Sustainable fertilization of vegetable crops

Training for farmers using manure in vegetable crops

2021

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CGIAR RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

CCAFS

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KPSBU® Lembang

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Aim of the training

To learn how to implement a sustainable fertilizer schedule including cattle manure in vegetable crops

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Note to the trainer: The training was developed by researchers from Wageningen University and Research and from the Indonesian Vegetable research Institute.
Herman de Putter has more than 25 year experience working in tropical countries involved in training and research at small holder vegetable farms.
Nikardi Gunadi .....
Witono Adiyoga has been working as an agro-economist for 35 years on vegetable crops
Deni Suharyono was field coordinator in research projects on sustainable management of cattle manure in Indonesia
Marion de Vries is researcher sustainable dairy production at Wageningen Livestock Research and led research projects on sustainable management of cattle manure in Indonesia

Foreword

Vegetables are increasingly recognized as an important component in food security and nutrition programs. Vegetables are a source of vitamins, minerals and fiber that are needed for health. Vegetables are generally cultivated intensively by small-scale farmers.

The high risk of crop failure and limited access to best practice information often encourage farmers to use inputs (e.g. fertilizers) excessively. This may not only have the consequences of causing economic inefficiency for farmers, but also pollution of the environment.

This module is designed to meet the needs of agricultural/animal husbandry extension workers and vegetable farmers regarding information on good practices on inorganic and organic fertilizer use. The module is prepared with the objectives of enabling trainees to (a) know the differences between various types of organic/manure fertilizers; (b) know the content of nutrients available in the soil;

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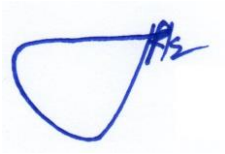
Foreword

(c) know the required nutrients for plants, (d) understand the plant nutrients absorption; and (e) determine the right amount of organic and inorganic fertilizers as required by the plant. This module can be used as a material for either training of trainers (TOT) or training of farmers (TOF). Most of the materials were designed based on the results of NutRecycle project (research cooperation between Wageningen University Research, the Netherlands; Indonesian Vegetable Research Institute; and North Bandung Cattle Breeders Cooperative).

Hopefully, this module can be useful not only for farmers, but also for agricultural extension workers in developing sustainable vegetable farming in West Java.

Bandung, October 2021

Kepala Dinas Ketahanan Pangan dan Peternakan Provinsi Jawa Barat,



Ir. H. Jafar Ismail, MM.

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Background

- This training was developed in the framework of the project 'Closing Regional Nutrient Cycles for low-emission Agriculture' (NutReCycle), which was a collaboration between Wageningen University and Research, IVEGRI, and the dairy cooperative KPSBU in Lembang. The NutReCycle Project was executed between 2018-2021 and aimed to increase the utilization of nutrients in locally produced cattle manure and thereby reduce environmental pollution in Lembang Regency. This project was funded by the government of The Netherlands, through CGIAR Research Program CCAFS.

Disclaimer

- The material and information in this training is developed and compiled according to the authors best knowledge. However, the use of this material and information is at the users risk and no responsibility will be taken by the authors.

Method

- Group session at a venue
  - Presentations
  - Group discussions
- Field visit
  - Manure application
  - Crop performance
  - Soil evaluation
  - Soil sampling instructions

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This is an internal note for the trainer

Trainers note.

- Please read the powerpoint before and select the slides you want to use at a training.
- Each slide contains note on how to use it or what can be explained.
- Advised is to prepare handouts so trainees can read along (also in case no projector can be used)
- In case projecting is not possible use a flipchard to explain and draw combined with the hand outs
- It is up to trainer to split up the training in more sessions
- The developed materials can be used as :
    - 1 session of 4 hours OR 4 sessions of 1 hour
    - Including a field visit is recommended

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Programme for a 4 hour venue session

- Welcome
- Introduction
- Current fertilizer practice
- Crop nutrient requirements
- Soils around Lembang
- Balance in nutrient management (In vs Out)
- Manure (nutrients and effect on soils)
- How to determine fertilizer need
- Closing

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Based on the programme established by the trainer the programme need to be adjusted accordingly.

Learning goals

- Know the difference between organic manure types
- Know about the soil nutrient content
- Know about crop nutrient requirement
- Understand nutrient uptake by plants
- Determine the right manure and chemical fertilizer amount needed for a sustainable vegetable production

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Next to the programme the trainer can inform the trainees would this training would like to achieve.

Welcome and Introduction

- Trainer and participants introduce themselves
  - Name
  - Job description
  - Years of experience
  - Vegetables grown the last years
  - Expectations from the training

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It depends on the trainer how to the introduction and welcome. Trainers can opt for different ways. One of them is shown here. Just simply ask everyone who he/she is and what they expect. Other questions can be added to this slide (or removed)

Required nutrients by vegetable crops

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This is the start of a technical presentation. The aim of this is to let trainees realize that for a good / proper growth nutrients are required that are taken up by the crops.

Healthy vegetables

- Vegetables are healthy because they contain a lot of nutrients and vitamins
- With harvest products contain these and are " taken away" or removed from the fields
- Taken away means: nutrient content in the field is reduced
- Let's take a closer look at the nutrients needed for crop growth first.

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In our diet vegetables should take a large part, only rice ,chicken and spices are not enough for our health. Vegetables contain a lot of vitamins, minerals and fibres. To produce these healthy vegetables the crops must be able to take up nutrients from the soil. But when those nutrients are taken up by the crop and the crop is taken away from the field it will lead to a lower nutrient content in the soil. Before we are going to have a look at this let's first look at what nutrients are taken up and for what purpose.

Crop nutrient requirements

- Just to start.....
  - Can you mention which nutrients are required by a crop?

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This can be asked to the trainees, let's see how many different nutrients they can come up and at the same time start up discussion difference between nutrients that plants take up and fertilizers that contain nutrients

Needed nutrients

- Macro elements
  - Nitrogen: N
  - Phosphorus: P
  - Potassium: K
  - Magnesium: Mg
  - Calcium: Ca
  - Sulphur: S
- Trace elements
  - Iron: Fe
  - Zinc: Zn
  - Molybdenum: Mo
  - Manganese: Mn
  - Cupper: Cu
  - Boron: B
- Hydrogen: H
- Carbon: C
- Oxygen: O

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Here is a list of nutrients that plants need, H, C and O are supplied by water and air. Other nutrients have to be supplied to the plant from other sources. It also means that just adding one type of fertilizer is not sufficient. A farmer has to consider all the elements availability

Different nutrients have different roles.

- Production of sugars/photosynthesis (N, Mg, S, P)
- Growth (N)
- Root formation (P)
- Health (K and Ca)
- Cell strength (Ca)
- Quality of fruits (Ca and K)
- Transport (K and P)
- Assisting with uptake of water and nutrients (K, P, micro nutrients)
- Flowering and fruit set (K and micro nutrients)

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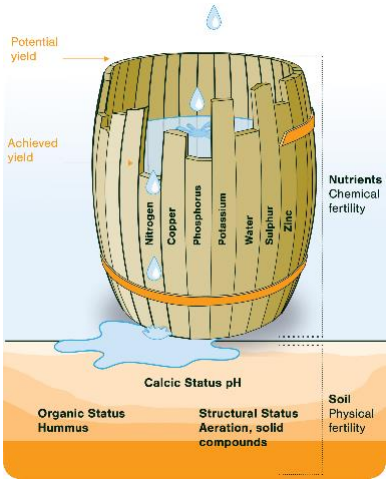
In crop production a vegetable requires many different nutrients. There are many processes in the crop growth and some examples of which nutrients are involved in different processes are shown here . Generally speaking macro nutrients such as nitrogen, phosphate and potassium are needed in large quantities while trace elements such as iron, boron and zinc are required in low quantities.
Since ther are different nutrients needed for different processes it also means that they can not take over roles. If a nutrient is lacking another nutrient can not take over.

All nutrients are needed, lack of one can not be compensated by another one

In this situation lack of Nitrogen is causing yield loss

Adding more potassium does not improve yield!



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Nevertheless a crop needs them all at the right quantities, not excessive but also not too low. A lack of one specific nutrient can cause yield loss and it is important to add more of this one only while adding more of others will not improve the yield.

Questions?

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Sources of nutrients

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What are sources of supply?

- With vegetable products quite some nutrients are "taken away" from the field.
- Need for nutrients to supply to the plants
- Quick round of asking farmers' ideas where plants can get the nutrients from.

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Now we have seen the need for a whole range of nutrients the next question is how to supply them. What can we do?
What can be used.
Note to trainer: To get an idea of the current knowledge level, ask the trainees first to list all kind of options. You can also write them down on a flipchart

Possible sources

- Fertilizers
  - Organic and inorganic
- Soil
  - Contains a lot of nutrients
    - Freely present in soil
    - Attached to or included in mineral particles
    - Organic matter
- Water (rain and irrigation)
- Air (deposition)

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Note to trainer: After the trainees have listed down their ideas you can go through them and add from this slide if missing.
To summarize sources are: soil, water, air, fertilizers, they all contain nutrients.
In the air a lot of sulphate and nitrates can be present, in the water phosphates and nitrates and the soil of course also a large stock of nutrients is present. However, differences between soils occur, clayey volcanic soils are richt while sandy soils are low in nutrient content. Also some red coloured clay soils can be low in nutrients.
In case the soil is high in organic matter is contains more nutrients than soils low in organic matter. So it is important to maintain the organic matter content. Each season large quantiiteis of Org matter is decomposed and from there nutrients are released for plant uptake.

