Soils and Fertilizers, the true story

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ISBN 978-974-225-688-3
First Edition June, 2012, 500 copies

Publisher Eco-community Vigor Foundation
Printed by Korn Creation Ltd., Part. Bangkok, Thailand. Tel: (66) 2-970-2958-9

Preface

As a result of the authors' 10 years of experience training farmers in Thailand and Laos, we have learned that farmers have a very limited knowledge of soils and fertilizers. This limited knowledge has led to inefficient use of fertilizer, high production costs on crop production, environmental problems and excessive dependence on others for wise use of fertilizer. Two years ago, the authors, with the generous contributions of many thoughtful and concerned people prepared a cartoon book on soils and fertilizers with the purpose of giving this knowledge to the children. We sent 33,000 copies of the cartoon book to 33,000 schools throughout Thailand. We found that farmers also enjoy reading the cartoon book.

The cartoon book was then translated into English by Prof. Dr. Praparat Hormchan, Entomology Department, Kasetsart University and subsequently edited by Dr. Russell Yost, Professor of Tropical Plant and Soil Sciences, University of Hawaii at Manoa. The purpose of the translation is to prepare the English version of the book, so that it could be translated into other languages for farmers in developing countries. The dissemination of the book will be supported by the Kyuma Fund which will be established at Kasetsart Foundation in June, 2012 by Dr. Kazutake Kyuma, Emeritus Professor of Soil Science, Kyoto University.

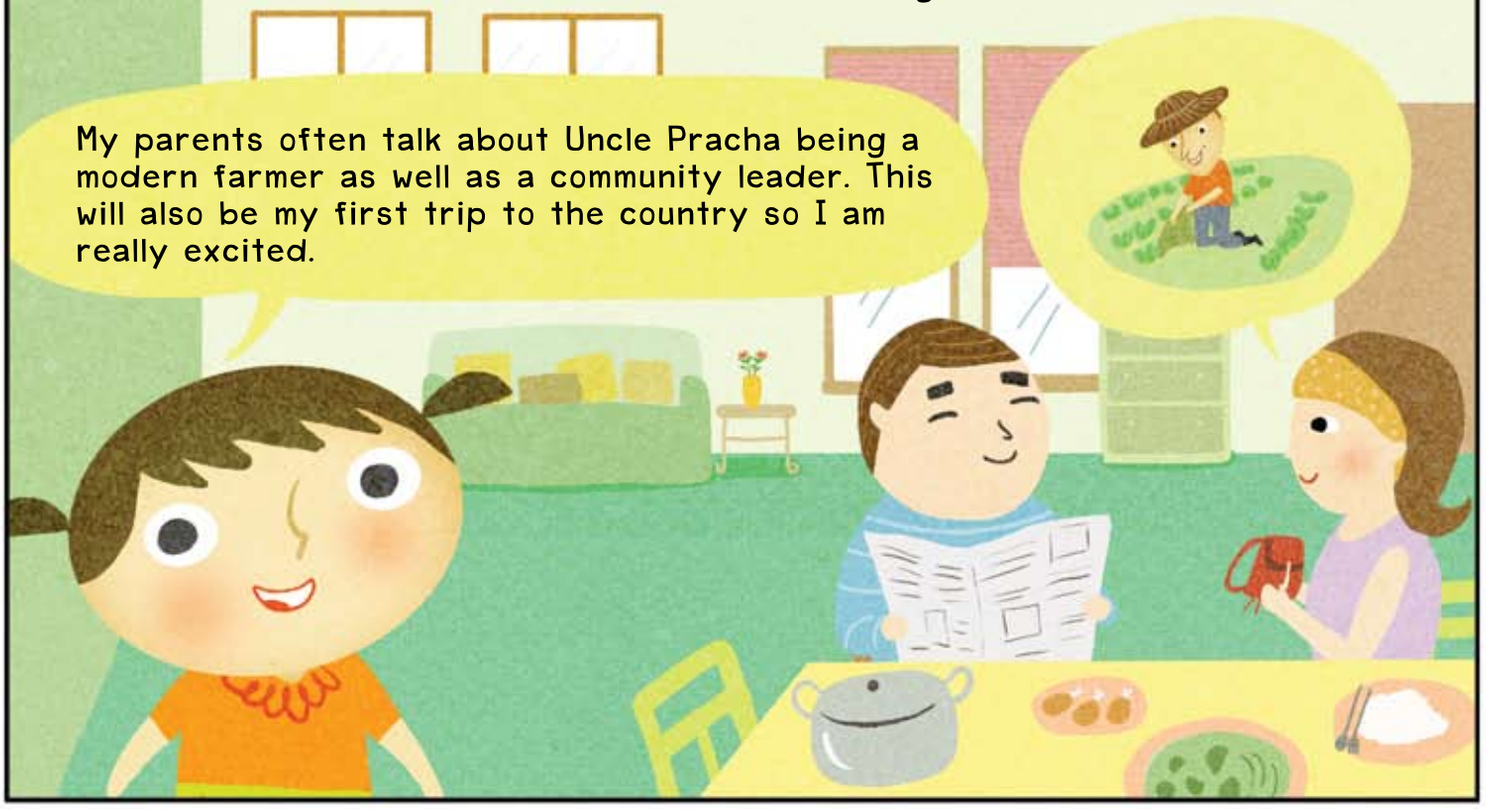
We would like to express our sincere thanks to Prof. Kazutake Kyuma for his financial support of the dissemination of the book to farmers in developing countries. Thanks are also due to Prof. Dr. Praparat Hormchan for the first translation and Mr. Robert McCarthy for the final editing of the book. We appreciated their kindness very much.

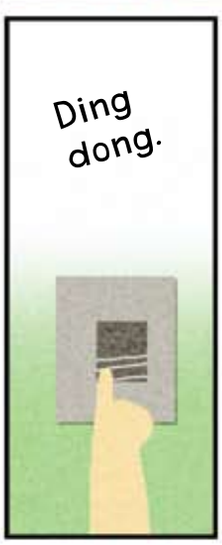
We hope that the children and farmers who read this book will begin to understand soils and fertilizers correctly and use this information to improve their food and environmental security.

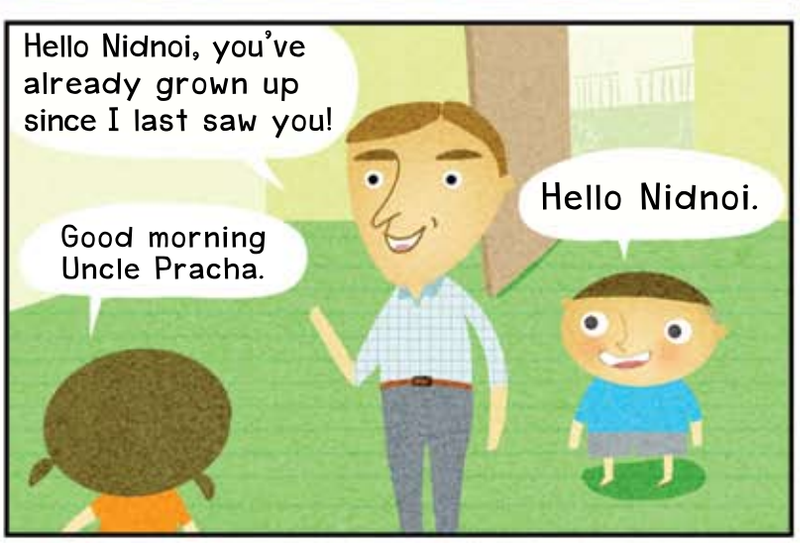
Tasnee Attanandana
Prateep Verapattananirund
Russell Yost
June, 2012

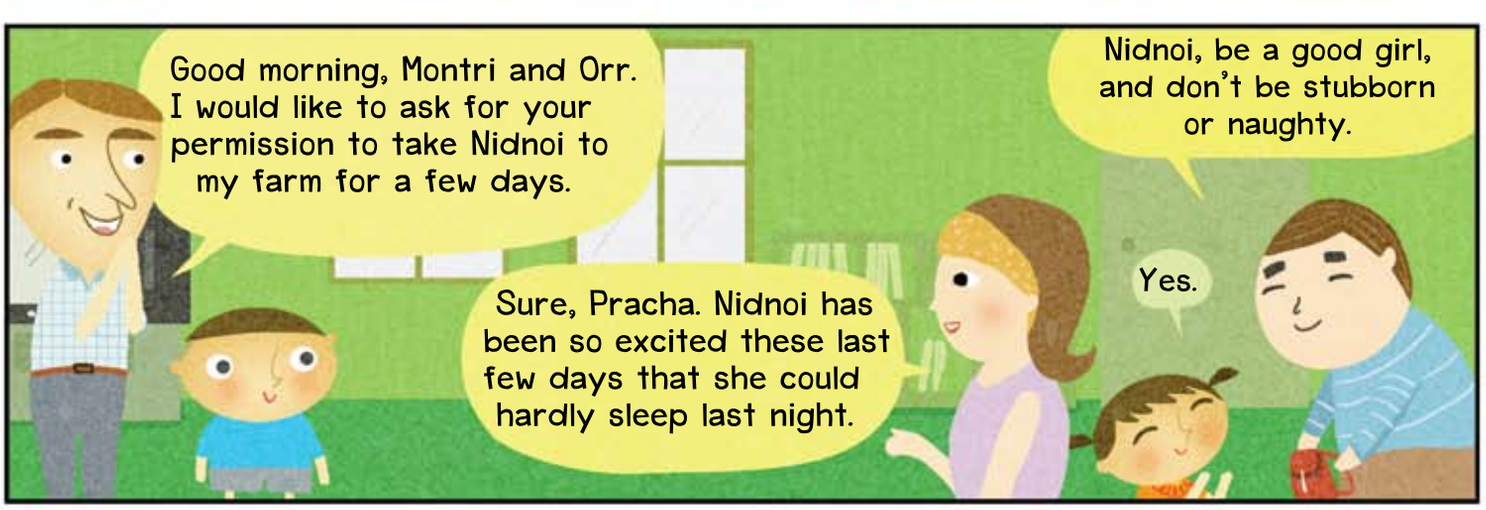
Part 1: Our Earth

It is a beautiful morning and Nidnoi is very excited because Uncle Pracha will take her to his home in the country during the school vacation. Uncle Pracha brings Pom, her cousin whom Nidnoi has not seen for a long time.

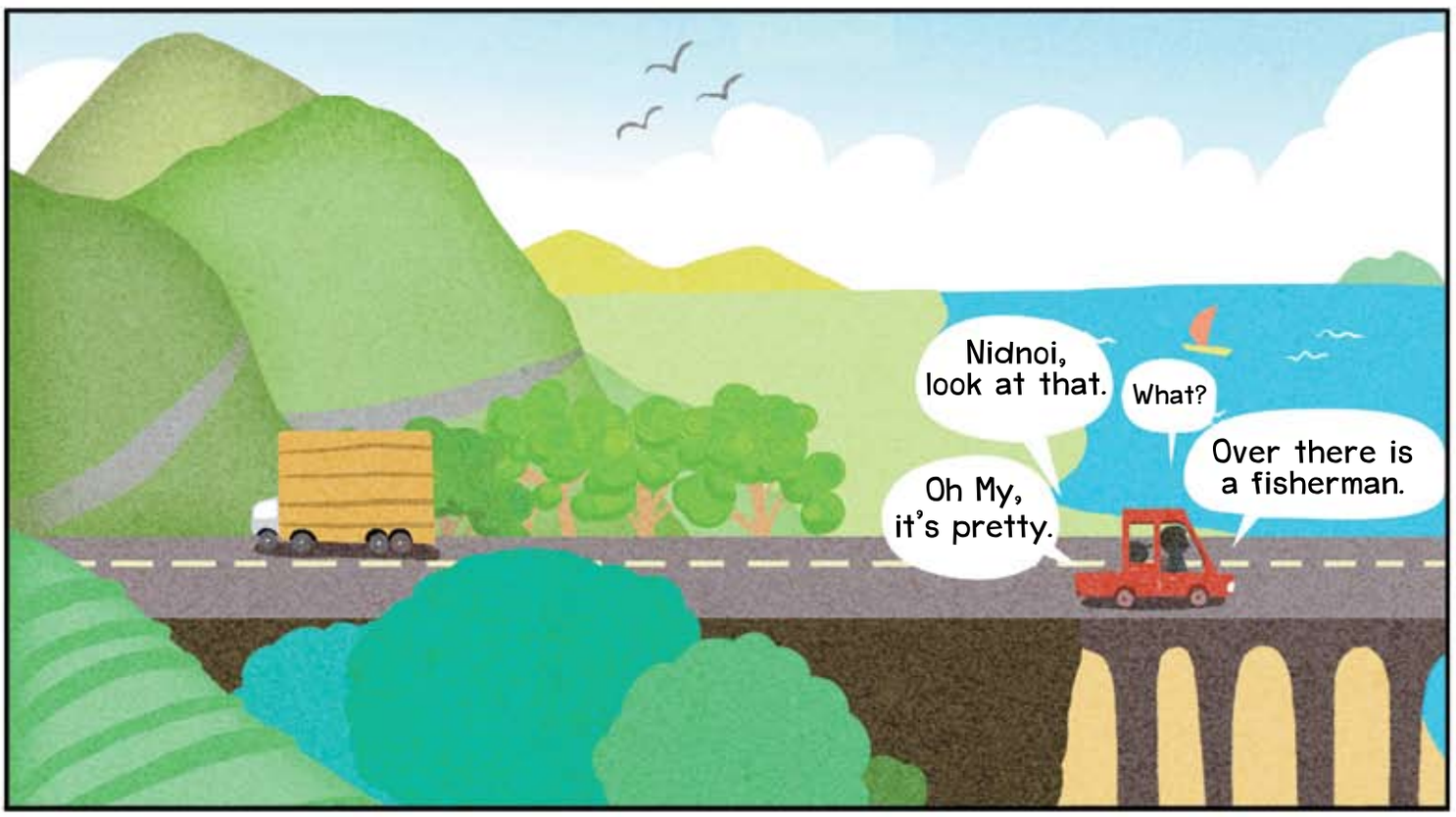




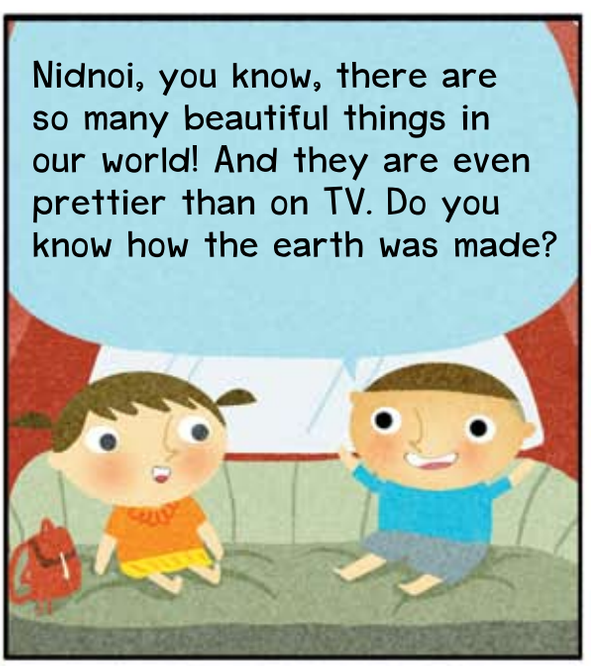





OK, children, are you ready?
Yes, we certainly are, Uncle.
So let's get in the car.
Bye. Bye.
Have a safe trip.

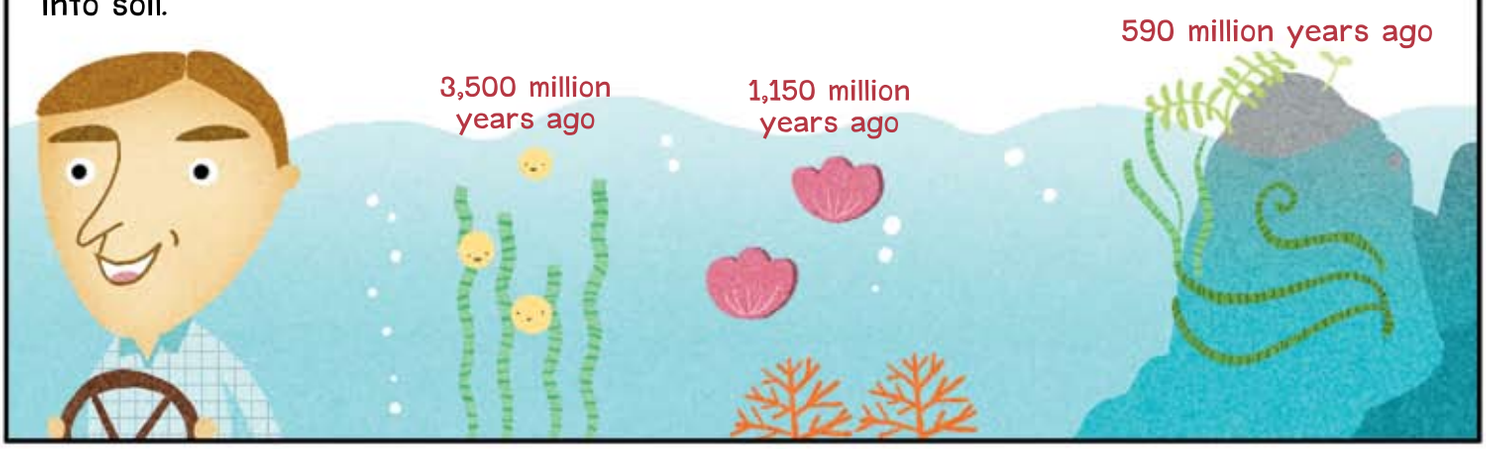

Nidnoi, look at that.
What?
Over there is a fisherman.
Oh My, it's pretty.


This is so much fun. I have never traveled this far before. We are passing beautiful scenery. I have only seen waterfalls, mountains, and seas on television. This is the first time I've seen the real thing.


Nidnoi, you know, there are so many beautiful things in our world! And they are even prettier than on TV. Do you know how the earth was made?


No, Uncle, how was the earth made?

Our earth is about 4,600 million years old. Scientists believed that the earth used to be part of the sun that later disintegrated and gradually cooled down. Its surface turned into hard rocks but the inner core remained hot rock, so hot that it is molten like a liquid. About 3,500 million years ago, one-celled organisms started to occur in the sea followed by green algae and bacteria. About 1,150 million years ago hard-shelled animals including mollusks, coral, and starfish began to appear. Plants attached to sea algae appeared 590 million years ago. They were brought to shore by sea waves where they became attached to the rocks. The plants grew and spread. They helped cause the rocks to disintegrate into soil.



Plants and animals appeared on land and, together with warm temperatures and water, aided in more soil formation. With the presence of soil, a variety of terrestrial plants and animals developed. Dinosaurs and later human beings developed. The soil layers gradually became deep and thick. They supply four essential requisites of human beings; food, clothes, home and medicine.

Part 2 : Soil

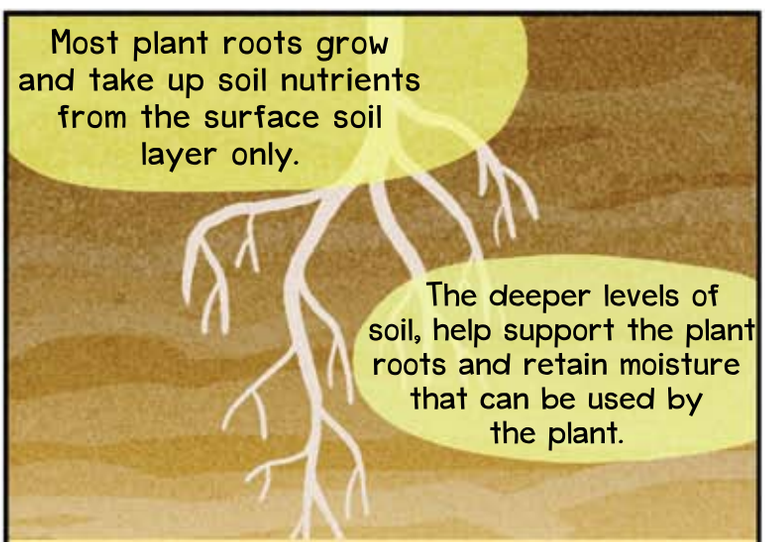

Woof
woof!
Oh! I forgot to introduce our companion. This small dog is called "Jao Dang"
How cute! Hi, Jao Dang.
I took Jao Dang in when she appeared one day in front of the house. I was afraid she would be hit by a car. She is a wise dog.
OK. Children! Come this way. I will take you to the farmers' fields over there.
Wow! This is so exciting.
Look at Jao Dang, she is leading us to the farmers' plots.
Ha ha.
She really is a smart dog!
What are they doing over there, Uncle? It looks quite interesting.
Ah! They are digging a new well. Look at the soil which was dug up. The soil has many layers that tell us much about the possible uses of the soil and sometimes, how it was formed.

Soil layers

We notice that the surface soil is often darker in color than the deeper soil layers. This darker layer is often the result of old, disintegrated rock, residues from long dead plants and animals

At the deep levels of the soil, above the parent rock, the rock is decaying and disintegrating.

At the deeper layers of soil, even deeper than the parent rock you can usually find the "bedrock". This is the rock layer that has not yet decayed and disintegrated.



Soils often differ in depth. In deep soils, where the surface layers are thick, there is more space for plant roots to absorb more nutrients than in shallow soils where the surface layers are thin.

It's not only just for growing vegetables and fruits. Soil is the source of four good things that humans need: food, clothes, home and medicine. In addition, soil is the life-base of farmers. Soil is a little bit like the air we breathe, if we take care of it and don't destroy it, it will be with us all of our lives. Just like we need to learn to keep air clean of smoke in order to use it, we need to keep the soil in good condition so it can continue to provide us with food, clothes, medicine, and a home.

