Support and consultation mission for the LEPL Agricultural Scientific Research Centre in Tbilisi, Georgia

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November, 2014

Report number 2014-11

Project no. 3236183914

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SUMMARY

On request of the Embassy of the Kingdom of the Netherlands in Tbilisi, Georgia a support and consultancy mission was carried out by two staff members of Wageningen University & Research centre and one staff member of BLGG laboratory for soil and crop analysis.
The support and consultation focussed on cultivation of fruit crops and the establishment of a laboratory for soil analysis.
Georgia was visited from 27 October – 1 November, 2014. During this visit discussions were held with staff members of Agricultural Scientific Research Centre and the Agricultural University. Our main contact person for fruit production was Dr. Zviad Bobokashvili, while Dr. Giorgi Ghambashidze, was our main contact person regarding the laboratory.
The experimental field station of the institute for fruit crops as well as the Agricultural University were visited.
Based on observations and discussions recommendations were made. A laboratory for soil analysis will be established using the common methods. It is advised that analysed samples are stored enabling correlation in case in future new analytical methods will be used.
Regarding the fruit production It is clear that the yield, quantity and quality, can be increased substantially by technical measures. However, also the socio economic conditions need attention.
Possibilities will be explored for funding future cooperation between Georgian institutions and Wageningen University & Research Centre. An exchange of students might be the first step for establishing a sustainable corporation.

1 Introduction

1.1 Introduction

The Embassy of the Kingdom of the Netherlands in Tbilisi, Georgia requested Wageningen University & Research Centre (Wageningen UR) to carry out a consultancy and support mission for the LEPL Agricultural Scientific Research Centre in Tbilisi (Appendix 1 Demands of the Centre). This mission was executed by two staff members of Applied Plant Research-Fruit of Wageningen UR and one staff member of BLGG, laboratory for soil and crop analysis.
Georgia was visited from 27 October – 1 November, 2014.

1.2 Georgia

Georgia is located east of the Black Sea (Figure 1) in a geopolitical 'hot spot' region.

Figure 1. Location of Georgia (http://www.bbc.com/news/world-europe-17301647).

Georgia became an independent state in 1991 after the collapse of the Soviet Union. In the years after 1991 the ties with the European Union (EU) have been strengthened. In June 2014 an Association Agreement (AA) has been signed. This AA foresees far reaching political and economic integration with the EU by significantly deepening political and economic ties, bringing Georgia closer to Europe (http://eeas.europa.eu/delegations/georgia/eu_georgia/political_relations/index_en.htm).

1.3 Readers'guide

In Ch. 2 the agriculture of Georgia and in Ch.3 the Agricultural Scientific Research Centre are briefly discussed. These chapters summarize information presented to us by Dr. Zviadi Bobokashvili and from information available at several internet sites. This information is included for readers not familiar with Georgia.
Ch.4 starts with the questions that were posed by mail from our side regarding the setting up of a laboratory for soil analysis while preparing the mission in the Netherlands. The answers are from the Georgian specialists. Thereafter the observations made during our visit are summarized followed by discussion. Ch. 5 deals with fruit production. This chapter has the same structure as Ch. 4. Questions, answers followed by observations and discussion.
In Ch. 6 the recommendations regarding soil analysis and fruit production as well as some other actions regarding the mission are summarized.
In Appendices 1 – 4, the demands of the Centre, four presentations, persons met and itinerary are presented.

2 Agriculture in Georgia

2.1 Introduction

Georgian agricultural production is still in transition following the breakup of the Soviet Union and the unrest in the years thereafter. The government is investing in improvements of the infrastructure.
Viticulture and winemaking are the most important agricultural activities. Over 500 species of local vine are bred in Georgia, and the country is considered as one of the oldest places of producing top-quality wines in the world. Actually Georgian wine is exported to 48 countries. Most wine was exported to Russia. Long time the borders were closed but recently opened again. Also dairy farming is an important economic activity.
Actually it is estimated that about 50% of the total labour force is employed in agriculture. A great part of the agricultural activity can be characterized as subsistence farming.
In Fig. 2 and Figure 3 the relative importance of Agriculture in the Georgian economy is presented.

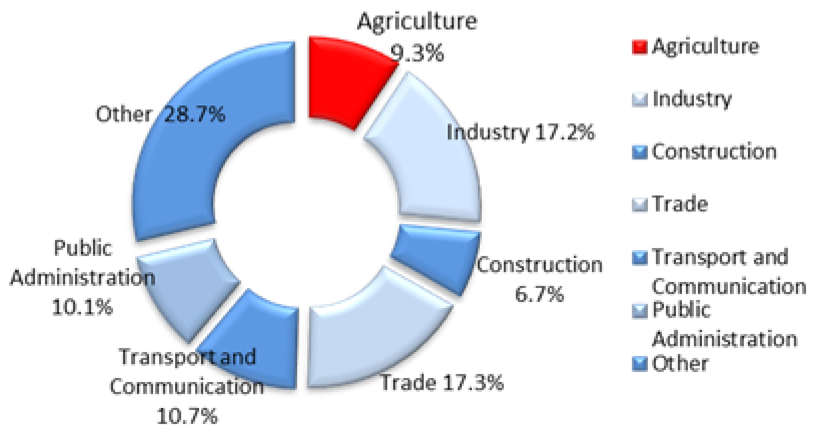

Figure 2. GDP by sectors in 2013.

Figure 3. Agricultural share in total GDP.

2.2 Climate

Georgia's climate is affected by subtropical influences from the west and Mediterranean influences from the east. The Greater Caucasus range moderates local climate by serving as a barrier against cold air from the north. Warm, moist air from the Black Sea moves easily into the coastal lowlands from the west. Climatic zones are determined by distance from the Black Sea and by altitude. Along the Black Sea coast, from Abkhazia to the Turkish border the dominant subtropical climate features high humidity and heavy precipitation, 1000 to 2000 mm per year. In this regions the midwinter average temperature is 5 °C and the midsummer average is 22 °C .
The plains of eastern Georgia are shielded from the influence of the Black Sea by mountains that provide a more continental climate. Summer temperatures average 20 °C to 24 °C , winter temperatures 2 °C to 4 °C . Humidity is lower, and rainfall averages 500 to 800 mm per year.
At higher elevations, precipitation is sometimes twice as heavy as in the eastern plains. In the west, the climate is subtropical to about 650 m; above that altitude (and to the north and east) is a band of moist and moderately warm weather, then a band of cool and wet conditions. Alpine conditions begin at about 2100 m, and above 3600 m snow and ice are present year-round.
(http://en.wikipedia.org/wiki/Climate_of_Georgia_(country)#Climate)

Table 1. Average precipitation (mm) in Tbilisi (http://www.georgia.climatemps.com/precipitation.php).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
19	26	30	51	78	76	45	48	36	38	30	21	496

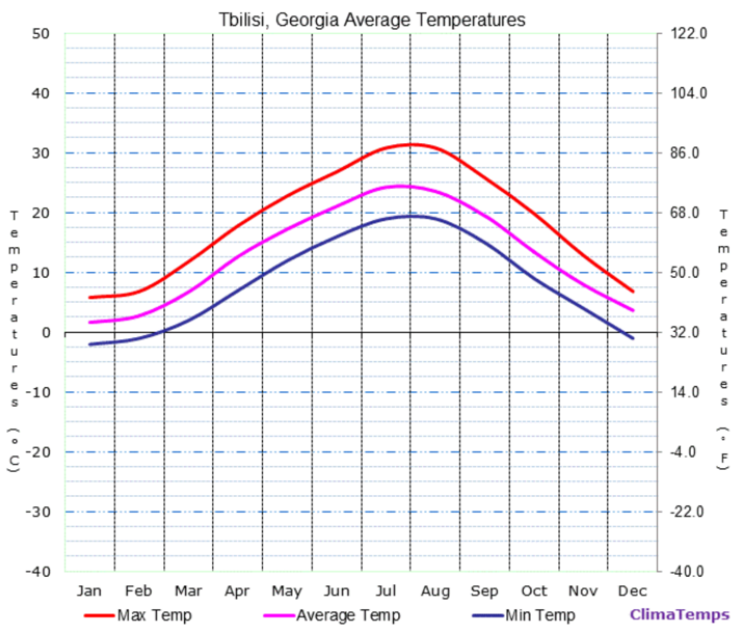

Figure 4. Temperature in Tbilisi (http://www.georgia.climatemps.com/temperatures.php).

In Tbilisi, July is the warmest month (average temperature 24.4 ^{0}C) and January the coldest with an average temperature of 1.7 ^{0}C.

2.3 Soils

In Georgia over 50 different soil types have been described. At the end of the 19th century the famous soil scientist Dokuchaev called Georgia 'Open air soil museum' (Urushadze and Matcha Ariani, 2009).
In 2009 a new soil map of Georgia (1 : 500.000) was published (Figure 5). The legend of this map is based on the the World Reference Base (WRB). This is the international standard for soil classification system endorsed by the International Union of Soil Sciences. The map was composed by more than 50 scientists and practitioners under the leadership of professor Tengiz Urushadze.
http://www.fao.org/soils-portal/soil-survey/soil-classification/world-reference-base/en/
The WRB has been translated into Georgian in 2005 (Urushadze and Matcha Ariani, 2009). Use of WRB enables international facilitates exchanging knowledge on soils and their use.