Nutrient inputs and outputs

Inputs	Outputs
Organic fertilizers	Harvested product
Chemical fertilizers	Volatilization losses
Crop debris	Leaching losses
Deposition	Erosion and run off losses

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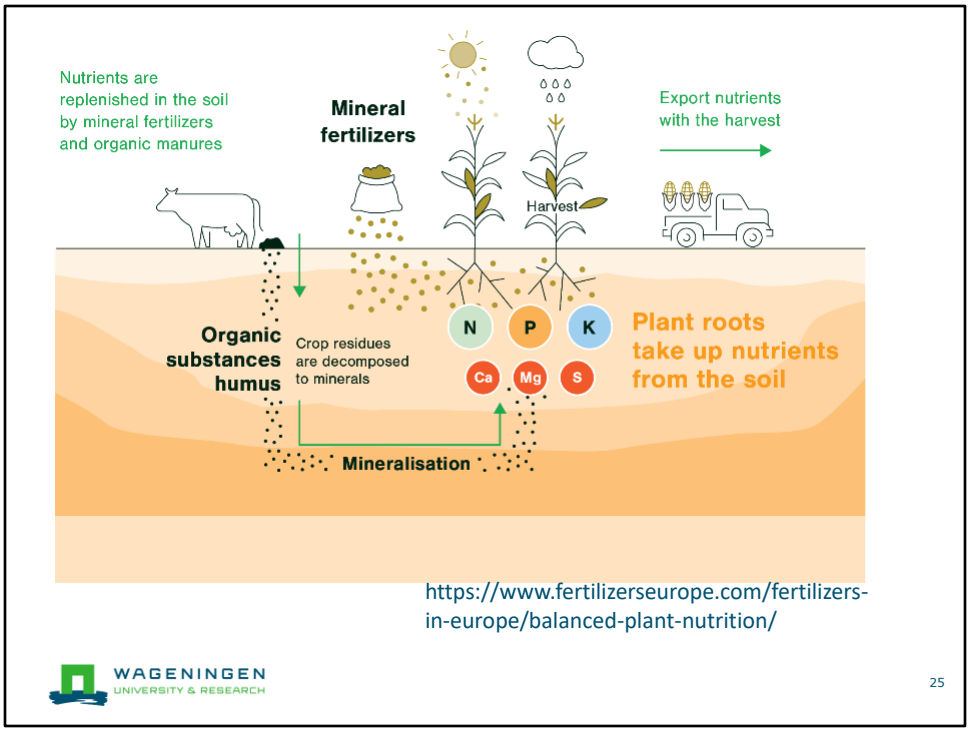
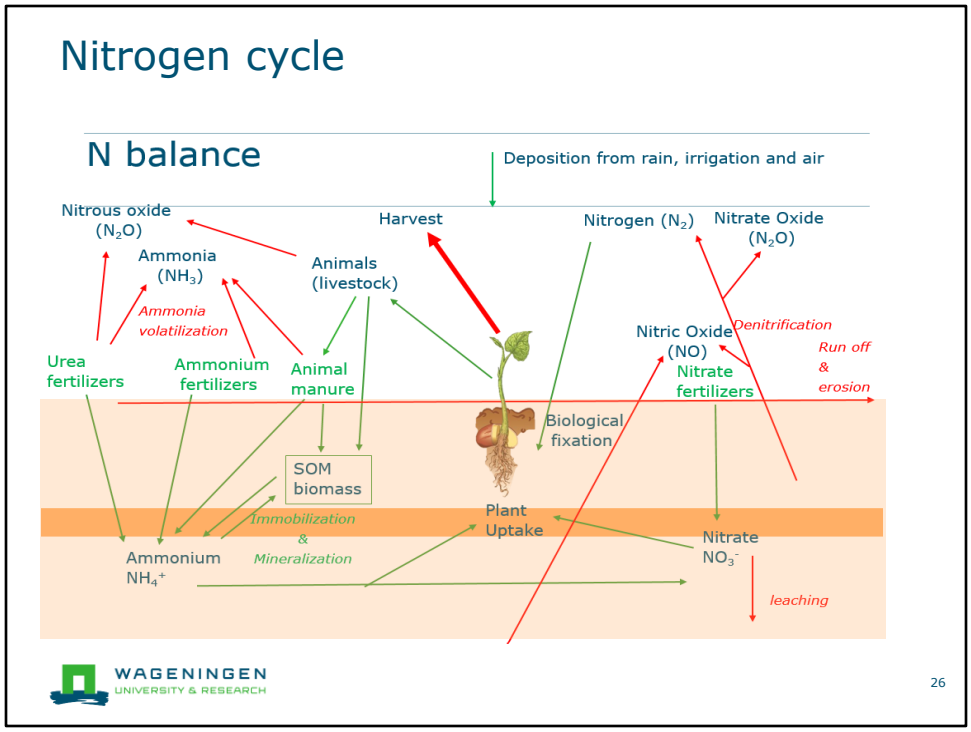
In fertilization we need to consider the balance between input and output. If the inputs are lower than the outputs it means a shortage and crops perform less. If the inputs are too high it means there are more nutrietns than the plant can consume and are wasted. Since the soil can not retain them forever there is a risk tha they will leach out from the soil or are lost by other means like volatizations. By harvesting the crop and taking it away the most nutrients are removed.



In nutrient management to make sure crops get enough, not too much but also nut too low, we need to consider inputs and outputs. Inputs are mainly organic and chemical fertilizers but also nutrients can be deposited in fields from rain and air. Outputs are nutrients with harvested products, but also leaching, gaseous losses and erosion can make that nutrients are taken away from a field.
As a result soils can be a rich source of nutrients and since the soil and the soil moisture acts as store and transport of nutrients to the plant the soil fertility levels should be optimal.



Note to the trainer: this slide is not for all groups interesting to show, only trainees with an advanced level might understand this. In case the level is estimated not high better skip this slide.
Green arrows are inputs, red are outputs
Inputs are fertilizers but in nitrogen there are different pathways, a vegetable crop prefers nitrates but many fertilizers supply ammonium. Ammonium and nitrate both have benefits and disadvantages.
Ammonium is less susceptible to leaching but volatilisation is a risk so it needs to be incorporated at application as also manure should be incorporated for this reason.
Nitrate is not susceptible to volatilisation but it is to leaching, thus better not apply it in rainy periods.
Since ammonium and manure is converted in the soil by organisms it is important to keep the soil healthy. No excess pesticide use, proper irrigation and drainage to keep a good oxygen level and avoid too low soil pH.

Questions?

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Chemical Fertilizers

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Can you name chemical fertilizers?

- Name?
- What is in it?
- How much?

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Note to trainer: Together with trainees try to make a list of fertilizers they use and try to determine to what extend the knowledge is there about what nutrients they contain and % of them

Chemical fertilizers

- Diverse
  - Ammonium sulphate, Urea
  - SP 36
  - NPK compound

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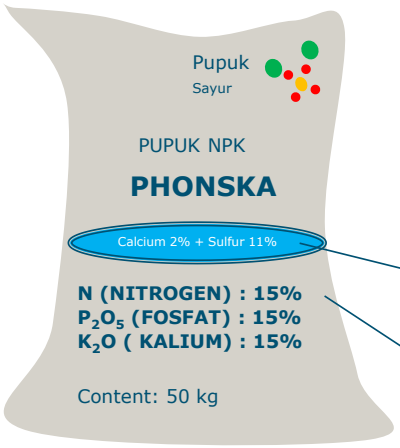
We just determined what kind of fertilizers are used and there are many of them, quite diverse, urea, AS, SP and all kind of mixes as NPK.

Fertilizers and nutrients



- Fertilizers do contain nutrients
  - 1 bag can contain different nutrients
  - Urea: Nitrogen only
  - NPK: nitrogen + fosfat + kalium combined

This bag contains also calcium and sulfur

Only 15% of this bag is nitrogen

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Note to trainer: based on the knowledge level you can explain more about this, or if the knowledge is already there this slide can be quickly summarised.

Example of Chemical fertilizers

Fertilizer	N %	P2O5 %	K2O %	S %	CaO %	MgO %
Ammonium sulphate	21	0	0	24		
Urea	46	0	0	0		
SP 36	0	36	0	11		
NPK Phonska	15	15	15	9		
NPK Mutiara	16	16	16			
KCL/MOP			60			
Calcium Nitrat	15.5				26	
Kalium Nitrat	13		46			
Magnesium Sulphate				13		16

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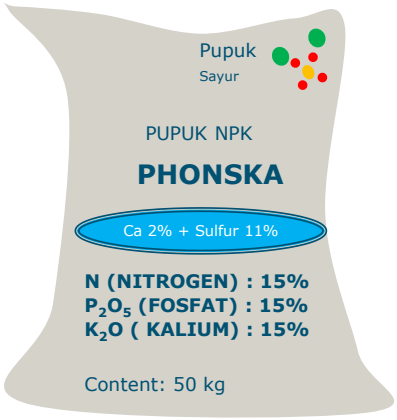
Many fertilizers are available and they contain most often only a few nutrients but at high levels. Ammonium sulphate for instance contains only 21% nitrogen and 24% sulphate, the remainder of ZA is oxygen and hydrogen and has no fertilizer effect. Urea only contains nitrogen as nutrient while for the rest is contains hydrogen, oxygen and carbon.
When ammonium and urea fertilizers are used they also make the soils more acid. Opposite to those there are calcium and kalium nitrates that also contains nitrogen but as nitrates which makes that the soils become less acid.

Fertilizers and nutrients



- In groups:
  - How much kilo Nitrogen is in this bag?
  - And how much Fosfat and Kalium?
  - How much kg Calcium is in this bag?
  - How many bags do you need to apply 300 kg Nitrogen on your field?

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Note to trainer: As an activity and to keep the trainees motivated you could do this, give this assignment and give the trainees 10 minutes to solve it.
Answers:
Nitrogen is 15% of 50 kg = 7.5 kg. Same for fosfat and kalium
Calcium is 2% so 2% of 50 kg = 1 kg of calcium in this bag
300 kg nitrogen is needed.
1 bag contains 7.5 kg nitrogen only
300 divided by 7.5 = 40 bags.

Questions?

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Current fertilizer practices

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In this session information about current practises observed at some farms in the Lemban area will be shown and discussed

What is the current practice?

- Please discuss on:
  - Which fertilizers are used?
  - When do you apply fertilizers?
  - Which organic fertilizer do you apply?
  - How much?
  - How do you determine how much is needed for your crop?
  - Finally, do you think you have the best strategy already? If not, what do you need?

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Note to trainer: with this assignment you can find out what the practice is at the trainees. This can be different and try to link the next info then also to their situation, compare.
Besides with the response to the last question as a trainer you can determine the current awareness.

Current practice observed at farms

- Use of manure
  - Mainly chicken manure (postal)
  - Produce from dairy cows
    - Vermicompost
    - Compost
    - Heap manure
  - 1x per year to each time per new crop

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Based on surveys and tracking practices for half a year at 6 farms found was that almost all farmers apply organic material. The source is quite diverse but mainly postal is used and next to that dairy cow or cattle manure is used.
From dairy farms different products can be used, fresh, mixed, composted or vermicompost is all possible.
Also farmers are applying it every time when starting a new crop or limit it to 1x per year. Also only when plastic mulch need to be replaced manure is added.