Soil has been developed from old, decayed rock mixed with plant and animal parts for millions of years. It is a natural resource that can not be rebuilt. Soil is thus a valuable resource that we should maintain and conserve.

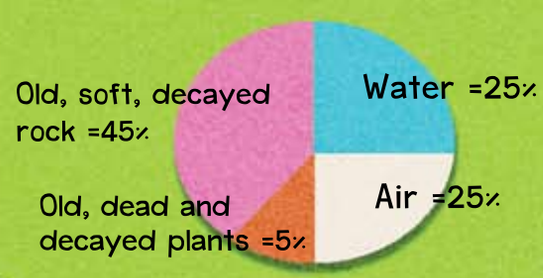
Oh My! How do you know? It's wonderful you understand so much!

My teacher has assigned us to do a report on soils during the school break. That's how I know.

Well! Excellent! So let me help you remember by telling us again. Please tell me and Nidnoi what the soil is made of.

Quite easy.

The soil is made of the following, which helps plants grow:



Each of these parts of soil does important things:

Water dissolves and carries soil nutrients to plant roots where they can help plants grow.

Air gives oxygen to plant roots for respiration.

The old, soft, decayed rock is a source of plant food.

Old, dead and decayed plants help the soil become loose, stay moist, and be easy for roots to grow in, they are also the food for tiny soil animals and plants.

Very good.

Wow! Pom knows a lot about soil!

Eh! How can we know which soil is good, sir?

Pom, can you answer that?

Yes, very easy.

Good soil has four things about it, isn't that right, sir?

(2) A good soil is not acid, or alkaline or salty, (nothing that stops growth, good chemical properties)

(1) A good soil has plenty of plant nutrients (plenty of "food" for plants!)

pH

N Ca S P K Fe Mg Mn

(3) A good soil is easy for plant roots to grow in, (loose and easy for roots, good physical properties

(4) A good soil has small creatures that help the plant grow, (many small helpful creatures, good biological properties)

You are right, Pom. Good soil or soils which plants grow well should be like that.

That means we add fertilizers to soil in order to add more plant food so plants can grow bigger and stronger. This helps the soil become more fertile, right?

Therefore, adding fertilizers (plant food) helps plants grow but the soil needs to be loose and easy for roots to grow in, have none of the things that stop plants from growing, and have many small helpful creatures.

So you mean that a fertile soil is not always a good soil, but a good soil must be a fertile soil. It sounds a little complicated.

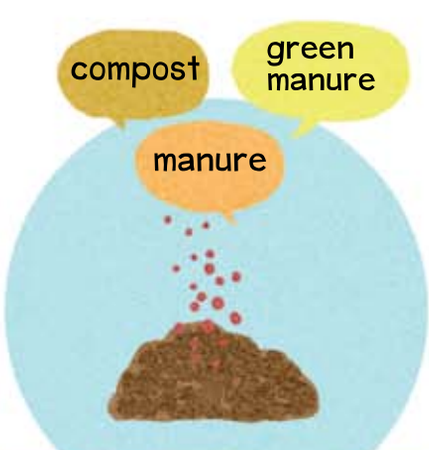
??

We have to start by determining which of the four things about soil causes it to be a poor soil, and then we can improve those things. We start by asking questions. For example:

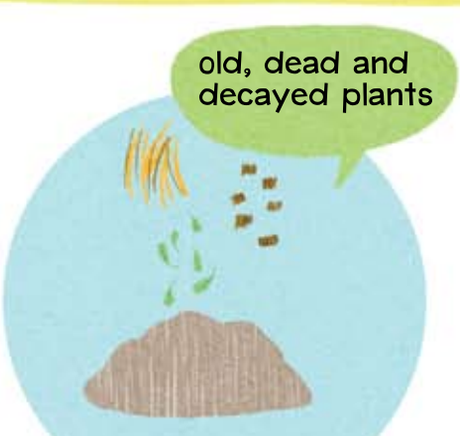
So how do we improve a poor soil, sir?

Does the soil contain sufficient plant food? We must determine how much plant food the soil contains: what levels, if low, chemical fertilizers should be applied

Is the soil too acid or alkaline? If the soil is acid, then marl or a limestone material can be added (liming). If the soil is too alkaline, then treat the soil with an acid material. If the soil is too salty, the salt must be removed, perhaps by applying lots of water so that the water moves down through the soil.

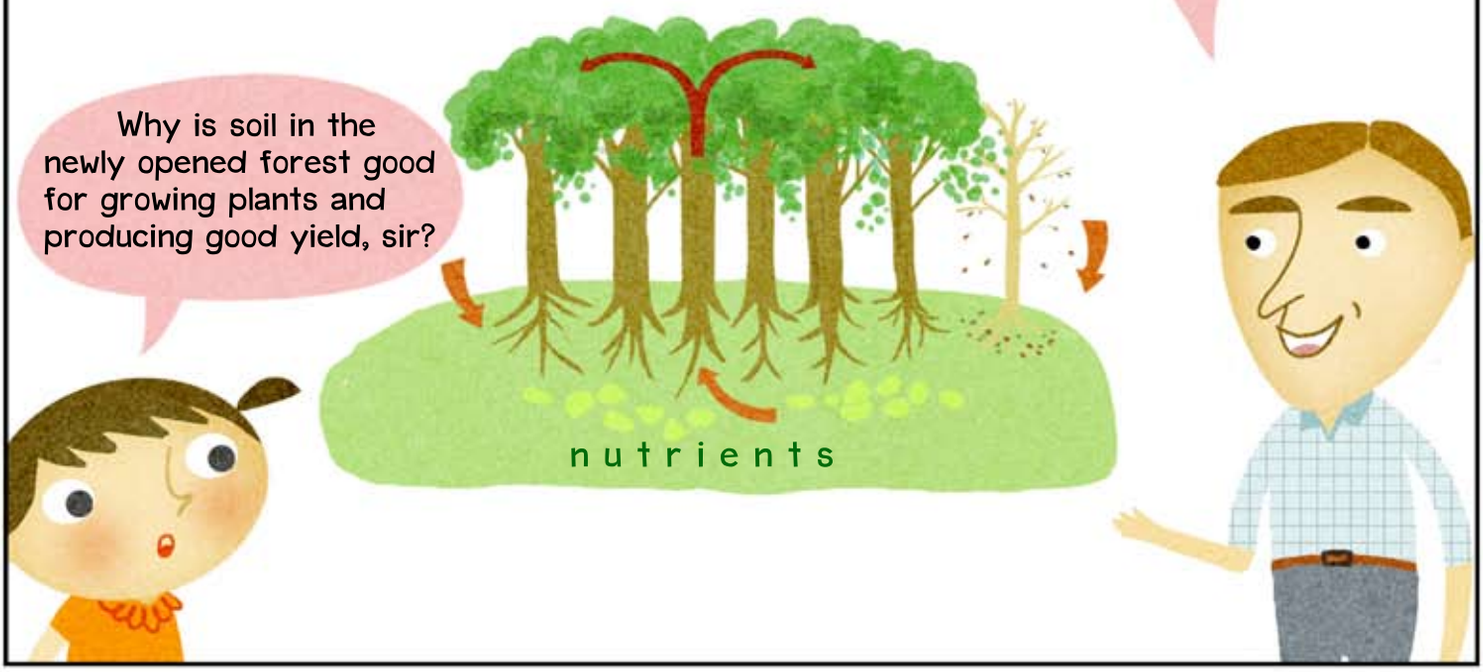


Is the soil loose and easy for roots to grow in?[66] Soils that are so hard that water does not soak in will not allow roots to grow normally. Dead and decomposed plants and animal parts; compost, manure and green manure should be added and mixed into the soil.

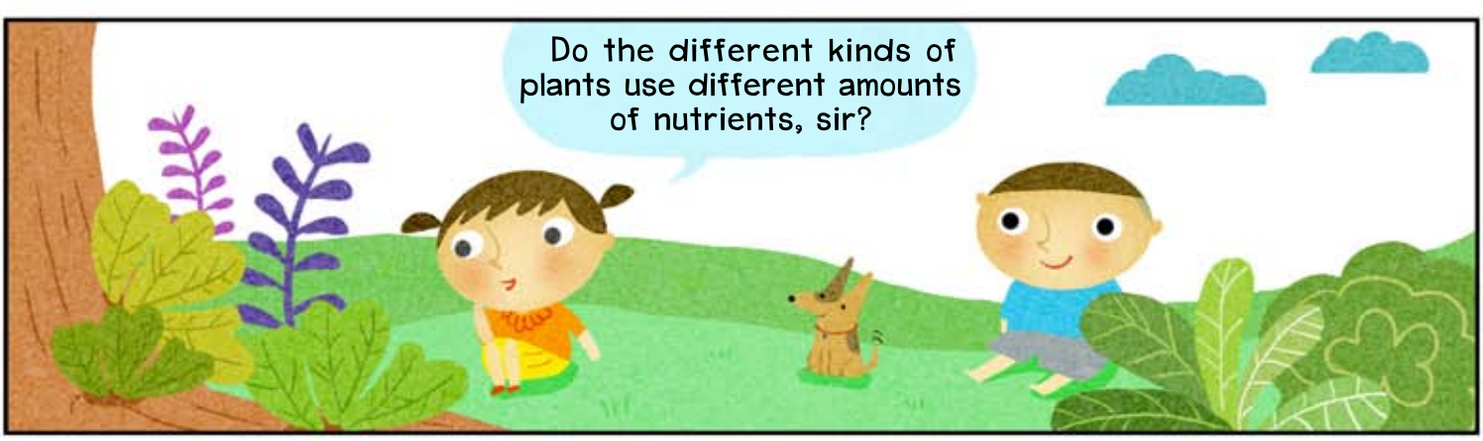


Does the soil contain many small creatures that help plant grow? Soils usually contain many tiny plants and animals, many of which are so small that they can not be seen. The bacteria mixed with legume seeds prior to planting will help plant obtain food from the air. The old, dead unused plant and animal parts can be added to the soil to increase the food for bacteria."

Soil in the forest usually is fertile because the tree roots take up nutrients from the soil to grow the leaves, fruits, stems and branches, and when the trees die, these plant parts fall onto the soil and decay, nutrients are released and become ready for use by new plants. When it rains, such nutrients will be removed to the deeper layer of soil as the water flows through the soil. From there, new plant roots will again take nutrients up for their growth. This cycle will go on and on.

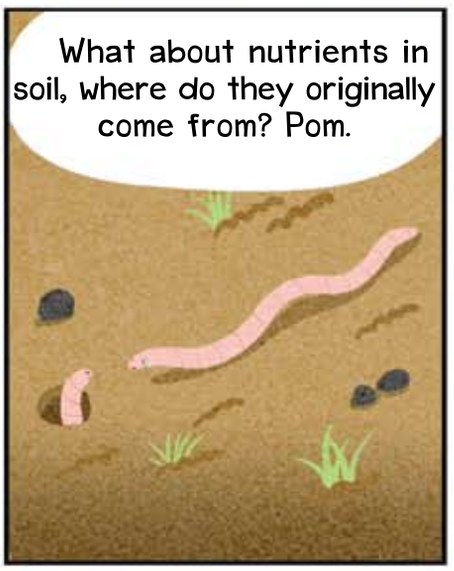


In soils used for agriculture, the nutrients are used up by the food plants and when we collect the food plants, we also take away the nutrients in the plants from the soil. In this way the soil loses nutrients because they are taken away in the food plants. So, without returning nutrients, a good agricultural soil can eventually become poor soil.

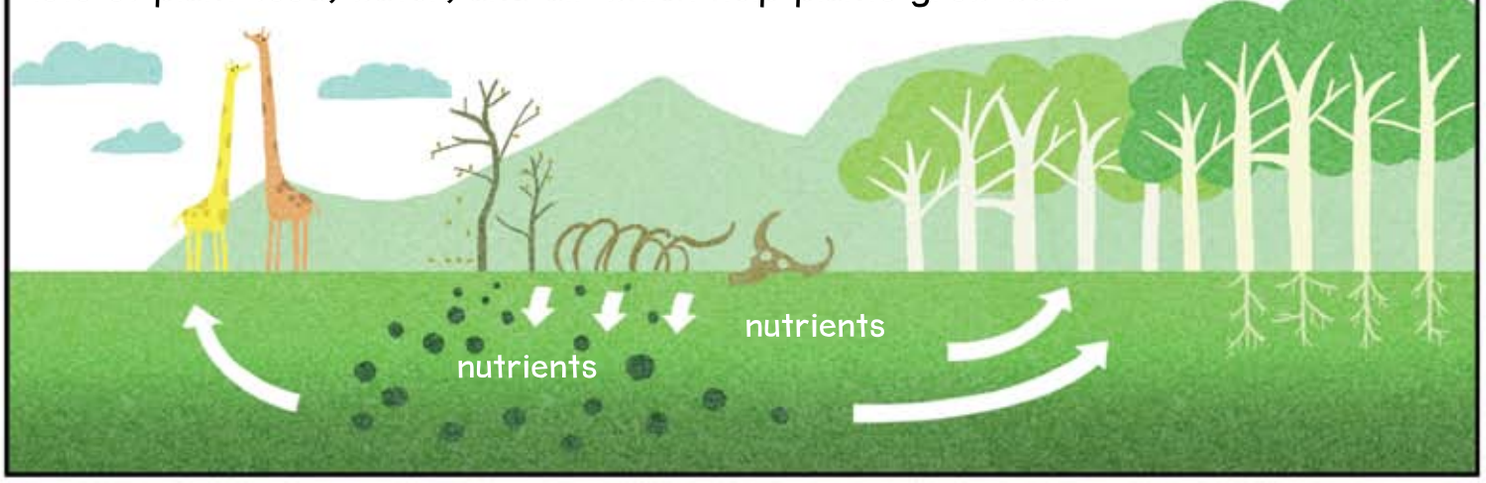


Different plants need different kinds and also different amounts of nutrients. For example: 1 ton of rice grain removes 12 kg of nitrogen, 3 kg of phosphorus and 3 kg of potassium from the soil where it is grown. There are even more nutrients removed in the straw, stem and roots needed to produce the rice grain. Therefore, returning the straw, stems, and roots to the soil helps to keep the soil fertile.

Be careful!. Try to avoid stepping on earthworms. Please do not be afraid of them. Did you know that earthworms are some of the many small creatures that are useful to soil? Earthworms loosen up the soil and improve it since they dig through soil making the soil loose, more open, and easy for roots to grow in. When earthworms die, they will be decomposed and return the nutrients in their bodies to the soils.



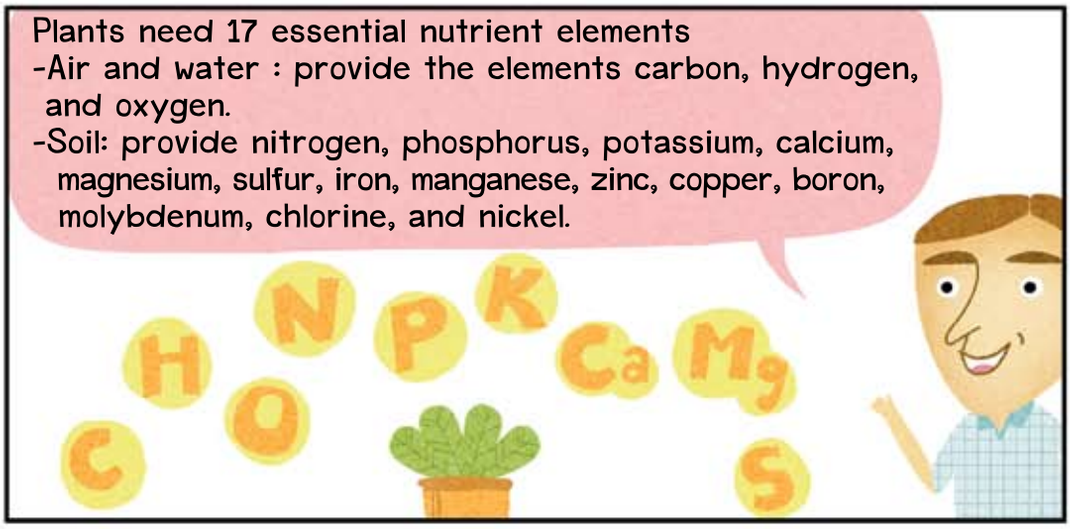
Soil nutrients (plant food) come from rock that becomes old and soft, soil minerals, plant and animal residues. Soil in newly-opened forests is usually good soil with lots of plant food, water, and air which help plants grow well.



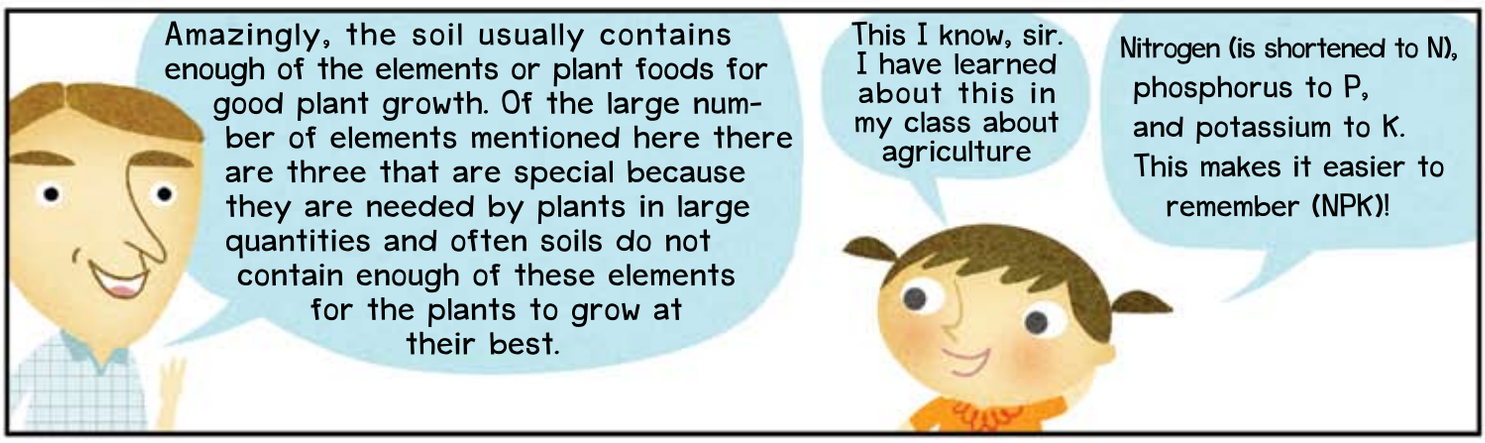
When forest is prepared for agricultural use, not only is the plant food removed when crop plants are harvested and the food is eaten, but nutrients may be lost from the area when rain seeps into the soil or when the rain carries soil away during a storm. The loss of soil nutrients in surface soils may result in the loss of so many nutrients that the plant no longer grows well..

Uncle Pracha, what are the essential foods for plants?

Plants need 17 essential nutrient elements
-Air and water : provide the elements carbon, hydrogen, and oxygen.
-Soil: provide nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc, copper, boron, molybdenum, chlorine, and nickel.



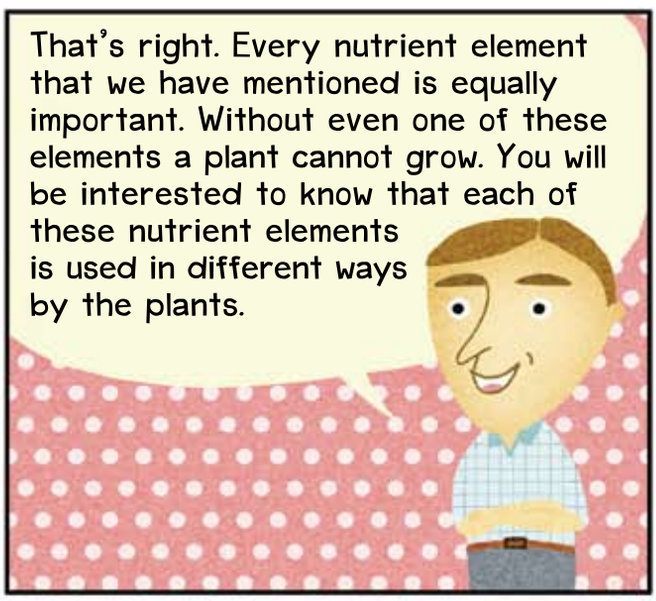
Amazingly, the soil usually contains enough of the elements or plant foods for good plant growth. Of the large number of elements mentioned here there are three that are special because they are needed by plants in large quantities and often soils do not contain enough of these elements for the plants to grow at their best.