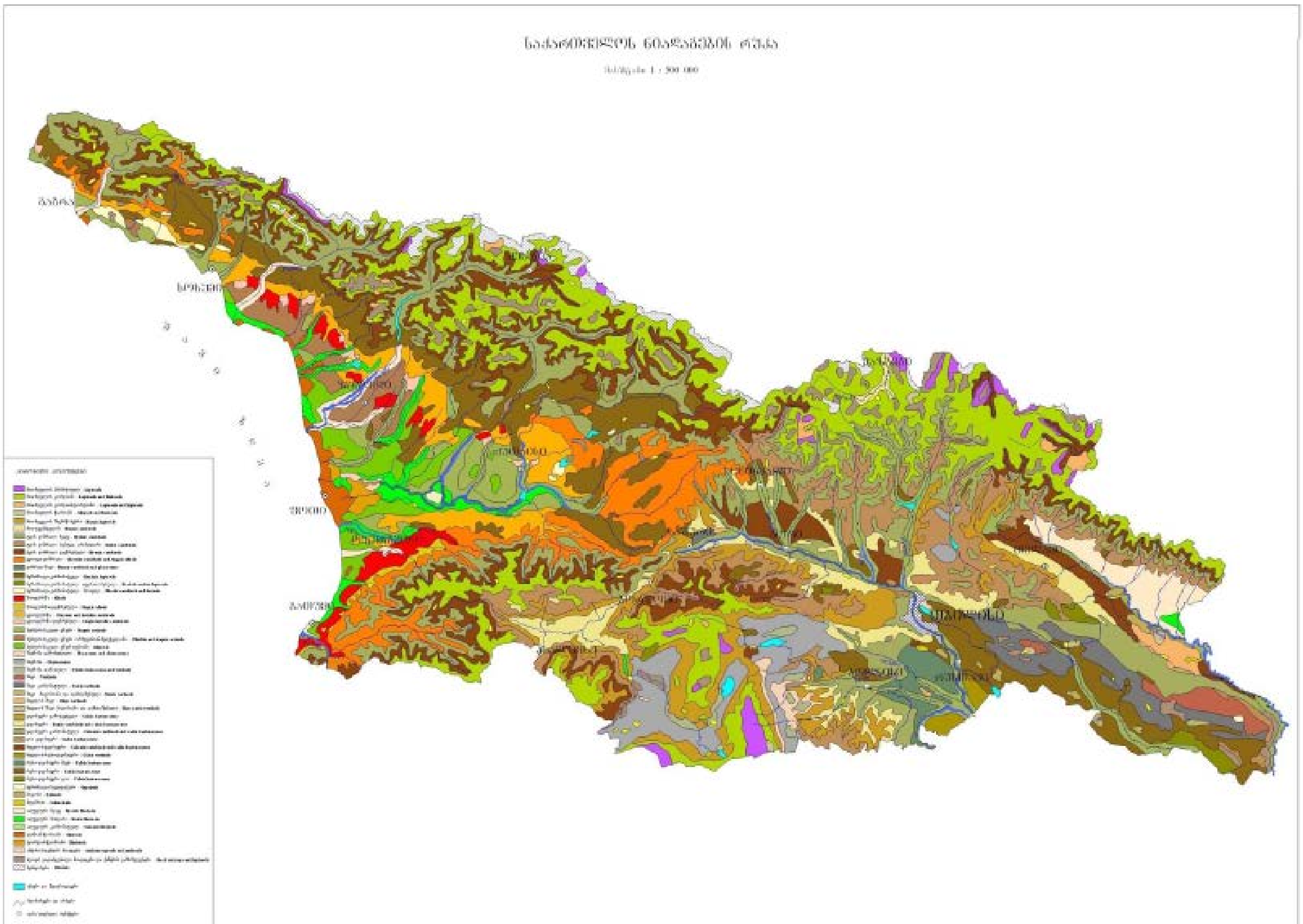

Figure 5. Soil map of Georgia 1 : 500.000 (Urushadze and Matcha Ariani, 2009).

2.4 Crops

The wide variation in climatic conditions enables cultivation of a wide range of crops: citrus, grape, tea, nuts, fruits and vegetables, etc.
Viticulture is a very important sector for Georgia. The country has a long tradition of winery.
In Georgia over 500 wine grape varieties are grown.

2.4.1 Yields

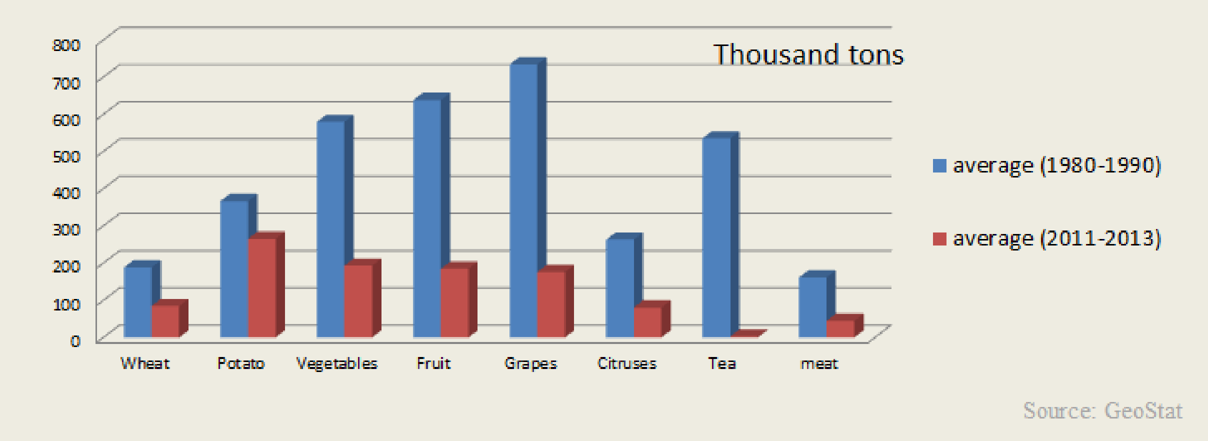

Figure 6. Yields of different crops in the periode 1980-90 and 2011-13 (presentation of Dr. Zviadi Bobokashvili on 28102014)..

In the period 1980-90 yields of different crops as well as the meat production were about three times higher than in the years 2011-13.
Some may question whether the yield levels in the period 1980-90 are accurate. However, the big differences indicate that it is probably safe assuming that yields were substantially higher than the yields in the period 2011-13. These differences indicate that there is a potential for increasing actual yields.
Also the questions arises what causes the yield decline?
Between the transition period important changes took place that affected yield levels negatively. As one of the main reason the breakdown of the irrigation organizational infrastructure was mentioned.

2.4.2 Fruit crops

In Figure 7 the relative importance of different fruit crops in Georgia is presented. The most important crops regarding extent are citrus and other subtropical fruits. The combined share of pome fruits (apple, pear and quinces) and stone fruits amounts to 42%.

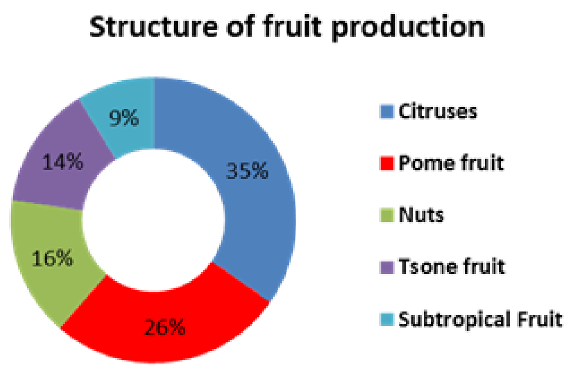

Figure 7. Structure of fruit production (presentation of Dr. Zviadi Bobokashvili on 28102014).

In Table 2 the yields of perennial crops in the years 2006-13 are presented. In most years the production of grapes is comparable or slightly higher than combined yields of fruits and nuts, excluding citruses.
In Table 3 the production of pome fruits, stone fruits and nuts of 2006 and 2013 are compared. The increase of the total fruit production in 2013 compared to 2006 is mainly due to increase of the production of apples, peaches and hazelnuts while the production of sour plums has halved.

Table 2. Yields of perennial crops (presentation of Dr. Zviadi Bobokashvili on 28102014).

PRODUCTION OF PERENNIAL CROPS IN GEORGIA (ths. tons)

	2006	2007	2008	2009	2010	2011	2012	2013
Fruit Total	153.3	227.5	157.6	181.2	124.1	187.3	157.9	217.6
Of which								
Apple	32.8	101.3	41.5	80.7	21.1	64.3	45.0	68.6
Pear	22.5	19.6	16.4	11.1	13.7	17.6	16.1	17.0
Quinces	1.1	1.5	1.2	2.2	0.5	0.9	0.9	2.1
Plums	12.8	16.3	12.6	6.3	6.7	7.2	10.7	8.7
Cherries	4.8	5.5	4.0	4.0	3.0	2.7	5.1	5.6
Apricots	0.5	0.3	0.7	0.2	0.8	0.3	0.7	0.7
Peaches	5.3	8.2	13.7	17.6	6.9	19.1	7.1	23.7
Sour plums	24.3	18.6	18.0	6.9	11.9	9.7	13.7	10.3
Wallnuts	3.9	11.8	6.2	8.2	6.1	5.7	4.8	10.8
Hazelnuts	23.5	21.2	18.7	21.8	28.8	31.1	24.7	39.7
Subtropical Fruit	21.2	22.1	23.7	21.4	22.4	25.3	26.2	27.8
Berries	0.6	1.1	0.9	0.4	0.8	1.8	1.2	0.7
Other Fruits	0.0	0.0	0.0	0.4	1.4	1.6	1.5	1.9
Grapes	162.5	227.3	175.8	150.1	120.7	159.6	144.0	222.8
Citruses Total	52.2	98.9	55.2	93.6	52.1	54.9	77.0	110.4
Of which								
Tangerines	48.4	93.6	51.6	90.5	48.6	53.1	71.1	107.1
Orange	1.9	3.7	1.9	1.5	1.4	0.6	3.5	1.4
Lemon	1.9	1.6	1.7	1.6	2.1	1.2	2.4	1.9
Tea	6.6	7.5	5.4	5.8	3.5	2.9	2.6	3.3

Table 3. Production of pome fruits, stone fruits and nuts in relation to total fruit production (in ths. tons and %) in 2006 and 2013.