Current nitrogen quantities (kg/ha)

Farm	Broccoli	Cauliflower	Petsai	Horenzo	Lettuce	Pakchoy	Siomak	Tomato	Chilli
A		663			57				
B						150	446		
C		492							
D				150					
E					88				269
F	268		105					222	
Average	268	578	105	150	72	150	446	222	269
equivalent Urea amount	582	1256	228	326	156	326	970	483	585

To put it in perspective the amount of urea with a same nitrogen amount is presented too

Any comments from the participants on these amounts?
Let's vote.

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Note to trainer: With these figures the idea is to check with trainees if they thin these amounts are high or not. The bottom row shows the nitrogen amount in terms of urea, so in broccoli about 12 bags of 50 kg was applied on 1 hectare. (58 gram urea per m2; as trainer you could convert these amounts to local field areas where 100 kg/ha = 10 g/m2), 1 Tumbak = 14 m2, so 100 kg/ha = 140 g/Tumbak. Multiply the KG/ha figure with 1.4 to get GRAM / tumbak.)
For voting it can be simple: ask first who thinks these quantities are optimal?, then who thinks they are too low? And who thinks they are too high? Raise your hand.
Or use three coloured cards and hand them out, raise green when you think the amounts are optimal, raise red when they are too low, and blue when too high.

Current applied nitrogen quantities (kg/ha)

Farm	Broccoli	Cauliflower	Petsai	Horenzo	Lettuce	Pakchoy	Siomak	Tomato	Chilli
A		663			57				
B						150	446		
C		492							
D				150					
E					88				269
F	268		105					222	
Mean	268	578	105	150	72	150	446	222	269

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During the field activities we have tracked the fertilizer and manure use in vegetable crops at 6 farms for half a year. As an example Farmer A has applied a total of 663 kg/ha in cauliflower while farmer E has applied 88 kg/ha in lettuce.

Note to trainer: With these figures the idea is to check with trainees if they thin these amounts are high or not. The bottom row shows the nitrogen amount in terms of urea, so in broccoli about 12 bags of 50 kg was applied on 1 hectare. (58 gram urea per m2; as trainer you could convert these amounts to local field areas where 100 kg/ha = 10 g/m2), 1 Tumbak = 14 m2, so 100 kg/ha = 140 g/Tumbak. Multiply the KG/ha figure with 1.4 to get GRAM / tumbak.)
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Or use three coloured cards and hand them out, raise green when you think the amounts are optimal, raise red when they are too low, and blue when too high.

Conclusion of this slide is:
When considering that more or less crops require 200 to 300 kg/ha nitrogen as a rule of a thumb it looks like some crops received excessive nitrogen.

Nutrient supply and costs in half a year

Farm	Costs (IDR/ha)	Manure (t/ha)	N	P_2O_5	K_2O	CaO	MgO	S
A	3,415,820	41.1	727	266	200	702	250	291
B	1,741,728	41.1	571	406	346	537	215	0
C	1,253,771	6.8	157	108	153	120	65	71
D	1,317,750	19.8	449	373	298	364	113	0
E	443,156	12.5	142	106	125	58	144	0
F	5,124,000	33.4	638	778	369	162	451	460
Average	2,216,038	25.8	447	340	249	324	207	137

Variation between farms in manure use and total nutrient quantities

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At a few selected farms where dairy manure products are used seen can be that in a period of half a year on average over 2 milj IDR is spend on nutrient supply. Between farms big differences from less than 0.5 to over 5 million. Does the amount of money spend on fertilizers surprises the trainees??
Manure use too differs a lot, 7 to over 40 t/.ha
In combination with the use of chemical fertilizers the total nutrient supply in half a year for N, P, K etc was calculated. Of course the crop plan will give different amounts but variation is still quite high for especially N and P. Since veg crops are low P users the amount of applied P on average seems too high. The same is present for nitrogen which seems to high for a sustainable nutrient management

Questions?

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Nutrient removal with vegetables

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Principle

- With harvest product is taken away from the field
  - Product contains nutrients
  - Nutrients are taken from the soil by the plants
  - The crop contains significant levels of nutrients at harvest
  - Crop product is harvested and taken from the field to the market
  - Nutrient level in the soil is now lower
- If nothing is added soils will be depleted after time

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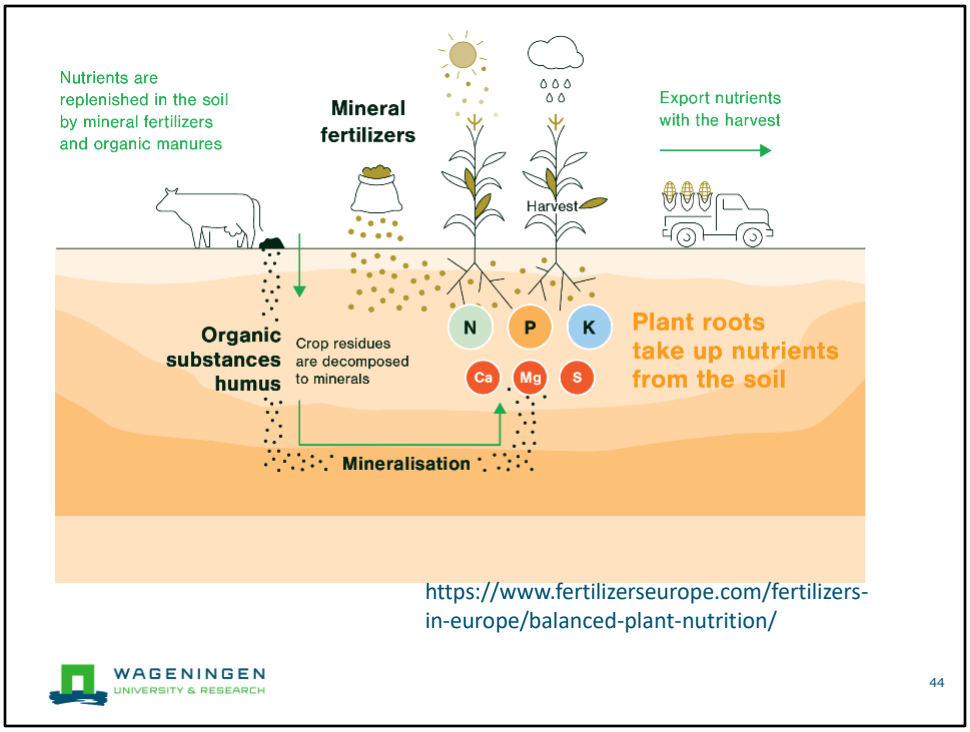
Key message, a major output of vegetables is the fruit, leaves or other plant part that is taken away. These parts are rich in nutrients that the plant has been taken from the soil. So each time when vegetables are grown and harvested and taken tot eh market nutrients are taken away from the field.



This picture was shown before but to get it right, nutrients are added and nutrients are removed, and this should be in line with each other.

Content of nutrients in crops of pilot farmers (g/kg product)

Crop	N	P	K	Ca	Mg	S
Broccoli	2.8	0.4	2.9	0.6	0.2	0.5
Cauliflower	2.6	0.4	2.4	0.8	0.1	0.3
Chinese cabbage (Petsai)	1.8	0.3	2.3	0.6	0.1	0.5
Horenzo	3.2	0.4	6.5	1.2	0.8	0.3
Lettuce	1.3	0.2	2.3	0.4	0.1	0.1
Pakchoy	1.3	0.3	2.7	0.7	0.1	0.4
Siomak	1.7	0.3	3.4	0.5	0.2	0.1
Tomato	0.3	0.1	1.4	0.1	0.1	0.1
Chilli (baby pepper)	4.7	0.6	4.4	0.6	0.2	0.5
Average	2.2	0.3	3.5	0.7	0.3	0.3
Rice white long	11.4	1.2	1.5			
Corn sweet raw	5.2	0.9	2.7			

Rice and sweet corn data from USDA Food data https://fdc.nal.usda.gov/

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Vegetable crops relative lower in P than staple crops
Low P demand

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Balances are about comparing nutrient inputs which are mainly by fertilizers and nutrient outputs which are mainly with the harvested product.

As an example 1 kg tomato contains only 0.3 gram nitrogen while Horenzo contains 3.2 g per kg product.

Note to trainer: in case you also want to discuss nutritional value, this slide can be used for that. N or nitrogen is the building block of protein and therefore higher rates means a higher protein level per kg. Meaning that Chili is higher in protein than other crops. However, the vegetable nitrogen level is still low compared to white rice grains with a N content of about 10.5 g/kg or twice as much.
In terms of healthy food, it seems that Horenzo is then supplying good amounts of N, P, K, Ca and Mg as compared to the other crops.
Still, this is only aspect of nutrition, next to the these nutrients there are other important ones like Iron and Zinc and of course all kinds of vitamins which can be much higher in fruiting crops than in leafy vegetables.

Yield of crops grown by pilot farmers

Crop	Yield (kg/ha)
Broccoli	7,655
Cauliflower	13,549
Chilli (Baby Pepper) (Intercropping With Tomato)	1,029
Chinese Cabbage (Petsai)	4,244
Horenzo	11,000
Lettuce	7,886
Lettuce (Intercropping With Chilli)	16,071
Pakchoy	18,500
Siomak	7,659
Tomato	18,327
Tomato (Intercropping With Chilli)	15,257

Nutrient Removal (kg/ha) = nutrient content (g per kg) x yield (kg per ha)

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To determine the output or outflow of nutrients with the crop it is important to know the yield level, the higher the yield and the higher the nutrient content per kg the higher the output.