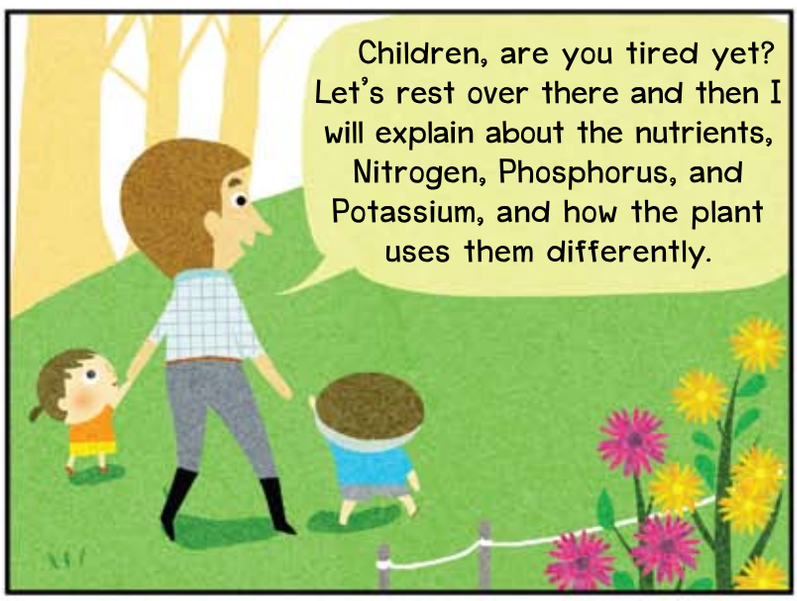
This I know, sir. I have learned about this in my class about agriculture

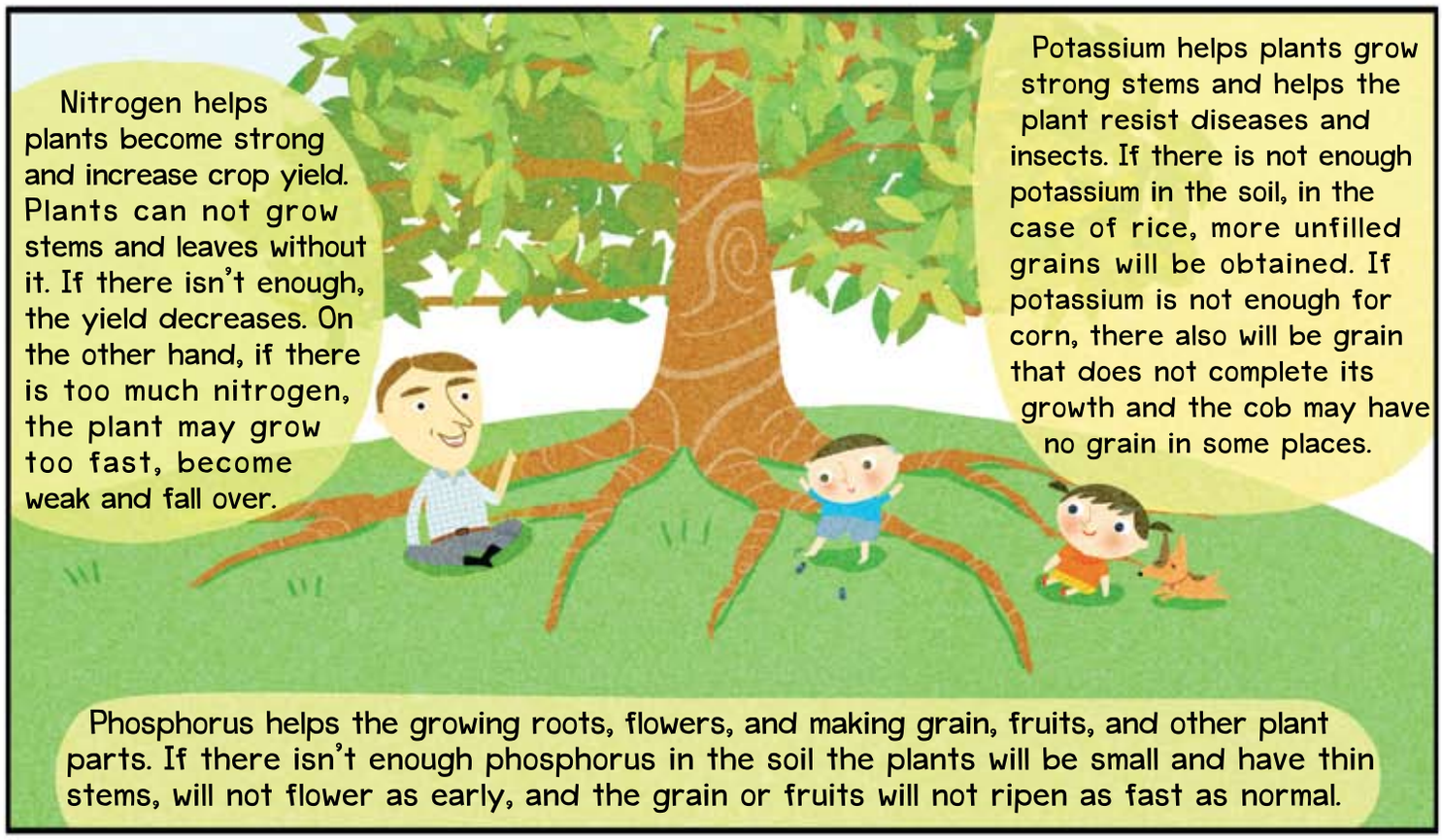
Nitrogen (is shortened to N), phosphorus to P, and potassium to K. This makes it easier to remember (NPK)!

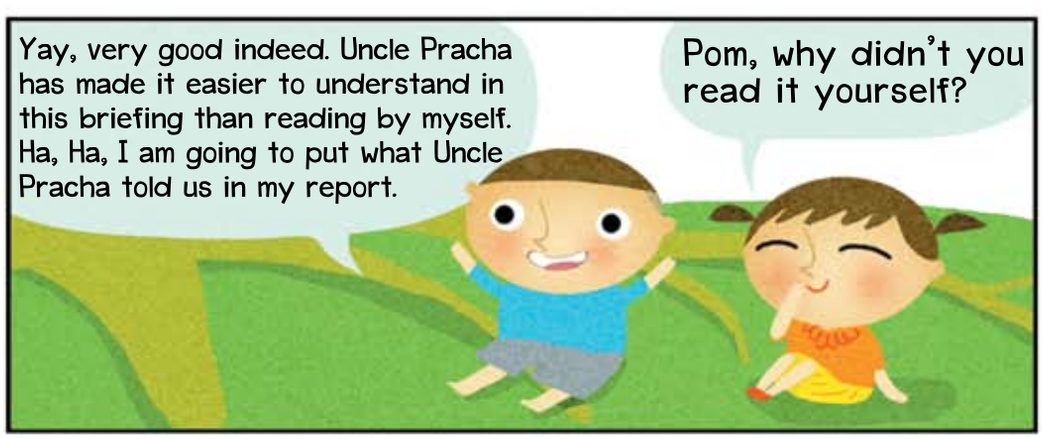
That's right. Every nutrient element that we have mentioned is equally important. Without even one of these elements a plant cannot grow. You will be interested to know that each of these nutrient elements is used in different ways by the plants.

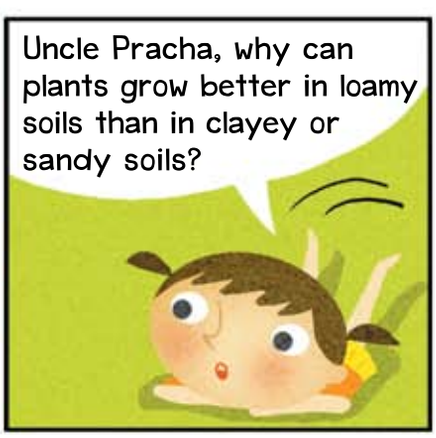


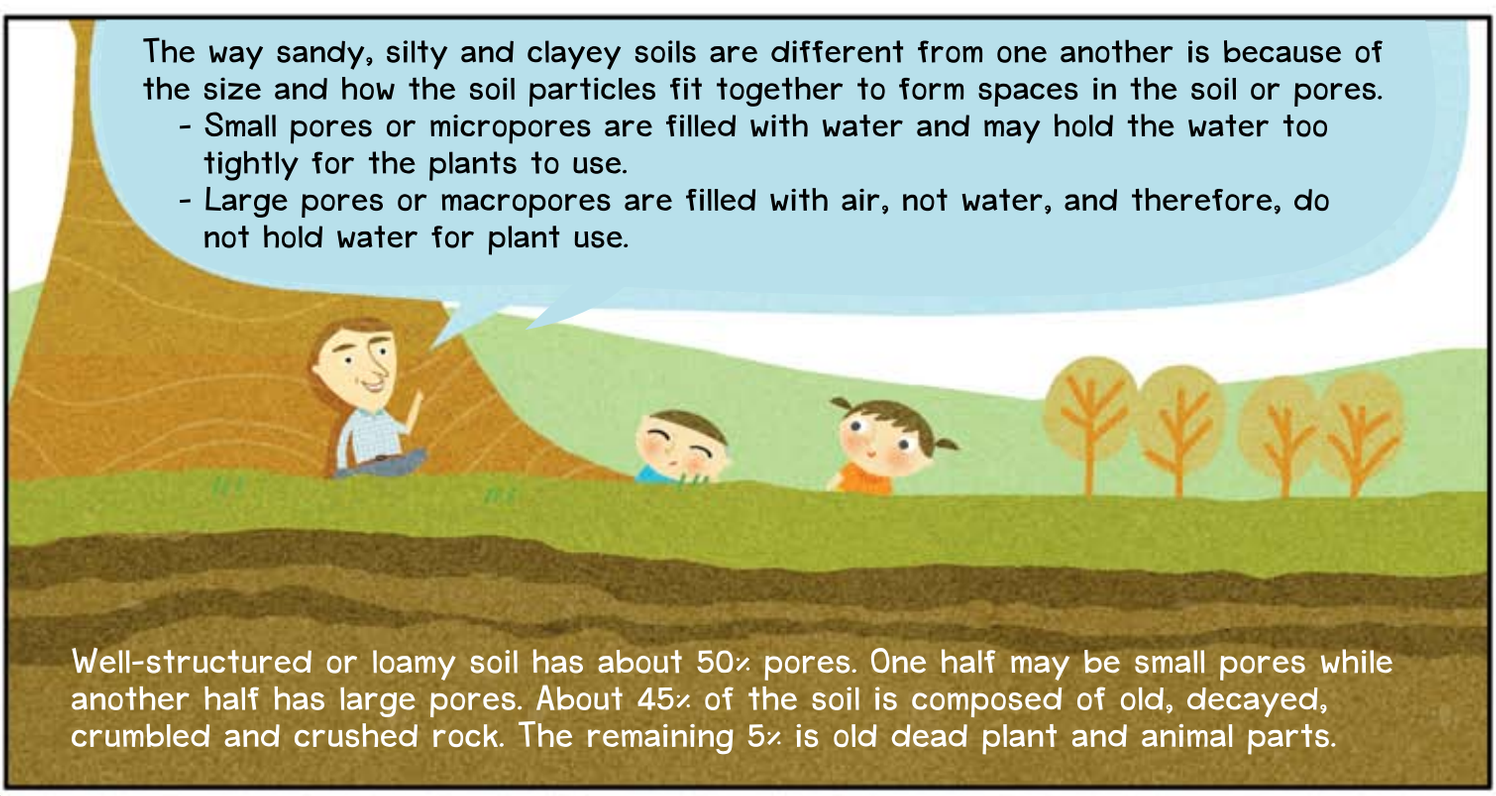
Children, are you tired yet? Let's rest over there and then I will explain about the nutrients, Nitrogen, Phosphorus, and Potassium, and how the plant uses them differently.




Nitrogen helps plants become strong and increase crop yield. Plants can not grow stems and leaves without it. If there isn't enough, the yield decreases. On the other hand, if there is too much nitrogen, the plant may grow too fast, become weak and fall over.
Potassium helps plants grow strong stems and helps the plant resist diseases and insects. If there is not enough potassium in the soil, in the case of rice, more unfilled grains will be obtained. If potassium is not enough for corn, there also will be grain that does not complete its growth and the cob may have no grain in some places.
Phosphorus helps the growing roots, flowers, and making grain, fruits, and other plant parts. If there isn't enough phosphorus in the soil the plants will be small and have thin stems, will not flower as early, and the grain or fruits will not ripen as fast as normal.


Yay, very good indeed. Uncle Pracha has made it easier to understand in this briefing than reading by myself. Ha, Ha, I am going to put what Uncle Pracha told us in my report.
Pom, why didn't you read it yourself?

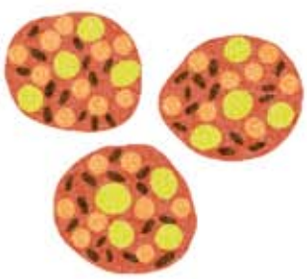

Uncle Pracha, why can plants grow better in loamy soils than in clayey or sandy soils?


The way sandy, silty and clayey soils are different from one another is because of the size and how the soil particles fit together to form spaces in the soil or pores.
- Small pores or micropores are filled with water and may hold the water too tightly for the plants to use.
- Large pores or macropores are filled with air, not water, and therefore, do not hold water for plant use.
Well-structured or loamy soil has about 50% pores. One half may be small pores while another half has large pores. About 45% of the soil is composed of old, decayed, crumbled and crushed rock. The remaining 5% is old dead plant and animal parts.

"Soil texture" is a scientific word that tells us about the size of the soil particles. It tells us how a plant might grow in the soil, particularly in terms of nutrients and water. A soil usually has particles of sand, silt, and clay, with sand being the largest, silt particles are smaller than sand, but larger than clay. Clay-sized particles are the smallest of all.

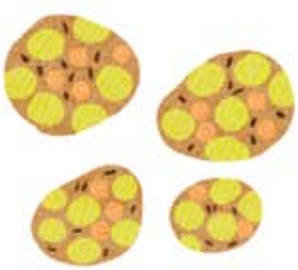
A clay soil may have as much as 50% clay-sized, 30% silt-sized and 20% sand-sized particles

A clay soil usually has more clay-sized particles than the other particles. This means clay soil will have more micropores, will be able to hold more water and release more nutrients to plants than sand. On the other hand, clay soil usually has a few macropores (large sized pores) and this may cause good aeration but less water and more drainage.



A silt soil may have 25% clay-sized, 35% silt-sized and 40% sand-sized particles.

Thus a silt soil has about the same amount of sand, silt, and clay particles. This type of soil has nutrients, water and air in the ratio suitable for plant growth.



Finally, a sandy soil may have 10% clay-sized, 20% silt-sized and 70% sand-sized particles.

A sandy soil has more sand-sized particles, thus has fewer micropores resulting in low water and nutrients holding capacity, and is less suitable for plant growth. However, sandy soils have many very large pores that do not hold water for plants and may have a drought problem.

The size ranges of soil particles :

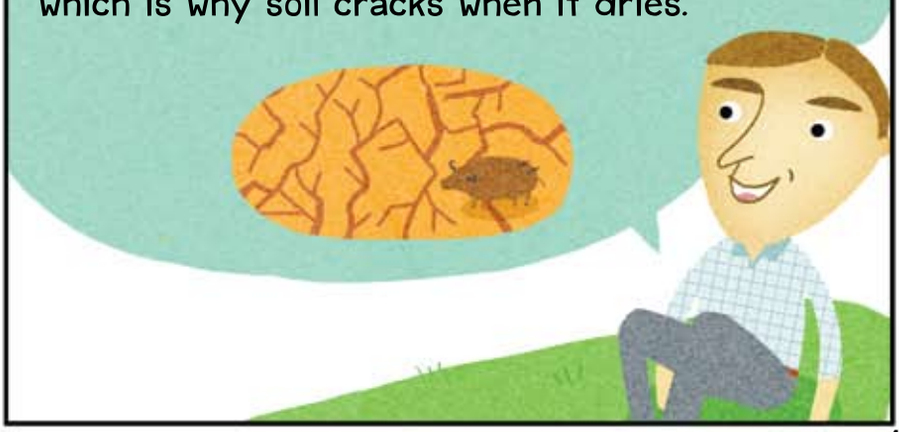
clay-sized particles : <0.002 mm

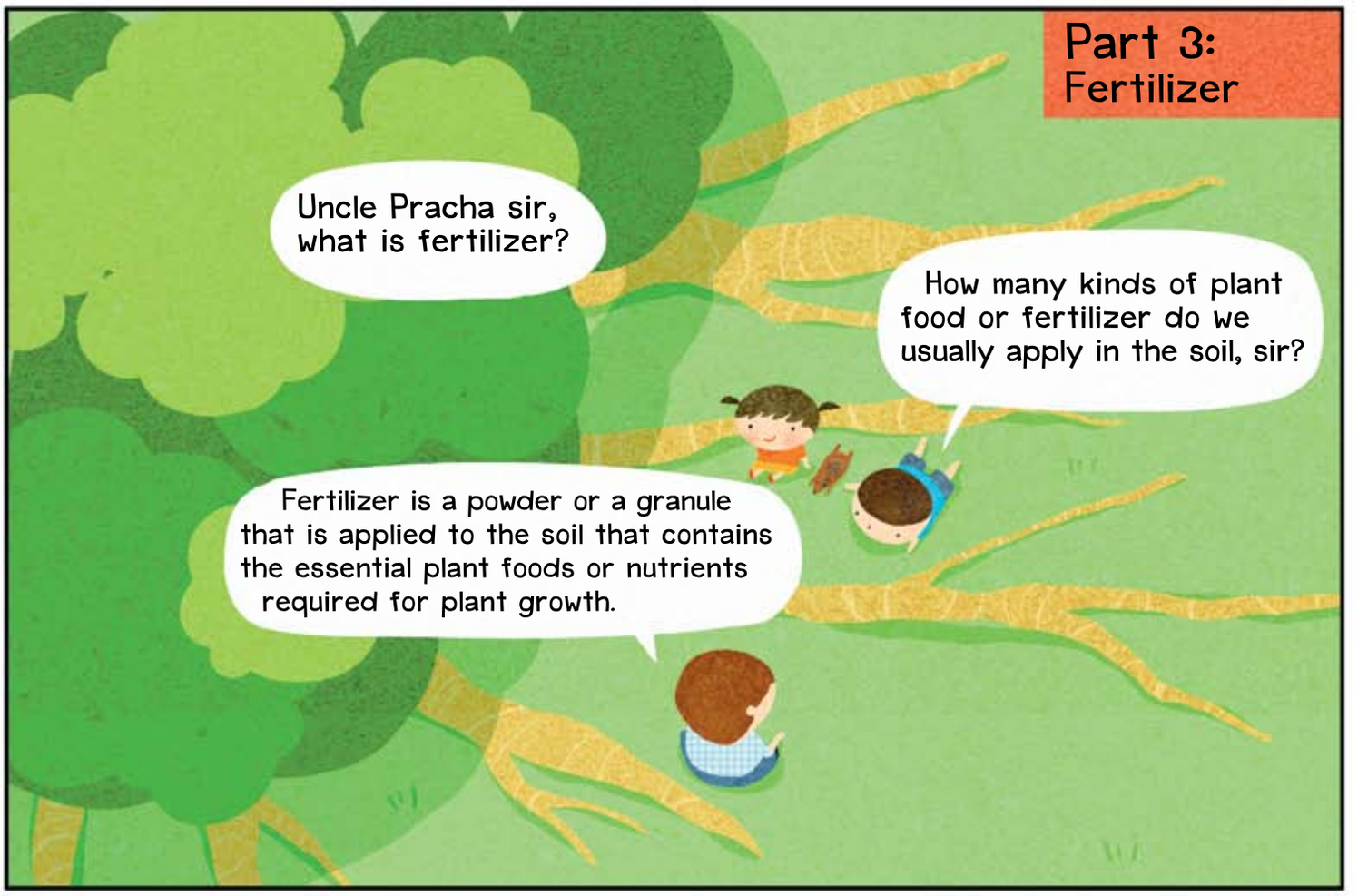
silt-sized particle 0.002-0.02 mm

sand-sized particle 0.02-2.0 mm

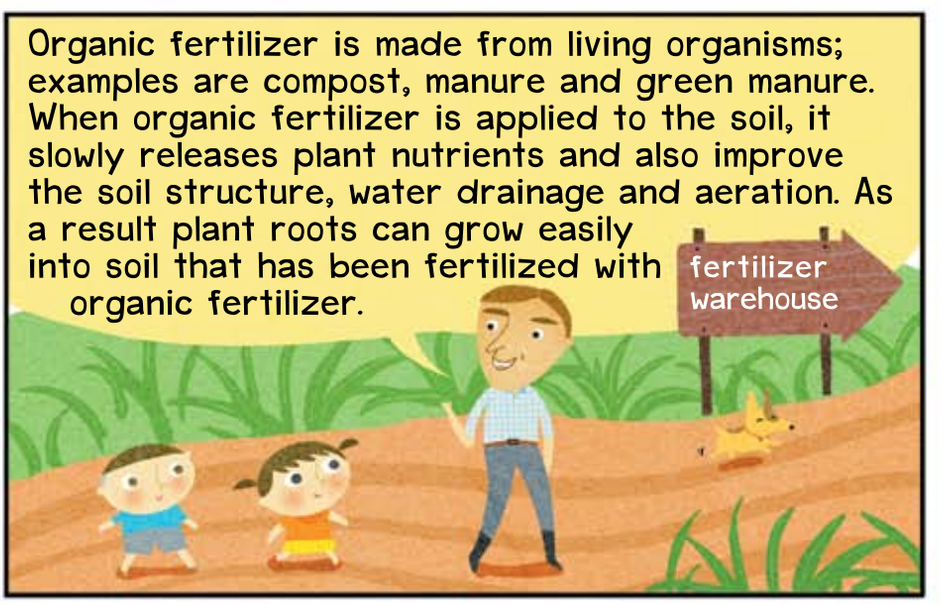
Question! Why does soil used in growing rice form big cracks when dry, sir? I have seen this on TV. Rice fields, after harvesting, appear to be dry with many cracks.

