NPK, pH Soil Test Kit Handbook

SOIL NUTRIENTS AND MANAGEMENT

Of the 16 essential nutrient elements for plant growth, 13 are derived from mineral constituents of most soils. Continuous cultivation of plants over long periods or many seasons may result in deficiency of nutrients to plants. Six elements are essential to plant growth and development and are required in larger quantities compared to the others. The six include N, P, K, Ca, Mg and S. Generally, nitrogen, phosphorous and potassium contents in the soils are low while calcium, magnesium and sulfur are normally sufficient.

Nitrogen (N) is the only element that is not a component of rocks and minerals. Nitrogen sources, ammonia and nitrates, in soils are decomposition products of soil organic matter by soil micro-organisms. The NH_4 and NO_3 ions are the chemical forms available for plant use. Nitrogen is an essential component of protein along with other organic compounds vital for plant development and growth. It is also an essential component of chlorophyll. Plants with sufficient nitrogen will typically have greener leaves, grow fast and have higher yields.

Management on Nitrogen Shortage

When nitrogen shortage occurs, the plant will grow slowly and exhibit yellowing leaves, stunted growth, late-flowering and low-production. The prescription of such symptoms is to apply fertilizer to the plant with N-fertilizer. Nitrogen fertilization can be from either organic or inorganic sources. In the case of organic fertilizers, it must be incorporated in the soils in advance of planting in order to allow time for decomposition and release of nitrogen. Inorganic fertilizers, such as ammonium sulfate or urea that contain high levels of nitrogen should be used in relatively smaller amounts for each application but frequently applied. It should be applied at the first sign of nitrogen shortage. Analysis of nitrogen in the laboratory often includes soil organic matter. In the case of analysis in the field, the levels of ammonium or nitrate may be assessed instead. The application of nitrogen fertilizer should be considered when medium to low levels of ammonium or nitrate are detected in the field.

The phosphorus (P) requirement by plants is less relative to nitrogen. When the plant has adequate amounts of P, strong root growth and developed and greater resistance to insects and diseases are observed. Improved flowering, fruiting and good quality of plant are also obtained with the sufficient P in the soils. Organic matter and phosphate minerals are the sources of P in soils.

Management on Phosphorus Shortage

When severe shortage of phosphorus occurs, the plant becomes stunted with dark green and purple lower leaves, and root development is poor. The recommendation to correct such symptoms is to fertilize the plant. The fertilizer used can be either superphosphate or triple super phosphate. It should be applied under the soil's surface and near to plant root as possible, in order to reduce phosphate fixation in the soils. The recommended application method is banding.

There are several extracting solutions for assessment of soil phosphorus levels. The one that is accepted and used should have a high correlation of extractable P with plant growth and yield or the uptake of phosphorus in the plant. The extractable P measured will indicate whether the level of P in the soil is low, medium or high. Fertilizer applications should be made when soil has low or medium level of phosphorus.

Potassium (K) The plants need K as much as it needs N. The K requirement is greater especially for plants with tubers and oil seed. K is essential in plant producing processes of sugar and starch including translocation of these nutrients to various growing plant parts and storage in tubers or stems. This results in the high requirement of K in sugarcane, tapioca, coconut, and oil palm. In addition, K is quite important in promoting yield quality, plant tolerance to diseases and insects and drought resistance.

Management on Potassium Shortage

When severe K shortage occurs, the plant will easily wilt, be stunted with leaves turning yellowish along the leaf edge, and produces low yield. With K deficiency, potato tubers will be smaller with low starch content, sugar cane stems will yield little sugar, and oil palm seeds will have low oil content. The recommendation is to amend the soil with K fertilizer application. In the case of coarse-textured soil, application should be by spot or banding while broadcast application is recommended for clayey soils.

The assessment of soil potassium level is similar to phosphorus, that is, the research-recommended extracting solution should be used. K application is recommended when the level of K is low or medium for course-textured soils and low for fine-textured soils.

Generally, in plant production, it is essential to increase N P K nutrients in fertilizer form. There are 2 groups of fertilizer, organic and inorganic or chemical. The organic fertilizer sources are manure, compost, seed meal and plant residues while the chemical fertilizer is the synthesized analytical fertilizer.

The main objective of organic fertilizer application is to improve soil physical properties, such as increased soil porosity and water holding capacity. The organic fertilizer when applied in the soils, will decompose and release nutrients for the plants in smaller quantities relative to inorganic fertilizer sources. At present, chemical fertilizers are very expensive, hence, recommendations to use them must be carefully determined. The initial levels of nutrient should be known or established so that only suitable amounts for plant growth be applied. This is for the greater efficiency of chemical fertilizer application with reduced costs and increased productivity.

SOIL pH

Definition

Acidic soils refer to soils with a chemical condition similar to a weak acid such as acetic acid. A soil is acid if it has H^+ or hydrogen ions in soil solution and adsorbed on surfaces of soil clay particles.

There are two types of acidity. The first type is active acidity, the second one is potential acidity.

The intensity of soil acidity depends on concentration of active acidity. When the active acidity is neutralized, the potential acidity will release H^+ to maintain the chemical equilibrium. This capacity of the soils is called buffering capacity.

An alkaline soil is a soil that has a lower concentration of active acidity of H^+ in the soil solution compared to OH^- ions. Furthermore, the potential acidity has already been inactivated or is present in small concentration.

Therefore, a neutral soil is a soil with soil solution having the acid and alkali in equal concentration.

The intensity of soil acidity-alkalinity is reported as pH values running on a scale from 1-14 with the value of 7.0 indicating neutrality of the soil. From pH 7 to 0, the soil is increasingly more acidic. A difference of 1.0 between pH values represents an intensity difference of 10. For example a soil at pH 5 is ten times more acidic than a soil at pH 6 and 100 times more acidic than a soil at pH 7. A soil is alkaline if the pH is greater than 7. The higher the pH values are, the greater the alkalinity will be.

