mL soil lead stabilizer B, shake well, and finally add 5.0 mL color developer, cover the stopper, and shake vigorously for 50 times, let it stand for 5 minutes, discard the upper layer of water and filter the organic layer in a cuvette with quantitative filter paper, and measure it immediately by the instrument.

- Turn the left wheel of the filter to set the value to 2, place the blank liquid in the light path, press the "colorimetric" key, switch the function number to 1, press the "adjust +" key, the LCD will display 100%; press the "adjust-" key, make the liquid crystal display 100%.
- Press the "colorimetric" key, the function number is switched to 3, put the standard solution in the light path, press the adjustment key to make the LCD display value 20.00.
- Put the solution to be tested in the light path, and the displayed reading is the content of lead (Pb) in the soil (mg/kg).

➢ **Determination of arsenic**

Draw 10.00mL each of the blank, standard, and test solution into three arsenic reaction flasks, add 1 drop of soil arsenic indicator, and then use acid-base regulator A drops (shaking the arsenic reaction flask while adding) until the solution just turned reddish, and then acid-base regulator B was added dropwise until it was colorless. Then add 30 mL of distilled water, 1.0 mL of soil arsenic masking agent, 5.0 mL of soil arsenic auxiliary masking agent, and 2.0 mL of acid-base regulator B (note that after each reagent is added, shake it well), and use the arsenic air tube to the arsenic reaction flask is connected to the arsenic absorption tank, and 3.0 mL of soil arsenic absorption solution is added to each absorption tank. Finally, 1.5 grams of soil arsenic reductant (weighed in advance and put into the reduction tube) is added to the arsenic reaction flask immediately. Seal it with the stopper of the reaction flask. If the reaction is too slow, shake the reaction bottle by hand to speed up the reaction. After reacting for ten minutes, put the color solution in the absorption cell in a cuvette, and use the machine for measurement.

- Turn the left wheel of the filter to set the value to 1, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the LCD will display 100%; press the "adjust-" key, make the liquid crystal display 100%.

- Press the "colorimetric" key, the function number is switched to 3, put the standard liquid in the light path, press the adjustment key to make the LCD display value 20.00.
- Place the test solution in the light path, and the displayed reading is the content of arsenic (As) in the soil (mg/kg).

➢ **Determination of chromium**

Transfer 5.00 mL each of the blank, standard, and test solution into three 25 mL colorimetric tubes, add 5 drops of soil chromium masking agent and 1 drop of soil chromium indicator, shake well and put into boiling water for 15 minutes of boiling without plugging them (if the solution fades during heating, add 1 drop of soil chromium indicator) and remove. After cooling, add 5 drops of soil chromium co-masking agent. After shaking, carefully add the soil chromium reducing agent dropwise to make the solution just fade to colorless. Use distilled water to bring the volume up to the 10mL mark, shake well, and set aside. Draw 2.00 mL of the prepared blank, standard, and test solution after treatment into three small reaction flasks, and add 2 drops of soil chromium auxiliaries, 3 drops of soil chromium masking agent, and 5 drops of soil chromium chromogenic agent (dropwise and shake well, then add the next one), shake well, let it stand for 10 minutes, pour it into a cuvette, and measure it on the instrument.

- Turn the left wheel of the filter to set the value to 2, place the blank liquid in the light path, press the "colorimetric" key, switch the function number to 1, press the "adjust +" key, the LCD will display 100%; press the "adjust-" key, make LCD display 100%.
- Press the "colorimetric" key, switch the function number to 3, put the standard solution in the light path, and press the adjustment key to make the LCD display value 20.00.
- Place the test liquid in the light path, and the displayed reading at this time is the content of chromium (Cr) in the soil (mg/kg).

➢ **Determination of cadmium**

Pipette 5.00 mL of the blank, standard, and test solution to three 50mL colorimetric tubes, respectively. Add 5 mL distilled water, 1.0 mL soil cadmium acidity regulator, 2.0 mL soil cadmium masking agent, and 8.0mL soil cadmium auxiliary masking agent. Then add 10.0 mL soil cadmium acidity regulator (shake well after each reagent is added before adding the next one), and shake well. Finally, add 5.0 mL of heavy metal developer, close the lid, shake it vigorously for 100 times, and let it stand for 30 minutes. Shake again vigorously 80 times and let stand for 5 minutes. Discard the upper aqueous phase, filter the organic phase in a 10mm cuvette with quantitative filter paper, and measure it on the machine.

- Turn the left wheel of the filter to set the value to 2, place the blank solution in the light path, press the "colorimetric" key, switch the function number to 1, press the "adjust +" key, the LCD will display 100%; press the "adjust-" key, make the liquid crystal display 100%.