Results of pilot farmers

Farm	N	P_2O_5	K_2O
A	26	8	31
B	62	33	147
C	55	24	84
D	106	32	259
E	41	16	57
F	35	15	69
Average	**54**	**21**	**108**

- Output (removal) of nutrients with harvested product in kg/ha

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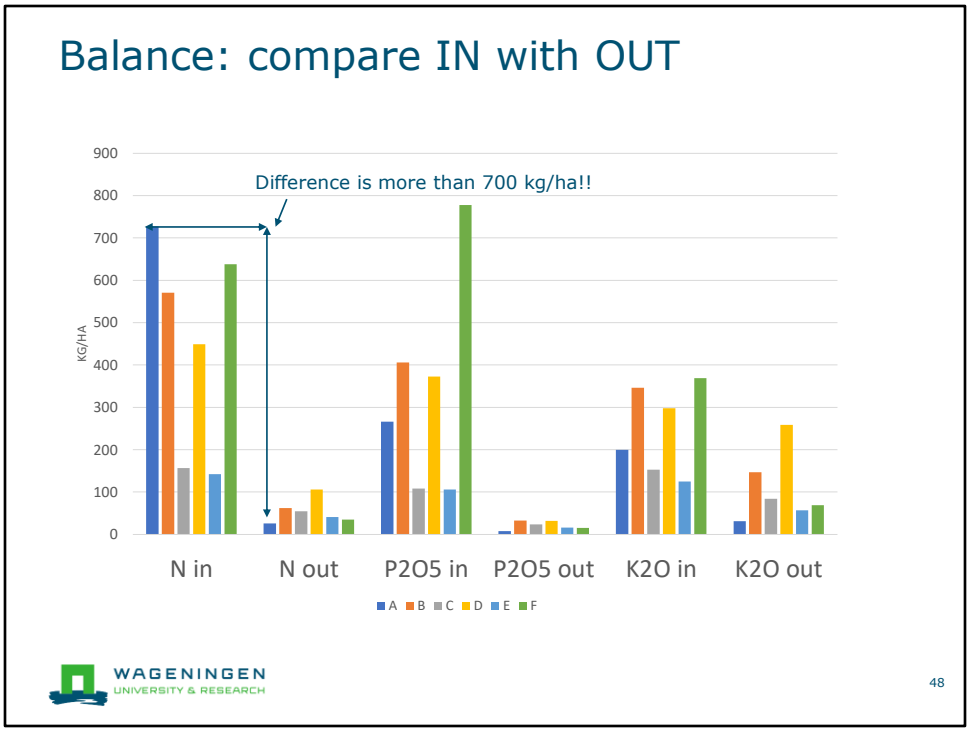
In this table the output is shown based on yield multiplied by nutrient content.
On average about 54 kg nitrogen is then taken away from the field, 21 kg P2O5 and 108 kg K2O.
Note to trainer: compare this now with the slide titled " current nitrogen quantities" shown before. Or ask the farmer if they can still recall that slide and figures what farmers apply, and ask them what their conclusion is. What do they think about the IN compared to the OUT of nitrogen quantities?



Note to trainer: after the discussion you might had at the previous slide this is the total overview of the balances that can be discussed with the trainees.
For each farm, A till F, a balance between nutrient inputs with fertilizers and nutrient outputs with crops was calculated. For nitrogen for instance one can see that the difference is more than 700 kg. But also at farm B, D and F the difference is quite high. At farms C and E the difference in N in and N out is not that large. For P and K also the balances are presented and for P also the differences are quite high while for K the differences are not than high.
It means that farmers should take more care about the N and P supply to make it more in line with the removal.

Current balances ($IN_{fertilizers}$ minus OUT_{crop})

Farm	N	P_2O_5	K_2O
A	701	258	169
B	509	373	199
C	102	84	69
D	343	341	39
E	101	90	68
F	603	763	300
Average	393	318	141

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This is actually the same but than as table as the previous slide. The trainer is free to show this instead off the previous slide or add it to it.

Soils

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Soil characteristics

- Soils are the source and medium for nutrient uptake by plants
- Presence of nutrients is not equal to availability
- pH and organic matter
- Soil samples are providing info on nutrient availability

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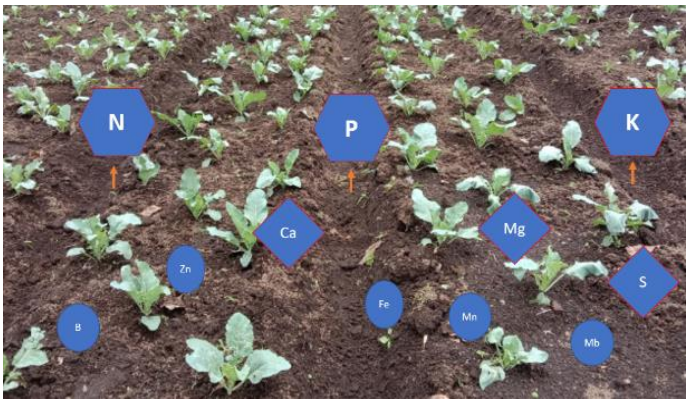
At the start of the training Inputs of nutrients are listed and a major parameter is the soil.
However, not soils are the same and the soil characteristics make that nutrients are available or not.
Important parameters next to the content of nutrients in the soil is therefore the soil pH which can influence the availability and the presence of organic matter that can provide nutrients to the soil and to the plant.
Taking soil samples and having them analysed by a lab will thus provide valuable information

soil as a source of nutrients



Uptake influenced by: pH, Balance, Quantity, Moisture

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Fertile soils, especially rich in organic matter, contain a wide range of nutrients, that are needed by the crop. Nutrients in the soil however, can be fixed or attached to soil particles or are present in an organic form. To make the nutrients available to the plant they need to be freely present in soil moisture. In many cases soil processes are required for that and pH, moisture, temperature, and soil life have an impact on this. If not optimal the nutrients will not become available and therefore good care has to be taken of your soil. It is your capital.

Participants opinion on their soils

- What can you tell about the soil of your field?
  - Is it fertile?
  - Is it a nice soil? And if yes why?
  - How do you take care of your soil?
  - Do you have information about nutrient content and pH of your field?

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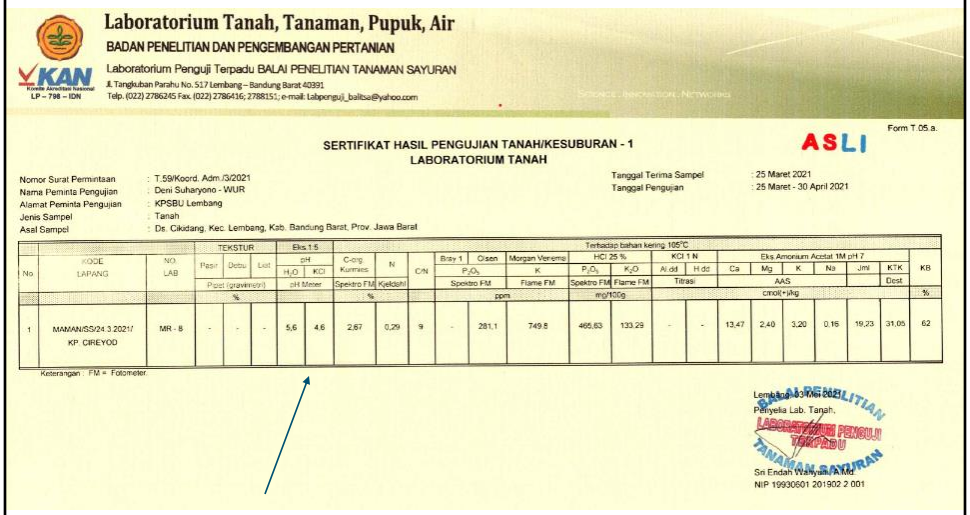
Since soil is so valuable which can hardly be expressed in money what is the trainees opinion on their own field.
Note to trainer: please start a discussion and try to write down the responses and come to a conclusion with the trainees

Example of a soil sample



Laboratorium Tanah, Tanaman, Pupuk, Air
BADAN PENELITIAN DAN PENGEMBANGAN PERTANIAN
Laboratorium Penguji Terpadu BALAI PENELITIAN TANAMAN SAYURAN
Jl. Tangkuban Parahu No. 517 Lembang – Bandung Barat 40391
Telp. (022) 2786245 Fax. (022) 2786416; 2788151; e-mail: balitsa@yahoo.com

Form T.05.a.

SERTIFIKAT HASIL PENGUJIAN TANAH/KESUBURAN - 1
LABORATORIUM TANAH

ASLI

Nomor Surat Permintaan : T.59/Koord. Adm./3/2021
Nama Peminta Pengujian : Deni Suharyono - WUR
Alamat Peminta Pengujian : KPSBU Lembang
Jenis Sampel : Tanah
Asal Sampel : Ds. Cikidang, Kec. Lembang, Kab. Bandung Barat, Prov. Jawa Barat

Tanggal Terima Sampel : 25 Maret 2021
Tanggal Pengujian : 25 Maret - 30 April 2021

No	KODE LAPANG	NO. LAB	TEKSTUR			Eks 1:5		Terhadap bahan kering 105°C																	
			Pasir	Debu	Lat	pH		C-org	N	C/N	Bray 1	Olsen	Morgan Wolf	HCl 25 %		KCl 1 N		Eks Amonium Acetat 1M pH 7						KB
						H_2O	KCl	Kurmies			P_2O_5		K	P_2O_5	K_2O	Al dd	H dd	Ca	Mg	K	Na	Jml	KTK	
			Pipet (gravimetri)			pH Meter		Spektro FM	Kjeldahl		Spektro FM		Flame FM	Spektro FM	Flame FM	Titrasi		AAS					Dest	
			%					%			ppm			mg/100g				cmol(+)/kg						%
1	MAMANISS/24.3.2021/ KP. CIREYOD	MR - 8	-	-	-	5,6	4,6	2,67	0,29	9	-	281,1	749,8	465,83	133,29	-	-	13,47	2,40	3,20	0,16	19,23	31,05	62

Keterangan : FM = Fotometer.

Lembang, 30 Mei 2021
Penyelia Lab. Tanah,

Sri Endah Wahyuni, A.Md
NIP 19930601 201902 2 001

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After the soil sample is analysed a report is written by the lab with the results. As an example here you can find that the pH of the soil is 4.5, which is telling you that the soil is acid. The next step is indeed to interpret the results.

Note to trainer: With trainees you could discuss now how this can be organised and implemented.
Cost aspect is important of course. However, you can also explain to the trainees that it is not necessary to take a soil sample every season, once per 5 years is already sufficient..
Of course the bigger the field the more beneficial it will be. It will be relatively more expensive for a 10m2 plot than for a 10,000 m2 plot. For both field the investment is the same while the expected returns can be much higher for a big field. As an example:
On a small field. Yield of cabbage is 50 kg, sold for .50 euros per kg = 25 euro income. Fertilizer use is 5 kg urea. It costs 1 euro per kg so 5 euros. Total balance = 25 – 5 = 20 euro.
With fertilizer advice a sample is taken: 50 euros (which is already more than what you can earn). Fertilizer savings are maybe 1 kg = 1 euro which will not outweigh the costs of the sample. Higher yield is perhaps 10%? So income is 55 kg x 0.5 = 27.5 euro. Still not enough to compensate for the extra investment.