Importance

Soil acidity is critical to plant growth. In strongly acid soil, plants do not grow very well because of the effect of excess H^+ ions instead of nutrient ions available for plant use.

There are many methods in determining soil pH, yet only 2 are more popularly used.

First method is by a pH meter which is quite expensive but gives the most accurate soil pH determination. This is more suitable for laboratory measurement than in the field. In the case of the portable type, it is still inconvenient, costly, and too risky because of easy breakage.

The second method consists of using indicators or dyes that will change to various colors with an increase or decrease of pH. As for pH test kit the indicator with original color of purplish blue can be used to determine pH range of 3.0-8.5. When drops are added into soil extract solutions with different pH values, the indicator will change the color of the solution. The new changed color is specific to each soil pH level. When compared to the color comparison chart, soil pH can then be easily determined.

Effect of acidity-alkalinity to nutrient availability in the soils

Calcium (Ca), Magnesium (Mg) and Potassium (K)

A soil with a low pH reading, indicating extreme acidity, some nutrient elements such as low concentrations of Ca+Mg, and this includes as well may still be available to plants. In extremely acidic soil, these nutrients will be easily leached and unavailable for uptake by plants. When pH falls between 5.5-8.5, there is generally sufficient Ca in the soil. If the pH is lower or higher than this range, the plant may exhibit deficiency symptoms of two elements. A soil with pH greater than 8.5 is likely to have low Ca and too much Na.

Phosphorous (P)

Plant uptake of phosphorus greatly depends on soil pH. An extremely acidic soil promotes phosphate fixation typically resulting in iron and aluminum phosphate compounds that render P unavailable to plants. This due to the increase of soluble iron and aluminum at pH lower than 5.0. When P fertilizer is applied to acidic soils, most of the fertilizer reacts with iron and aluminum with only small amounts of P available to plants, commonly less than 10% of the available P. Soil pH of 6 to 7 is quite suitable for soil phosphate availability to plants since at that pH level, soil phosphorus is least fixed. With increasing pH, the availability of soil phosphorus to plants is reduced owing to phosphate fixation by Ca and Mg.

Micronutrient

The degree of availability of soil micro-nutrients greatly depends on soil pH. For example, iron readily exists in water soluble form at low pH especially pH lower than 5.0. Water soluble iron decreases with the increasing soil pH until the neutral level is reached. The shortage of iron may occur when soil pH equal 7.0 or higher. For example, there is always iron deficiency in Lop Buri clay (pH 7.2), for peanut, jackfruit, banana, grape, etc.

Similar to iron, water soluble Mn is found in large quantities in very strongly acid conditions. Sometimes, the high concentration of Mn is detrimental to plants. With increasing pH, Mn becomes insoluble and becomes least soluble at pH near neutral. Hence, Mn availability to plants is reduced when soil pH is rather high. Manganese deficiency occurs at soil pH 6.5 to 8.0. Generally, a clay soil has sufficient amounts of iron and manganese even at pH 6-7. However, both are typically low in sandy soils.

Zinc is readily soluble in acid soil especially at pH 5.0. When soil pH is raised from 5 to 6.5, zinc becomes less soluble resulting in decreasing availability of zinc to plant. At pH 6.5, zinc is the least soluble. However, when soil pH increases to greater than 7.0, zinc will be converted from a caution to an anion (zincate). In alkaline soil with high calcium, zinc is found as calcium zincate that is insoluble in water and unavailable to plants. If there is a large quantity of sodium in a high pH soil, zinc is found as sodium zincate which is readily soluble in water and available to plants.

Copper is readily soluble in water when soil pH is more acidic than alkaline or neutral. Still, this element is not quite related to soil pH. A soil with copper deficiency is a soil with small amount of copper. When a large quantity of copper is present in soil even in alkaline or neutral soil, the plant will not be exhibit any symptoms of copper deficiency

In neutral or alkaline soils, boron is insoluble in water. When lime is added to amend soil acidity, the amount of boron available to plant also decreases while calcium concentration increases. The greater the plant uptake of calcium, the greater the plant need of boron. Critical boron-calcium ratio is approximately 1 to 1 500, hence, when more calcium is added to the soil, it is necessary to apply more boron in order to maintain that ratio. This is why boron deficiency is observed when lime is applied to the soils.

Molybdenum in the soil is in anion form and is taken up by plants in molybdate form. The greater the soil pH, the higher is the solubility of molybdenum. This is just the opposite to iron, manganese and zinc. In acidic soils, legume plants are likely to express molybdenum deficiency. Liming to increase soil pH is carried out not only to improve pH level appropriate for plants but also to increase molybdenum level available to plants. Fig 1 presents the relationship between soil pH levels and available micronutrient to plants.

Soil pH is related not only to micro-nutrient levels but also to microorganism activity in soils. The level of activity, especially of bacteria, is at its highest capacity when soil pH is near neutral and slow to lower levels in acid soils. Conversely, fungi can function better than bacteria at acid pH. In alkaline soil, although fungi are able to function, does not do as well as bacteria. Microbial activity levels can be used to monitor levels of nitrogen, phosphorous and sulfur available to plants. When such activity is high, the levels of P and S availability will be raised. In addition, improved N-fixing from the atmosphere by some symbiotic microorganisms occurs in neutral to weakly acid soils. As a result, lime is recommended for acid soils before planting legumes, in order to raise the soil pH level to weakly acid or to near neutral.

Soil pH values can be used as approximate values. Therefore, even though the measured soil pH value is somewhat less precise, it is still very useful in measuring soil acidity and alkalinity affecting cultivated plants. It is hence common to refer to soil pH levels as moderately strong or weakly acid instead of the actual pH values. In other words, the layman will have better understanding of the degree of pH strength than the numerical values.