- Press the "colorimetric" key, switch the function number to 3, put the standard solution in the light path, and press the adjustment key to make the LCD display value 2.50.
- Put the test solution in the light path, and the displayed reading is the content (mg/kg) of cadmium (Cd) in the soil.

3) **Determination of heavy metal mercury in soil**

➢ **Preparation of test solution:**

Take three clean 250 mL conical flasks with a ground mouth and mark them as No. 1 (for blank), No. 2 (for standard), and No. 3 (for samples). Put several glass balls into them (soaked in 10% Nitric acid overnight and rinsed with tap water and distilled water). Add 1.00 mL of mercury standard solution to bottle No. 2, add 1.0 g of soil sample to bottle No. 3, and add mixed acid B (perchloric acid: nitric acid = 1:9, Volume ratio), 20 mL, and 5 mL concentrated sulfuric acid (as a sample). Install the absorption device separately, add water to the small reaction flask in the device until the outlet of the absorption device just meets the water surface, and then rotate the conical flask to prevent local carbonization. Finally, heat it on the electric hot plate at the same time (if some samples become black during the digestion or spraying, you need to remove the conical flask and replace the absorption liquid in the absorption flask with distilled water before continuing to heat), until the flask starts to heat up. When there's white smoke and the solution turns yellow, remove the conical flask, add about 20 mL of distilled water after cooling, and then put it on the electric furnace to boil and keep it boiling for 1 to 2 minutes before removing it. After cooling, the solution is to be tested.

➢ **Color development and determination:**

Add soil mercury indicator to each of the digested blank, standard, and test solution to make it purple, and then carefully add soil mercury masking agent to make the purple just fade, then add 12 mL of ammonia water, and transfer all of them to a 50mL colorimetric tube without loss after cooling. (about 40 mL). Use ammonia water to adjust the pH value to 1- 2 carefully (use a precision test paper with a pH of 0.5 to 5.0 to check the acidity of the solution, and the color should be close to pH 1.5). Then add 1.0 mL of soil mercury masking agent, shake well, and leave the plug open for 10 minutes. Then add 2.0 mL of soil mercury masking agent, shake well, and finally add 3.0 mL of heavy metal color development reagent and dilute the volume to 50 mL with distilled water. Tighten the cuvette plug and shake it 220 times, leave it for 20 minutes, discard the upper aqueous phase, filter the organic phase in a 10 mm cuvette with quantitative filter paper, and measure it on the machine.

- Turn the left wheel of the filter to set the value to 2, place the blank solution in the light path, press the "colorimetric" key, switch the function number to 1, press the "adjust +" key, the LCD will display 100%; press the "adjust-" key, make the LCD show 100%.
- Press the "colorimetric" key, switch the function number to 3, put the standard solution in the light path, and press the adjustment key to make the LCD display value 0.50.
- Place the test liquid in the light path, and the displayed reading at this time is the mercury (Hg) content (mg/kg) in the soil.

Attachment: Determination of total nitrogen, total phosphorus, and total potassium in soil

The standard solution is prepared by diluting the soil mixed standard stock solution 100 times with distilled water; that is, use a 1mL pipette to transfer 1.0 mL of the soil nutrient mixed standard stock solution, put it into a 100 mL volumetric flask, and then bring to the mark volume with distilled water.

1) **Preparation of the test solution** (can be used for the determination of soil total nitrogen, total phosphorus, and total potassium)

- **Preparation of total nitrogen test solution (excluding NO_3-N)**

  Weigh 1.0 g or 1.0 g (1+water content) g of air-dried soil sample in a conical flask, moisten it with 10 drops of water, add 4 mL of concentrated sulfuric acid, 10 drops of soil total nitrogen oxidizer, and cover with a small, curved neck funnel. Placed on an electric stove lined with asbestos nets, a large amount of white smoke was produced after being heated by a low fire. Removed when whirling around the bottle mouth (approximately 4-5 minutes, but the length of time varies with the power of the electric stove). After cooling slightly, transfer all the liquid into the bottle (including the curved-necked small funnel) to a 100 mL volumetric flask, use distilled water to bring the volume, shake well, and let it stand.

  Use a pipette to transfer 20 mL of the supernatant into a 100 mL volumetric flask, and add 1.0 mL of soil total nitrogen regulator (1:1 NaOH solution). Shake well and dilute with distilled water and filter. The filtrate is the solution to be tested.