Big field. 50,000 kg cabbage = 25,000 euro. Fertilizer = 5,000 kg urea = 5,000 euro .

Balance = 20,000 euro.
Fertilizer advice wit sample = 50 euro. Savings on fertilizer = 10% less urea. = 500 euro. Here the savings already outweigh the costs.

Kriteria penilaian hasil analisis tanah

	Sangat rendah	Rendah	Sedang	Tinggi	Sangat tinggi
C-org (%)	< 1	1 - 2	2 - 3	3 – 5	> 5
N – total (%)	< 0.1	0.1 – 0.2	0.2 – 0.5	0.5 – 0.75	> 0.75
P2O5 (Bray)	< 5	5 – 10	11 – 15	16 – 20	> 20
P2O5 (Olsen)	< 10	10 - 20	21 - 40	41 – 60	> 60
K2O (mg/100g)	< 5	5 - 16	17 - 24	25 – 40	> 40

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Based on research and tests it is possible to check the soil on nutrient levels. To check the soil one can now take a sample and let it analyse by a soil lab. This lab will also give feedback on whether the found levels are optimum low or high.
This table shows the criteria and is used to develop optimal fertilizer advices. When the soil results are in line with the figures shown in the red box a standard fertilizer advice will be advised to the farmer. In case the figure is lower than this more fertilizers will be advised and when higher lower fertilizer rates will be advised.
To analyse the phosphate status of a soil the lab uses either Bray or Olsen. This depends on the acidity of the soil, if pH-H2O is lower than 5.5 Bray is used, otherwise Olsen. The principle of the methods is to simulate the availability of P to plants, and this differs with the pH of soil.

Results of 6 Soil samples Lembang region

- Taken at vegetable farms using manure

Farm	pH KCl (1:5)	C-Org %	N Tot % (Kjeldahl)	P2O5-Bray (ppm)	P2O5-Olsen (ppm)	K2O mg/100 g
A	4.1	8.1	0.7	86		51
B	4.9	2.5	0.3		353	749
C	4.6	7.4	0.7	130		98
D	4.6	6.2	0.7	87		74
E	4.6	2.7	0.3		281	133
F	4.9	3.8	0.4		1183	104

Acid soils

On average high

Very high content

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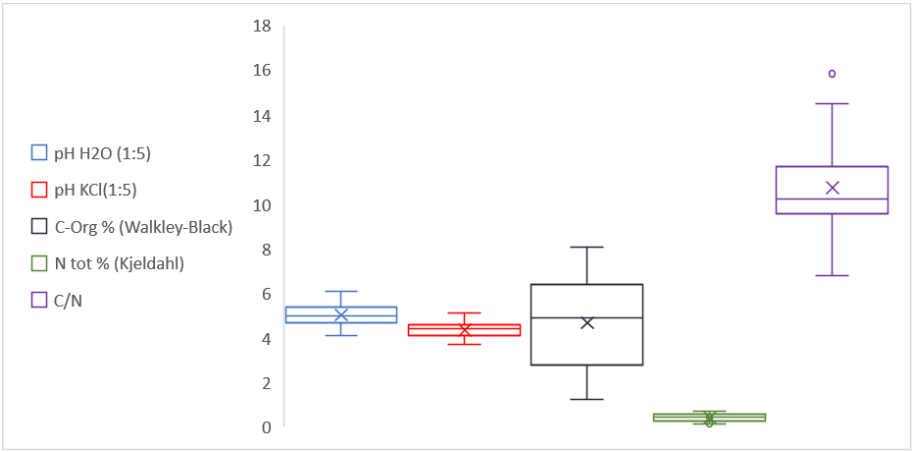
In the region at 29 fields samples were taken from the soil and analysed for soil fertility. This tables shows only the results of the pilot farmers we followed for half a year.

In general terms soils in the region around Lembang are acid, meaning that the uptake of fosfat can be limited. To improve fosfat uptake by plants one can add lime, but for this 1.5 to 3 t p[er hectare is required to have an effect. However, it takes about a month before the lime is effective in increasing pH. With lower amounts available it is better to concentrate the lime then in the plant holes, but realize that the pH will not be immediately high. For this purpose it is best to use very fine lime which reacts faster.

However, available fosfat, kalium and also nitrogen is quite high still and also the organic matter content of the soil is quite high. In terms of fertilizer advice this would mean that for those soils no high quantities of fertilizers are needed since the soil already contain a lot of nutrients.

Results of 29 samples taken around Lembang



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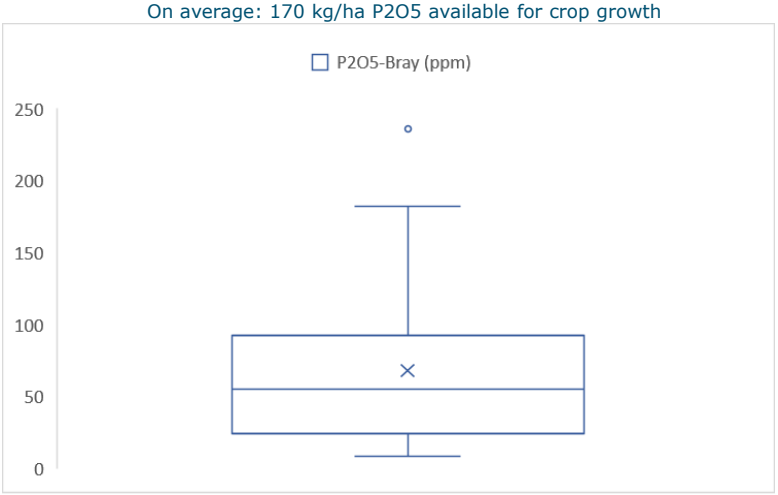
In this graph you can see that most samples have a pH between 4.5 and 5.5 with some samples having even lower or a higher pH. pH H2O is determined with a different method than pH-KCL. This makes it that pH-KCl is lower, more or less a point, than the pH H2O. Both methods are good pH indicators but make sure to compare the same ones when evaluating acidity of different fields.
Organic matter of most fields is between 3 and 7%. This Org Mat % is quite high and excellent for vegetable growth. Some soils have a low Org matter and especially for those the use of cattle manure is recommended since it will increase the org matter.
Even though the organic matter content is high the total N content is low, this might be due to fast mineralisation and leaching or uptake of the nitrogen from the organic matter.
C/N ratio tells something about the quality of the organic matter in the soil. If it is very low it means the organic matter is a lot of green stuff/fresh leaves and will decompose quickly and not contribute a lot to stable long term organic matter., If it is very high it means it contains a lot of carbon that will decompose very slowly and will remain a long time in the soil but will not release a lot of nutrients to the crop since it is not decomposing fast. It will consume a lot of nutrients instead which can make less nutrients available to the crops. So with low C/N ration no need to add a lot of fertilizers but with high C/N it is.

Phosphate status of soils

On average: 170 kg/ha P2O5 available for crop growth



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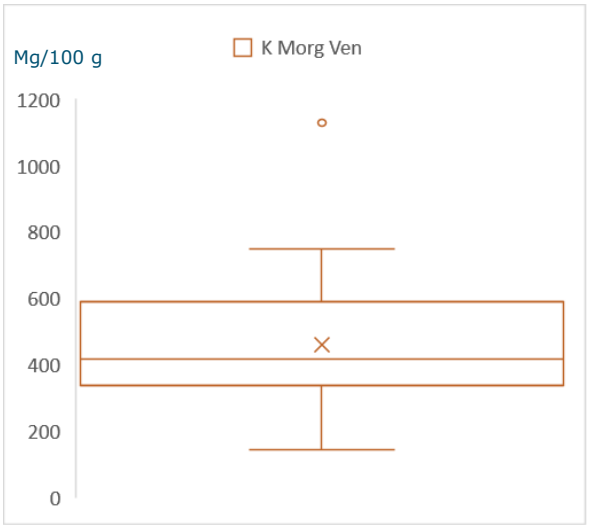
For phosphate most soils have a content between 25 and 100 mg/1000 g soil with extremes to 250 mg, the average is around 70 ppm or 70 mg/kg soil.
This means that the soil contains quite sufficient amounts since the optimum level is between 11 and 15 ppm.
With 70 ppm it means that about 170 kg P2O5 is present, to make it more visible.....
In case of SP36 this means a same amount as 475 kg SP 36 or 9 ½ bags of 50 kg SP36 per hectare is already in the soil for the crop.

Potassium status of soils

- Average:460
- Range:
  - 340
  - 600



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Most samples have a content between 340 and 600, with some lower and some higher. The average is 460 mg/100 g. Which is much higher than the optimum of 17 to 24 mg/100g.
With high K levels in the soil the risk is there that this will compete with uptake of calcium and magnesium leading to poor fruits. Blossom end rot can be a risk

Blossom end rot

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Ask the trainees if they have seen this and what they think it is and what is the cause. This is blossom end rot and is caused by disrupted calcium uptake. This can be because of low calcium levels but most often due to poor irrigation, high salt content / fertilizer content in the soil, too high urea or ammonium in the soil and too high levels of K that restrict Calcium uptake by the plant eventhough there is enough in the soil.

Conclusion

- Soils are high in nutrients
  - Especially P and K
- Soils contain a lot of organic matter
- Soil tend to be acidic
  - Lot of P not available

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Soils are extremely rich in P, but due to acid (low pH) a lot of fosfat (P) is not available. Still available P is quite high and with liming even more P will become available. One aspect is that with adding nutrients using either chemical or organic fertilizers one should not apply too much anymore since it will increase the P and K content of the soil even more.

Questions?

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Manure use in vegetables

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Short group discussion

- How much used?
- What is used?
- For what reasons is manure used?
  - Advantages
  - Disadvantages
- How are rates determined?
  - How do you know how much to apply/use?
  - Differentiation per crop and field considered?
    - Why not or why yes?

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Note to trainer: this activity is to assess the situation at the trainees places.
How many of them apply manure, how often, why, which products etc, also how is it used.
Try to write answers down on a flipchart and summarise them and conclude with the group.

Manure types

- Source from animal origin
  - Chicken
  - Cow
  - Goat
- Mixed and processed
  - With or without bedding material (straw, rice husk etc)
  - Composted or not

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Next to chemical fertilizers organic fertilizers can be used. The origin is the animal that produces the manure but after that it is the management and processing of the manure how the final product is. Are the animal faeces mixed with bedding material or left over feed residues, is it kept dry to reduce the water content of the manure, is it composted or not, are mixes made with other manures or not. In the end for horticultural purposes the manure should be rich in nitrogen and potassium and not so much in fosfat since horticultural crops are low in fosfat need.