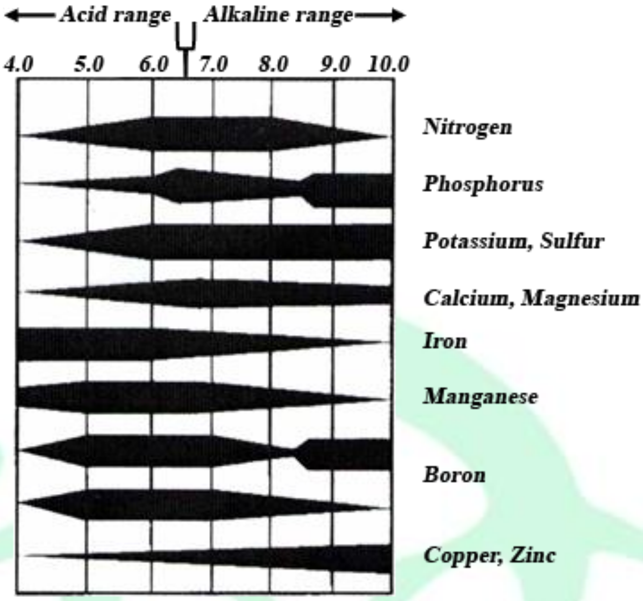


Fig. 1. General relationship between soil acidity – alkalinity with pH ranges of 4.0-10.0 and ratio of nutrient availability to plants. Wide or narrow bands indicate comparable quantities of availability through these pH ranges.

Different kinds of plants grow well at different soil pH levels. The legume family likes neutral and weakly alkaline soils while some plants prefer acid soil, such as potato and yam. Still, most plants develop well around soil pH 6-7. Fig 2 presents soil pH levels suitable for growth of some plants. Measured soil pH is compared with this chart to match such pH values with the growing requirements of needed plants.

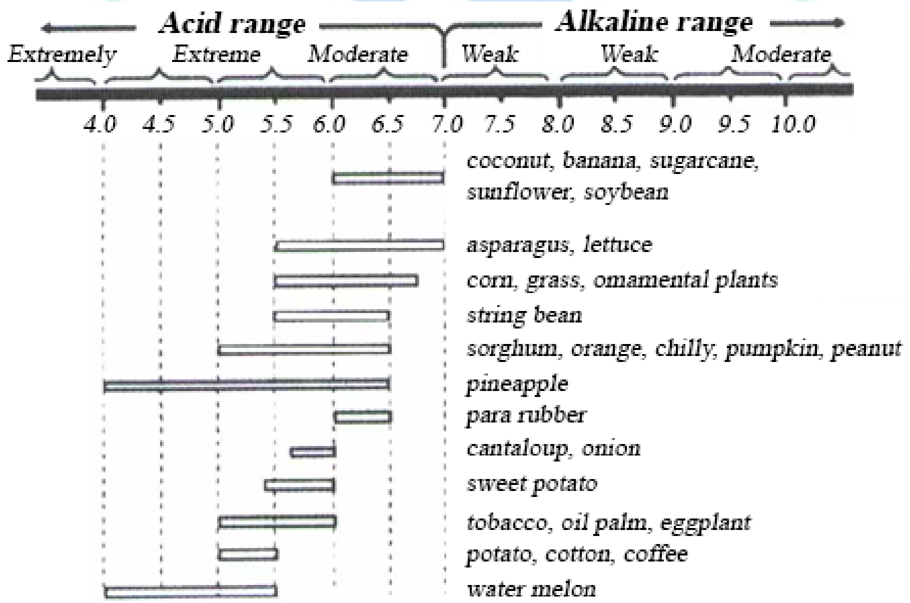


Fig. 2. Soil pH ranges suitable for some plants.

Amendment for soil acidity

When a soil is extremely acidic especially with pH lower than 5.0, a common amendment used to reduce soil acidity and make the soil more suitable for planting is lime. Some examples of liming materials include fine ground limestone, marl, dolomitic limestone, burned shell, slaked lime. The quantity to apply depends on the initial soil pH value and soil texture. Needed quantity can be obtained by laboratory analysis, yet, the approximate amount can also be acquired from the measured soil pH and soil texture as presented in Table 1, 2 and 3

Table 1 Classes of soil acidity-alkalinity (pH_W 1:1)

pH_W	< 4.6	4.6 - 5.5	5.6 - 6.5	6.6 - 7.5	7.6 - 8.5	8.6 - 9-1	$\geq$ 9.1
Class	Extremely Acidic	Strongly Acidic	Acidic	Neutral	Alkaline	Strongly Alkaline	Extremely Alkaline

Table 2 Guidelines in soil amendment

pH_W	Guidelines in Soil Amendment
< 4.6	Liming is needed to adjust soil acidity to make it more suitable for crops. In an area where lime is hard to get or very expensive, only crops with acid tolerance should be selected for planting. Adding organic matter to extremely acid soils is likely to reduce some effects of soil acidity.
4.6 - 5.5	Amendments are generally worth the economic risk for increased productivity. Adding organic matter to an inorganic soil can minimize the cost of amendments. In area where lime is hard to get or very expensive, growing plants with acid tolerance will greatly help reduce liming expenses.
5.6 - 6.5	Generally, soil amendment is worth the economic risk. Application of lime to adjust soil acidity for planting crops sensitive to acid conditions. The common recommendation will be "lime requirement" suitable for plants.
7.6 - 8.5	Plants might show micro-nutrient deficiency especially if too much lime is added.
> 8.6	Only salinity-tolerant plants can be grown. There is the problem of micro-nutrient deficiency. A soil with ECSE > 2 dS/m may be saline soil. Thus, for preliminary management, the level of water table has to be controlled. If ECSE is < 0.7 dS/m, the soil may be a sodic soil. Soil amendment can be made by planting legumes with the addition of gypsum.