	2006	2013
Total fruit production	153.3	217.6
Pome fruits	56.4 (37%)	87.7 (40%)
Stone fruits	47.7 (31%)	38.7 (18%)
Nuts	27,4 (18%)	50.5 (23%)

3 LEPL Agricultural Scientific Research Centre in Tbilisi, Georgia

The mission of the LEPL Agricultural Scientific Research Centre is to promote agricultural development and food production, research and to introduce new technologies and extension programmes for the wide farming community of Georgia.
The Department of Perennial Crop Research and Planting production material has four sections: Viticulture, Fruit crops, Agroforestry and Mulberry production (Bobokashvili, 2014).
The Head of Department, Dr. Zviad Bobokashvili, was our main contact person regarding fruit production. Dr. Bobokashvili has also a part-time appointment as associate professor at the Agricultural University of Georgia.

Main aims of Fruit growing section:
- Providing of basic and applied research;
- Production of planting materials of promising fruit crop varieties.

Therefore the following main activities are carried out.

Activity 1
-Evaluation and testing biological, agronomical and commercial aspects of newly introduced fruit crop varieties in Georgia, including potential of local varieties.
Expected outcomes:
A database will be established with more than 80 cultivars of fruit crops. Based on this research recommendations will be made which cultivars are suited for local farmers.
Local endangered autochthonous varieties of fruit crops will be collected and evaluated.
Modern approaches of phenotyping and genotyping will be implemented.
All data will be included in the crop data bases available worldwide, e.g. Hortivar , Eurisco

Activity 2
-Elaboration and improving of technologies for fruit tree production and training
Expected outcomes:
Technologies will be improved and tested, including production of high-quality trees (trees with a good number of feathers).
Modern approaches of pruning will be tested and, if necessary adapted. Training will take place regarding planting techniques, ULO and other relevant topics.

The Department has an experimental station that is located at 580 to 620 m above sea level East of Tiriphon - Mukhrani Valley at a distance of approximately 26 km West of Tbilisi.
The total extent of the station is 80 ha which is used as follows:
26 ha Grapevine; collections, demonstration vineyards, mother plant plots;
34 ha Fruits; collections, demonstration orchards and mother plant plots;
6 ha Land for nurseries;
8 ha Reserve plots;
5 ha Roads, offices, other facilities, wind protection lines.

4 Soils and soil analysis

The condition of the soil is the basis of agricultural production, usually referred to as soil fertility. A common definition of soil fertility is 'the crop production capacity of the soil'.
Soil fertility is a function of the parent material of the soil, climatic conditions, soil forming processes and agricultural practices.
Soil fertility has three main components : physical, chemical, and biological. The level of soil fertility depends on the interactions between these three components.
The physical soil fertility relates soil texture, soil structure and moisture holding capacity. Chemical soil fertility relates to acidity, salinity and capacity of the soil to supply and retain nutrients. Biological soil fertility relates to the tremendous variety of organism, mostly being positive or neutral for crop production, and a minority (though of great importance) are plant pathogenic.
On soils with high inherent or improved soil fertility, high-yielding production systems can be built. To obtain insight in crop nutrient requirements and optimal soil fertility status, soil testing started at the end of the 19th century. In the Netherlands, the interest in soil-dependent crop productivity increased in the beginning of the 20th century and demands by farmers for soil tests increased correspondingly. In 1927, the laboratory for routine soil tests was split off from State Experimental Station, and continued independently as BLGG (www.blgg.com).

4.1 Questions

The questions concern the establishment of a laboratory for soil analysis.

Question (NL): What kind of analysis will the lab carry out?
Answer (Georgia): The laboratory will conduct a wide range of soil analysis to assess soil fertility and soil quality under various agricultural use including permanent pastures and hay lands.

The Netherlands: Soil testing to assess soil fertility and for plant nutrition is common for all sectors. About 2.000.000 ha is used as agricultural land. Grass and maize are the most important crops (*Figure 8*). (followed by arable crops (among others: ware potato, seed potato, winter wheat, onions, sugar beet) and horticultural crops like lettuce, strawberry, leek, and carrots. Every year >100.000 soils are analysed for fertilization recommendations. Most farmers have their fields analysed at least once every four years.

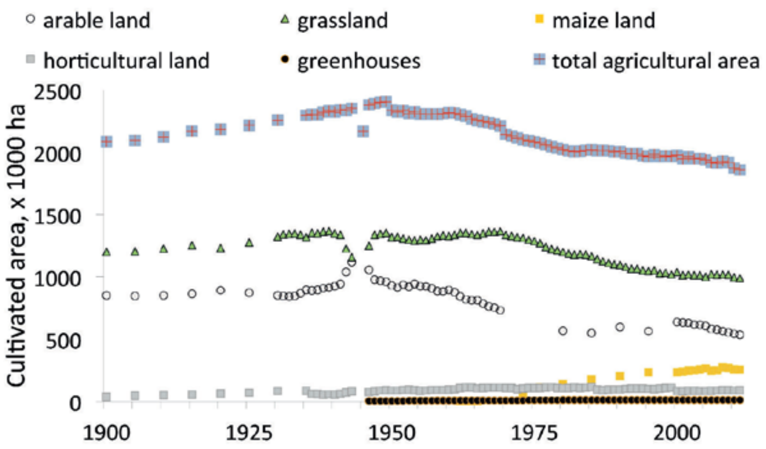

Figure 8. Agricultural land use in the Netherlands in the period 1900-2010.

Most farmers use soil tests to monitor soil fertility and to get insight in the possible need for fertilization of their crops. Besides soil chemical, also soil physical information is on request presented to farmers, including soil texture (clay, silt, sand), risk of soil slaking, and the moisture holding capacity. Soil biological information is also available, however mostly requested in relation to agricultural research. Insight in among others active bacteria, total bacteria, active fungi, total fungi, non-plant parasitic nematodes is possible. This kind of soil analysis is far more time consuming than routinely executed soil chemical and physical tests; about 1500 soil biological reports are done on a yearly basis. However, analysis of soil nematodes is much more common in the Netherlands. The number of plant parasitic nematodes reports amounts to >10.000 per year.

Question (NL): Routine analysis or more research oriented analysis?
Answer (Georgia): Our laboratory is more research oriented, but also routine analysis for assessment of soil fertility is expected.

In the Netherlands about 95% of the soil analysis can be characterized as routine analysis. The remaining 5% is carried out in relation to agricultural research.

Question (NL): How many samples, chemical and physical, are actually annually analysed and which number is anticipated for the future?
Answer (Georgia): Currently, we are preparing the building for our soil laboratory, which will be equipped next year. Due to that we think to have up to 1000 samples in the first year, which probably will be doubled later.

The Netherlands: The number of soil samples increased from several 1000 soil samples in the 1930s to >100.000 soil samples in the 1990s. The number of soil samples decreased until 2000. Thereafter the number of soil samples increased again due to two main reasons. Firstly, the amount of P that may be applied depends on the soil-P content. Therefore the soil-P content need to be analysed. Secondly, soil fertility and plant nutrition was widely recognised by farmers, advisors, policy makers, and researchers as yield and quality determining factors. Analysis were promoted a.o. in farmers' study groups, agricultural magazines etc.

Question (NL): What kind of physical analysis you want to carry out?
Answer (Georgia): Soil texture, soil structure, permeability, bulk density, soil porosity, soil resistance, soil moisture, water holding capacity, soil temperature, aggregate stability.

The Netherlands: The focus of routine soil analyses has long been on the chemical soil fertility and plant parasitic nematodes (soil biological analyses) However, in the last decade serious efforts have been made to offer farmers more insight in soil physical and soil biological (other than parasitic nematodes) characteristics. Nowadays, a soil test report includes information about soil texture (percentage of clay, silt, and sand), soil structure (soil slaking, soil fracturing) calcium carbonate ($CaCO_3$), and the pF-curve (water holding capacity). These physical characteristics are all based on clay, silt, sand, $CaCO_3$, and organic matter. For example, the pF-curve is based on clay, silt, sand and organic matter.
The research oriented (so, non-routine analyses) part of the BLGG laboratory, as well as the laboratory of Wageningen University offer the above mentioned physical characteristics. However, the price is considerable higher (twofold or more) than routine soil testing and these characteristics are only used for (field) experiments.

Question (NL): What are the main chemical analysis anticipated?
Answer (Georgia): OM, pH, EC, mobile and total forms of macro and micro nutrients, toxic elements (e.g. arsenic, heavy metals), anions (e.g. chloride, fluoride, sulphate, bicarbonate, nitrate, nitrite). Also, assessment of radioactivity and content of pesticide residues is planned.

The Netherlands: A routine soil test includes N-total, C/N ratio, S-total, C/S ratio, P-Al (ammonium lactate), P-$CaCl_2$, K-CEC (Cation Exchange Capacity), K-$CaCl_2$, Mg-, Na-, Si-, Mo-, Zn-, Cu-, Co-, Mn-, Se-, Fe-, B-$CaCl_2$, soil organic matter (SOM), soil organic carbon (SOC), inorganic carbon ($CaCO_3$), clay%, silt%, sand%, pH, CEC, and Ca-, K-, Mg-Na-CEC. In addition mineral N and mineral S can be included.
Toxic elements are not routine analyses. Still, a wide range of toxic elements and anions is offered to the agricultural market. Radioactivity is not offered, Hundreds of pesticide residues can be analysed, >95% mainly on request by large food companies.

Question (NL): Who is collecting samples in the field, staff of the lab or farmers?
Answer (Georgia): Soil sampling for research purposes will be done by staff members, but we will train farmers and provide instructions to collect samples from their plots for soil fertility assessment.