Benefits

- Adding more to the soil than just one nutrient (e.g urea only applies nitrogen)
  - A range of nutrients is added including trace nutrients
- Adding organic matter to the soil
  - Improves water balance in the soil
  - Acts as a buffer for nutrient supply
- Slow release of nutrients (nitrogen and phosphate)
- Using manure reduces the chemical fertilizer use
  - Less impact on pH decline

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The use of manure in horticulture has several benefits. It adds a range of nutrients to the soil and the crop and not just one macro nutrient. Next to that it contributes to the organic matter in the soil which is positive since this has a positive impact on the gradual release of nutrients to the crop and it also retains a lot of water making it available to the plant in more drier periods.
By using manure a farmer is able to reduce the use of urea and ammonium sulphate and other chemical fertilizers. Since urea and ZA use will be reduced this will also have a positive effect on the soil pH. Manure has no or a low impact on the soil pH.

Disadvantages

- Low nutrient content (bulky)
  - High volumes of manure needed
- N-P-K ratio not in line with plant requirement
- Unknown and variable nutrient content
  - Hard to assess the required quantities
- Risks of importing unwanted elements
  - Weed seeds
  - Pathogens
  - Heavy metals (lead, cadmium)

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Unfortunately manure contains low percentages of nutrients and also the ratio of nitrogen fosfat and kalium are not in line with the crop need. High volumes are therefore needed and also to avoid pollution of the soil with one nutrient manure can not be applied more than the nutrient that has the lowest need by the plant. In most case it is then the fosfat requirement that sets a limit to the use of manure. Since manure contains relatively low percentages of nutrients like NPK high volumes are needed compared to higher concentrated chemical fertilisers. This requires more transport and labour. Also manure is a mix of nutrients and relatively more or same amounts of P and N are present. Since vegetables require significant less P than N a farmer can only apply manure until the P requirement is met. It will still lack N so this needs to be applied with chemical fertilizers or other sources. In case a farmer applies the manure till the N requirement is met it means very large amounts of P is applied that is not required by the plant. In that case the excess P can cause pollution of the environment.

Since the manure is an organic product and not manufactured the content of nutrients is not guaranteed and also it is variable. Even when obtaining it from the same farm the nutrient content of manure supplied today will be different from the one obtained a month ago. The best way would be to measure nutrient content each time.
For horticulture it is important to use good quality manure since the crop could be otherwise contaminated by unwanted elements in the manure. When the manure

producer is not taking care and is not professional the manure could contain a lot of weed seeds that will be added to the field, but also pathogens to the crop and to humans who will be the end used and presence of heavy metals can contaminate the field and lead to poisoning of the end consumer.

Typical content of manure types

Types	DM%	Ntot (%)	N-NH3	P (%)	K(%)	N-NH3 % in tot N
Dairy manure: manure heap (solid manure)	39.3	0.72	0.03	0.19	0.27	3.8
Diary manure: compost	42.4	0.85	0.03	0.33	0.43	3.7
Dairy manure: vermi-compost	35.1	0.80	0.03	0.41	0.38	4.2
Postal (broiler chicken manure with rice husks)	70.8	1.99	0.20	0.58	1.65	9.8

% based on wet weight of the manure product

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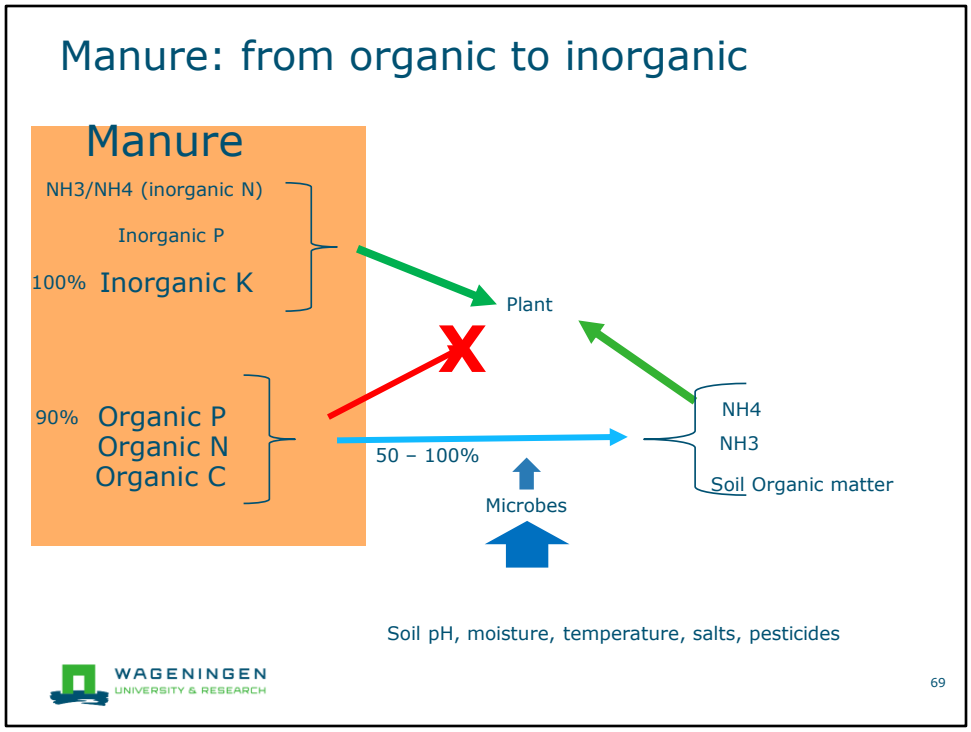
Based on samples taken in Indonesia this gives an idea of content,. The reason why dairy manure products are better for vegetable crops is the lower NH3% content. When this is high it means a lot of ammonia can be released at one time causing burning of crops. With cow manure this ratio is lower. It also means that with cow manure the organic N will supply a more steady supply.
Postal has higher P, N and K than dairy manure and is also drier seeing a higher Dry matter %



Manure is a complex fertilizer containing all kind of nutrients, the content is present mostly in an organic form for P and N and only a very small part is present as inorganic salts which are immediately available to plants. The organic nutrients first need to mineralise and for this microbes in the soil are needed. When applied to a crop it takes time to mineralise and the availability is depending on crop duration and how fast microbes can break down the organic stuff 50 to 100% of the organic nutrients. Microbe activity is the highest when soil moisture is not too low and not too high, the pH of the soil is neutral, the temperature is not too low and when the salt content and pesticide residues in the soil is low. The use of plastic mulch that creates a more moist and more higher temp of the soil will speed up the process of mineralisation.
Since nitrogen can be lost due to gas formation the manure is best to incorporate the manure in the soil.

Release of nutrients from manure

- Total Nitrogen = N-mineral + N organic
  - Manure contains immediately available N or N-mineral and slowly release of nitrogen from N organic
  - About 10 – 20% is immediately at application
  - In about 60 days 50 % of the total Nitrogen has been released
- P is mostly fixed in manure and is released slowly
  - In about 60 days 30 to 50% of the total P has been released
- K is for 70-80% immediately available at application date.
  - In about 60 days 100% of the K has been released

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The decomposing process takes time and especially with short crop cycles not all nutrients from the manure can be used by a crop.
For nitrogen the ammonium part is immediately available but from the organic part about half to 70% depending on soil conditions will be available to a crop during 60 days. Also phosphate needs to be released due to decomposing processes and in about 60 days 30 to 50% is available.
K is easy available and within 60 days all is available.
In case a farmers starts new with applying manure this needs to be taken into account, however, when a farmer applies every year manure this is not so essential to know since what is not released from the just applied manure will be available to the crop in the next growing season.

Consider the after supply in the next crop

- From manure applied in one crop about 10 to 20% of the nutrients will only become available in the next crop.

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In case of manure use realize that not all nutrients will be used by the crop grown after the application of manure but will be used by the second crop or even the third crop.
Using manure is a long term effort.

How much needed? (or possible to use)

- Crop need (example by approximates):
  - 250 kg/ha N
  - 75 kg/ha P2O5
  - 300 kg/ha K2O
- Crop duration 90 days
- Vermicompost
  - 0.8 % N -> 80% available = 0.64%
  - 0.4 % P2O5 -> 80%available = 0.32%
  - 0.4 % K2O

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How much manure is possible

- Nitrogen need is 250 kg/ha
- 1 ton vermicompost supplies: 1000/100 * 0.64 =
  - 6.4 kg N
- 250 / 6.4 = 39 ton vermicompost
- 1 ton vermicompost supplies 1000/100 x 0.32 =
  - 3.2 kg P2O5
  - 39 ton x 3.2 = 125 kg P2O5 per hectare
- Crop need is: 75 kg p2O5
  - So with 39 ton 50 kg P2O5 too much is applied
  - Limit is 23 ton vermicompost, more will apply more P2O5 than advised.

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When applying manure one should consider limits for other nutrients, advised is not to apply more than for each of the NPK is advised. So in this example P2O5 is a limiting factor and not more than 23 ton should be advised then. It does mean that nitrogen requirement will not be covered by this so extra urea, potassium nitrate or ammonium sulphate should be added still

Example prices of manure

Product	IDR/kg
Compost/heap manure 1:5	300 – 850
Heap compost	100 – 150
Postal	350 – 1,000
Vermicompost	350 – 1,000

Per hectare about 5 to 10 ton is needed

Example: 10 t/ha vermicompost at 500 IDR/kg will cost then 5,000,000 IDR/hectare

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It is not easy to put a value on manure, since it contains many other nutrients and is a good source of organic matter. Besides it has a positive effect on the soil characteristics.
Costs of manure are shown in the table.

Effect of manure on organic matter content of soils

- Each year soil organic matter decreases
  - Decomposing of organic matter by organisms
  - Release of nutrients
- Manure consist of different solids
  - Fast degradable matter
  - Slow degradable matter
- Only the slow degradable part will add to soil organic matter
- About 30 tons/hectare is needed to maintain a same level with manure having a dry matter of at least 25%

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Next to supplying nutrients the use of manure has a positive impact on soil organic matter. Each season part of the soil organic matter decomposes thus it will decrease. But this decomposing is needed to release nutrients. Manure contains different types of dry matter, part is fast degradable and part is slow degradable. The slow degradable part contributes to the soil organic matter and will turn into the more stable humus.
To keep the organic matter at its level about 30 ton per hectare manure is needed with a dry matter content of at least 25%.
However, to determine the rate of manure that can be applied to a field a farmers should consider the nutrient content as well in order not to apply too much where nutrient levels in the soil will be extremely high and can leach out.