Table 3 Approximate quantity of finely ground $CaCO_3$ recommended for acid soil amendment making it suitable for planting by determination of measurable pH values together with soil texture

pH	kg/ha (finely-ground lime)[1/]			
	Sandy soil	Sandy loam	Loam	Clay, Clay loam[2/]
5.0	1,250	1,875	2,500	3,125
4.5	4,375	5,000	6,250	6,875
4.0	6,875	8,125	11,250	13,125
3.5	10,000	12,500	15,625	18,750
3.0	13,750	17,500	20,000	25,000

1/ There are several kinds of liming material used as soil amendments. The values in Table 3, shows the recommended quantities of finely-ground lime in kg/ha. In case other kinds of liming material are used, the following numerical values are to be employed in calculating the quantity of lime to add.

1. numbers in the table x 0.74 = kg/ha ($CaCO_3$)
2. numbers in the table x 0.56 = kg/ha (CaO)
3. numbers in the table x 0.92 = kg/ha (Ca, Mg $(CO_3)_2$)
4. numbers in the table x 1.25 = kg/ha (Marl soil)

2/ **Classes of Soil texture**

1. Sandy soil: soil particles are gritty and loose. When dry, it does not form clods and is unstable under wet conditions.
2. Loamy Sand soil: When dry, soil clods are easily broken. When wet, it is moderately stable. A ribbon of only < 1 cm long can be made between the thumb and fingers at the moist condition.

3. Silt: When dry, the dry soil feels like flour or talcum powder. Stable clods form under moist conditions. No ribbon can be formed at the moist condition.
4. Clay and Clay loam: When dry, the soil is very hard and stable. In wet condition, it will sticky and slippery. A ribbon of >1 cm is formed when pressed between the thumb and fingers.

SOIL TESTING FOR N-P-K

Two procedures are employed in N-P-K quantities test:

1. Soil testing in the laboratory
   This procedure has to be conducted under laboratory conditions employing expensive materials and equipment. It is time consuming and requires the services of a trained and experienced technician.
2. Rapid Test
   This is a simple chemical method adjusted to make it easy and rapid to obtain results in only a few minutes. The kit is relatively inexpensive and easily used by farmers or laymen. The result is just an approximation but can correctly assess the N-P-K status in a soil in a short time.

Steps employed in rapid test of N-P-K

Two steps are employed:

The extraction procedure

Put the ground soil in a plastic bottle using the provided spoon. Add 20 ml of Solution no 1 using a syringe. Shake the mixture for 5 minutes. Filter soil solution with filter paper.

Determination procedure

Test the filtrate for NPK quantities by the following procedures:

1) Ammonium quantity Test
   Pipette 2.5 ml. of filtrate and place in the test tube. Add 1 small spoonful of Dye no. 2, Add 5 drops Solution no. 3. Cap the tube and shake well. Leave for 5 minutes and read ammonium value by comparing the color with ammonium standard color chart. For blue shades, use color chart no. 1. For green shades, use color chart no. 2.
2) Nitrate quantity Test
   Pipette 2.5 ml. of filtrate and place in the test tube. Add 0.5 ml of Solution no. 4. Add 1 small spoon of Dye no. 5. Cap the tube and shake well. Leave for 5 minutes. Read the nitrate value against nitrate standard color chart.
3) Phosphorus quantity Test
   Pipette 2.5 ml. of filtrate, place in the test tube. Add 0.5 ml of Solution no. 6. Add ½ small spoon of Dye no. 7. Cap the tube. Shake well and leave for 5 minutes. Read phosphorus value against the phosphorus standard color chart.
4) Potassium quantity Test
   Pipette 0.8 ml. of filtrate and place in the test tube. Add 2 ml. of Solution no. 8 into the tube. Add 1 drop of Solution no. 9A. Add 2 drops of Solution no. 9, shake well and leave for 1 minutes. If sediment occurs, this indicates high potassium concentration. If a clear solution is obtained, compare the color with the standard color chart. Dark orange indicates low K while light orange indicates medium K.

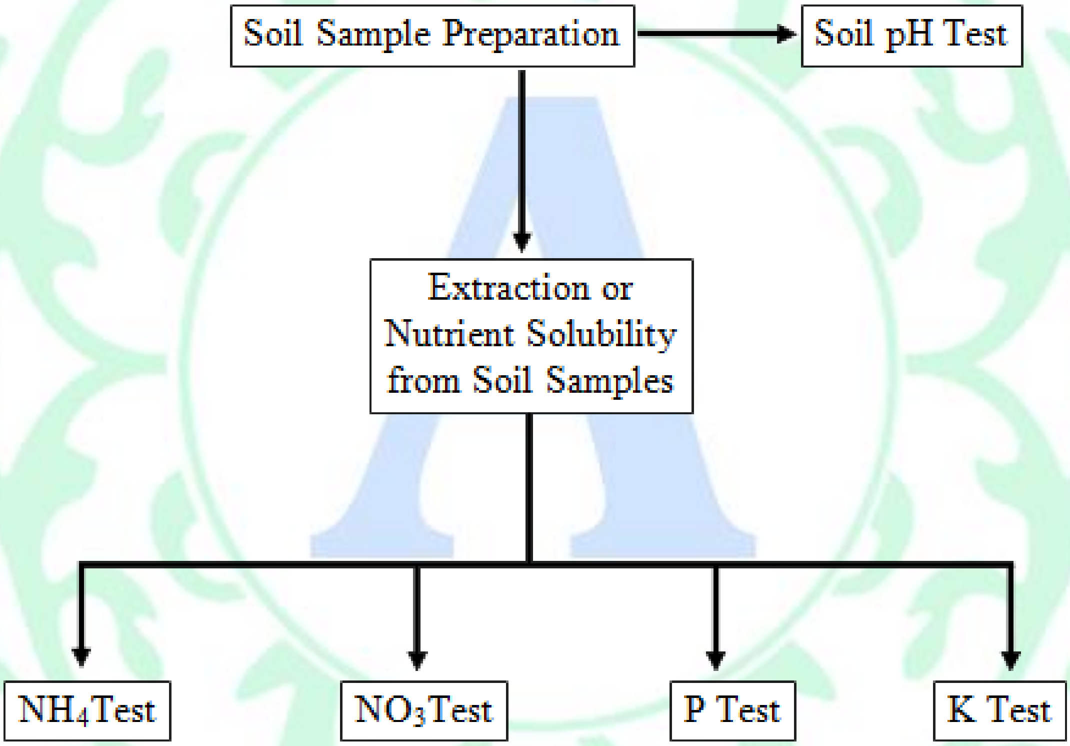
Remarks Before potassium color is made, Solution No. 9 must be prepared. Pipette 3 ml. of distilled water and place it in bottle no. 9 with chemical powder. Shake well for 5 minutes until complete solubility of chemical powder. After use, store in a refrigerator. This can be kept for up to 3 months. Room storage will hold for only 7 days. Dry chemical powder can be stored forever.