The Netherlands: BLGG has divided the Netherlands in about 30 regions. Every region is supervised by a manager. This manager supervises several 'sample takers', but he also takes and collects samples himself. 'Sample takers' not only take soil samples but also feed samples (maize and grass forage), soil nematodes, water quality, manure, greenhouse analyses and more.

Question (NL): Are the senders of the samples assisted in interpreting the analytical results?
Answer (Georgia): The analytical results will be interpreted by our staff members and suitable recommendation on fertilization will be provided based on soil test and crop demand.

The Netherlands: A soil report not only gives the results of the soil analyses, but also presents a fertilization recommendation. The fertilization recommendations are largely based on several guidelines for fertilization. The recommendations are computerized. Staff members update this system year round.

4.2 Observations

The presentation 'Towards higher yield and crop quality' (Appendix 2) functioned as start of the discussion. It became clear that there is a strong wish to establish a new soil laboratory and embedding soil testing into Georgian agricultural practice.
In general farms have a limited size and land is often rented. In case the farmer is not the owner of the land then improving the soil fertility, e.g. increasing the P- or K status, of the land is complicated.
Farmers will only invest in soil fertility if he can benefit himself of this investment. This is only possible when the farmer has a long-term lease, at least 5 to 10 years. Even if it is evident that investments are essential It is difficult financing this improvement when no immediate effect on yield or quality can be expected. Moreover
there is always a risk that when the investments in the soil fertility result in higher yields the owner will increase the lease price.

On the second day of our visit a.o. an extension services centre was visited.
The extension services is supported by the government and started one and a half year ago. Georgia is divided into 54 regions and every region has an extension services centre. Advisors give advice for all sectors, from viticulture, fruit production, arable crops to dairy farming. The advisors are paid by the government, the farmer does not have to pay for their services. The extension services provide recommendations to groups of farmers, but more often the advisor advises the farmer on an individual basis. The advisors are partly specialised. So, when farmers want information on a specific subject, the specialist for e.g. water management, fruit quality or fertilization, is consulted. Advisors are trained on the job and use the internet to improve their knowledge about the wide range of topics. The advisors indicate that soil testing is not common, but that they would highly acclaim soil tests and fertilization recommendations based on soil characteristics.
Improving soil fertility status by animal manure is difficult in this region as no manure is available.
The third day we visited the Agricultural University and we met Prof Dr. Tengiz Urushadze who is coordinator of the World Reference Base for Soil Resources (WRB) for Georgia.

The legend of the new soil map of Georgia is based on WRB. The facilities at the University were visited and soil fertility and plant nutrition related issues discussed with Dr. Giorgi Ghambashidze. He is not only employed as assistant professor by the University but also affiliated with the Research Centre and responsible for establishing a routine soil test laboratory. Dr. Ghambashidze emphasized the need for robust analytical appliances that will last > 10 years. He also explained that, although soil testing is not yet common in Georgia, it is anticipated to test samples of the layers 0 – 20, and 20 – 40 cm, and possibly also 40 – 60 cm.
For optimal fertilization it will also be necessary to test the quality of mineral fertilizers. Sometimes the nutrient content originating from outside Europe or North America is questionable.

The last day we presented our findings (Appendix 2) and discussed the outcome with Dr. Ghambashidze, our other contacts of the Research Centre and Mrs Ekaterine Sanadze of the Ministry of Agriculture.

4.3 Discussion

Soil tests can play a major role in farmers' decisions on fertilization and soil management. Many farmers first consider the results of soil tests when making fertilization plans. Earlier, analysing individual soil characteristics was expensive and time consuming. However, with new analytical techniques (like NIR) soil can be analysed rapidly and in a relatively low cost manner.

Crop (tissue) analyses can also play an important role in monitoring crop quality and nutrient requirements. Crop analyses are not very common in the Netherlands. Until recently they were mainly used for fruit crops. However, interest in tissue analyses additionally to soil tests is increasing. One of the advantages of soil testing over tissue of crop analyses is that soil tests will be able to detect shortages in the soil (when using mild extracts to establish plant available nutrients) earlier than crop analyses.

In the Netherlands soil testing is part of a collaboration of government, university, research institutes, extension services and farmers. The laboratory BLGG has been part of this collaboration almost since the beginning of agricultural research in the Netherlands (BLGG was founded in the 1930s). Currently, Dutch agriculture is one of the most productive in the world as illustrated by the yield of cereals (*Figure 9*). These high yields are for a great part due to soil fertility management of which soil tests are an integral part. Soil testing is common in the Netherlands.

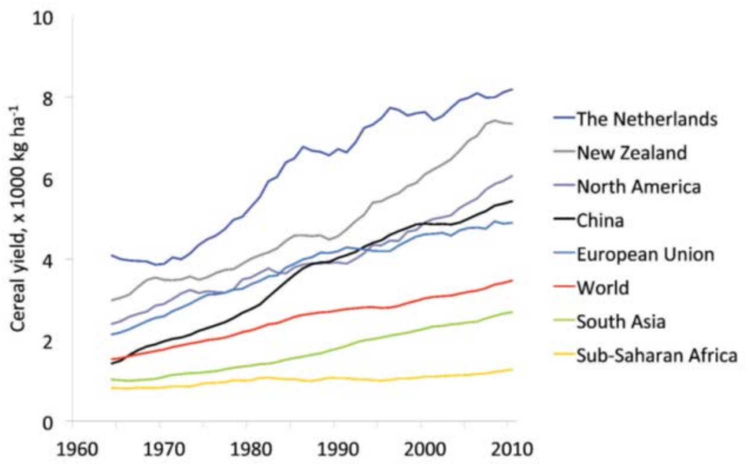

Figure 9. Changes in mean yield of cereals in different regions.

The information provided by the soil test report has increased gradually over the years. In the earlier days, each soil characteristic was analysed separately. This way of analysing was expensive and time consuming as different parameters require different procedures and extractants that varied per soil type.
Houba et al. (1990; 1994) and Van Erp (2002) proposed introducing the use of 0.01 M $CaCl_2$ as single extractant to assess readily plant available nutrients. From 2004 onwards, this method was gradually introduced. About the same time, the Near Infra-Red (NIR) method was introduced to assess basis soil characteristics in a rapid and relatively low cost manner, including soil texture, SOM, CEC, exchangeable cations, etc. Nowadays, only three basic soil test methods (0.01 M $CaCl_2$, NIR, and P-Al) are used. With NIR > 20 soil characteristics can be measured in one jar of glass (including N-total, S-total, CEC, exchangeable cations, SOM, SOC, $CaCO_3$, soil texture, pH). All these soil characteristics enable farmers to monitor and to improve soil fertility and consequently optimizing yield and crop quality.
In the soil test report a crop specific fertilization recommendation is included. Additional information is provided on the risk of soil physical decline, an organic matter balance is presented (how to maintain soil organic matter level) and the water retention curve (pF curve) is presented. The latter is used for determining the maximum amount of water that can be irrigated.

Most recommendations in the Netherlands are based on scientific research. Each sector (grassland and fodder crops, arable crops, vegetable crops, flower bulbs, nursery stock and fruit crops) has a steering committee for establishing fertilizer guidelines. In these committees farmers, extension workers, researchers and representatives of analytical laboratories are represented.

Worldwide, fertilization recommendations are generally based on a single soil test. However, combining two or more soil tests may provide more insight into the temporal dynamics and availability of soil nutrients to plant (especially P) and the crop response to fertilization (Appendix 2). The combination of P intensity (amount of P readily available for plant uptake), P buffering capacity, and P quantity has been the subject of several studies. From 2004 onwards, the combination of P quantity (P-Al), and P-intensity (P-$CaCl_2$) and P-buffering (P-Al/P-$CaCl_2$) was introduced and reported to farmers and their advisors.
More insight in soil characteristics will appeal to advisors to discuss the management options (which mineral fertilizer would be suitable, should the farmer invest in soil structure, etc.).
Apparently, in Georgia, all prerequisites are met to introduce routine soil testing for improving agricultural productivity and crop quality comparable to the Dutch system. The government, the University, the Research Centre, the Extension Services, and the farmers (according the advisors) all seem interested.

In the former Soviet Union everywhere the same soil analytical methods were used despite the wide range of different soil types. It is probable that not all analyses are suitable for predicting the soil-crop relationship and response to changes in soil fertility status in Georgia. Part of establishing a soil laboratory is to research which analytical methods are most suitable for fulfilling the objectives.

Worldwide many different soil tests are used. Mild extracting agents such as $CaCl_2$ can be useful for short-term fertilization recommendation (crop based) and stronger extracting agents (like P-Oxalate or P-Al) are useful for longer-term fertilization strategies. In most countries only a single soil test is used to establish fertilization recommendations. Using only one soil test (intensity test or quantity test) does not seem to justify the large differences in intensity which can occur within (for example) a given P-Al range. The difference between direct available nutrients and the stock present in the soil is also explained in Appendix 2. Moreover the analysis should help developing fertilizer guidelines for predicting the yield response to application of a specific nutrient.
In order to develop fertilizer guidelines for different crops fertilizer response experiments should be established for the main crops on the main soil types. The yield of the crop should be measured, quantitatively as well as qualitatively. Therefore also the nutrient uptake of crops should be analysed.

High labour costs in the Netherlands are an important reason for changing analytical methods while the quality of the analytical results is at least the same or even better than with traditional methods. Therefore the methods with different extractants for different nutrients was replaced by $CaCl_2$ as single extractant to assess readily plant available nutrients (except Ca). More recently the NIR method was introduced (firstly for quantity characteristics and more recently also for intensity characteristics like Ca-, and K-plant available).
Based on the discussions we had the institute wants to establish an analytical laboratory using the current methods.
It is anticipated that also in long term labour costs in Georgia will increase and cheaper methods that produce high quality results will become attractive. In order enabling correlation between different methods analysed soil samples should be stored in case new methods are introduced in the future.