- **Preparation of total nitrogen test solution, including NO_3-N**

  Weigh 1.0 g or 1.0 (1 + water content) g of fresh soil or air-dried soil sample into a conical flask, moisten it with 10 drops of water, add 0.2 g of soil total nitrogen reducing agent, 4 mL of concentrated sulfuric acid, and 10 drops of soil total nitrogen oxidizer. After shaking it by hand a few times, cover it with a small funnel with a curved neck and place it on an electric stove lined with asbestos net, heat it with a low fire until a large amount of white smoke is produced. Take off when turning around the bottleneck (approximately 4-5 minutes). The time required varies with the power of the electric furnace. After cooling slightly, transfer all the liquid into the bottle (including the curved-necked small funnel) to a 100 mL volumetric flask, use distilled water to bring the volume to a constant, shake well, and let it stand.

  Use a pipette to suck 20 mL of the supernatant into a 100 mL volumetric flask, and add 1.6 mL of soil total nitrogen regulator (1:1 NaOH solution). Shake well, use distilled water to bring the volume, and filter; the filtrate is the test solution.

2) **Determination of total nitrogen in soil**

   Add 2 mL of the blank solution (distilled water), standard solution, and test solution to three small glass bottles. To these three small glass bottles, add the following, respectively:

   4 drops of soil total nitrogen reagent No.1.

   4 drops of soil total nitrogen reagent No.2.

   2 drops of soil total nitrogen reagent No.3.

   Shake well, transfer to three cuvettes after 10 minutes, and measure on the machine:

- Turn the left wheel of the filter to set the value to 1, put the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument displays ≤100%; press the "adjust-" key to make the instrument display 100%.
- Press the "colorimetric" key, the function number is switched to 3, put the standard solution in the light path, and press the adjustment key to make the instrument display value 1.20.
- Put the solution to be tested in the light path, and the instrument reading at this time is the total nitrogen content of the soil (g/kg).

Note: In general, the NO_3-N content in the soil does not exceed 1% of the total nitrogen and can be ignored. The first method is used to prepare the test solution for normal soil. If the soil contains higher NO_3-N, the second method can be used to prepare the solution.

3) **Determination of total phosphorus in soil**

Add 2 mL of the blank solution (distilled water), standard solution, and test solution to three small glass bottles. Add the following content to these bottles, respectively:

1 drop of Soil Total Phosphorus Reagent No. 1 (slowly and carefully, shake until there are no bubbles).

4 drops of Soil Total Phosphorus Reagent No. 2, shake well until there are no bubbles.

1 drop of Soil Total Phosphorus Reagent No. 3, shake well.

Shake well, let stand for 10 minutes, and transfer to three cuvettes respectively, and measure on the machine:

- Turn the left wheel of the filter to set the value to 6, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" key to make the instrument show 100%.
- Press the "colorimetric" key, switch the function number to 3, put the standard solution in the light path, and press the adjustment key to make the instrument display value 1.20.
- Put the solution to be tested in the light path, and the instrument reading at this time is the total phosphorus content of the soil (g/kg).

Note: When the room temperature is lower than 20°C, it is recommended to extend the side-front reaction time appropriately until the color of the solution is stable before measuring. The indicator of stable color is that the reading is stable after standard adjustment, and there are no air bubbles attached to the cuvette wall.

5.6.3 Determination of total potassium in soil

Add 2 mL of the blank solution (distilled water), standard solution, and test solution to three small glass bottles. To these three small glass bottles, add the following content, respectively:

4 drops of soil total potassium reagent No.1.

4 drops of soil total potassium reagent No. 2 (if the solution has been stored for a long time, add 1-2 drops more).

Shake well, immediately transfer to three cuvettes, and measure on the machine:

- Turn the left wheel of the filter to set the value to 6, place the blank solution in the light path, press the "**colorimetric**" key, the function number will switch to 1, press the "adjust +" key, the instrument displays ≤100%; press the "adjust-" key to make the instrument display 100%.
- Press the "**colorimetric**" key, switch the function number to 3, put the standard solution in the light path, and press the adjustment key to make the instrument show value 5.00.
- Put the test solution in the light path, and the instrument reading is the total potassium content of the soil (g/kg).

5.7 Determination of Total Nitrogen, Total Phosphorus, and Total Potassium in Organic Fertilizer

5.7.1 Preparation of the test solution

Accurately weigh 0.5 g of the finely sieved fertilizer sample (accurate to 0.01g) into a conical flask, add a few drops of water to moisten, add 5.0 mL concentrated sulfuric acid and 5-10 drops of organic fertilizer digestion accelerator in turn, and shake gently. A small curved-neck funnel can be put on the bottle's mouth. Heat it on the electric stove at a low temperature, and cook for 10 minutes. If the sample is still black or brown, remove the conical flask, add 2-5 drops of organic fertilizer digestion accelerator (Do not drip onto the small funnel or conical flask) after it has cooled slightly. Continue to digest it on the electric stove until it becomes white, take it out, and cool down.