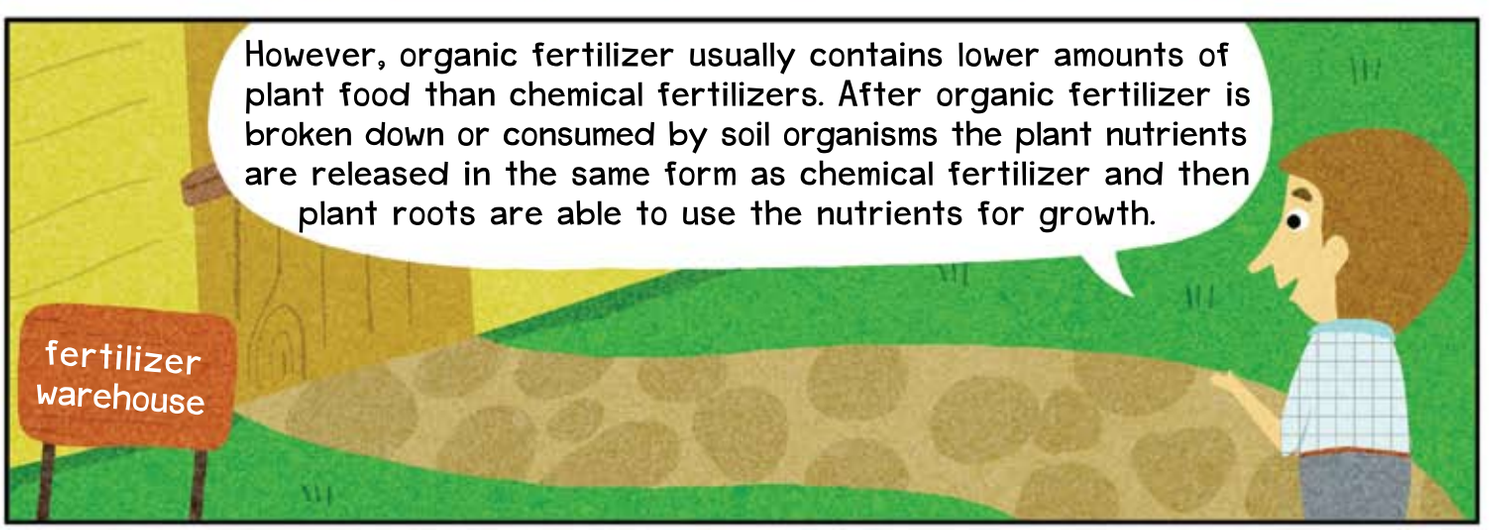
Most soils used for rice are clayey and contain a type of clay that swells when wet and shrink when dry, thus we see the result of shrinking, which is why soil cracks when it dries.




Part 3:
Fertilizer
Uncle Pracha sir, what is fertilizer?
How many kinds of plant food or fertilizer do we usually apply in the soil, sir?
Fertilizer is a powder or a granule that is applied to the soil that contains the essential plant foods or nutrients required for plant growth.


The popular type of fertilizer used are chemical fertilizer, organic fertilizer and bio-fertilizer. In a minute, I will take you to the fertilizer warehouse to show you different kinds of fertilizer.


Organic fertilizer is made from living organisms; examples are compost, manure and green manure. When organic fertilizer is applied to the soil, it slowly releases plant nutrients and also improve the soil structure, water drainage and aeration. As a result plant roots can grow easily into soil that has been fertilized with organic fertilizer.
fertilizer warehouse


However, organic fertilizer usually contains lower amounts of plant food than chemical fertilizers. After organic fertilizer is broken down or consumed by soil organisms the plant nutrients are released in the same form as chemical fertilizer and then plant roots are able to use the nutrients for growth.
fertilizer warehouse

Manure

Manure is an organic fertilizer which is animal droppings from ducks, chickens, pigs, buffaloes, etc. Animal manure will often contain 0.5% nitrogen, 0.25% phosphorus and 0.5% potassium.

The amount of nutrients in animal manure depends, partly, on the kind of foods the animal eats. New or fresh manure fertilizer usually has more nutrients than manure that has been stored for a long time. Also a caution, manure stored or placed outdoors could lose nutrients to rain or to the air as gas.

Therefore, manure should be placed under a roof protecting it from sunshine and rain. Fresh manure can be harmful to plants since it is not fully decomposed. Fresh manures can be mixed with plant residues, e.g. rice husk, straw, sawdust, etc., for a while or sun-dried before use.

Compost

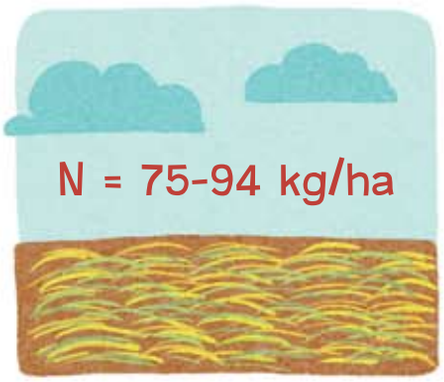
Compost is an organic fertilizer resulting from the composting process. Compost may be formed from dry grass, leaves, rice straw, food remnants, garbage as well as other organic materials.

The farmers can make their own compost by making a heap of plant residues or other organic materials 30 cm above ground, stomping on it until compacted, apply thin layer of manure including 1.5-2.0 kg of 15-15-15 chemical fertilizer for 1 ton of plant residues, watering and the second layer of plant materials is placed over followed by manure and chemical fertilizers as the first heap.

The process is continued till a heap of 1.5 x 2.0 m is obtained. On the top layer, soil is placed after which intermediate watering is made followed by covering it with grass or rice straw. The heap must become hot in order to kill harmful bacteria and micro-organisms.

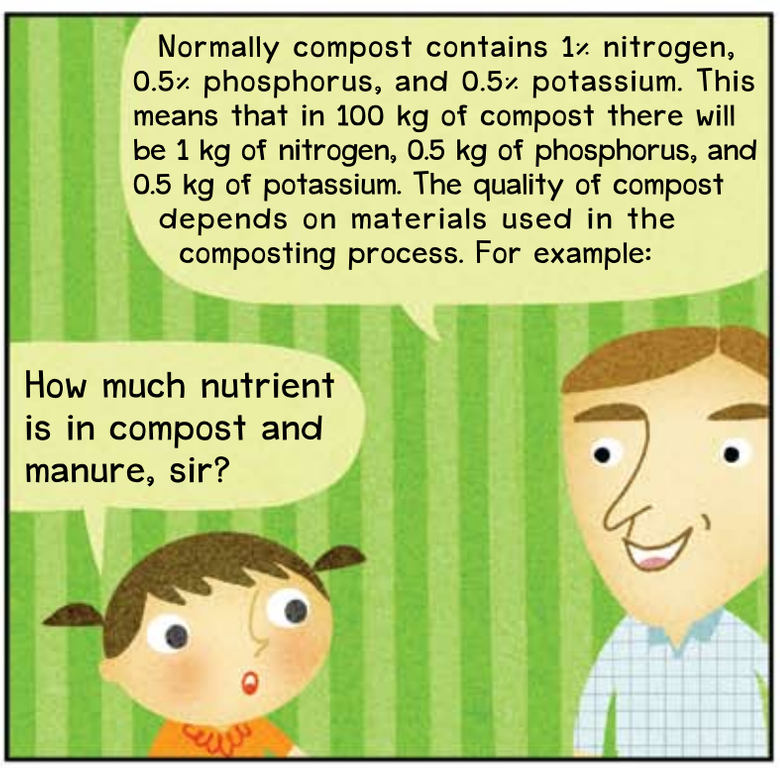
Green manures - these are fertilizers made from fresh plant parts such as leaves, stems, and roots.

Green manures are often legumes, such as Vigna, Sesbania, and Crotalaria. These plants are grown to the flowering stage and then are ploughed into the soils. After a short period of a week or so the main crop can be planted to take advantage of the nutrients released by the green manure.



Legumes can be planted in an area of 1 hectare, and may produce as much as 3.1 tons of dry plant. This amount of legume plant may add as much as 75 to 94 kg/ha of nitrogen to soils

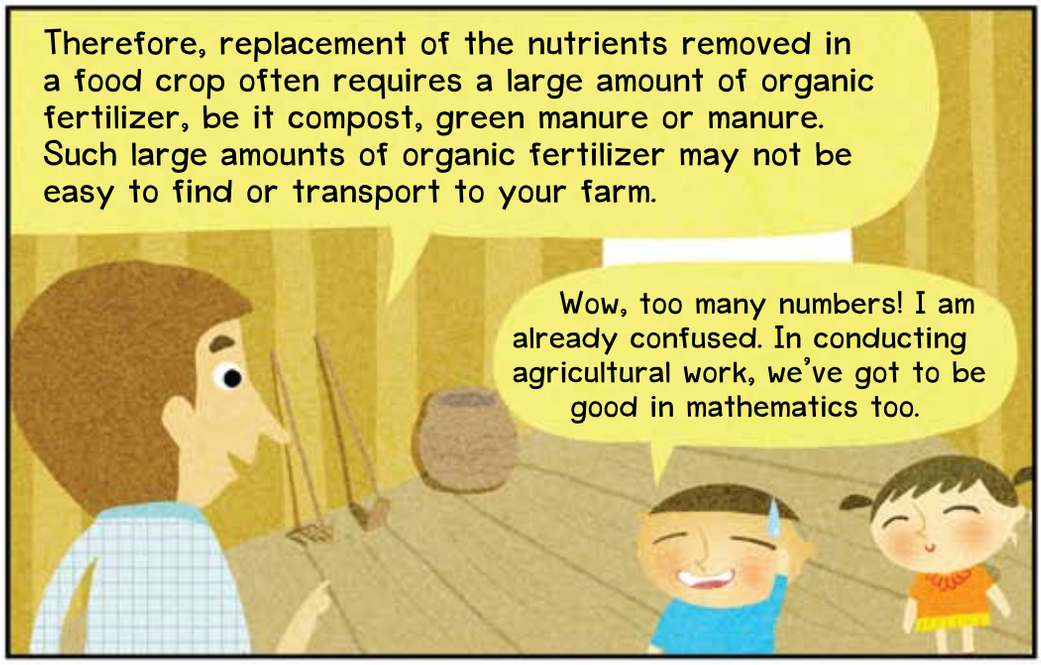
The best green manures are legumes which grow fast and have dense leaves and branches that can compete with weeds. They should also have strong root systems which can grow deeply into the soil.

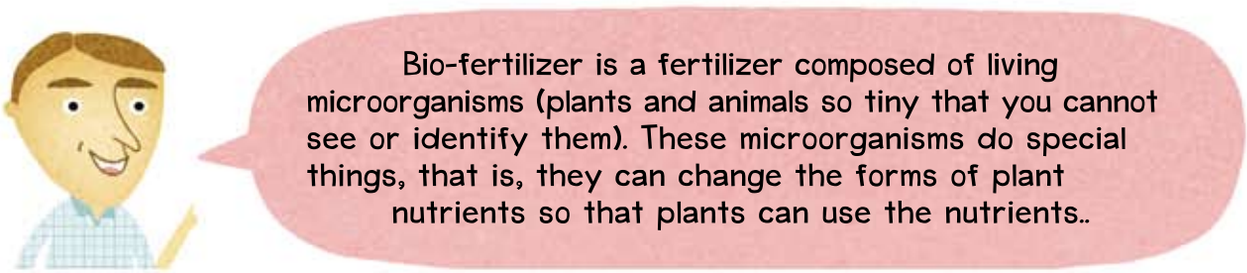


100 kg of rice straw contains 0.6 kg nitrogen, 0.1 kg phosphorus, and 1.7 kg potassium.

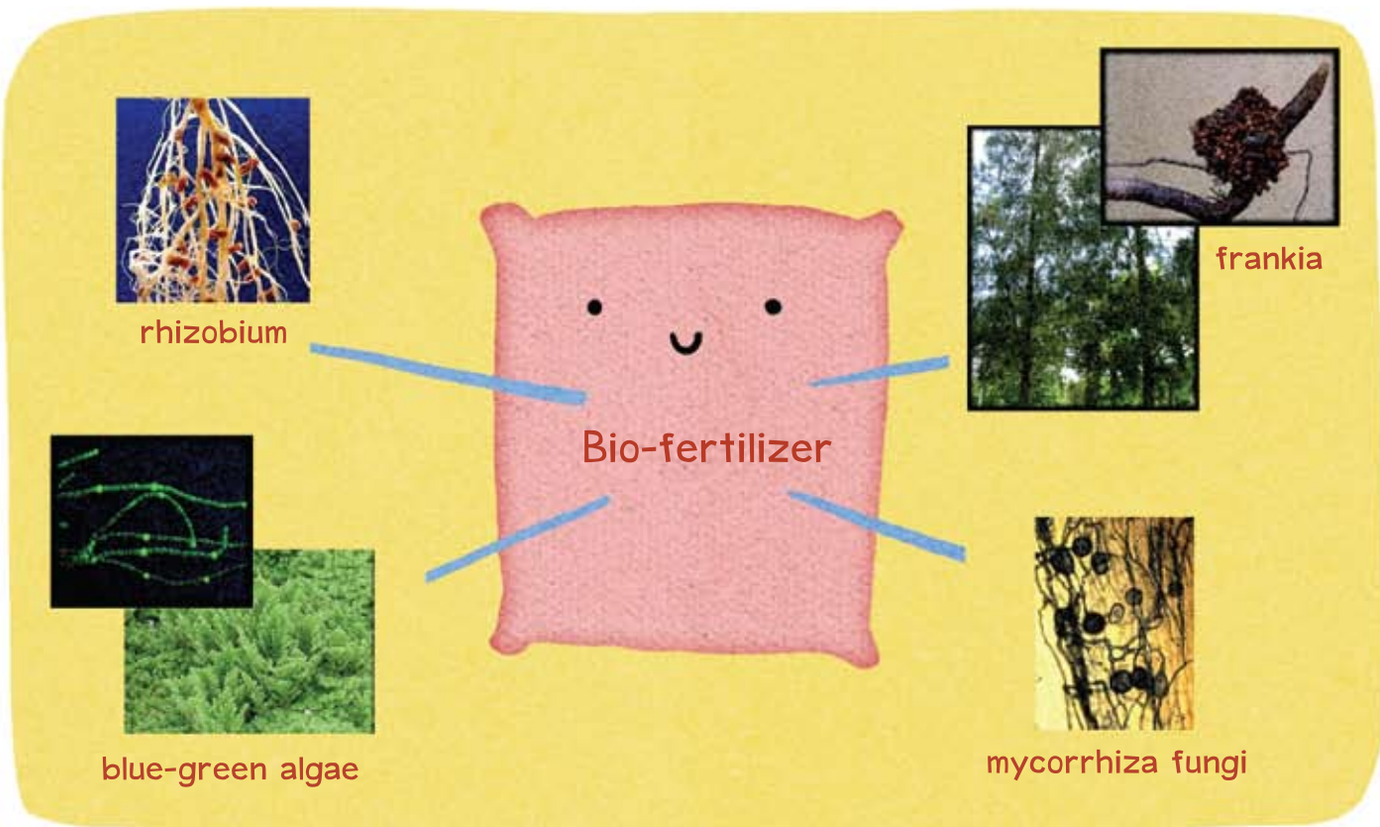
100 kg of rice husk, no nitrogen, 0.2 kg phosphorus, and 0.8 kg potassium.

100 kg of chicken manure contains 2.4 kg nitrogen, 6.3 kg phosphorus, and 2.1 kg potassium

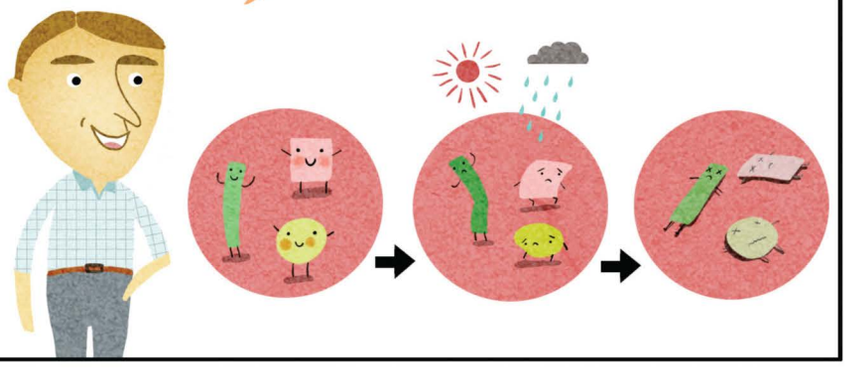




Some examples of this kind of microorganisms are rhizobium in legume root nodules, frankia in Casuarina root nodules, and blue-green algae in leaves of the tiny azolla fern that grows on water. An example of microorganisms which can change the form of plant nutrients from unavailable to be available is mycorrhiza fungi, a beneficial type of fungi, which can dissolve phosphorus that plants can not use due to the chemical form in the soil making it so that plants can absorb the phosphorus.

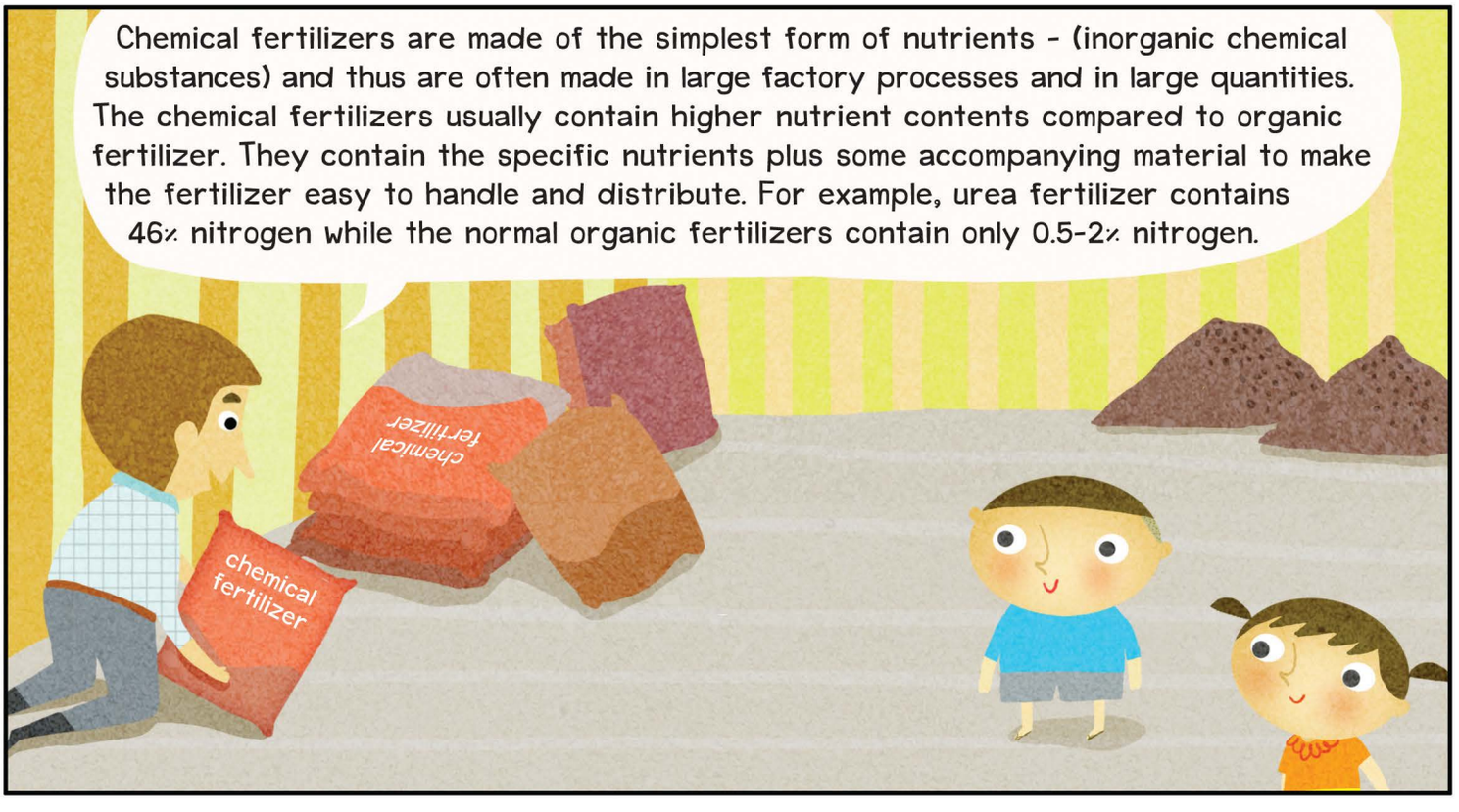


Therefore, the storing and handling of bio-fertilizer needs extra care. If the special microorganisms are dead before use, the bio-fertilizer will no longer benefit the plants.

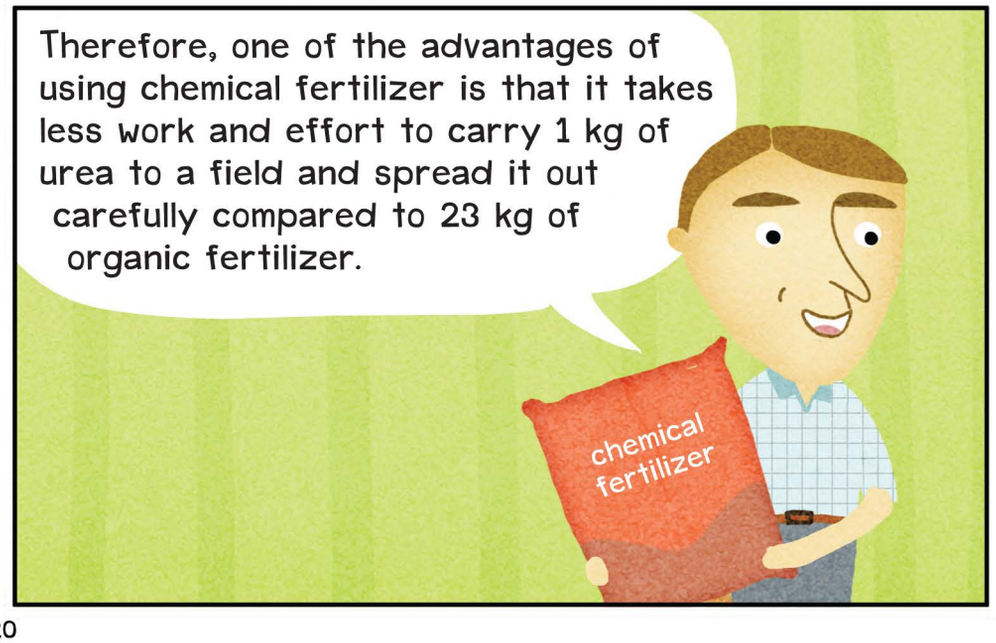


The next fertilizer we should discuss is chemical fertilizer.