5) Soil pH Test
   Spoon soil sample into ½ plastic cavity plate, gradually drop Solution no. 10 (indicator) into the soil until saturated. Then add another 2 drops. Shake the tray around back and forth, and leave for 5 minutes until the soil particles settle to the bottom of the plate. Check clears color of the solution from tray edge and compare the color with the standard color chart.

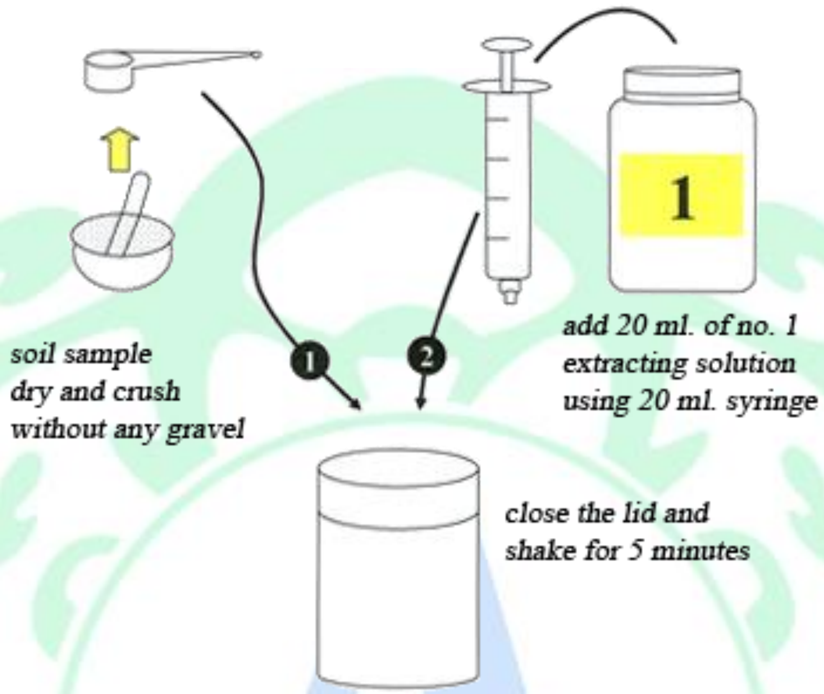
Things to remember when use soil test kit

1) Solutions and chemical powder in aqueous test kit have acidic, basic and salt qualities, thus, when used, do not make hand, mouth or eye contact.
2) Keep the test kit out of reach of children. These are toxic chemicals when consumed or in direct contact.
3) Solution no. 8 for making potassium color is a volatile solution (alcohol). Beware of its high flammability. Do not strike the match or smoke during its use.
4) The readily prepared solution no 9 for making potassium color is an easily decomposable solution if stored at room temperature. Refrigerated storage can hold it for 3 months. Daily use can also be administered while stored in the refrigerator. Label it well to prevent wrong misuse.
5) When the solutions are used up, they can be purchased separately
6) After using of the test tubes and measuring equipment, clean them thoroughly with clean water, rinse with distilled or deionized water, and air-dried.
7) Use only very clean measuring equipment with soil solution no. 1. For best results, use within 6 months after opening.

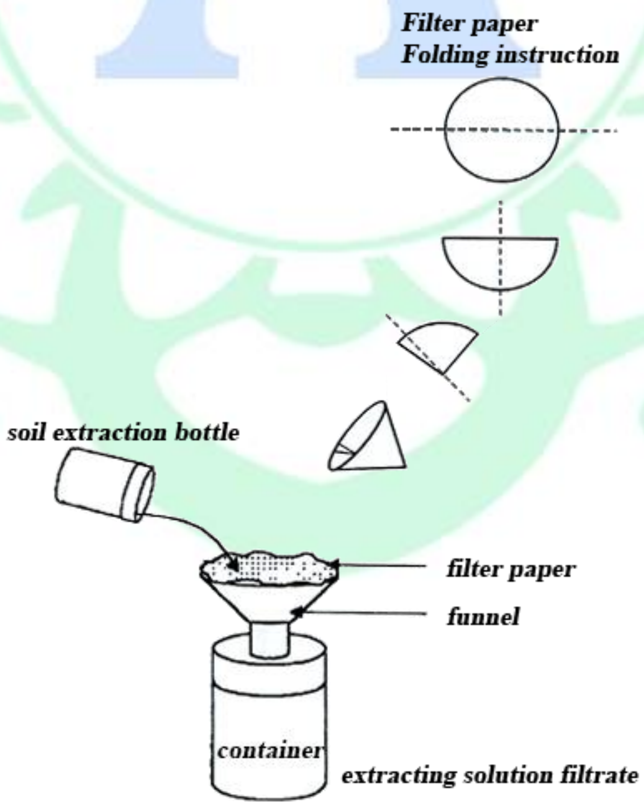
Steps in use of NPK pH test kit for Soil