Carefully use distilled water to transfer the processed solution to a 100 mL volumetric flask, and use distilled water to make the volume. Shake well and filter into a conical flask (if the conical flask is wet, discard the initial filtrate). Transfer 10 mL of the filtrate into a 100 mL volumetric flask, bring to volume with distilled water, and shake it up to complete the test solution.

5.7.2 Measurement Steps

- **Measure total nitrogen content**

  Add 2.0 mL of distilled water (for blank solution), fertilizer standard solution, or test solution into three small glass bottles, and add the following reagents in sequence:

  4 drops of fertilizer Ammonium Nitrogen reagent No. 1
  4 drops of fertilizer Ammonium Nitrogen Reagent No. 2
  4 drops of fertilizer Ammonium Nitrogen Reagent No. 3
  2 drops of fertilizer Ammonium Nitrogen Reagent No. 4

  Shake well, let stand for 10 minutes, transfer to three cuvettes, and measure on the machine:

- Turn the left wheel of the filter to 1, place the blank solution in the light path, press the "**colorimetric**" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" key to make the LCD show 100%.
- Press the **"colorimetric**" key, the function number is switched to 3, put the standard solution in the light path, and press the adjustment key to show the value in the table.

- Put the liquid to be tested in the light path, and the value shown at this time is the total nitrogen content of the fertilizer (%).

➢ **Measure total phosphorus content**

Add 2.0 mL of distilled water (for blank solution), fertilizer standard solution, or test solution into three small glass bottles, and add 7 drops of fertilizer phosphorus reagent to them in sequence.

Shake well, and after standing for 20 minutes, transfer to three cuvettes for measurement on the machine:

- Turn the left wheel of the filter to set the value to 1, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" key to make the LCD show 100%.
- Press the "colorimetric" key, the function number will switch to 3, put the standard solution in the light path, and press the adjustment key to display the value as in the table.
- Put the test solution in the light path, and the displayed value at this time is the total phosphorus content (%) of the fertilizer.

➢ **Determination of total potassium content**

Add 2.0 mL of distilled water (for blank solution), fertilizer standard solution, and test solution into three small glass bottles, and add the following reagents in sequence:

4 drops Fertilizer Potassium Reagent No. 1

4 drops of fertilizer Potassium Reagent No. 2

4 drops of fertilizer Potassium No. 3 Reagent (If the storage time is longer, you can add 1-2 drops more appropriately).

Shake well, transfer to three cuvettes, and measure on the machine:

- Turn the left wheel of the filter to set the value to 6, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" key to make the LCD display 100%.
- Press the "colorimetric" key to switch the function number to 3. Put the standard solution in the light path, and press the adjustment key to display the value in the table.
- Put the solution to be tested in the light path, and the displayed value at this time is the total potassium content of the fertilizer (%).

5.8 Determination of the content of available nitrogen, available phosphorus, and available potassium in organic fertilizer (containing organic compound fertilizer)

5.8.1 Preparation of the test solution

Accurately weigh 1.00 g of the finely sieved fertilizer sample into a conical flask, add 50.0 mL of fertilizer extractant, seal it tightly with a rubber stopper, and shake it on the shaker until it is completely dissolved (or 30minutes). Filter and transfer it into a clean and dry conical flask (discard the initial filtrate if the flask is wet).

For pure organic fertilizer, add 10.0mL of filtrate into a 100mL volumetric flask (for organic compound fertilizer, add 2mL).

After adding distilled water, add a small flat spoon (about 0.5 g) of organic fertilizer decolorizer. After shaking for 5minutes, filter and transfer into another clean conical flask (discard the initial filtrate if it's wet), the filtrate is the organic fertilizer test solution.

5.8.2 Measurement Steps

1) **Measurement of nitrate nitrogen content**

Add 1ml of distilled water (for blank solution), fertilizer standard solution, or test solution into three small glass bottles, and then 2 mL of distilled water into these three small glass bottles. and then separately join in order:
2 drops of fertilizer Nitrate Nitrogen Reagent No. 1
4 drops of fertilizer Nitrate Nitrogen Reagent No.2
1 drop of fertilizer Nitrate Nitrogen No. 3Reagent (Before dropping, shake vigorously or heat in hot water at about 70°C for 3 minutes to suspend the sediment before use.)
Shake well, let stand for 20 minutes, transfer to three cuvettes, and measure on the machine:

- Turn the left wheel of the filter to set the value to 2, place the blank solution in the light path, press the "**colorimetric**" key, the function number will switch to 1, press the "adjust+" key, the instrument shows ≤100%; press the "adjust-"key to make the LCD show 100%.
- Press the "**colorimetric**" key, the function number is switched to 3, put the standard solution in the light path, and press the adjustment key to show the value in the table.
- Put the test solution in the light path, and the displayed value is the nitrate nitrogen content (%) of pure organic fertilizer (or organic compound fertilizer).