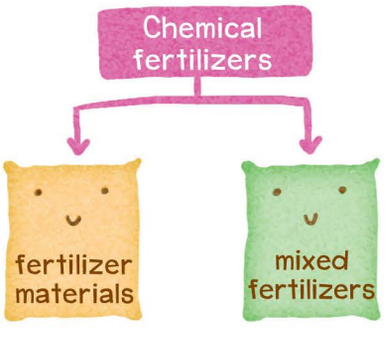
Chemical fertilizers are made of the simplest form of nutrients - (inorganic chemical substances) and thus are often made in large factory processes and in large quantities. The chemical fertilizers usually contain higher nutrient contents compared to organic fertilizer. They contain the specific nutrients plus some accompanying material to make the fertilizer easy to handle and distribute. For example, urea fertilizer contains 46% nitrogen while the normal organic fertilizers contain only 0.5-2% nitrogen.



Therefore, one of the advantages of using chemical fertilizer is that it takes less work and effort to carry 1 kg of urea to a field and spread it out carefully compared to 23 kg of organic fertilizer.

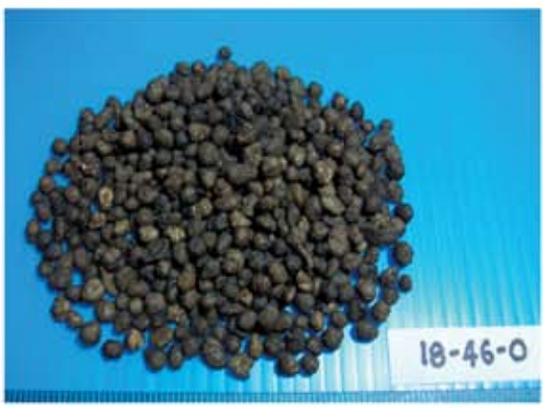


Chemical fertilizers that you can buy usually come in 2 groups- fertilizer materials and mixed fertilizers.

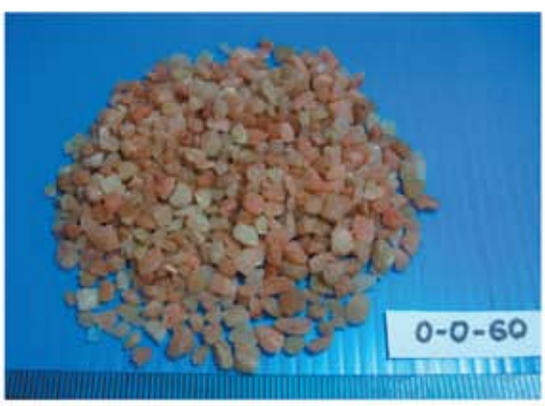


A "Fertilizer material" is chemical substance with at least one important nutrient. Usually the fertilizer material can dissolve in water, which is necessary for plants use the nutrient. "Fertilizer materials" can be directly used or they can be mixed with other fertilizer materials in "bulk blending" process.

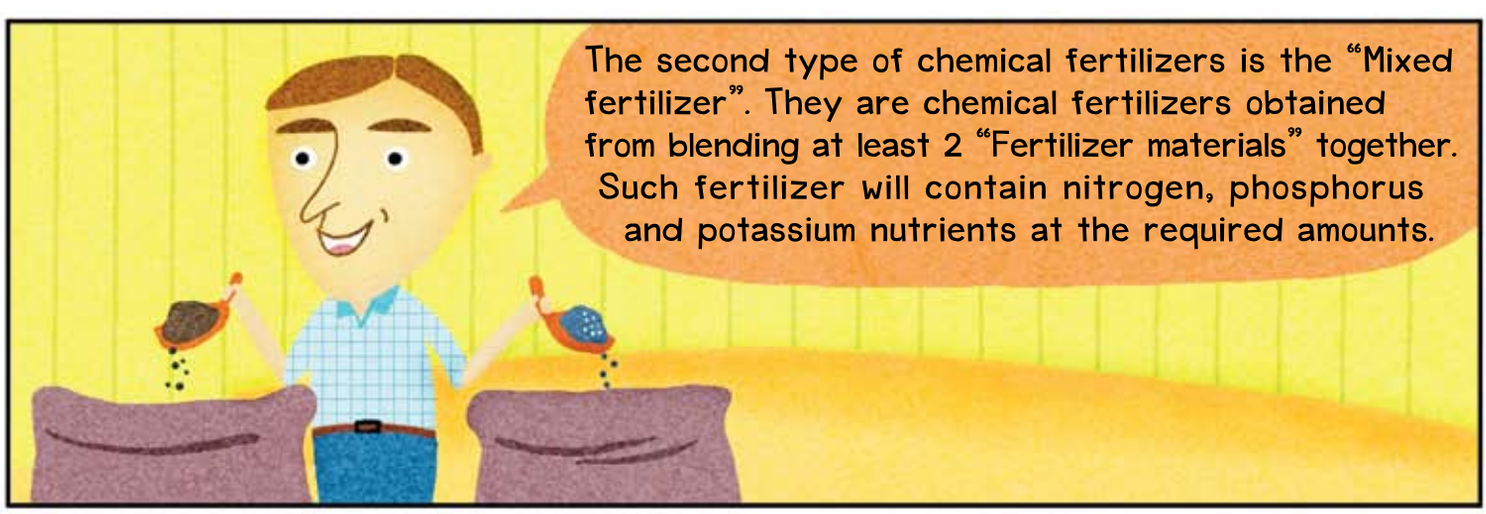
Nitrogen fertilizer materials: Urea, the chemical formula: $(NH_2)_2CO$ (46-0-0). Another N fertilizer material is ammonium sulfate with the chemical formula of $(NH_4)_2SO_4$ (21-0-0).



Phosphate fertilizer materials: Triple superphosphate, which has a chemical formula of $Ca(H_2PO_4)_2 \cdot 2\ H_2O$ (0-46-0). Another phosphate fertilizer: Diammonium phosphate or DAP, whose chemical formula is $(NH_4)_2HPO_4$ (18-46-0).



Potassium fertilizer materials include Potassium chloride, whose chemical formula is KCl (0-0-60) and Potassium sulfate, whose chemical formula is K_2SO_4 (0-0-50).



The second type of chemical fertilizers is the "Mixed fertilizer". They are chemical fertilizers obtained from blending at least 2 "Fertilizer materials" together. Such fertilizer will contain nitrogen, phosphorus and potassium nutrients at the required amounts.

We can illustrate how mixed fertilizers are made. A mixed fertilizer of 17-17-8 can be made by mixing 22, 37 and 14 kg of urea, diammonium phosphate and potassium chloride, respectively.

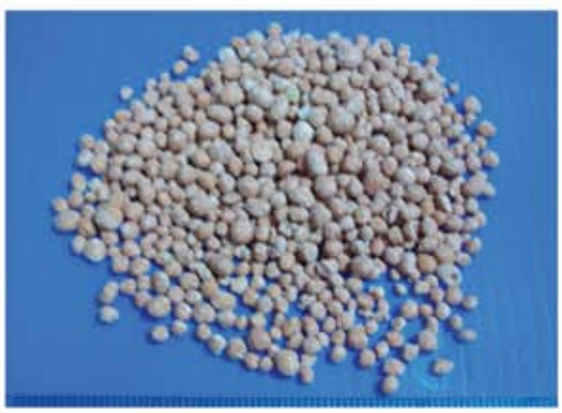
A mixed fertilizer of 17-17-8

urea
(46-0-0)

diammonium phosphate
(18-46-0)

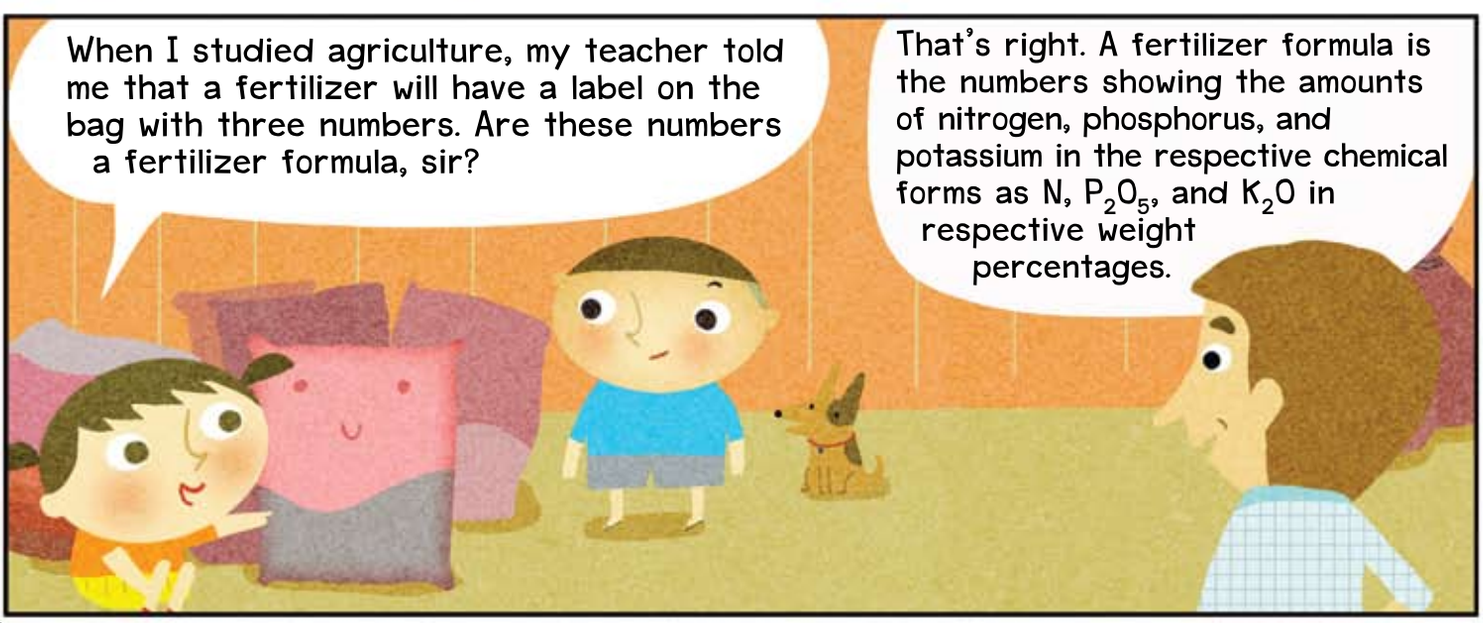
potassium chloride
(0-0-60)

There are several ways that fertilizers can be handled. These include granule, powder, and liquid forms. There are also 2 forms of mixed granule fertilizer.



The first form is compound fertilizer. The fertilizer materials are mixed and ground, then made into granules.

The second form is bulk blend fertilizer. The fertilizer materials which have similar sizes are mixed and used directly.



I'll give you an example. 15-5-25 fertilizer formula means 100 kg fertilizer has nitrogen, phosphorus, and potassium nutrients of 15%N, 5%P_2O_5 and 25%K_2O, respectively. Therefore, when the farmer buys 100 kg fertilizer, he will get only about 45 kg of nutrients.

100 kg fertilizer

N, P_2O_5, K_2O
15 + 5 + 25 = 45

Therefore, the farmer gets 45 kg of nutrients

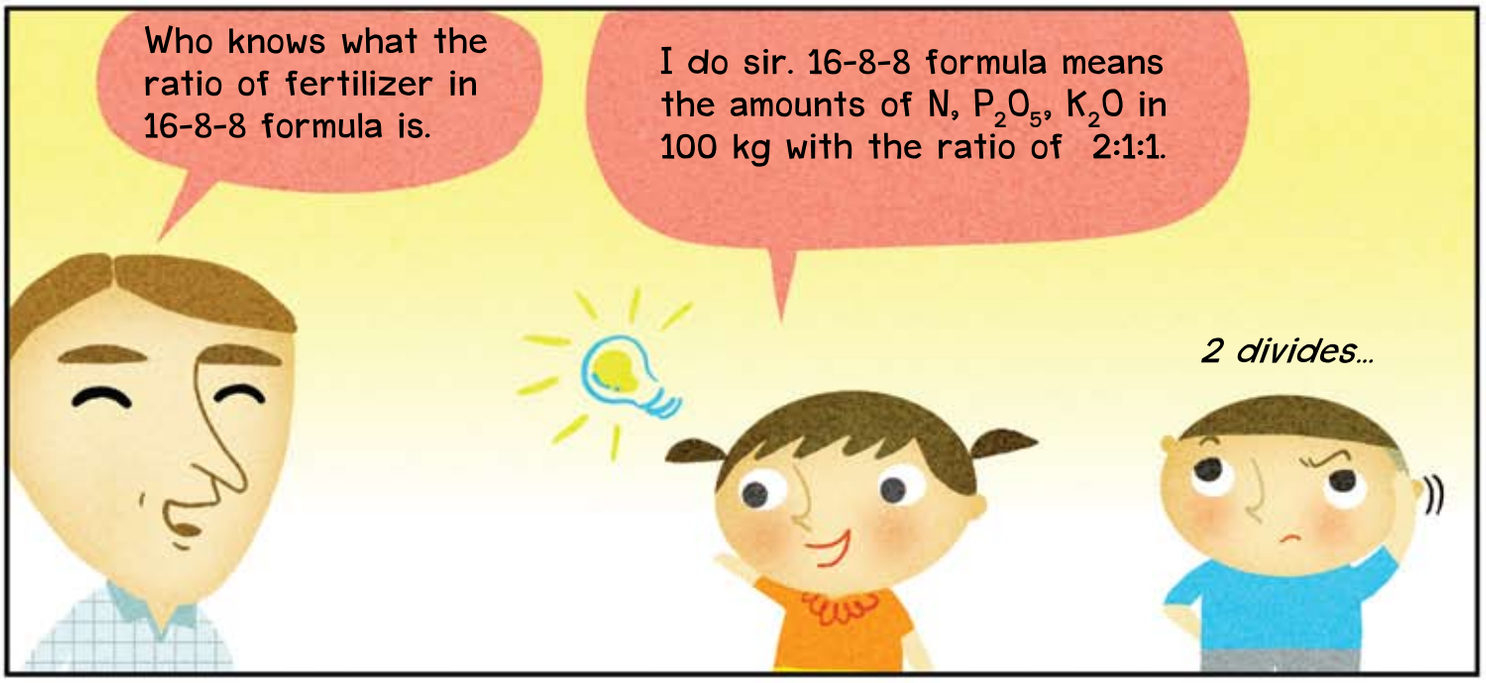
I have also heard about fertilizer ratio, what does that mean, sir?

Ah yes, fertilizer ratio is the ratio of N-P-K in fertilizer. Although fertilizer formulas are different, if they have the same ratio, they are considered to be the same kind. The only difference is the concentration of total nutrients in each fertilizer formula. Hence, they can easily be substituted one for the other.

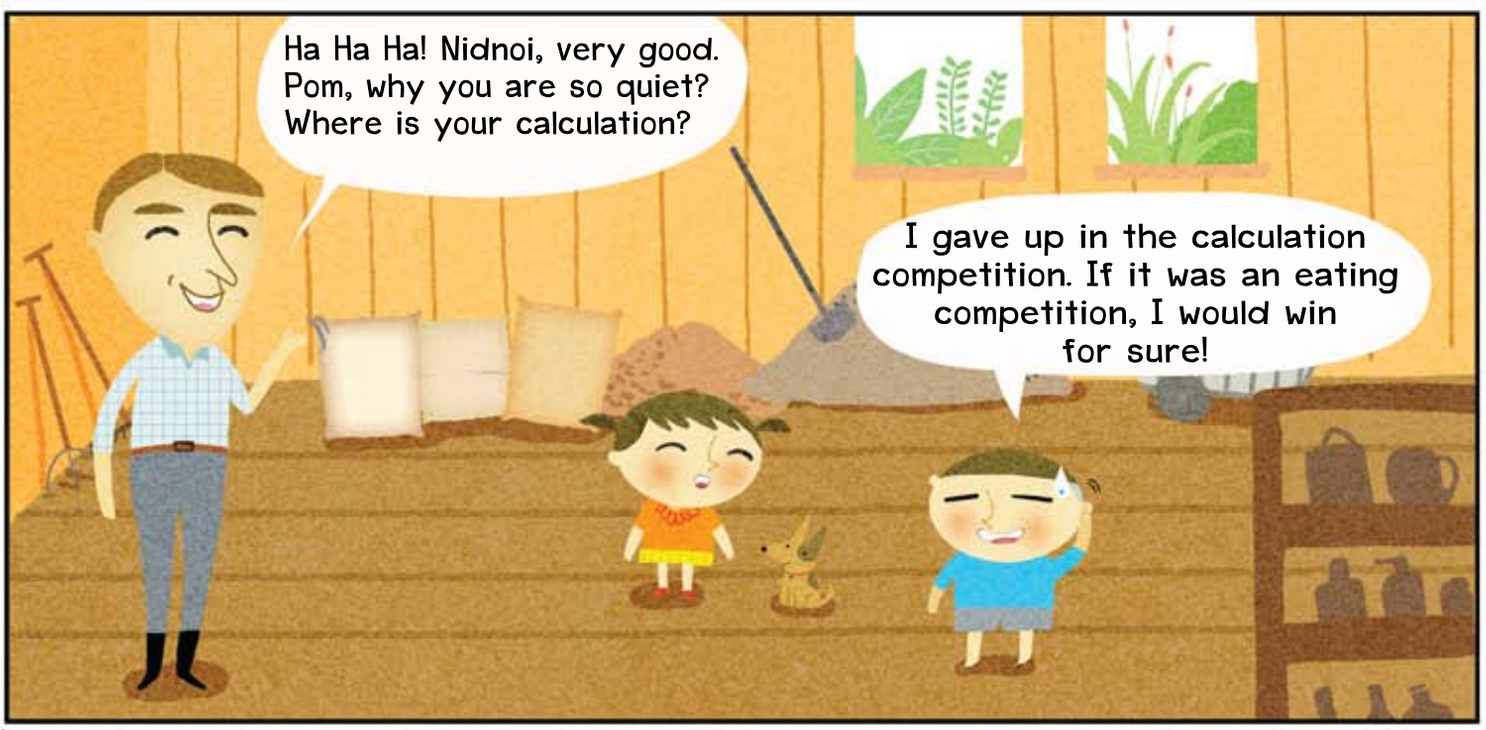
Now, I'll give you a quick calculation. Whoever can answer first, will win an ice cream.

Good, sir

Yay, ice cream


Who knows what the ratio of fertilizer in 16-8-8 formula is.
I do sir. 16-8-8 formula means the amounts of N, P_2O_5, K_2O in 100 kg with the ratio of 2:1:1.
2 divides...

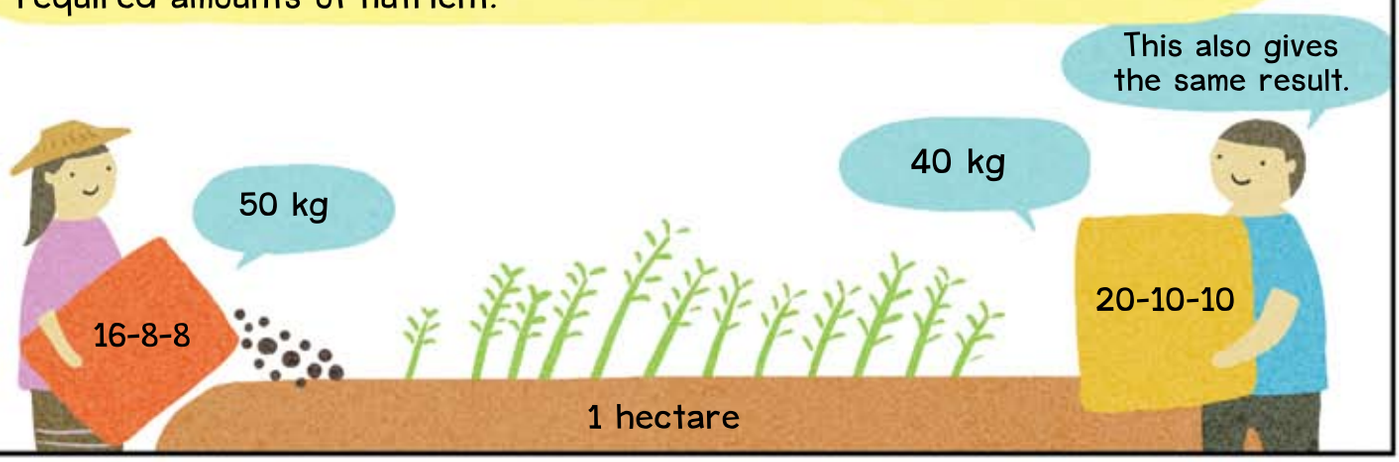

If it is 20-10-10 formula, what is its fertilizer ratio?
I got it! 20-10-10 formula has the same ratio as 16-8-8 formula, 2:1:1 but 100 kg of 20-10-10 will contain more actual nutrient than 100 kg of 16-8-8.
I surrender
woof!


Ha Ha Ha! Nidnoi, very good. Pom, why you are so quiet? Where is your calculation?
I gave up in the calculation competition. If it was an eating competition, I would win for sure!

Uncle Pracha, how useful is the fertilizer ratio, sir?

Fertilizer ratio can help us in selecting various fertilizer formulas for the most suitable use as recommended in fertilizer application.

For example: In the recommendation to use 50 kg/ha of 16-8-8 fertilizer formula, which is the low fertilizer formula of 32% nutrients, it can be substituted with only 40 kg/ha 20-10-10 fertilizer formula having 40% nutrients. Both give the same required amounts of nutrient.



In addition, a fertilizer ratio can give a hint as to the intended purpose of the fertilizer.