Questions?

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Fertilization strategies

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Split applications

- Split applications
  - At planting
  - Side dressings 2 to 3x per crop season
- Why are they recommended?
  - Short enquiring with farmers
  - Write down answers and formulate conclusion

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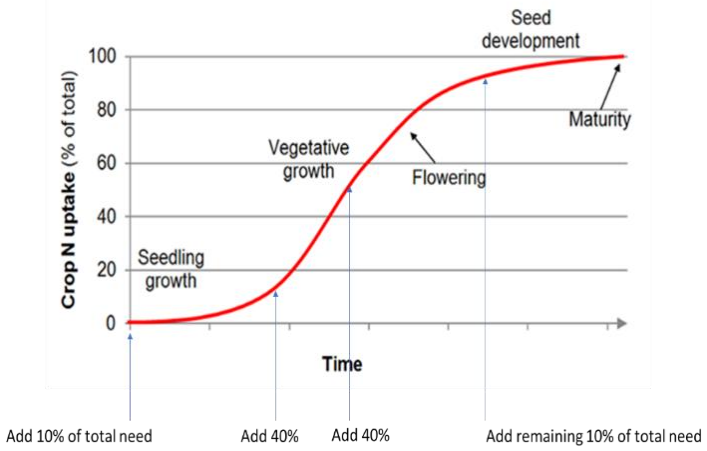
Conclusion is that crops require a total quantity but can not take up this all at once at one time. So when 100 kg nitrogen is added the plant takes up only 1kg per day, leaving the rest in the soil until the next day and so on. The longer nitrogen is left in the soil the more can be lost due to rain or volatilisation or uptake by other organisms. More splits will result in less losses.

Uptake of nutrients



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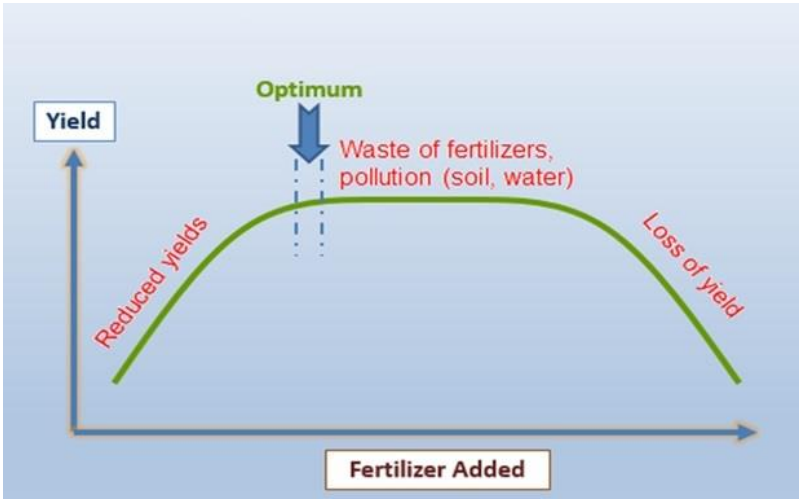
Not discussed yet and also not included in the recommendations is the timing of fertilizer splits.
More or less a crop takes up nutrients at different rates over the season. During the first weeks the uptake is slow, while during the vegetative growth and start of flowering a lot is taken up.
When looking at this it is therefore important not to apply a lot of nutrients at planting or sowing since a lot will be idle and can be lost. Also towards harvest it is not recommended to apply high volumes anymore.
Practical it will mean that organic dairy manure will be applied before planting and application of plastic mulch. It is important to incorporate the manure in the soil. Otherwise a lot of nitrogen can be lost since during the decomposing of the manure ammonium gas will be formed that will enter the air. At later dates chemical fertilizers containing nitrogen and kalium can be applied then,.

Too low or too high is not good!



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The recommendation is based on the optimum, where is the yield and the profit the best, so not immediately on nutrient balance. However, also with this approach low use of fertilisers will result in reduced yield while too much will result in waste and pollution. Excessive use can even result in loss of yield since too high content of salts in the soil can reduce water uptake.

Fertilization: summary

- Adding fertilizers should be in line with the balance!
  - Too much:
    - Loss of money!
    - Pollution of environment
  - Not enough:
    - Loss of money!
    - Lower yield

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How to determine fertilizer rates

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Use of soil samples

- Take a soil sample
- Analyse content by lab
- Evaluate levels of nutrients
- Link fertilizer advice to levels

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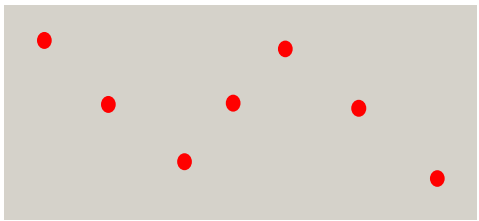
In this session explained will be how to take a soil sample and how to establish advises and give some advice examples

How to take a soil sample

- 1 sample per hectare (2 hectares means 2 samples)
- 20 cores per hectare
- Core depth till root depth (20 -30 cm deep)
- Take the cores in a zig-zag pattern



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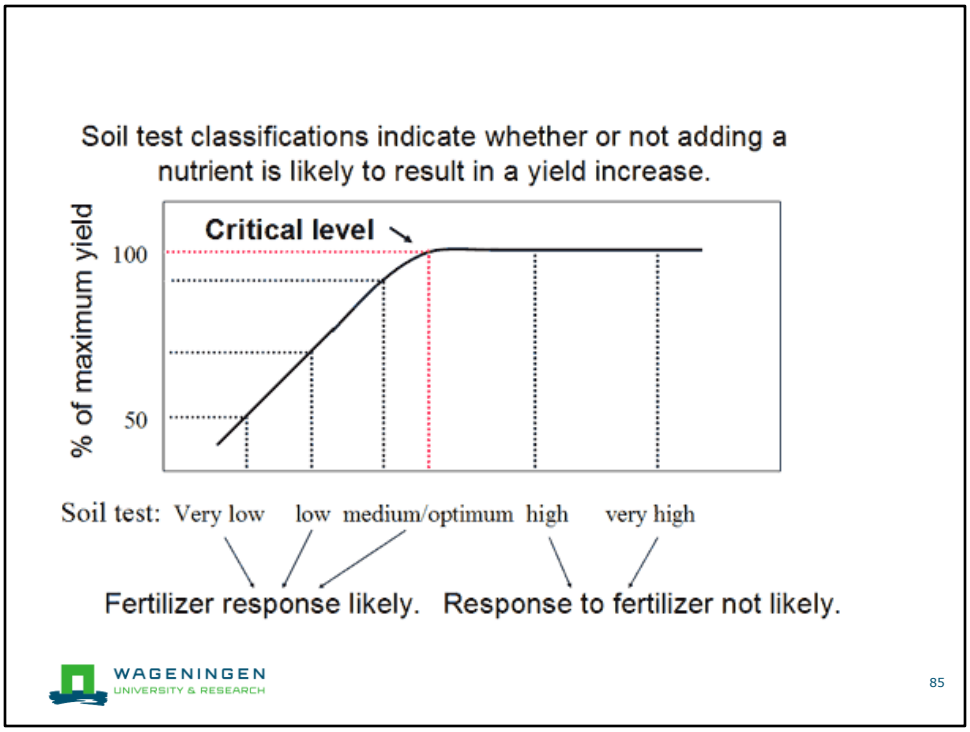
A lab is able to analyuse soil and will return a result. However, considered should be that accurate sampling is needed. One hectare contains 1,200,000 kg soil and only 1 gram in the end is analysed. From a field 500 gram is taken so the lab is able to take out a sample from there. It is essential than that the final 1 gram is representative for the field.
Advised is to take only samples form the beds where crops are grown and from the rootzone, nutrients below the rootzone are not available to the roots and will give false results when sampling is done below the rootzone. In many countries a depth of 0-30 cm is recommended but when felt that tha roots are not penetrating the zone lower than 20 cm than advised is to take a sample till 20 cm only. Roots can be limited in growth due to waterlogging or hardpans.



Note for trainer: in case trainees are curious to know how recommendations are developed this figure can be used.
When soil levels are low yield is low and adding fertilizers will show a response. If the soil status is high adding more fertilizers will not increase yield.
At high status one can still apply fertilizers to maintain the level that will otherwise drop.

With the lab result an evaluation fertilizer rates are determined that will contribute to the crop performance. When the levels are low or very lo, adding nutrients by fertilizers or manure will increase yield. At high levels adding will not automatically result in yield increase but will make that the soil fertility status is kept at a same level for the future.
At very high levels adding nutrients can even result in negative results where yield can drop due to excess salts. Nutrients are salt.

Ivegri develops recommendations per crop

Fertilizer (Urea, SP-36 and KCl) doses based on nutrient status (low-L, medium-M and high-H) for Cabbage grown in Andisol.

Nutrient status		Single Fertilizer				Compound Fertilizer	
Phosphorus	Potassium	ZA	Urea	SP-36	KCl	NPK 15-10-12	ZA
		..... kg/ha				..... kg/ha	
L	L	100	150	225	150	525	100
	M	100	150	225	100	525	100
	H	100	150	225	75	525	100
M	L	100	150	185	150	450	100
	M	100	150	185	100	450	100
	H	100	150	185	75	450	100
H	L	100	150	150	150	350	100
	M	100	150	150	100	350	100
	H	100	150	150	75	350	100

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Based on soil sample info recommendations can thus be developed. With the evaluation of P and K at low, medium or high levels for soils around Lembang different recommendations per crop are given since crop requirements are also different, one crop needs more nitrogen while the other one needs more kalium. Either use the single fertilizers or the compound NPK with ZA.