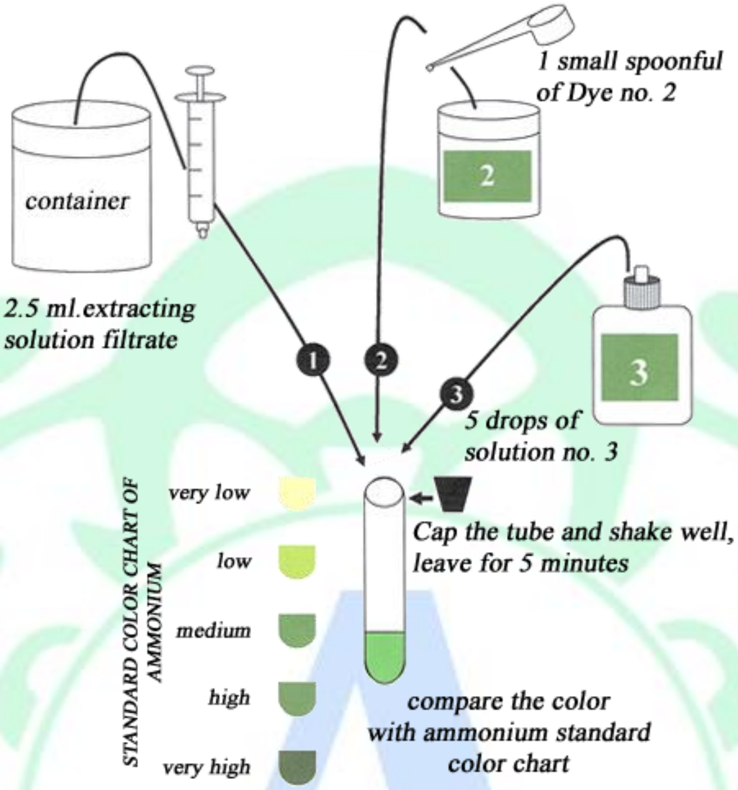
SOIL SAMPLE PREPARATION AND N-P-K EXTRACTION FROM SOILS