4.3.1 Quality control

When setting up a laboratory it is essential developing procedures for controlling the quality of results produced. BLGG distinguishes three types of validation. Here the procedures for soil analyses are described but the same procedures apply also for tissue (crop) analyses.

First type
Regularly standard soil samples are analyzed. BLGG uses three standard soil samples for several years. These samples were extensively tested before they were introduced as standard samples. Great quantities of these three soils were collected and thoroughly homogenized.
If the results of the standard soil samples meets the criteria, the results of the (non-standard) soil samples are accepted. In case the results of the standard samples do not meet the criteria, the entire badge is analysed again.

Second type
The second type of validation includes several rules that may be used independently or simultaneously.
Single and duplicate analyses of non-standard soil samples are executed and results assessed.
For assessment of analytical results agricultural expert knowledge is used, e.g. soil organic matter of arable land on Dutch dune sands is not very likely to be higher than 3%.
Soil chemical relations (regression; e.g. soil pH is not very likely to be < 7 when $CaCO_3$ is > 10%).
The standard deviation of standard sample is monitored over period of weeks.
Occasionally soil samples analysed are resampled and analysed again.
For assessment of NIRS data, every week the NIR results are validated with results of 'classical' analyses which are executed in triplo.

Third type
BLGG participates in several laboratory exchange programmes in which the sample is analysed by the participating laboratories and the results are validated. These exchanges programmes exist for soils as well crop tissue samples, e.g. WEPAL (http://www.wepal.nl)

5 Fruit crops

5.1 Questions

Question (NL): Are young fruit trees locally grown or imported?
Answer (Georgia): We are producing fruit trees in our nursery – these are local trees

Question (NL): What is the relative importance of the different fruit species that are grown?
Answer (Georgia): In decreasing order of importance - apple, pear, plum, cherry

Question (NL): Which storage facilities are available?
Answer (Georgia): We have regular temperature controlled cold storages

Question (NL): What kind of analysis are anticipated in the pomological lab?
Answer (Georgia):
Pomological – tree size, harvest, fruit amount;
Chemical – brix, sugar, titrable acids, nitrate content, calcium content;
Morphological – fruit size, weight, flesh resistance (= fruit firmness), ripening process;
Phenological stages by BBCH;
Fruit cells – quantity and size of stomata.

5.2 Observations

During our visit we got an impression of on-going research in fruit production in Georgia. Due to lack of time we did not visit smallholders. The field visit to the research station gave us an insight in production of plant material and cropping systems.
The institute focusses on intensifying planting systems using semi dwarfing rootstocks (Wertheim, 1998). Visiting the field experiments made clear that the plant distance in the row was shortened while the distance between rows was maintained because of available machinery. A kind of replacement pruning is applied, whereby branches of three years or older, are removed down to the stem. It is thought that pruning methods can be improved.
More options than changing the planting distance are available for modernization of actual fruit production. In fact an integral approach is required of which planting is a part.
In the development of fruit production systems the light interception of PAR is the most important parameter for production levels and external as well as internal fruit quality.

In the integrated system approach, it is recommended to focus directly on aspects like pruning, bending and other growth regulation techniques, irrigation, cropping history, shelter for winds, tree shape and labour requirements.

5.3 Discussion

5.3.1 Technology of propagation of fruit rootstocks

In the Netherlands, vegetative propagation by soft cuttings is not the most common used method. The time between rooting and having reached a size suitable for budding, is relatively long when the generally small sized summer cuttings are used. Therefore layering and in vitro propagation are commonly used. Softwood cuttings (summer cuttings) are only used when starting production of a new type of rootstock or in specific situations. E.g. the company is specialised in working with summer cuttings, fits better in the activities of the company or the cuttings are produced on special order.

Another reason might be that some growers do not trust in vitro propagated rootstocks because confidence is lacking that all root stock properties are maintained when in vitro propagation is used.
It is known that most rootstocks used for apple, cherry, peach and plum growing can be propagated by summer cuttings. It is difficult to describe a standardized method as the rooting success depends on many parameters, e.g. variety, climatic conditions, juvenility of the (mother) stock plants, light interception of the stock plants (Tromp et al., 2005).

In the Netherlands trials with west - east planted hedges showed that the rooting success of cuttings from the shaded north side of mother plants is much lower than north - south orientated planted hedges.
Softwood cuttings are made in spring or early summer. Later in the season is not recommended, because the period till winter becomes too short. If cuttings are made too late survival rate in winter will strongly decline. There are two ways to increase the survival rate:
Firstly, it is important to transplant fresh rooted cuttings as soon as possible in bigger containers.
Secondly, to protect plants against very low temperatures. Ideally plants are brought to a controlled storage room. Otherwise, plants outside need to be covered. It is advised not to move boxes with young plants during periods with frost.
A factor with a positive effect on rooting is the time of the day the cuttings are made. It is recommended to make the cuttings early in the morning. Of course, a very quick and protected environment during transport is of utmost importance.
Cuttings must be dipped in water and transported in plastic bags containing some water. In general we take cuttings of 20 cm length with 3 or 4 leafs, but also much smaller cuttings have proved to be successful.
Generally we use rooting powder, talc to which plant growth regulators (plant hormones) are added. The following growth substances have been registered in the Netherlands (common concentrations used):

- Indole-3-acetic acid - IAA (0.5%, 0.7% and 1%);
- Indole-3-butyric acid IBA (0.1%, 0.25%, 0.4%, 0.6%, 0.8%. In the form of Rhizopon AA are the concentrations of 0.5%, 1%, 2%, 4% and 8% are available);
- α-napthylacetic - NAZ or brand Rhizopon B (0.1% and 0.2%).

For Malus species use of IBA is recommended.
The rooting powder to be used and the concentration depends on the type of plant. The Rhizopon company has published tables with recommendations. Cuttings are taken of juvenile (young) mother plants. Next, up to 1 - 2 cm of the cuttings are dipped in the rooting powder. Excess powder is removed by shaking. Thereafter cuttings are inserted into the cutting medium. Then the cuttings are placed in a hot and humid environment, e.g. by covering with plastic and spraying water. It is important to prevent the cutting from drying out. The cutting medium must be well moistened. It is also possible to place cuttings for 4 to 24 hours in a solution of the growth substance.
In general, a proven method to apply auxins by dipping the bases of cuttings for a few seconds (try different concentrations of IBA). IBA is light sensitive, solutions need to be light protected and stored cool. The dipping period and the concentration depends on the material and cultivar.

Fungicide treatment: if you have an authorized systemic agent, it is recommended to use this fungicide just before cuttings are placed in the moist medium.

Media: there are many different media available for stimulating root development of cuttings. For preparing mixtures that drain well peat, bark, sand, vermiculite and perlite are used.

Wounding: in most times, soft wood cuttings are not wounded. Wounding means to scratch 2 cm of the base of the cutting with a sharp knife, just to increase the surface for rooting and take up the added rooting stimulator.

Reducing evaporation: Best results are made using added mist and fog. The vapour pressure deficit should be kept as small as possible. Root development of 'difficult' cultivars can be stimulated in glasshouses with automatic 'dry fog' control. Specialised supply companies are listed in 5.3.2.

Shading: another method to reduce evaporation is shading of the glasshouse. This also prevents overheating of the cuttings. Only 25% full sunlight is necessary for development of a good quality root system.

After the cuttings have rooted, the hardening process must start. Hardening off in glasshouses is controlled by reducing the air moisture content. The period of rooting should be kept as short as possible. Consequently the rest of the season plants can grow outdoors and the hardening process can start.

5.3.2 The identification of suitable equipment for greenhouse propagation

Below a list of some Dutch horticultural companies that sell equipment for propagation in greenhouses is presented. The list is without any value judgement and the order is at random.

Mist and fog systems for propagation
www.bspnederland.nl
www.reldair.nl

Plant production tables
www.valeka.nl
www.kweektafel.eu
www.filclairkassen.nl
www.vermeulenkassen.nl
www.keesgreeve.nl
www.horticoop.nl

Construction of glasshouses
www.amevotechniek.com
www.alleblas.nl
www.alweco.nl
www.hermanbatist.nl
www.boalgroup.com
www.boschinveka.com
www.boukens.com
www.keesgreeve.nl
www.havecon.com
www.vanderhoeven.nl

5.3.3 Fruit tree feathering technology

The Netherlands has a classification system for the quality of fruit trees based on branching. However, the system is flexible as many companies have developed their own system in an attempt to distinguish themselves on the market.
The following standard classification was used for many years.

Standard Dutch Classification for fruit trees:
1. AA (the best quality)
2. A
3. B
4. Unfeathered trees

A tree with six well-placed branches was top AA quality for many years. However, more branches are nowadays needed in order to compete on the international market.

Feathering methods are based on the influence of the apical dominance (Tromp et al., 2005). In short, the influence of auxin versus cytokinin balance determines whether lateral buds will develop into shoots. Auxins are produced in top shoot and transported downwards (basipetal) while cytokinins are produced in stem and roots and transported to the top (acropetal).
How this process works is not yet fully elucidated. Regularly still new substances are found that have a plant hormone like activity. However, based on the balance between auxins and cytokinins the chemical industry is working on substances that influence branching. Several active ingredients with different brand names are available on the Dutch market. In particular, 6-BA (=6-benzyl-adenine) is most commonly used to promote branching. Some products contain besides 6- BA also the gibberellin A4/7 (GA4/7). In particular 6-BA has proven, when used repeatedly during the growing season, to effect branching positively. The effect is species-specific and a general guideline is not available. A disadvantage of 6-BA is that it reduces the angle with the central stem. This may cause the breakage of branches. Carefully bending in the first year after planting is recommended. It is also recommended to start trials with as variables, varieties, concentration of the ingredient and time of application. In this way knowledge is acquired for the main apple varieties in relation to climatic and soil conditions.
The first application of 6-BA should be done when the shoot has reached a certain length, e.g. 12 cm. Another possibility when a certain number of leaves is present, e.g. 6 leaves. The effectiveness of plant growth regulators can sometimes be improved by the addition of a wetting agent, like Citowet, produced by Dupont. Citowet or comparable products can also be used for increasing effectiveness of herbicides, insecticides and fungicides
We developed methods for reducing the use of chemical feathering substances. Most effective is the combination of the chemical 6-BA treatment with pinching in the season. We had good results using 6-BA once and pinching the top leaves 5 times in the period May to the end of July.