Fertilizer (Urea, SP-36 and KCl) doses based on nutrient status (low-L, medium-M and high-H) for Hot pepper grown in Andisol

Nutrient status		Single Fertilizer				Compound Fertilizer	
Phosphorus	Potassium	ZA	Urea	SP-36	KCl	NPK 15-10-12	ZA
		..... kg/ha				..... kg/ha	
L	L	150	130	165	185	400	150
	M	150	130	165	165	400	150
	H	150	130	165	150	400	150
M	L	150	130	150	185	350	150
	M	150	130	150	165	350	150
	H	150	130	150	150	350	150
H	L	150	130	130	185	300	150
	M	150	130	130	165	300	150
	H	150	130	130	150	300	150

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These recommendations are for chemical fertilizers only, however, we can simply substitute these with manure and add chemicals complementary to them

Fertilizer (Urea, SP-36 and KCl) doses based on nutrient status (low-L, medium-M and high-H) for potato grown in Andisol

Nutrient status		Single Fertilizer				Compound Fertilizer	
Phosphorus	Potassium	ZA	Urea	SP-36	KCl	NPK 15-10-12	ZA
		..... kg/ha				..... kg/ha	
L	L	185	200	525	300	1200	185
	M	185	200	525	250	975	185
	H	185	200	525	185	750	185
M	L	185	200	450	300	1200	185
	M	185	200	450	250	975	185
	H	185	200	450	185	750	185
H	L	185	200	400	300	1200	185
	M	185	200	400	250	975	185
	H	185	200	400	185	750	185

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Potato is a heavy feeder on potassium and phosphate and thus more is advised.

Recommendation with Vermicompost from dairy manure

	Vermi Compost t/ha	Urea Kg/ha	SP36 Kg/ha	KCl Kg/ha
hot pepper	10	144	0	92
shallot	10	195	44	152
cabbage	10	141	8	27
potato	15	203	194	141

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This table provides recommendations when using vermicompost which replaces the chemicals as much as possible. Base is the recommendation formulated by Ivegri for single fertilizers use at high P and medium K soil status.
In terms of soil pH a consideration may be still to use ammonium sulphate which ahs a lower acidifying effect than urea or even better is to use Kaliumnitrat which will increase the soil pH on the long term. However, the cost aspect could be a consideration although on the long run the higher cost of this fertilizer will generate more money due to a better crop performance.
Since soil pH is low it is advised anyway to apply lime to increase the pH.

Recommendation with compost from dairy manure (cow + chicken mix)

	Compost t/ha	Urea kg/ha	SP36 kg/ha	KCl kg/ha
hot pepper	10	140	16	84
shallot	10	191	73	144
cabbage	10	138	37	19
potato	15	203	81	57

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How to determine fertilizer needs without soil sampling?

- Crop removal as start
- Fertilizer efficiency
- Soil status
- Manure application till limiting nutrient
- Additional chemical fertilizer
- Split applications

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This needs some calculation and is therefore nor easy for trainees, but the principle is that for this the data collected from crop samples and the overall assessment of nutrient status is estimated. Also default figures are applied to compensate losses, or efficiency %. Not all fertilizers will be taken up, some will remain in the soil or will be fixed and not available anymore.

Recommendation with vermicompost based on Nutrient balance

	Vermicompost	Urea	KCl
Broccoli	5	40	11
cauliflower	5	98	34
chilli	5	0	0
chinese cabbage	5	0	0
horenzo	5	119	153
lettuce	5	0	8
pakchoy	5	73	86
siomak	5	21	23
tomato	5	44	16

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When considering the nutrient balances where inputs with fertilizers will not exceed the outputs with the crop plus compensating for losses the recommendations are significant lower. However, one should take into account that for this only a limited number of samples was taken. To optimize this more it is recommended to follow up with more crop samples and soil samples.

Recommendation with Compost use

	Compost	Urea	KCl
Broccoli	5	36	5
cauliflower	5	94	37
chilli	5	0	0
chinese cabbage	5	0	0
horenzo	5	116	147
lettuce	5	0	0
pakchoy	5	71	79
siomak	5	19	17
tomato	5	39	10

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This is the same but then with compost instead of vermicompost

Questions

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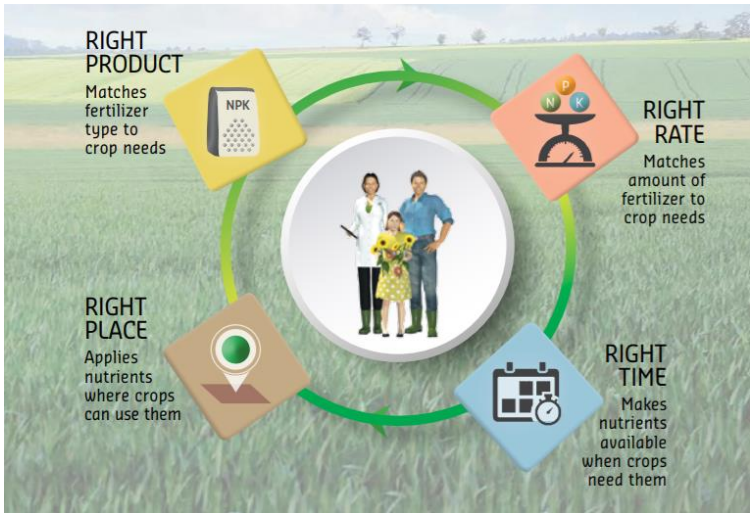
Remember the 4R's



https://www.fertilizerseurope.com/wp-content/uploads/2019/08/Fertilizer_Basics.pdf

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In fertilization it is important to consider the 4R's. Make sure to apply the right product (manure of good quality plus chemical) at the right time (when the crop need it) at the right place (near plant / in the root zone) and right rate (do not overapply, this will result in loss of money and pollution)

Summary

- Do not apply more nutrients than the crop needs
  - Excess rates of organic and chemical fertilizers pollutes the environment and costs money
- Apply lime to increase the soil pH to improve the P uptake
- With reduced use of Urea and Ammonium the soil pH will also not drop further
- Dairy manure is a good source of supplying nutrients
- Dairy manure is an excellent source to maintain soil organic matter
- Avoid losses by incorporating the manure properly in the soil

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Test

- 5 multiple choice questions
  - Questions are projected with multiple choice answers
  - Small groups of 3-4 persons discuss first on the question and select an answer
  - With voting signs (A B C D) they indicate their answer

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Note to trainer: Beforehand prepare for each group four cardboards with A, B, C. or D written on it
In case a screen and projector are available you can project the next questions on screen and ask participants to show their answer.
It is nice doing this by grouping trainees in groups of 3-4 persons, after showing the question they have 1 minute time first to discuss in their group which answer it should be.
Once the trainer states: Please raise your answer" all groups have to put up their answer simultaneously.
Based on the answers you can make it interactive by asking groups why they have chosen a certain answer, can they explain it to the others.
In case you want to make it more competitive you can write the group names on a flipchart and when the group has provided a correct answer a point is awarded. After 5 qstns a winner can be appointed. Try to organize also small gifts for the winners (and also prepare to have a shared winners)

Test

- Five multiple choice questions
- Name:.....
- Date:.....
- Location:.....

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In case you would like to have an individual test, please use the separate booklet with test and evaluation form that can be handed out to the trainees.

1) What is an input of nutrients?

A. Erosion
B. Leaching
C. Irrigation water
D. Harvested produce

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What is an input of nutrients?

A. Erosion
B. Leaching
C. Irrigation water
D. Harvested produce

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The slides with the answers are hidden. When the trainer wants to go through the answers with the trainees/participants he/she needs to unhide them.

2) Why is cattle manure better for vegetable crops than postal?

A. It is heavier
B. Less burning risks
C. Contains more dry matter / organic stuff
D. Contains more nutrients

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2) Why is cattle manure better for vegetable crops than postal?

A. It is heavier
B. Less burning risks
C. Contains more dry matter / organic stuff
D. Contains more nutrients

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In most cases cattle manure contains more water and is heavier to transport which is a nuisance but has no effect on vegetable crops. In most case the cattle manure has lower orgasnicmatter content and less nutrients. It is especially a good product since nitrogen is released in a gradually way leading to less burning risks and also a more steady qualitative growth of the plant.

3) What is true?

A. Manure can be applied without limitations on soils near Lembang
B. Soils are low in Kalium and thus need a lot of manure
C. Soils are high in phosphate and therefore care has to be taken with manure use
D. Manure can be spread over the beds and left lying on top of the soil without any risk

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3) What is true?

A. Manure can be applied without limitations on soils near Lembang
B. Soils are low in Kalium and thus need a lot of manure
C. Soils are high in phosphate and therefore care has to be taken with manure use
D. Manure can be spread over the beds and left lying on top of the soil without any risk

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Soils are relatively high in nutrients and thus manure can not applied at very high amounts since it will add more phosphate to the soil. Soils are also high in K.
So there are limitations.
Advised is also to incorporate manure in the soil since otherwise a lot of nitrogen can be lost due to volatilisation.

4) What is not true?

A. Manure contains a wide range of nutrients
B. Manure has a positive impact on soil organic matter
C. Content of nutrients in manure is always the same
D. Manure improves soil fertility

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4) What is not true?

A. Manure contains a wide range of nutrients
B. Manure has a positive impact on soil organic matter
C. Content of nutrients in manure is always the same
D. Manure improves soil fertility

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5) What is not true:

- At high nutrient levels in the soil: Apply fertilizers since it will increase yield
- At high nutrient levels in the soil: Apply fertilizers, yield will not increase but it will maintain the nutrient content level
- At very high nutrient levels adding fertilizers still will reduce yield
- At low and very low soil nutrient levels adding fertilizers will increase yield

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5) What is not true:

- At high nutrient levels in the soil: Apply fertilizers since it will increase yield
- At high nutrient levels in the soil: Apply fertilizers, yield will not increase but it will maintain the nutrient content level
- At very high nutrient levels adding fertilizers still will reduce yield
- At low and very low soil nutrient levels adding fertilizers will increase yield

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At high levels most likely adding fertilizers will not show an effect, but is needed to supplement the nutrients that are removed to maintain the current soil fertility level. At very high levels adding fertilizers will cost money and can reduce yield levels, it will also lead to pollution

Field visit

- Description of activities and guidance

- Discuss in field performance of crops
- Discuss what the farmer has applied and how he plans
- Check root system
- Check soil with visual inspection
- Demonstrate soil sampling

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Note to the trainer: At the end of the training this template needs to be printed. Please note that the name and the location and date need to be added still!

Evaluation form (please thick the relevant box per question)

	Not good	Neutral	Very good
Content of training			
Usability of information for own farm			
Performance of trainer			
Organisation of the training			

Other comments:.....

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Training date:.....Location:.....

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Healthy food

For a nutritional vegetable dish nutrients are needed for a good crop

But……. All in balance