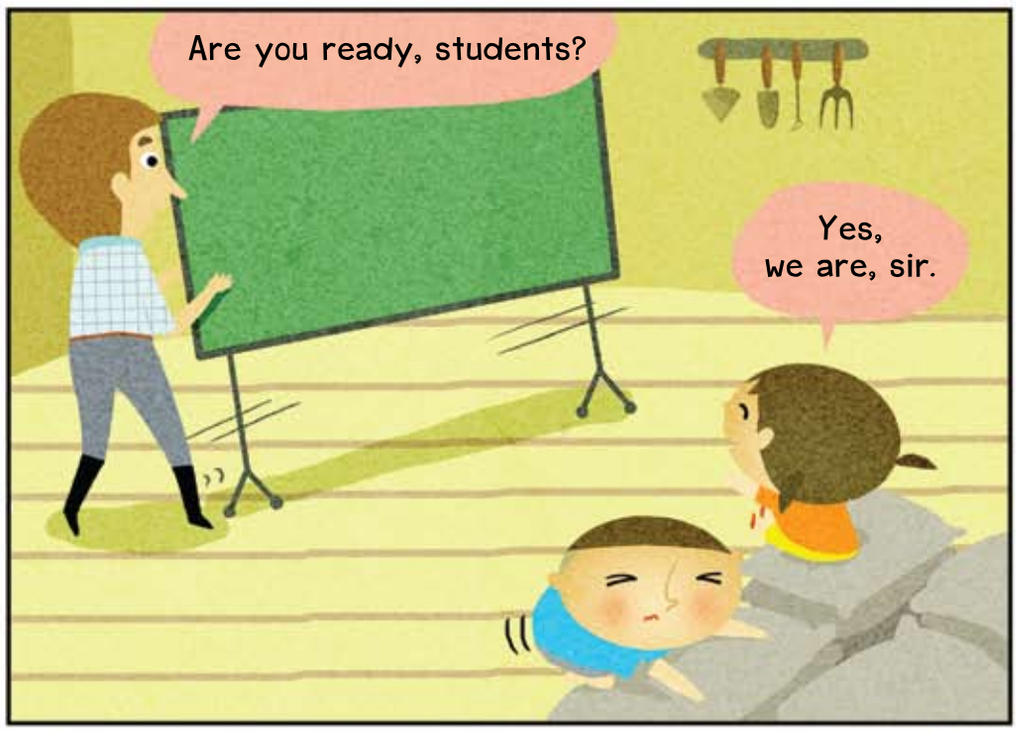
A Fertilizer ratio with a high first number, such as 2:1:1 of 20-10-10 formula will help increase vegetative plant growth.

A Fertilizer ratio with a high last number, such as 1:1:2 of 10-10-20 formula will help on plant quality.

I have already learned so much. How can "Fertilizer materials" be made for the bulk blending of fertilizers, sir?

A Fertilizer ratio with a high middle number, such as 1:2:1 of 10-20-10 formula will help the functions of fruiting and root growth.

Let's go that way, children, I am going to show you how to calculate the mixing of fertilizer.



For an example of mixing chemical fertilizer according to the fertilizer recommendation from soil analysis, we will use "Fertilizer material" sold in the market, such as 18-46-0, 0-0-60 and 46-0-0, etc.

Fertilizer recommended for rice will be shown in nutrient weight per area (kg/ha). For example, the recommendation of N-P-K is 50-25-50 kg/ha, respectively. However, it is recommended to apply N twice, each time of equal weight, that is at the time of planting and top dress application before flowering since N is easily lost.

Method of application	N	P_2O_5	K_2O	
1. To be put at the same time of planting	25	25	50	kg/ha
2. Second time, top dress	25	0	0	kg/ha
Totaling	50	25	50	kg/ha

As for the calculation method, the needed nutrient P has to be calculated first which equals to 25 kg/ha using "Fertilizer material" DAP or 18-46-0.

Then 46 kg of P_2O_5 is derived from 100 kg of 18-46-0 fertilizer, and if 25 kg P_2O_5 is needed as 18-46-0 fertilizer then we have 25/0.46 = 54.3 kg of the 18-46-0 fertilizer has to be applied.

The 54.3 kg fertilizer has N in it. One hundred kg of 18-46-0 has 18 kg N. Therefore, 54.3 kg of 18-46-0 will contain N equaling to 0.18 x 54.3 = 9.8 kg

Therefore, 54.3 kg of 18-46-0 will give 9.8 kg N. However, in the first application we have to apply 25 kg N, so how much N is still lacking?

In the first application, we are lacking 25-9.8 = 15.2 kg, sir.

Next is 46-0-0.

That's right, Nidnoi.

Remember 46 kg nitrogen is derived from 100 kg of 46-0-0 fertilizer formula. If 15.2 kg more nitrogen is needed, 46-0-0 fertilizer formula of 15.2/0.46 = 33.0 kg weight has to be applied.

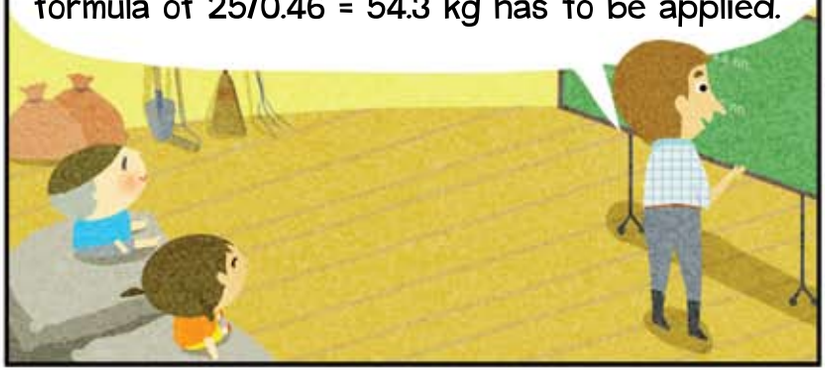
15.2/0.46 = 33.0 kg

Also remember that 60 kg potassium is derived from 100 kg of 0-0-60 fertilizer formula. If 50 kg of K_2O are needed, 0-0-60 fertilizer formula of 50/0.60 = 83.3 kg has to be applied.

50/0.60 = 83.3 kg

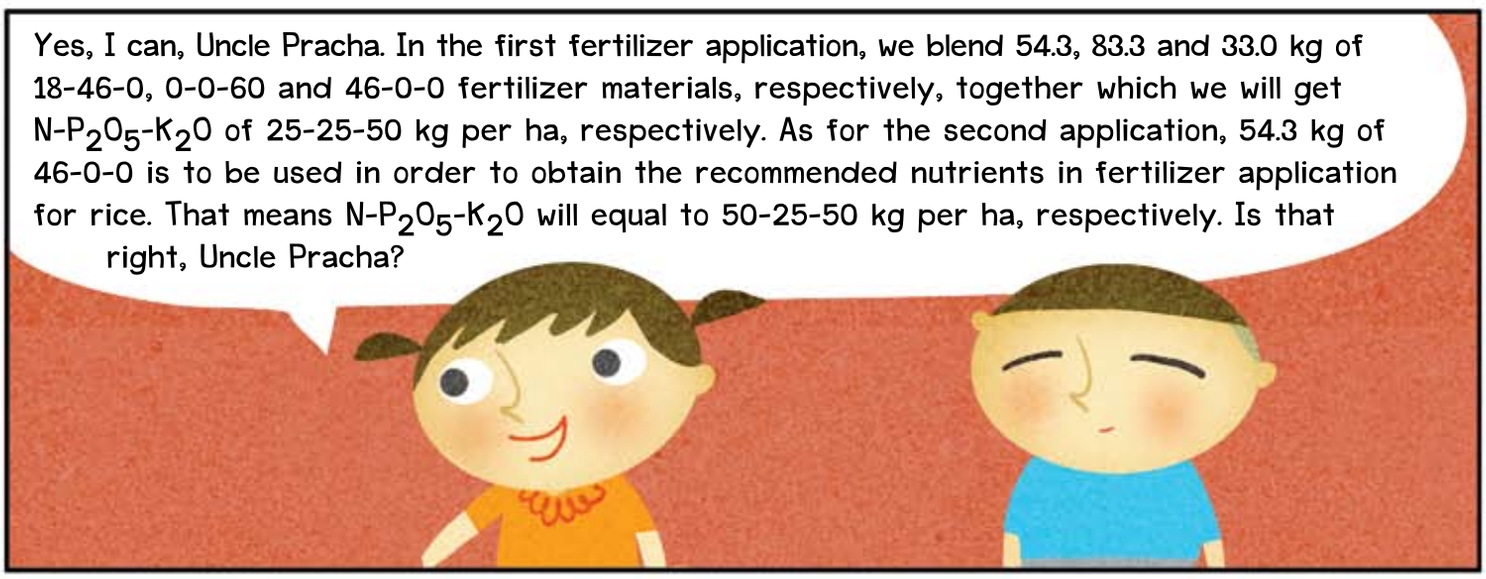
Since we divide nitrogen fertilizer into two applications, each of 25 kg, hence, it has to be calculated as to how much of 46-0-0 fertilizer is needed to get 25 kg for the second application.

Remember that 46 kg nitrogen is derived from 100 kg of 46-0-0 fertilizer. If 25 kg nitrogen more are needed, 46-0-0 fertilizer formula of 25/0.46 = 54.3 kg has to be applied.



So who can come up with the answer to how much fertilizer is required for 1 hectare of rice according to such recommendation?

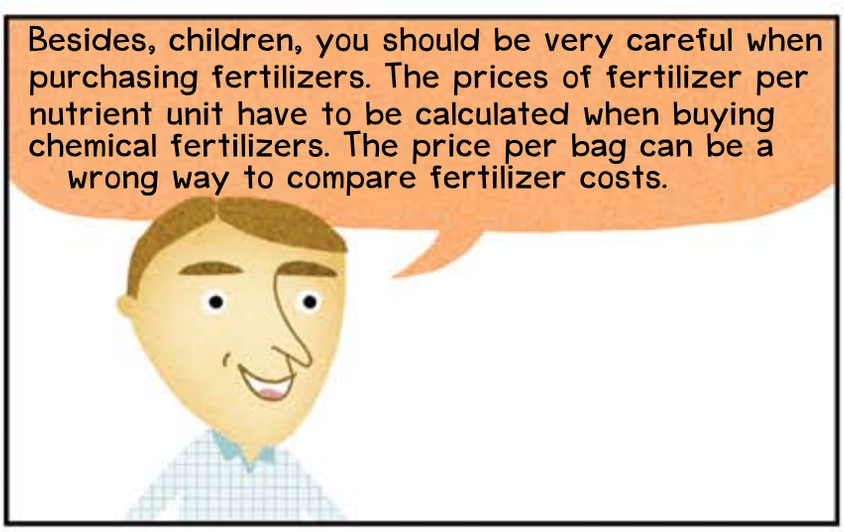
Yes, I can, Uncle Pracha. In the first fertilizer application, we blend 54.3, 83.3 and 33.0 kg of 18-46-0, 0-0-60 and 46-0-0 fertilizer materials, respectively, together which we will get N-P_2O_5-K_2O of 25-25-50 kg per ha, respectively. As for the second application, 54.3 kg of 46-0-0 is to be used in order to obtain the recommended nutrients in fertilizer application for rice. That means N-P_2O_5-K_2O will equal to 50-25-50 kg per ha, respectively. Is that right, Uncle Pracha?



That's right Nidnoi, very good indeed, my niece.

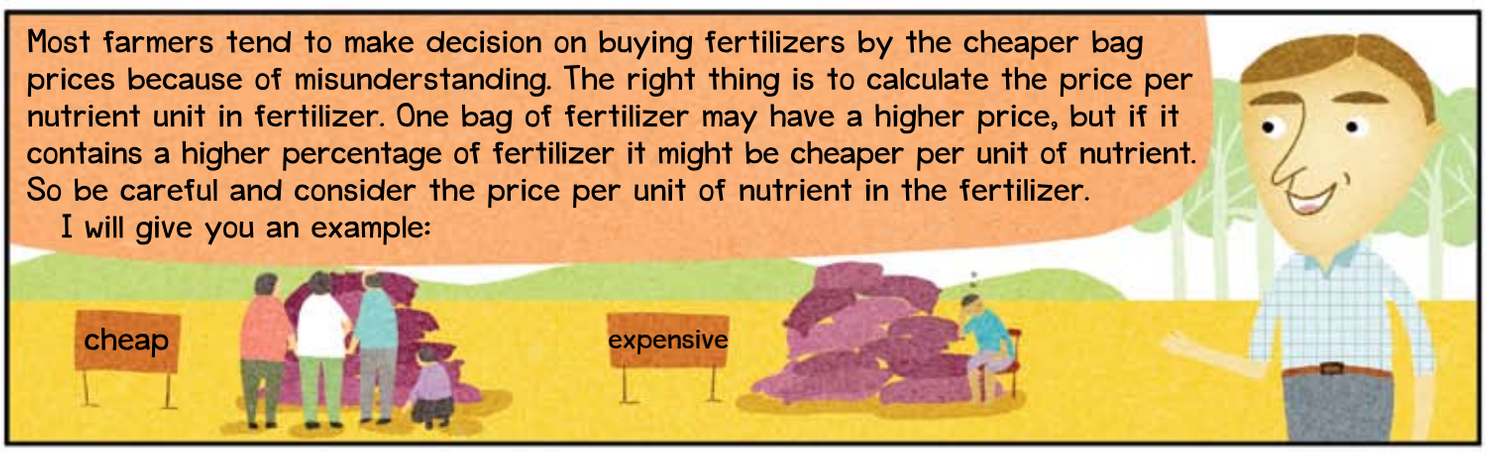
Good indeed.

Besides, children, you should be very careful when purchasing fertilizers. The prices of fertilizer per nutrient unit have to be calculated when buying chemical fertilizers. The price per bag can be a wrong way to compare fertilizer costs.



Most farmers tend to make decision on buying fertilizers by the cheaper bag prices because of misunderstanding. The right thing is to calculate the price per nutrient unit in fertilizer. One bag of fertilizer may have a higher price, but if it contains a higher percentage of fertilizer it might be cheaper per unit of nutrient. So be careful and consider the price per unit of nutrient in the fertilizer.

I will give you an example:



The first example is to compare the price of two bags of fertilizer material containing nitrogen. The two bags have labels of 46-0-0 and 21-0-0. The prices are $473 and $250 per ton, respectively

To calculate the price on the per unit of nutrient basis do the following:

The fertilizer 46-0-0 costs $473 per ton which means 1000 kg fertilizer has 460 kg nitrogen costing $473.

Therefore, the price of 1 kg nitrogen is $473 /460 = $1.02

VS

The fertilizer 46-0-0 that costs $473 per ton

The fertilizer 21-0-0 that costs $250 per ton

The other fertilizer with the label 21-0-0 costs $250 per ton which means 1000 kg fertilizer has 210 kg nitrogen costing $250. For this fertilizer the cost per unit nutrient is 250/210 = $1.19.

The result is that the 21-0-0 fertilizer will cost more than 46-0-0 fertilizer, even though the price per ton is less for the 21-0-0 fertilizer.

Oh Wow! If it is not worked out by calculation, we will never know.

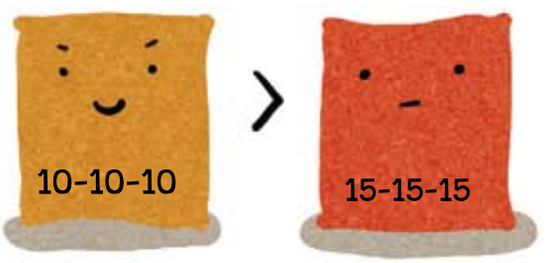
Yes, yes.

Let's look at another example, children. Let's compare prices of 15-15-15 and 10-10-10 fertilizer for example. We learn from the fertilizer store that the cost of the two fertilizers, 15-15-15 and 10-10-10, is $673 and $460 per ton, respectively.

We carry out the calculations as follows:
15-15-15 formula costs $673 per ton which means 1000 kg fertilizer has 450 kg nutrients costing $673. Therefore, the price of 1 kg combined N, P_2O_5, K_2O equals 673/450 = $1.49

The other fertilizer, 10-10-10, in our example costs $460 per ton which means 1000 kg fertilizer has 300 kg nutrients costing $460. Therefore, the price of 1 kg of combined N, P_2O_5, K_2O equals $460/300 = $1.53

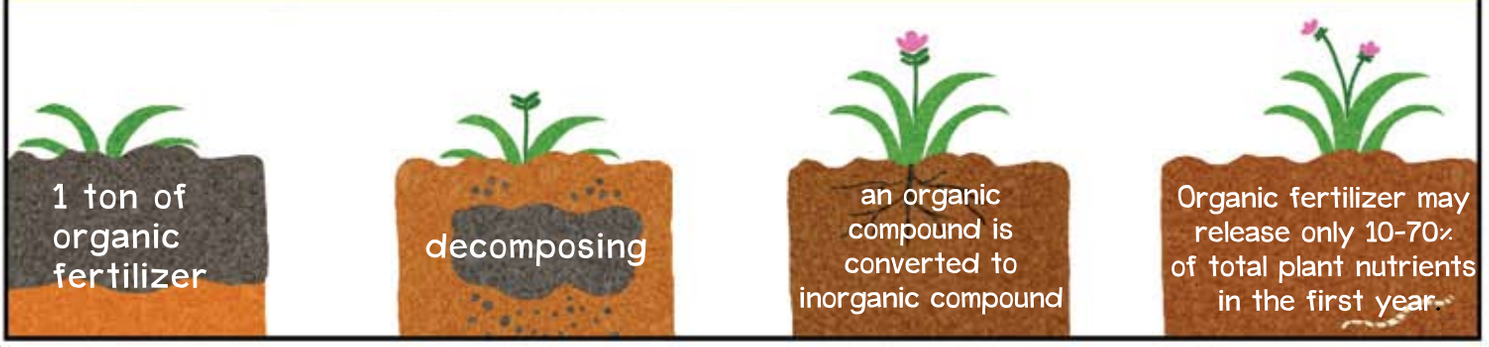
Our calculation of the the cost of fertilizer on a nutrient basis tells us the surprising result that although the cost per ton of the 10-10-10 fertilizer is less than the price per ton of the 15-15-15 fertilizer, it actually is more costly when we compare the costs per unit nutrient in the fertilizer.



The last example is the calculation of plant nutrient costs in organic fertilizer. In our example we learn that organic fertilizer, with a label of 2-1-1 costs $233 per ton. This means 1000 kg of organic fertilizer has 40 kg nutrients. Therefore, 1 kg nutrient is equal to $233/40 = $5.82.

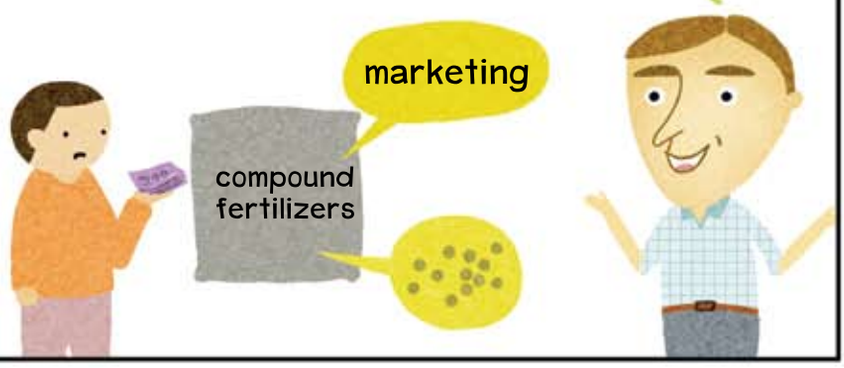
This detailed comparison of the cost on a nutrient basis shows that in this example, organic fertilizer is more expensive than chemical fertilizer.

There is one additional thing to consider about organic fertilizer. All 40 kg of nutrients in 1 ton of organic fertilizer usually is not available to plants because they are in the form of an organic compound. The organic fertilizer must decompose and decay to simple inorganic nutrients by microorganisms before the plant can actually use them. Organic fertilizer may release only 10-70% of total plant nutrients in the first year. This depends on the kind of organic fertilizer and soil condition.



So should the farmers buy mixed fertilizers or fertilizer materials to prepare bulk-blending fertilizers themselves?

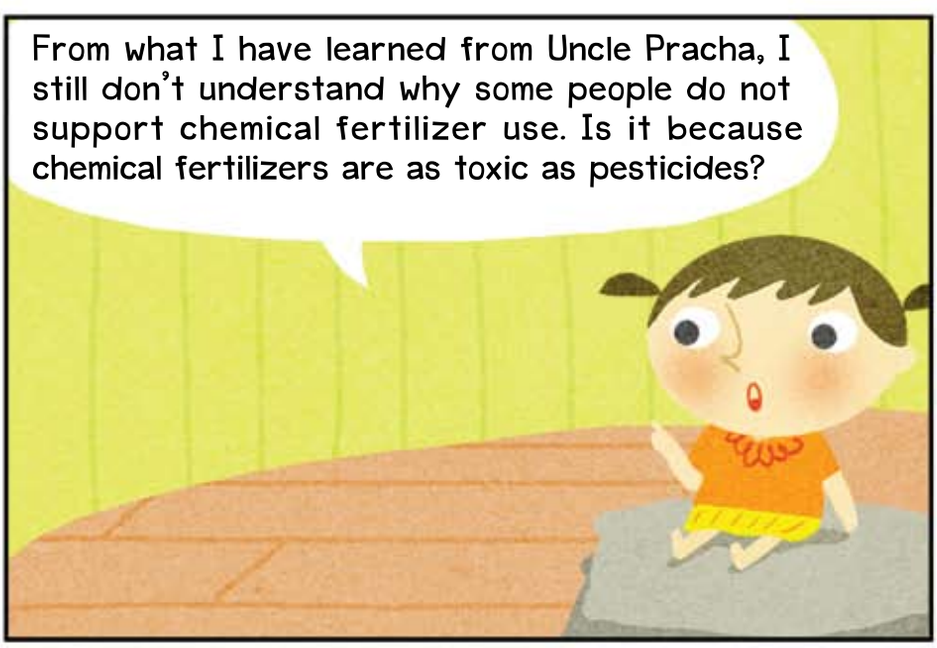
Preparing bulk blending fertilizer is a way for the farmers to apply fertilizer effectively, moreover, the cost is cheaper because the expenses on granulation and marketing are included in the price of "compound fertilizers."