5.3.4 Evaluation of fruit cultivars

As discussed during our visit, it is highly recommended to use international standards for both the evaluation of rootstock and fruit varieties. These standards can be downloaded from the UPOF site (www.upov.int). Using these standards makes it possible to compare results obtained elsewhere.

5.3.5 Equipment for a pomological laboratory

In the Netherlands a pomological pre- and postharvest lab is used for measuring three important characteristics:

1. Prediction of the harvest date;
2. Quality of the harvested product;
3. Developing storage protocols for new varieties.

Harvesting at the right moment is important as it will increase the length of storage time.
We learned that in Georgia the storage technology used by small holders is simple. Apples are mainly kept in cellars without the possibility of temperature or air composition regulation. Especially the traditional varieties are suitable for this type of storage. In these cellars apples can be stored from harvest till spring (November – March).
As economic development will progress in Georgia it is anticipated that demand for better quality fruit will also increase. The relevant varieties require improved storage conditions and the moment of harvest need to be predicted accurately.
Internationally the Streif method is widely used for predicting the right moment of harvesting. Implementing this method can contribute substantially for improving the product quality in complete chain from producer through retail to consumer.
The method is described in detail by Van der Geijn et al., (2012). The optimal period of harvest is indicated by the Streif Index coefficients. The first step is that these coefficients need to be measured for varieties grown in Georgia.

Streif Index = firmness / (soluble solids x starch index)

The practical usefulness of the Streif Index method is the ease of evaluating the degree of maturity in relation to its suitability for long-term storage with Controlled Atmosphere (CA) or Ultra Low Oxygen (ULO) conditions.

At Wageningen UR we have much experience with prediction optimal harvest periods and related storage conditions. Also courses on this topic are available.
On the market equipment is available that evaluates maturity using the Streif method. Also characteristics like firmness, content of sugar and iodine are measured at one and the same time.
Also the required camera for background colour and software are available.

For developing a strategy for fruit storage it is important focussing on products for which storage provides an added value. The remaining fruits may be sold on the local market or processed.
The Streif index supports producers to take marketing decisions. The institute could take a leading role in this process.

6 Recommendations and actions

6.1 Soil analysis

Opportunities for NIR
NIR is a spectroscopic method using the near infra-red region of the electromagnetic spectrum from 800 – 2500 nm. BLGG uses NIR to analyse roughage, raw materials and soil samples. For reliable results it is of utmost importance that pre-treatment of soil samples is uniform and that the mathematical model used to calculate the desired characteristics is based on a large data base. Over the years, BLGG has set up a large number of calibration sets containing data from samples that are analysed by both NIR and reference methods. The data base consist of >100.000 soil samples originating from countries worldwide with very different soil characteristics; for example different clay minerals, clay content (from 0 tot >50%), and organic matter content (from 0.2 - >35%). One way for exploring the possibilities of NIR could be by sending 100 soil samples to BLGG. The samples will be analysed and we will then study whether the Georgian data ($CaCO_3$, pH, and organic matter) fit in the current mathematical NIR-model.This study will support Georgian scientists in their decision which methods to be used.

When soil testing is widely adopted and is done routinely, composing fertilization recommendations by hand is time-consuming. At least part of these recommendations could be computerized, e.g. the pH-recommendation. In this way also possible errors can be excluded.

In case the results of soil analysis are accompanied by fertilization recommendations, still most farmers want to discuss these results with an advisor. Therefore it is important to improve the knowledge of advisors regarding soil characteristics, fertilization and crop requirements.

Soil test procedures or methods are regularly adapted based on new knowledge. Therefore it is important to be able to correlate the 'old' and 'new' results. Storage of analytical results and samples enables such a correlation.

Invest, or keep investing in field research for scientific purposes, but also to demonstrate farmers and advisors the benefits of soil testing and recommendations. It will show land owners that it can be profitable investing in soil fertility.

To stimulate the use of soil tests, the government could, at least in the beginning, (partly) subsidize soil testing.

A visit of Georgian scientists to BLGG Laboratories is thought to be useful. During such a visit the working procedures of BLLG can be discussed as well as in-depth discussions with different experts, a.o. NIR, 0.01 $CaCl_2$ method, soil pre-treatment, storage of soil, soil sample-takers, can be held.

6.2 Fruit crops

Regarding fruit cultivation the following stepwise approach is proposed:

1. Making an analysis of the national and international opportunities for the Georgian pip fruit (apple and pear) cultivation;
2. Translate these challenges into the production and marketing, both technically and including the socio-economic context of the production in different regions;
3. Writing a plan to achieve these goals with the specific role of all stakeholders in the Georgian fruit chain. Stakeholders are a.o., growers, Georgian government, Agricultural Scientific Research Centre, extension agents, retailers and consumers;
4. Identification of knowledge gaps in the production phase;
5. Probable solutions for handling these knowledge gaps;
6. Stepwise introduction of new techniques in logical order and timeframe.

We did not visit production orchards. Therefore specific recommendations regarding these orchards are not possible.
During our visit we got a good overview of the on-going research activities of the Centre. Attempts are made for intensification of fruit production. However, an integrated approach is recommended and probably required for establishing new orchards.

Important topics that are related to the introduction of modern fruit growing are:.

a. Describe new high density cultivation systems that are financially sustainable, for traditional as well as new high potential pip fruit varieties;
b. The establishment of orchards that can be used for research as well as for transfer of knowledge;
c. Introduction of required machinery for modern high density pip fruit production;
d. Linking each release to (free) courses;
e. Train the trainer programs for local consultants on each new aspect of the production system.

The Agricultural Scientific Research Centre could start with:

- Vegetative production of rootstocks (summer and winter cuttings), including pest control and management of the propagation;
- Budding technique for uniform rootstocks in open field;
- Winter grafting of rootstocks;
- Planting techniques;
- Growth regulation technique
    - Pruning techniques
    - Bending
    - Thinning (bloom and fruits)
- Selecting machines for intensive fruit production.

6.3 Other actions

Future cooperation between Georgian institutions and Wageningen UR was discussed with Dr. Huub Löffler, director of Wageningen International of Wageningen UR. Three questions need to be answered:

- What is the added value of cooperation for both parties?
- On which topics cooperation can be established?
- Who is financing the cooperation?

A start with formulating answers to the first two questions was made during our visit and is continued in this report.
It is us not yet clear whether European funding is available for financing a probable cooperation. This might be possible under the Association Agreement with the European Union that has been signed in June 2014. Dr. Löffler supports the exchange of students as a start of establishing a sustainable cooperation.

With Mr. Rien Bor (Wageningen UR - Bureau of International Communication & marketing) the invitation to participate in the Education Fair to be held in February, 2015 in Tbilisi was discussed. In December 2014 the bureau of will decide on the programme for 2015. Then will be known in which countries Wageningen UR will participate in promotional activities.

Prof. Urushadze is organizing an Olympiad for soil science students. He invited Dutch students to participate in this contest. Winners will be invited to join a 10 day lasting fieldtrip in Georgia. The costs, except the air ticket to Georgia, will be covered by the organizers.
The Olympiad was discussed with Dr. Jetse Stoorvogel of the Chair group Soil Geography and Landscape of Wageningen UR. Dr. Stoorvogel will forward the invitation to students of the discipline 'Soil, water and atmosphere'.
From the Dutch side it is also proposed to exchange students. A student of Wageningen University may spend a certain period in Georgia and the other way around. In case both parties agree on a certain topic such an exchange can be the start of further cooperation. Possibilities for funding will be explored, e.g. Erasmus programme of the EU.

In the period 1980-90 average yields of many crops were at least three times higher than yields in period 2011-13 (Figure 6). In these years important changes have taken place. In any case the gap indicates that there is a potential for increasing the actual yields.
The question arises why yields have declined. As one of the important reasons the collapse of the irrigation infrastructure was mentioned. Probably also other factors related to the switch of a planned to a smallholder agriculture have played an important role.
Technical measures may help increasing yields but also socio-economic aspects, including entrepreneurship of farmers, need to be considered. A stakeholder analyses in the agricultural production chain helps identifying areas for intervention aiming at strengthening the position of farmers.

The Dutch organization NUFFIC manages various programmes that specifically aim to strengthen the performance of individuals, organisations and institutions in developing countries or to help them develop their capacities by extending their expertise, know-how and skills (http://www.nuffic.nl/en).
In consultation with the Dutch Embassy will be explored which programme is most suited for strengthening cooperation between Georgia and the Netherlands.

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http://www.wepal.nl
http://www.nuffic.nl/en

Appendix 1 – Demands of the Centre

Specification of the demands of the Centre

In the field of standardization of rootstocks, scions and planting material for permanent crops (e.g. vines and fruit trees):

* Technology of propagation of fruit rootstocks (type Gf 667, Gisela 6 and etc.) propagation by hardwood, semi hardwood and green cutting method.

* The identification of suitable equipment (mist irrigation, climate control, Tables for propagation chambers and etc.) for propagation greenhouse. Tables for propagation chambers and etc. for propagation greenhouse.

* Fruit tree feathering technology (methods, timing).

* Planting material standards (size, caliper).

* Approach of evaluation of fruit cultivars (Yield, storage, phenological and phenototipical issues).

* Equipment for a pomological lab.

In the establishment of a laboratory for soil analysis:

* Support in the creation of a data base for analysing samples and its effective management.