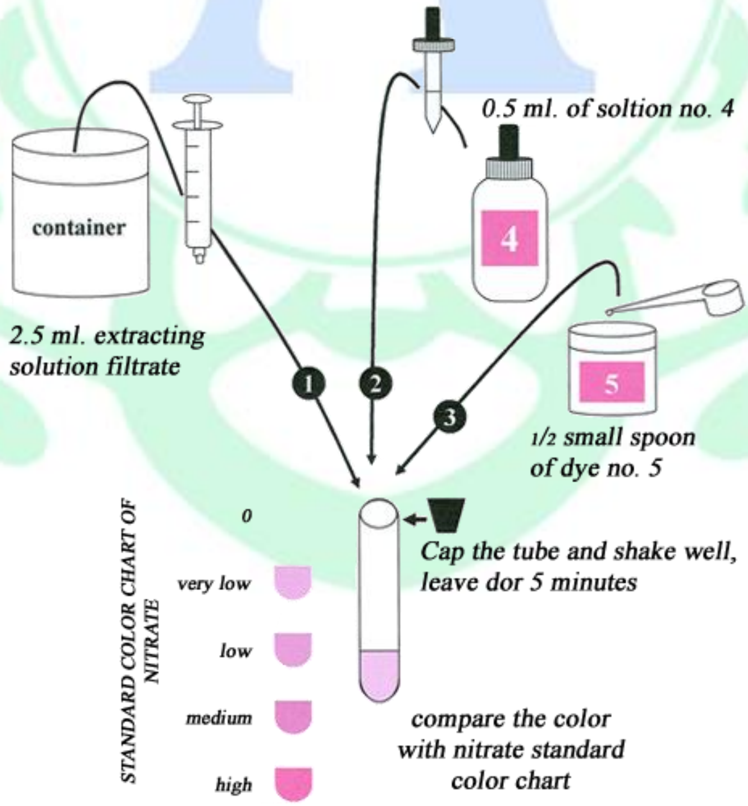
FILTRATION OF EXTRACTING SOLUTION



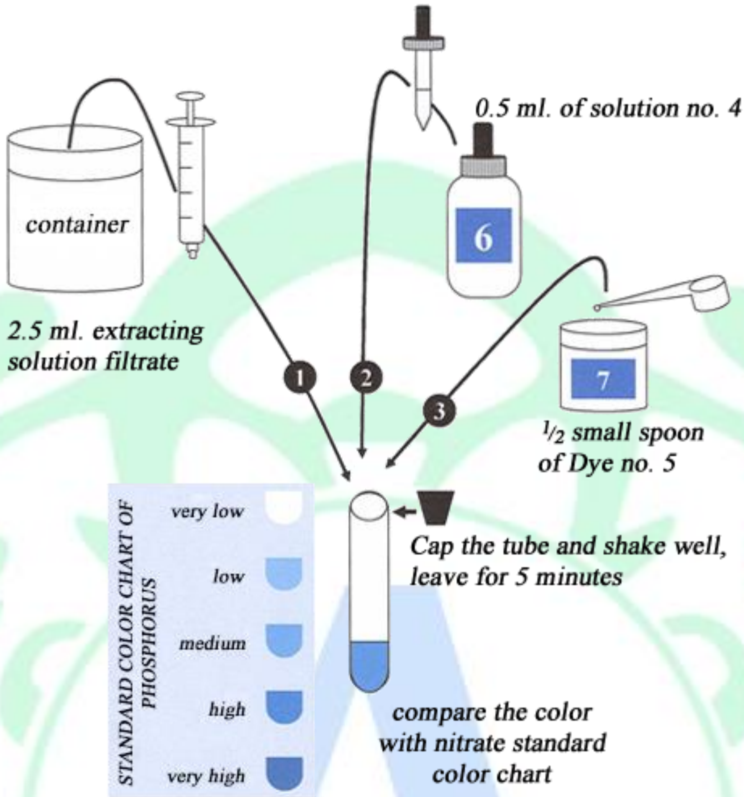
AMMONIUM MEASUREMENT PROCEDURE



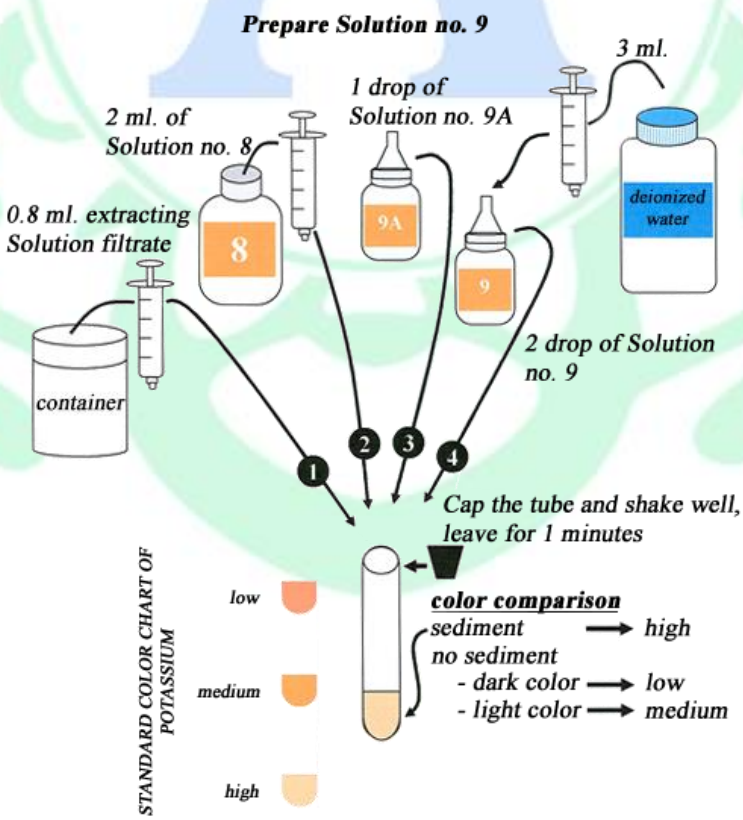
NITRATE MEASUREMENT PROCEDURE

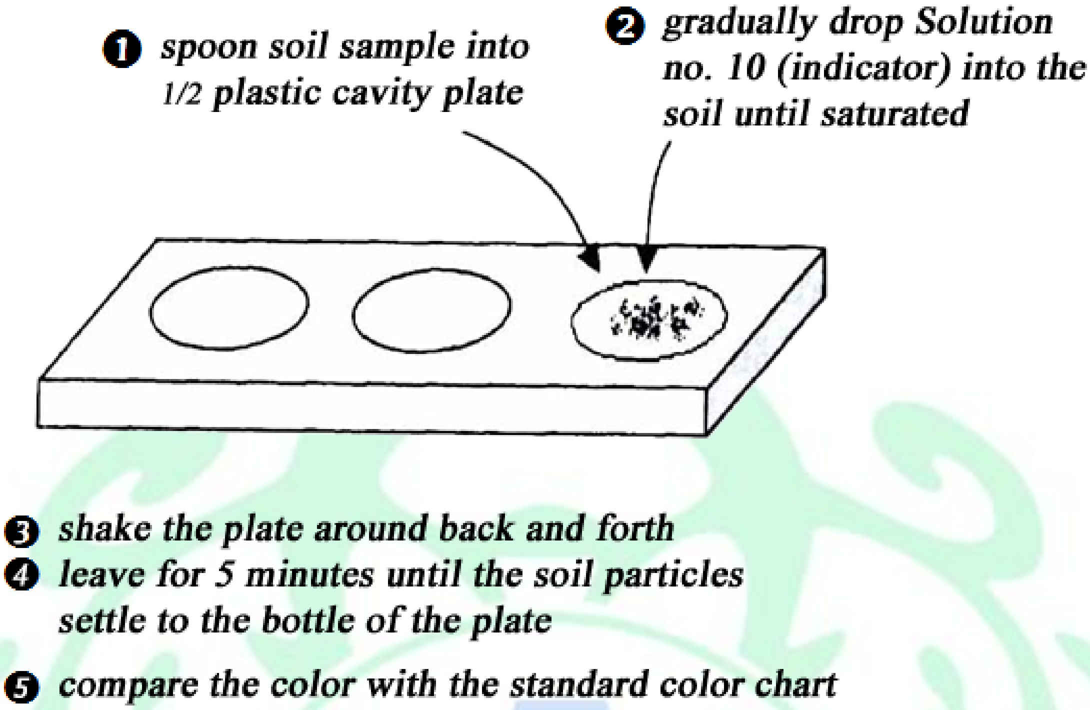


PHOSPHORUS MEASUREMENT PROCEDURE



PHOSPHORUS MEASUREMENT PROCEDURE

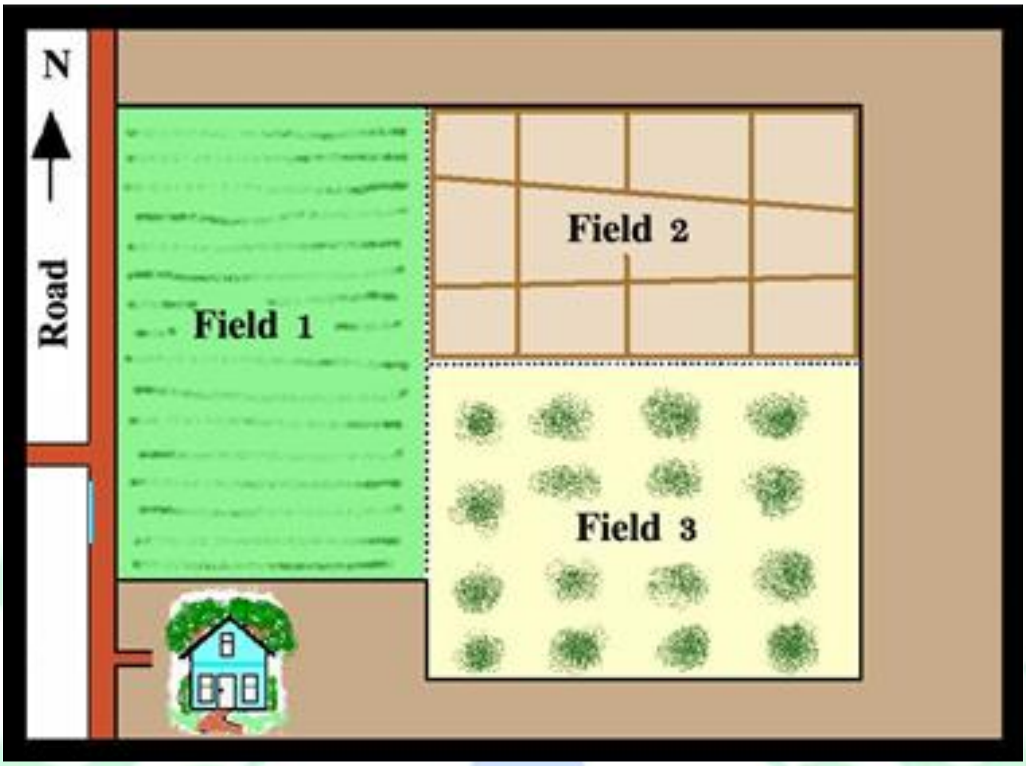




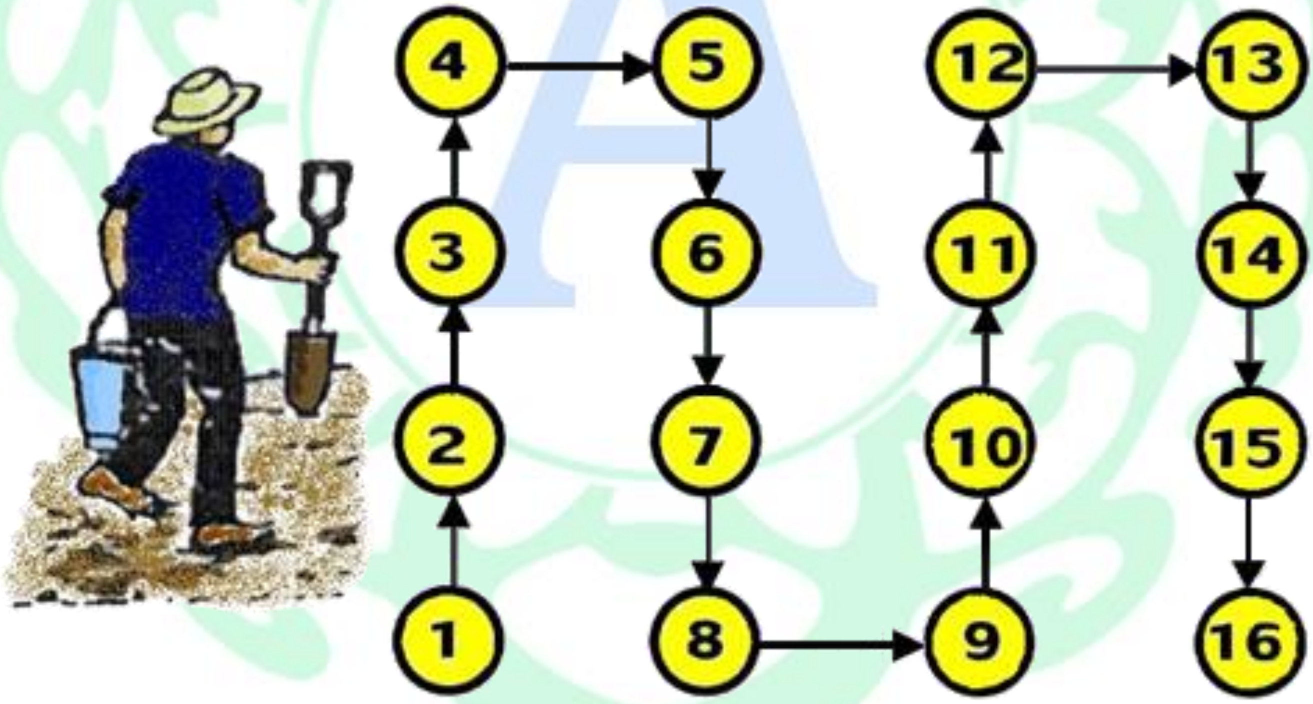
SOIL SAMPLING PROCEDURE

1) Soil samples taken must be a good representative of soils in that area.

2) Equipment and materials used in soil sampling must be clean.
3) Before soil samples are taken, the area should be surveyed for soil texture, color, type of existing vegetation, previous fertilizer application, including topography to indicate whether the area is flat, hilly or sloping. A complex, heterogeneous terrain should be divided into small plots. If the terrain is homogeneous but is of one big plot then it should be divided into plots of 1-3 ha.



4) Randomly take soil samples from within the small plots at a minimum spacing 40m. You should have a minimum of 16 composite samples from the one ha plot.



5) Thoroughly mix all soil samples into 1 sample per small plot.

Remarks on soil sampling

At each soil sample location, get rid of grass or other vegetation, using a spade, collect the soil sample from the middle of the spade (not take soil sample only from the surface or from too deep layer).

For vegetables, flowers, ornamental and agronomic plants, take soil samples from plots at a depth of 0-6 inches (0-15 cm).

For nurseries, grassland pasture for animal grazing or lawn, take soil samples at a depth of < 3 inches (5-7 cm).

For fruit and tree plantation crops, take soil samples from 2 levels: one at the depth of 0-6 inches (0-15 cm), the other at the depth of 16-20 inches (40-50 cm).

REFERENCES

1. Handbook of soil pH test kit single soil no.10, Academic Development of Soil, Fertilizer and Environment Project, Dept of Soil Science, Faculty of Agriculture.
2. Handbook of NPK- pH Test Kit. Academic Development of Soil, Fertilizer, and Environment Project, Dept. of Soil Science, Faculty of Agriculture.

ASIANMEDIC CO., LTD.

Tel: 6689-185-8999, 6690-898-5188

sales@asianmedic.com

www.asianmedic.com