2) **Measurement of the content of available phosphorus**

Add 2.0mL of distilled water (for blank solution), fertilizer standard solution, or test solution into three small glass bottles, and add 7 drops of fertilizer phosphorus reagent to each.
Shake well, let stand for 20 minutes, and transfer to three cuvettes respectively, and measure on the machine:

- Turn the left wheel of the filter to set the value to 1, place the blank solution in the light path, press the "**colorimetric**" key, the function number will switch to 1, press the "adjust+" key, the instrument shows ≤100%; press the "adjust-"Key to make the LCD show 100%.
- Press the "**colorimetric**" key, the function number is switched to 3, put the standard solution in the light path, and press the adjustment key to display the value as in the table.
- Put the test solution in the light path, and the value displayed at this time is the content (%) of the fertilizer's available phosphorus.

3) **Measurement of available potassium content**

Add 2.0 mL of distilled water (for blank solution), fertilizer standard solution, or test solution into three small glass bottles, and add the following reagents in sequence:

4 drops of fertilizer Potassium No. 1 Reagent
4 drops of fertilizer Potassium No. 2 Reagent
4 drops of fertilizer Potassium No. 3 Reagent (if the storage time is longer, add 1-2 drops more)

Shake well, transfer to three cuvettes, and measure on the machine:

- Turn the left wheel of the filter to set the value to 6, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument displays ≤100%; press the "adjust-" Key to make the LCD display 100%.
- Press the "colorimetric" key, the function number is switched to 3, put the standard solution in the light path, and press the adjustment key to display the value in the table.
- Put the solution in the light path, and the displayed value at this time is the content (%) of the available potassium of the fertilizer.

4) **Measurement of acidolytic nitrogen**

➢ **Preparation of test solution:**

Add 4.00 mL (for pure organic fertilizer) or 1.00 mL (for organic compound fertilizer) of the undiluted fertilizer extract prepared in step (1) into a clean conical flask, add distilled water to bring up to 10 mL, and then add 10 drops of fertilizer hydrolyzing agent. Heat it on an electric stove until the water boils and white smoke is emitted, take it off and cool it. Transfer it to a 100 mL volumetric flask, bring up to the volume with distilled water, and shake well to complete the acid-decomposed nitrogen test solution.

➢ **Measurement procedure**

Add 2.0 mL of distilled water (for blank solution), fertilizer standard solution, or test solution into three small glass bottles, and add in sequence:

4 drops of fertilizer ammonium nitrogen reagent No. 1
4 drops of fertilizer Ammonium Nitrogen reagent No. 2
4 drops of fertilizer Ammonium Nitrogen reagent No. 3
2 drops of fertilizer Ammonium Nitrogen reagent No. 4

Shake well, let stand for 10 minutes, transfer to three cuvettes, and measure on the machine:

- Turn the left wheel of the filter to set the value to 1, place the blank solution in the light path, press the "colorimetric" key, the function number will switch to 1, press the "adjust +" key, the instrument shows ≤100%; press the "adjust-" key to make the LCD show 100%.
- Press the "colorimetric" key, switch the function number to 3, put the standard solution in the light path, and press the adjustment key to adjust the value as in the table.
- Place the test solution in the light path, and the displayed value at this time is the content (%) of the acid-decomposed nitrogen of the organic fertilizer.
  Add this measured value and the nitrate nitrogen value to obtain the available nitrogen content of the fertilizer.

Note: The scope of application of this method is:

	Nitrate N	Available P	Available K	Acid Decomposition N
Pure organic fertilizer	0.15—0.45	0.15—0.90	0.5—0.9	0.38—1.5
Organic compound fertilizer	3.0—9.0	3—18.0	10—18	1.5—6.0

6. Accessories

Optional Accessories

Model no	Accessory
LMSNT-A100-S1	Soil organic matter reagent
LMSNT-A100-S2	Trace element reagents for soil, plants, and fertilizers (calcium, magnesium, sulfur, iron, manganese, boron, zinc, copper, chlorine, silicon)
LMSNT-A100-S3	Heavy metal reagents (lead, chromium, cadmium, mercury, arsenic)
LMSNT-A100-S4	Total nitrogen/total phosphorus/total potassium pretreatment reagents