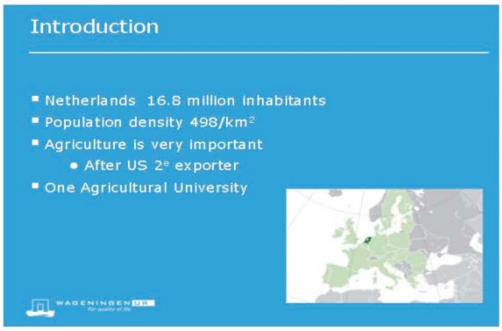
* Support in the management of reagents and consumables data base.

* Support in the organization and exchange of data within the laboratory.

* Support with the field equipment to take soil samples and study soil physical properties in the field conditions.

* Support in the laboratory equipment and modern methodologies for laboratory investigation of soil physical properties.

Appendix 2 – Presentations



Introduction

Animal husbandry

- Different farm types (2013)

	Dairy	Pig	Poultry
No. of animals	1.5 m	1.2 m	80 m
Av. per farm	83	2209	40.000

Milk production 8000 l/cow/year

Introduction

Arable farming

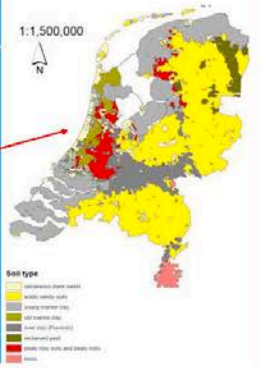
- Main crops in 2013

Crop	Surface area ha	Average yield t/ha
Wheat	152.753	8.8
Potatoes Edible - Starch - Seed -	 71.568 44.031 40.223	 50 42 36
Sugar beet	73.194	77

- Average farm size 26 ha

Introduction

Soil map

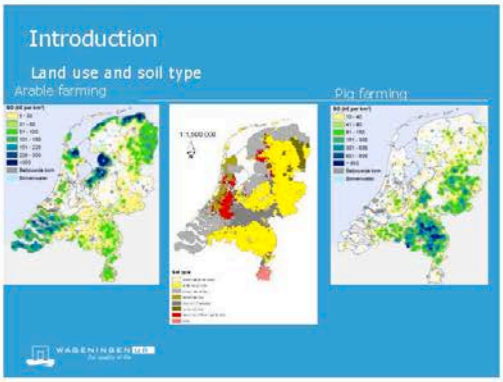


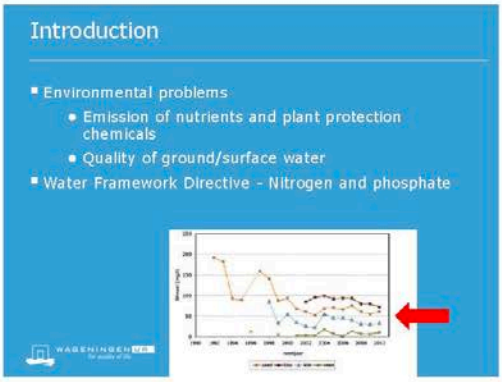
Introduction

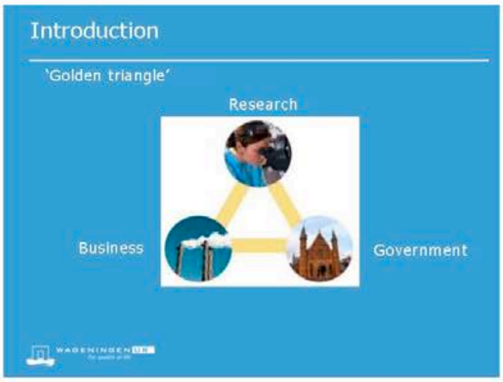
Land use

Arable farming

Pig farming


Introduction
Land use and soil type
Arable farming
Pig farming
1:1,500,000
Soil type
WAGENINGEN UR


Introduction
Environmental problems
Emission of nutrients and plant protection chemicals
Quality of ground/surface water
Water Framework Directive - Nitrogen and phosphate
WAGENINGEN UR


Introduction
'Golden triangle'
Research
Business
Government
WAGENINGEN UR


Wageningen University & Research Centre
One Agricultural University
Wageningen location of many institutes
Wageningen University & Research Centre
5.000 staff
10.000 students
107 nationalities
BLGG AGROXPERTUS
WAGENINGEN UR


Wageningen University & Research centre
Wageningen University
Contract Research Organisation

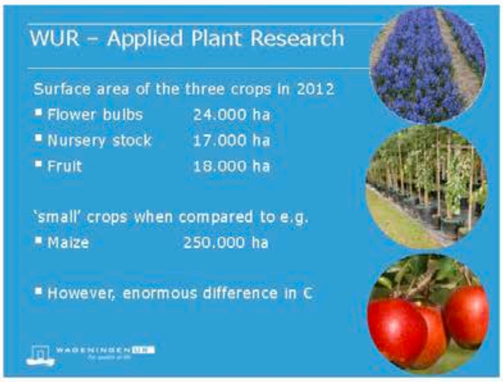

Wageningen University & Research centre
Wageningen University
Contract Research Organisation


Wageningen University & Research centre
Wageningen University
Contract Research Organisation

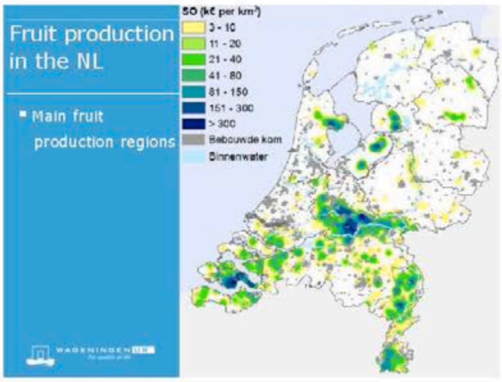

WUR - Plant Sciences Group
Wageningen University
Plant Sciences
Plant Research
International
Praktijkonderzoek
Plant & Omgeving/Applied
Plant Research
Fundamental
Strategic
Applied
•Arable farming & vegetable cultivation
•Greenhouse horticulture
•Flower bulbs, Nursery stock & Fruit

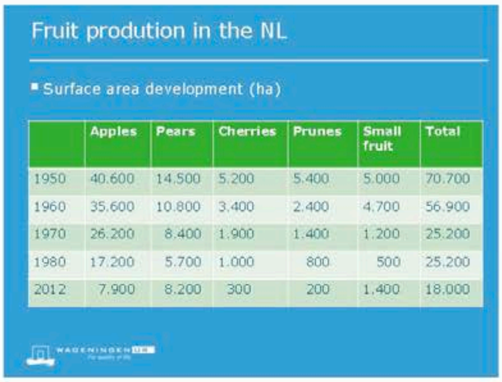

WUR - Flower bulbs, Nursery stock and Fruits
Lisse
Flower bulbs
Randwijk
Nursery stock and Fruits


WUR - Characteristics of applied research
Complete chain of plant production and it's direct environment
Make knowledge applicable by co-operation of research and practice
Network both in practice and research
Sustainable solutions to improve output and innovative strength of individual companies


WUR – Applied Plant Research
Surface area of the three crops in 2012
Flower bulbs 24.000 ha
Nursery stock 17.000 ha
Fruit 18.000 ha
'small' crops when compared to e.g.
Maize 250.000 ha
However, enormous difference in €


WUR-Applied Plant Research
Main research topics
Soil and water
Sustainable production systems
Quality in the chain
Street Trees and Urban Green
Optimize cultivation
Plant health

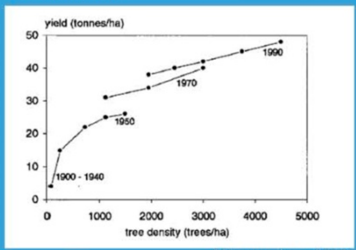




	Apples	Pears	Cherries	Prunes	Small fruit	Total
1950	40.600	14.500	5.200	5.400	5.000	70.700
1960	35.600	10.800	3.400	2.400	4.700	56.900
1970	26.200	8.400	1.900	1.400	1.200	25.200
1980	17.200	5.700	1.000	800	500	25.200
2012	7.900	8.200	300	200	1.400	18.000

Fruit production in the NL

Intensification



(Wagenmakers, 1995)

Fruit production in the NL

Fruit trees

Year	Surface area ha	No. of companies	Average farm size ha
2000	1251	363	3.45
2005	1257	232	5.42
2010	1375	212	6.48
2013	1589	209	7.60

Fruit production in the NL

Surface area development (ha)

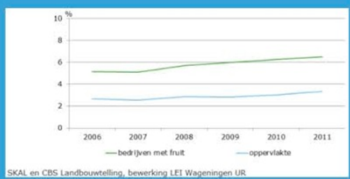
Year	Apple	Pear	Other fruit	Fruit trees	Total
2000	12834	6019	1747	1251	21851
2005	9737	6692	2138	1257	19825
2010	8681	7995	2800	1375	20851
2013	7906	8509	2647	1589	20651

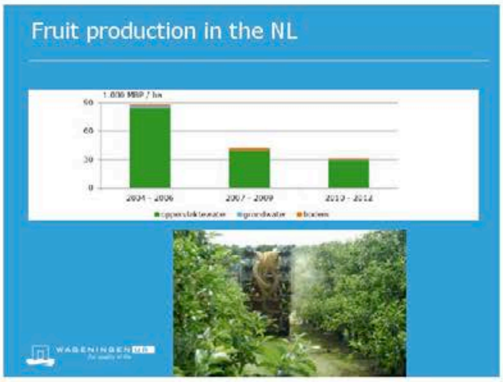
Average farm size (ha)