Then the farmers should buy "Fertilizer materials" to make bulk-blended fertilizer themselves. It is not only that the farmers can get the required formula as needed for their plants and soils, but also this helps in solving the problem of low quality or fake fertilizer.

Therefore, the government should encourage more selling of "Fertilizer materials" so that the farmers can prepare bulk-blended fertilizers themselves.

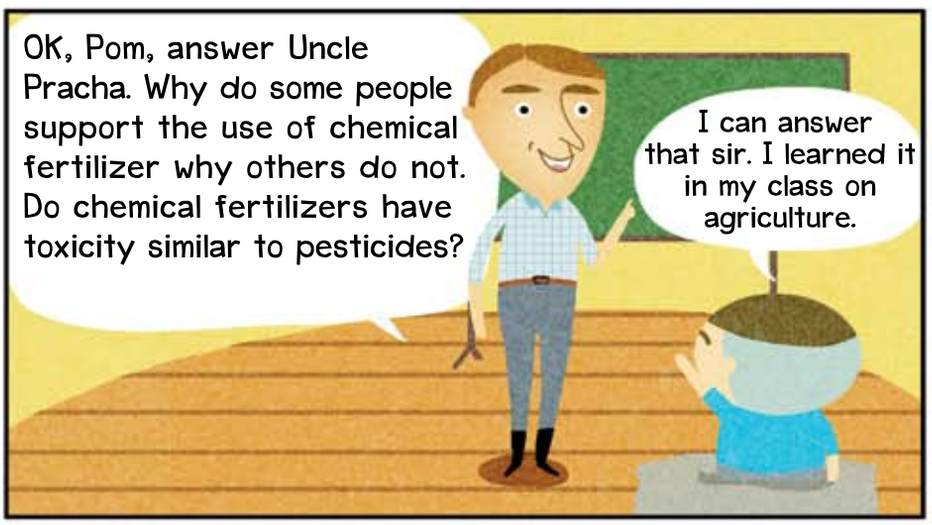
From what I have learned from Uncle Pracha, I still don't understand why some people do not support chemical fertilizer use. Is it because chemical fertilizers are as toxic as pesticides?



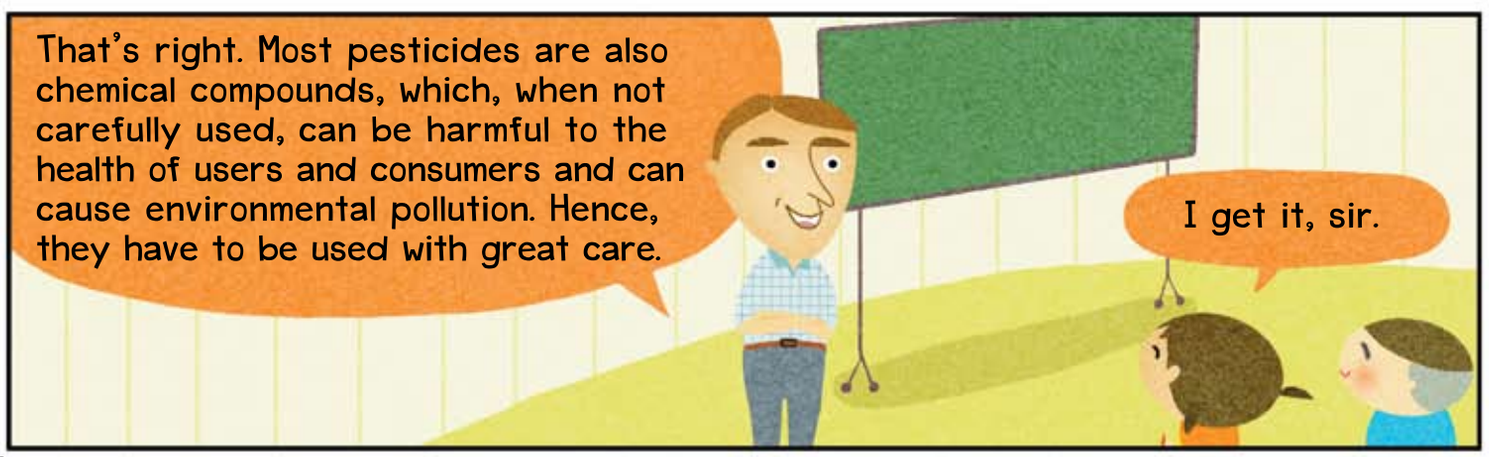

Oh My!
Z...
z z

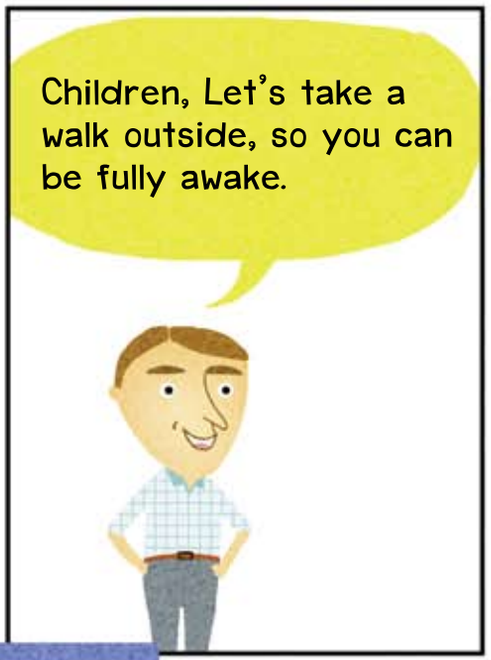

Pom has fallen asleep!
Hey Pom, wake up!
What?


Boy! I don't know when I fell asleep. Where were you, Uncle Pracha?

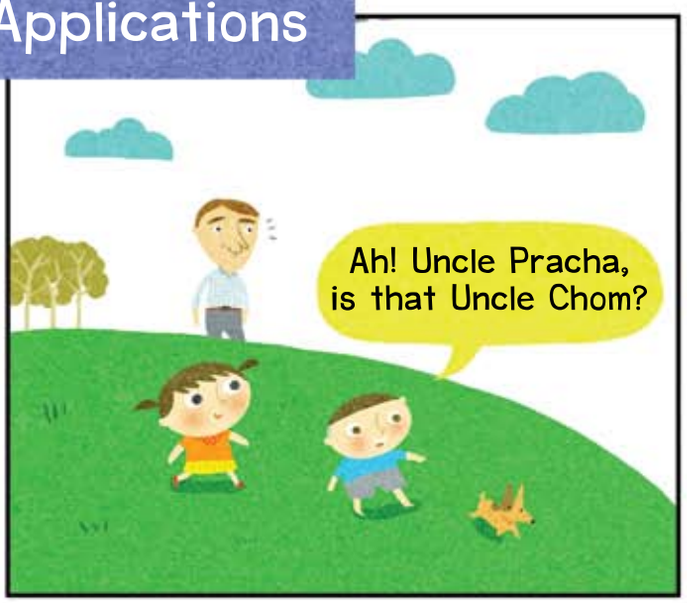

OK, Pom, answer Uncle Pracha. Why do some people support the use of chemical fertilizer why others do not. Do chemical fertilizers have toxicity similar to pesticides?
I can answer that sir. I learned it in my class on agriculture.

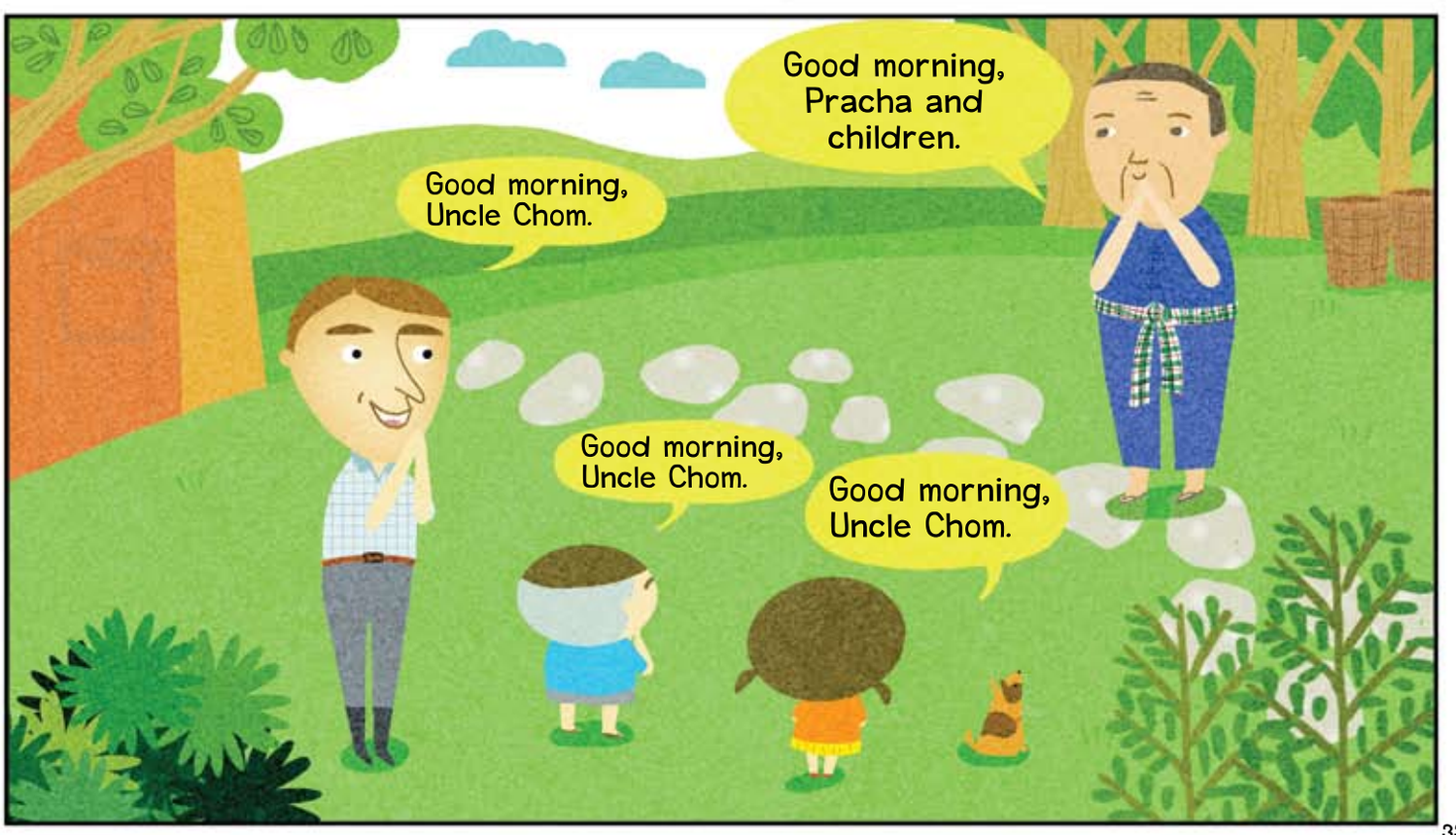

Chemical fertilizers are not toxic. They have different functions from pesticides. Chemical fertilizers supply plant food.
Pesticides are also chemicals, but they help protect plants, grain, and other food from diseases, insects and weeds.
Chemical fertilizers
pesticides

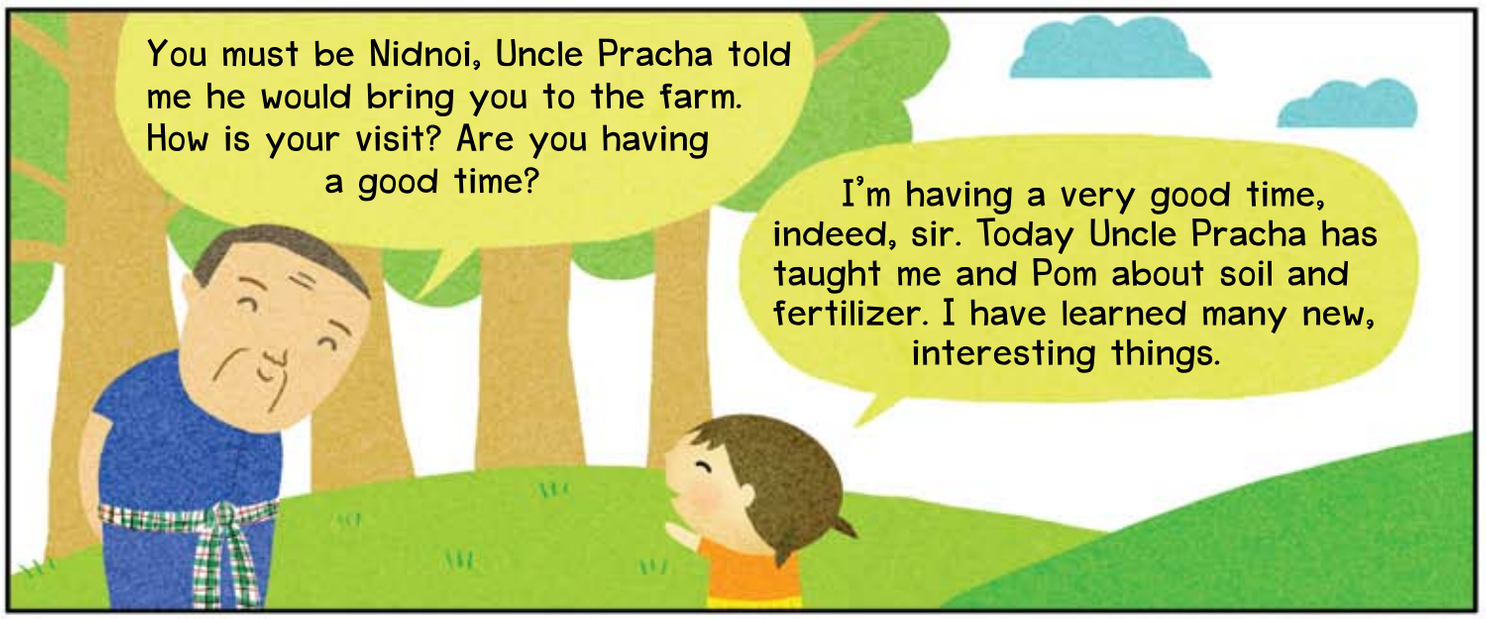

That's right. Most pesticides are also chemical compounds, which, when not carefully used, can be harmful to the health of users and consumers and can cause environmental pollution. Hence, they have to be used with great care.
I get it, sir.



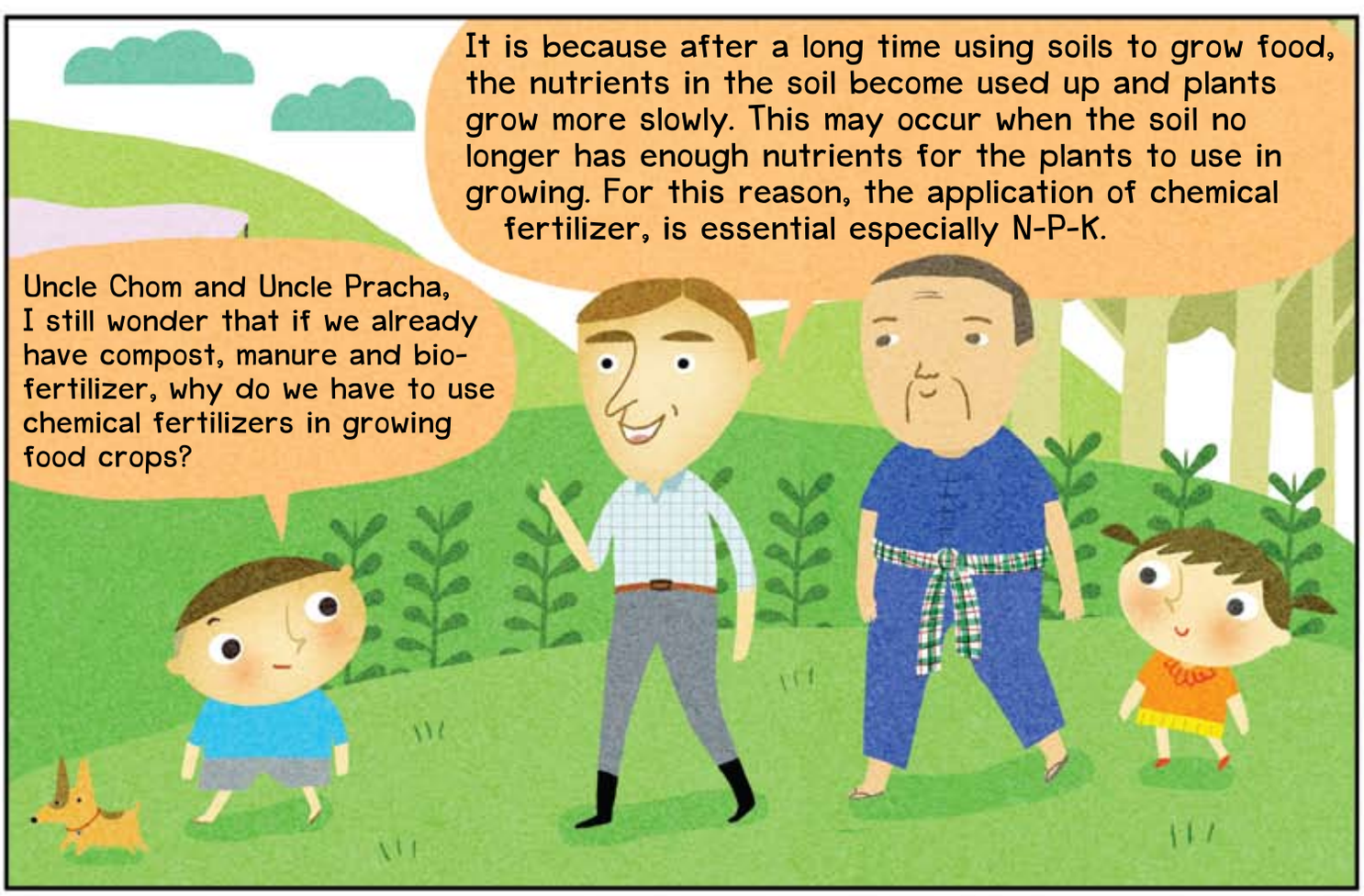
Part 4 : Efficient Fertilizer Applications






You must be Nidnoi, Uncle Pracha told me he would bring you to the farm. How is your visit? Are you having a good time?
I'm having a very good time, indeed, sir. Today Uncle Pracha has taught me and Pom about soil and fertilizer. I have learned many new, interesting things.


Uncle Chom, I am taking the children to look around. Would you care to join us?
Sure. I have just finished watering my vegetable plots.


It is because after a long time using soils to grow food, the nutrients in the soil become used up and plants grow more slowly. This may occur when the soil no longer has enough nutrients for the plants to use in growing. For this reason, the application of chemical fertilizer, is essential especially N-P-K.
Uncle Chom and Uncle Pracha, I still wonder that if we already have compost, manure and bio-fertilizer, why do we have to use chemical fertilizers in growing food crops?

Aside from this, chemical fertilizers usually have a lower cost because the amount of required nutrients can be accurately calculated and easily obtained.

The organic fertilizer has a lower content of nutrients. If it is applied alone, a large amount of organic fertilizer is needed. The high transportation costs to bring the organic fertilizer to the field is another limitation. However, in continuous use, organic fertilizer will improve soil aeration and loosen the soil for better plant root growth, resulting in the efficient use of chemical fertilizer.

To sum it up, chemical and organic fertilizers used together will give the best results.

Yes, it is like that.

But how do the farmers know when to use chemical fertilizers, what kind, how much and what method should be used?

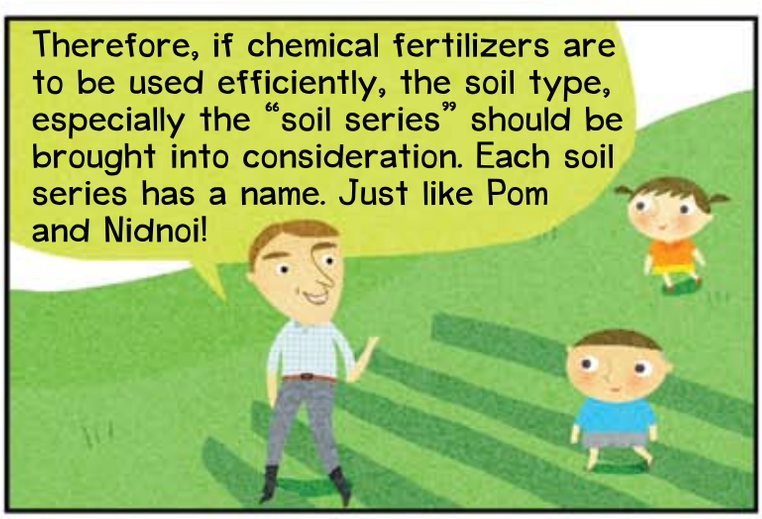
Costs of adding fertilizer follows "the law of minimum". This law means the most deficient nutrient element will be the one limiting plant growth. So it's important to add the most limiting nutrient when fertilizing. However, the farmers have to know the food plants they wish to grow and also know their soils.

Determine the limiting nutrient

Uncle, sir, the other day I read about something called "soil series identification". What is "soil series identification?" How can it be used? What is it based on?

Plants grow better in some soils than in others. Soils in Thailand have been identified and given names to help others know and discuss their properties. The Land Development Department has identified 240 types of agricultural soils in Thailand. These soil types are called "soil series." The soil properties that do not change quickly (soil texture, soil color, depth, pH, etc) were used for identification. These properties usually stay the same for many years or decades, although the amounts of nutrients in soils can vary with how many crops are grown and how much fertilizer is applied.

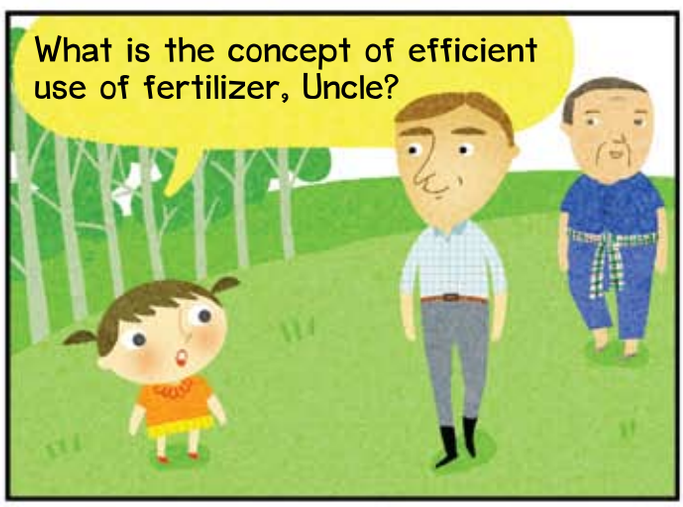
Therefore, if chemical fertilizers are to be used efficiently, the soil type, especially the "soil series" should be brought into consideration. Each soil series has a name. Just like Pom and Nidnoi!

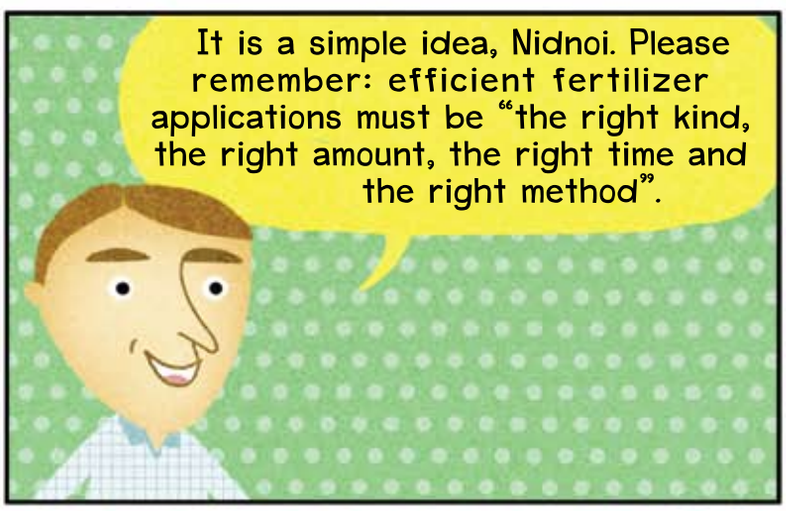


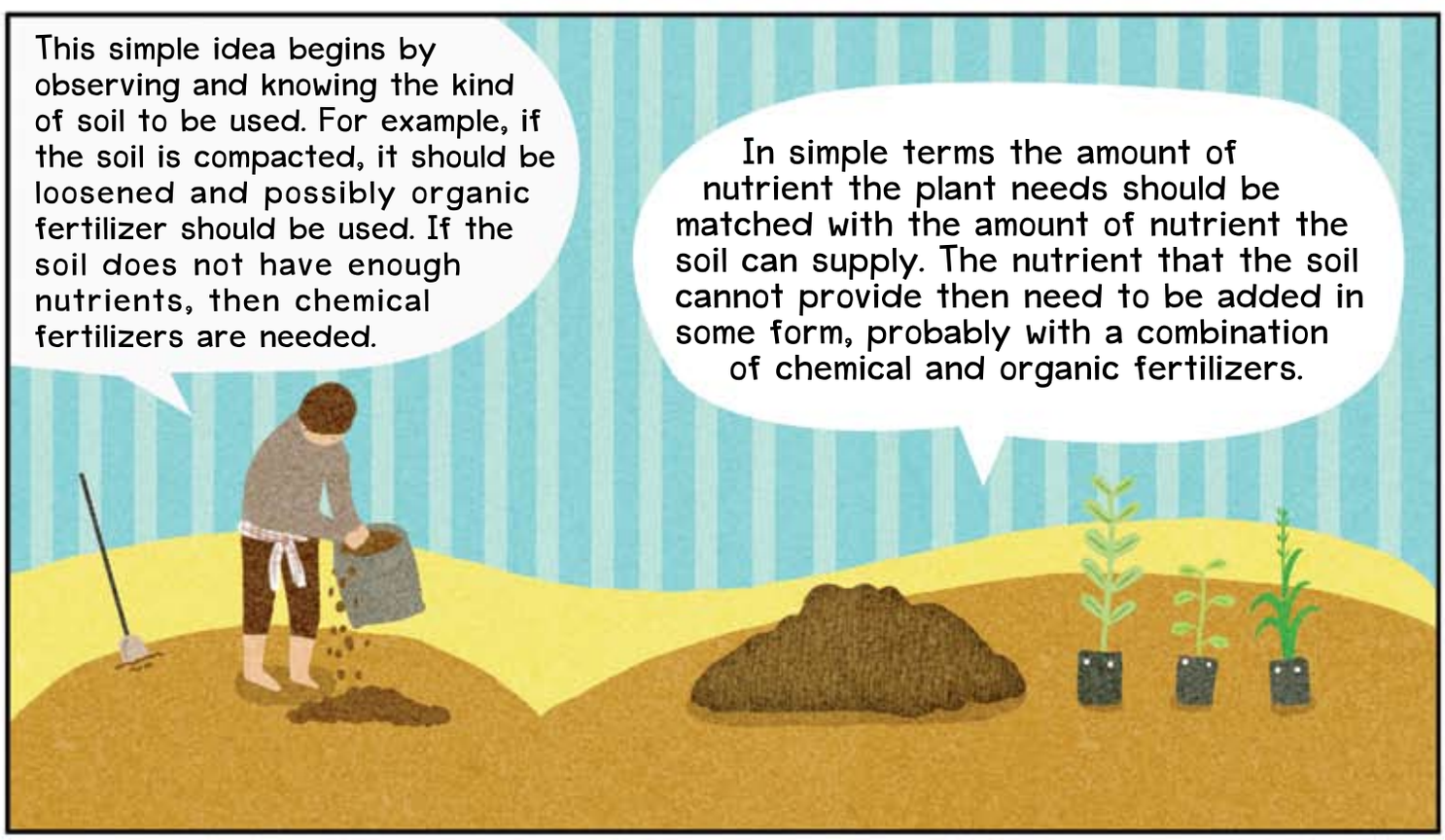
So, after we have learned the name of our soil series, how much fertilizer should be applied?

Farmers can learn which and how much nutrients should be applied by analyzing their soil before planting. They also need to know which food plant they want to grow because each plant needs different kinds and amounts of nutrient elements. Soil scientists have already conducted experiments to find out how much fertilizer should be applied after soil analysis.


Farmers must apply fertilizers at the right time and in the right amount so that the plants have nutrients which they need for growth. This means it is important to understand how plants grow and use nutrients. It depends on the duration of plant development.
After we have learned how much fertilizer should be applied, how about the method of application?


What is the concept of efficient use of fertilizer, Uncle?


It is a simple idea, Nidnoi. Please remember: efficient fertilizer applications must be "the right kind, the right amount, the right time and the right method".


This simple idea begins by observing and knowing the kind of soil to be used. For example, if the soil is compacted, it should be loosened and possibly organic fertilizer should be used. If the soil does not have enough nutrients, then chemical fertilizers are needed.
In simple terms the amount of nutrient the plant needs should be matched with the amount of nutrient the soil can supply. The nutrient that the soil cannot provide then need to be added in some form, probably with a combination of chemical and organic fertilizers.

In addition, children, we have to apply fertilizer at the right time by the right method.

Right kind, right amount, right time, and right method. We can remember now, sir.

By the way, plant residues should be incorporated into the soil when they are present. Green manure and manure should be used for soil improvement; suitable bio-fertilizers will help in reducing the use of chemical fertilizers.

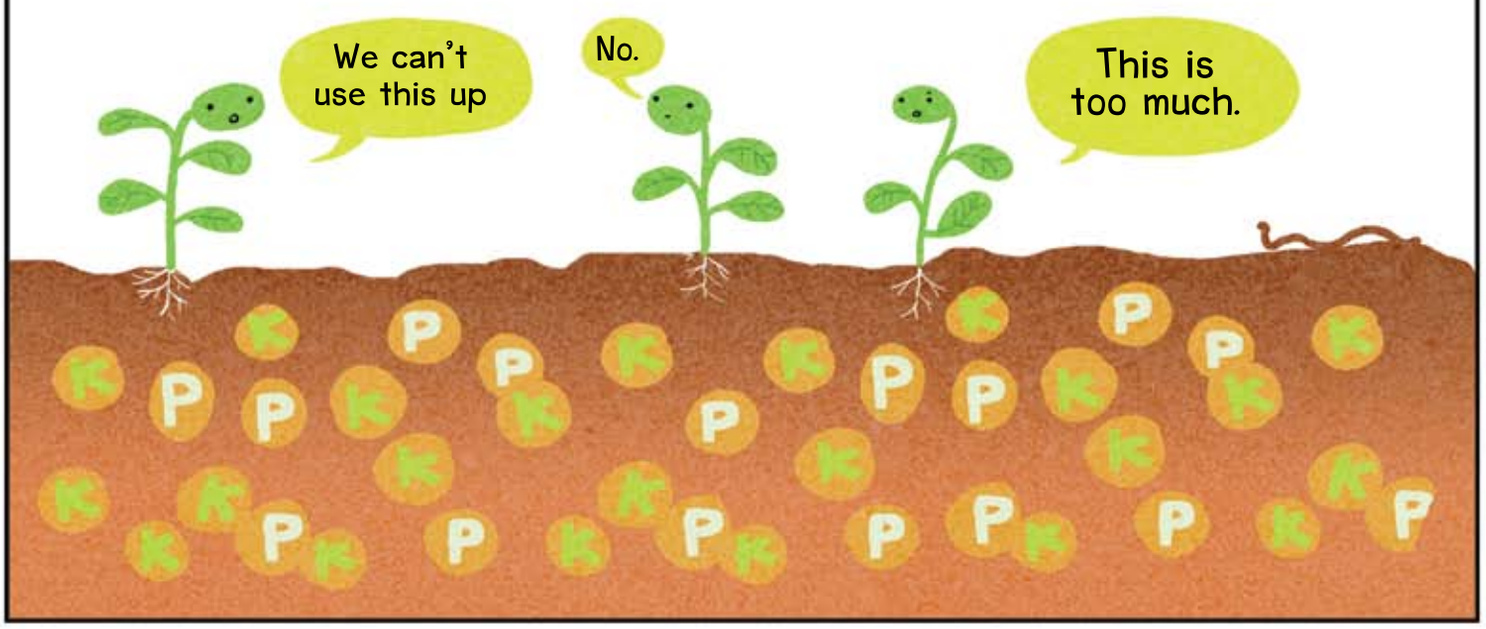
Will chemical fertilizers pollute the soil?

No, they won't, Nidnoi, but too much nutrient can hurt the food plant. For example, too much nitrogen fertilizer may cause the plant to be weaker, produce too many leaves. As a result, insects and disease damages will be followed. When too much nitrogen fertilizer is applied the excess is easily leached down into underground water and to canals and rivers. The water becomes polluted.

Nitrogen coming from animal manure, garbage and dirty water from communities, without good management, will also pollute the environment.

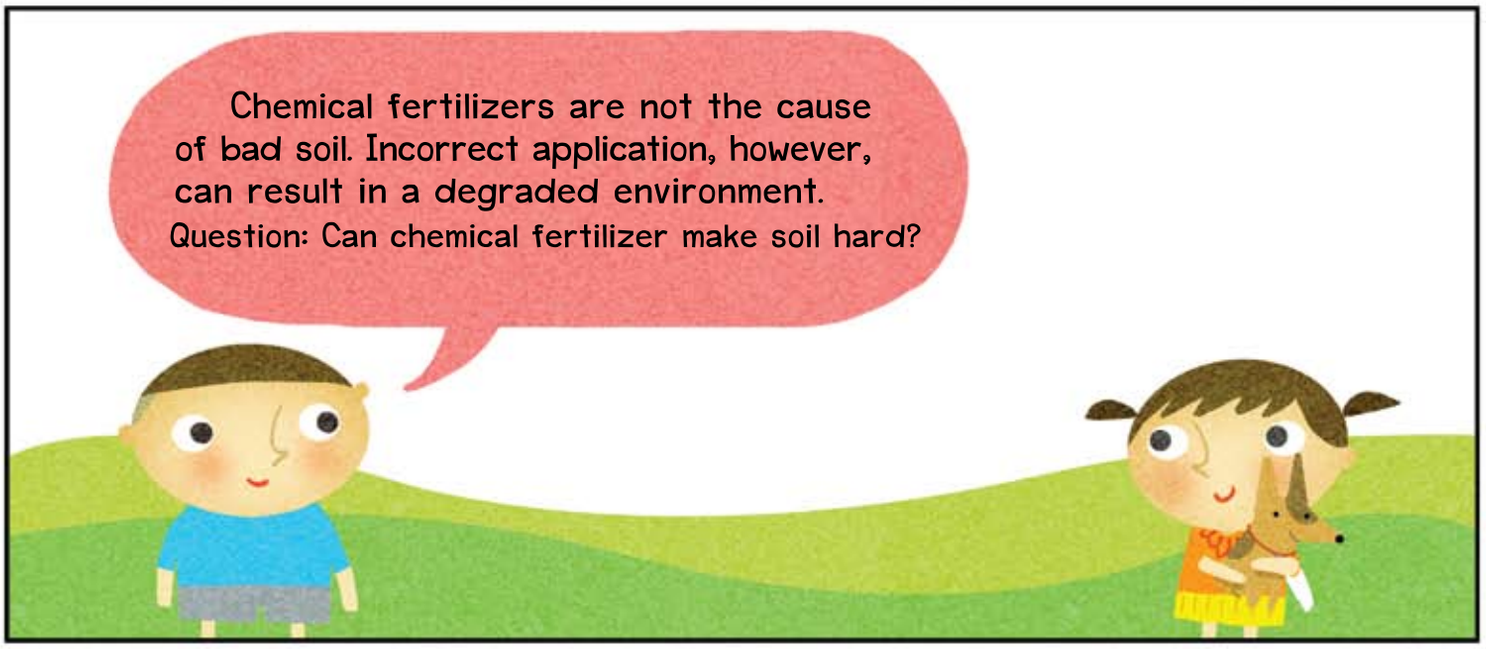
I will tell you a story. If the rice farmers use too much nitrogen fertilizer, it may give some disadvantages such as rice plants fall before they can be harvested and yield decreases. Insects and diseases may follow resulting in more pesticides application, higher production cost and grain no longer safe for human consumption.

Too much phosphorus and potassium fertilizer does not turn good soil into bad soil. These fertilizers, however, can accumulate in soil but have no benefit, thus wasting money. The right application of fertilizer is to apply only the deficient nutrients.



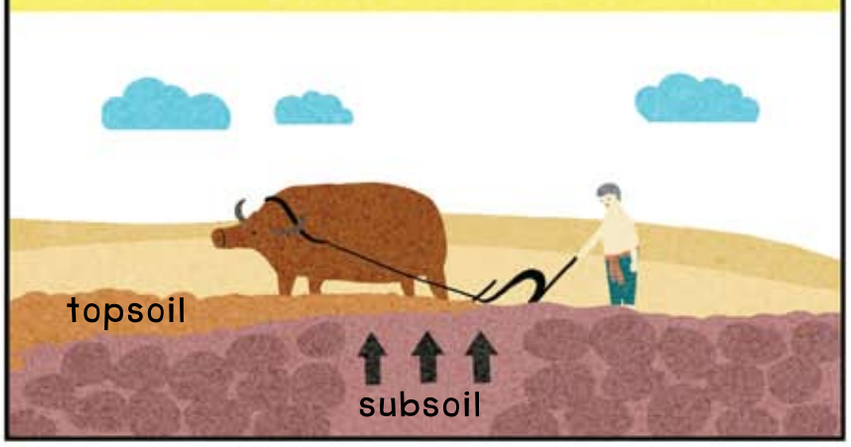
Chemical fertilizers are not the cause of bad soil. Incorrect application, however, can result in a degraded environment.

Question: Can chemical fertilizer make soil hard?



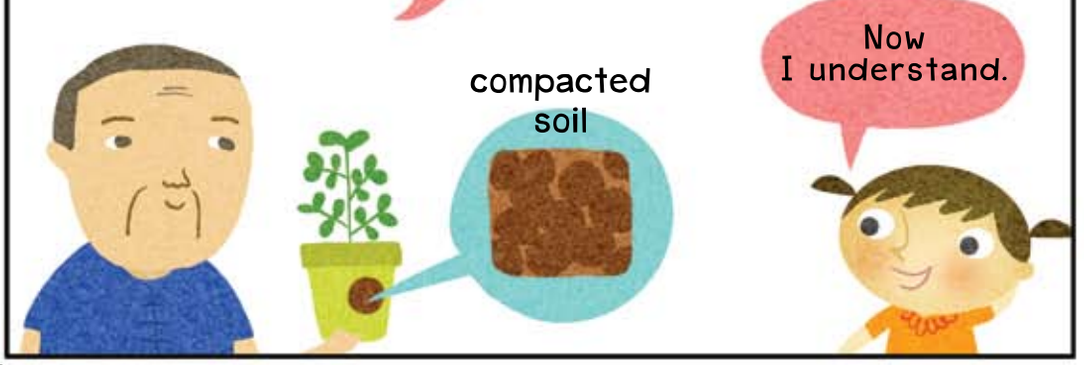
Applying chemical fertilizer is not the cause of hard soil or compacted soil. Hard soil or compacted soil can happen in many ways, such as, soil ploughing with a big machine or buffalo, or tilling when the soil conditions are not suitable.

Hard or compacted soil can result from losing topsoil. For example, soil erosion can occur in sloping areas when it rains heavily, or in soil preparation. In such cases, top-soil is removed exposing a layer of subsoil which may be hard and compacted.

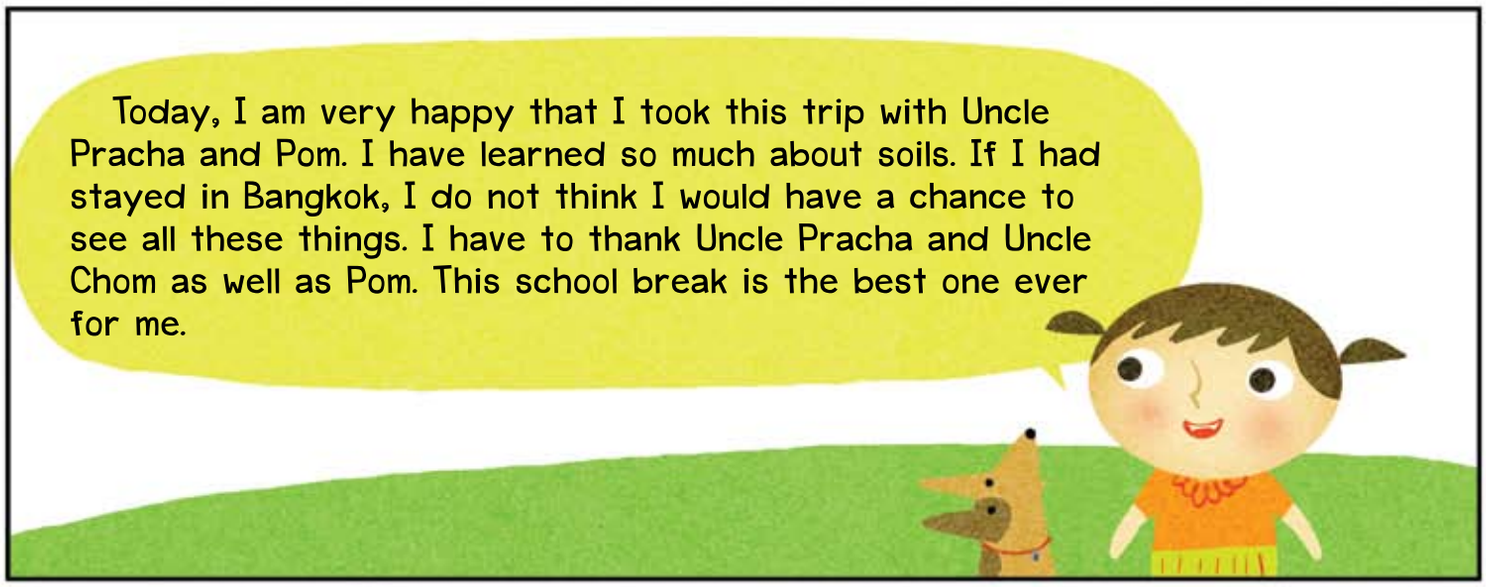


Children, the reduction in the amount of organic matter in soil can also result in hard, compacted soil.

Organic matter in soil usually decomposes over time. When soil has been used to grow food plants for a long time, even in pots, there will be a decrease in the amount of organic matter. The loose soil gradually becomes compacted, hence, it is essential to regularly add organic materials to maintain a loose soil.



Nidnoi, isn't it fun?


Today, I am very happy that I took this trip with Uncle Pracha and Pom. I have learned so much about soils. If I had stayed in Bangkok, I do not think I would have a chance to see all these things. I have to thank Uncle Pracha and Uncle Chom as well as Pom. This school break is the best one ever for me.


In the next school break, I would like to come back here again. May I bring along my friends?


Certainly, Nidnoi. You are always welcome here.
You can bring all your friends, so I will get to make new friends as well.


I also have some gifts for your parents. I can see that there is not much space at your house to grow plants, so I will try to choose some potted-plants for you. Is it alright?


Oh My! It's very kind of you, Uncle. I just want my home to be as shady as your farm house here. In Bangkok, there are not many trees and it is quite hot.


Besides, here there is Jao Dang to play with. At my home, we don't have enough space to keep dogs. I have to play with the small dog at my neighbor's house
So you have to come here often. We've got to go now; Pom and Nidnoi must be hungry already
Aunt Kaew should have finished cooking dinner for us by now.
I am very hungry.
Ha Ha.

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ISBN 978-616-90047-7-6