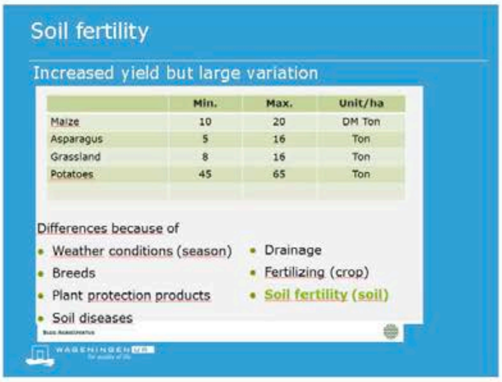
Year	Apple	Pear	Other fruit	Fruit trees
2000	5.60	2.69	1.27	3.45
2013	5.81	5.65	2.46	7.60

Fruit production in the NL

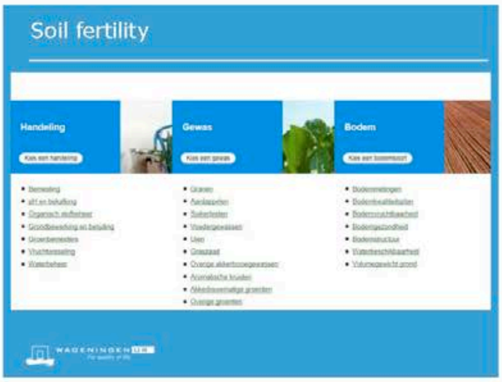
Organic fruit







	Min.	Max.	Unit/ha
Maize	10	20	DM Ton
Asparagus	5	16	Ton
Grassland	8	16	Ton
Potatoes	45	65	Ton




Thank you for your attention

BLGG

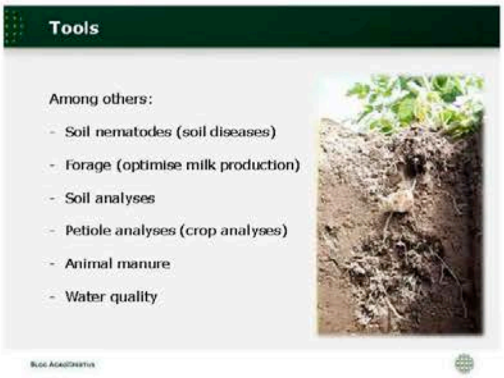
BLGG

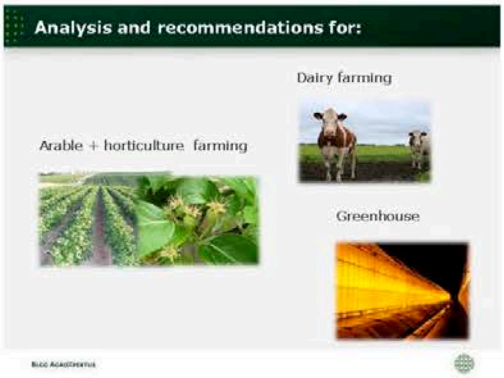
- Agricultural laboratory: > 500,000 samples per year
- Head office: Wageningen, The Netherlands

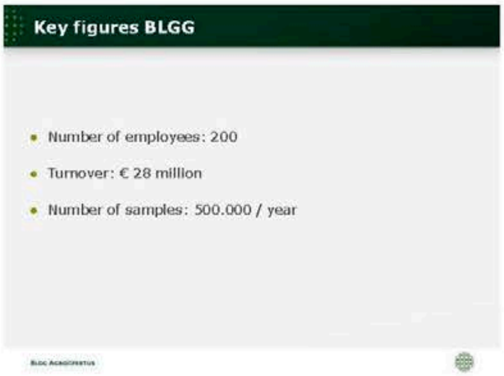
BLGG objective

Supply 'tools' to farmers to obtain

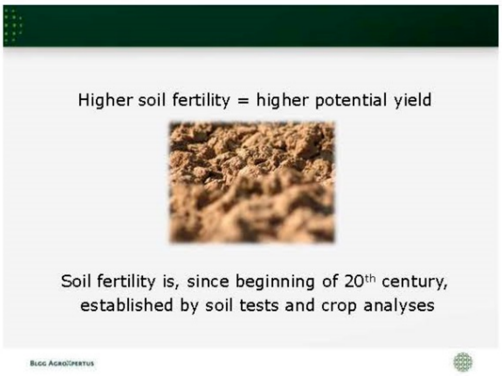
- High production (yield)
- High crop quality
- Efficient use of nutrients (artificial fertilizer, manure..)


Tools
Among others:
- Soil nematodes (soil diseases)
- Forage (optimise milk production)
- Soil analyses
- Petiole analyses (crop analyses)
- Animal manure
- Water quality

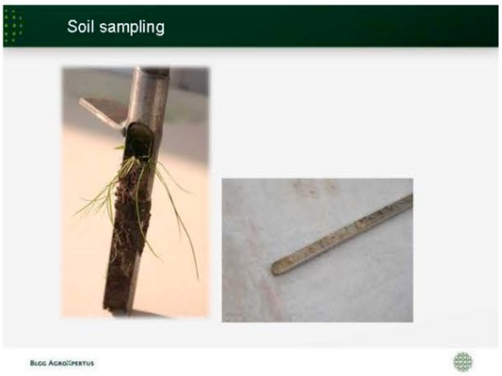

Analysis and recommendations for:
Dairy farming
Arable + horticulture farming
Greenhouse


Key figures BLGG
Number of employees: 200
Turnover: € 28 million
Number of samples: 500.000 / year

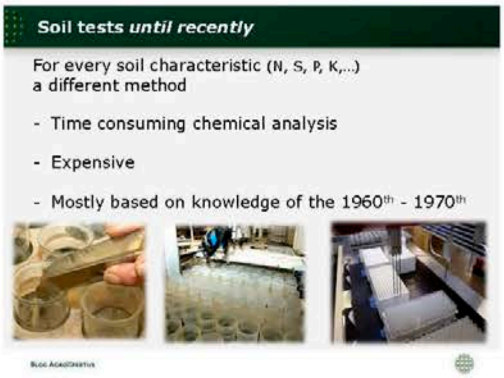

Soil fertility & Plant nutrition


Higher soil fertility = higher potential yield
Soil fertility is, since beginning of 20th century, established by soil tests and crop analyses

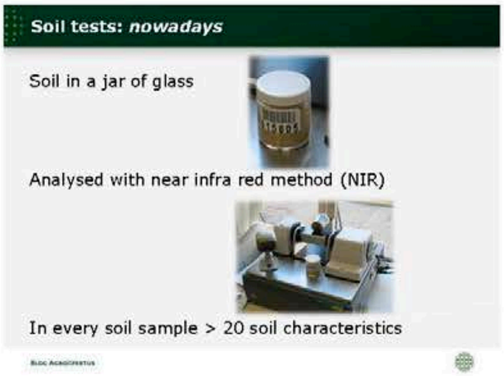

Soil sampling

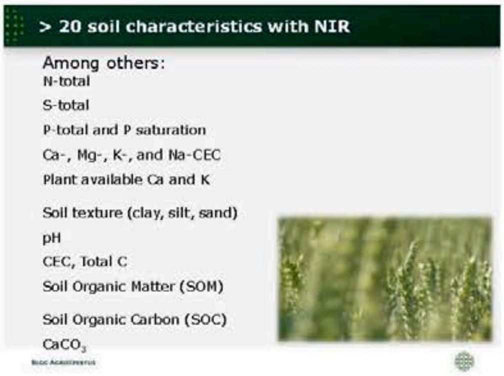

Soil sampling


Soil tests: until recently


Soil tests until recently
For every soil characteristic (N, S, P, K,...)
a different method
- Time consuming chemical analysis
- Expensive
- Mostly based on knowledge of the 1960th - 1970th

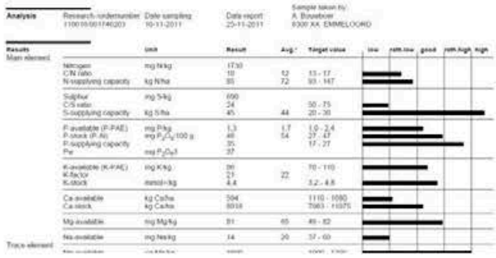

Soil tests:
nowadays


Soil tests: nowadays
Soil in a jar of glass
Analysed with near infra red method (NIR)
In every soil sample > 20 soil characteristics


> 20 soil characteristics with NIR
Among others:
N-total
S-total
P-total and P saturation
Ca-, Mg-, K-, and Na-CEC
Plant available Ca and K
Soil texture (clay, silt, sand)
pH
CEC, Total C
Soil Organic Matter (SOM)
Soil Organic Carbon (SOC)
CaCO3

From soil test to report

Those > 20 soil characteristics of the soil test are transformed to a report



Analysis	Research-/ordernumber	Date sampling	Date report	Sample taken by
	110016/001740203	10-11-2011	25-11-2011	A. Bouwboer 8300 XX EMMELOORD

Results		Unit	Result	Avg.*	Target value
Main element	Nitrogen	mg N/kg	1730		
	C/N ratio		10	12	13 - 17
	N-supplying capacity	kg N/ha	85	72	93 - 147
	Sulphur	mg S/kg	690		
	C/S ratio		24		50 - 75
	S-supplying capacity	kg S/ha	45	44	20 - 30
	P-available (P-PAE)	mg P/kg	1.3	1.7	1.0 - 2.4
	P-stock (P-Al)	mg P_2O_5/100 g	48	54	27 - 47
	P-supplying capacity		35		17 - 27
	Pw	mg P_2O_5/l	37		
	K-available (K-PAE)	mg K/kg	86		70 - 110
	K-factor		21	22	
	K-stock	mmol+/kg	4.4		3.2 - 4.8
	Ca-available	kg Ca/ha	594		1110 - 1680
	Ca-stock	kg Ca/ha	8018		7983 - 11075
	Mg-available	mg Mg/kg	81	65	49 - 82
	Na-available	mg Na/kg	14	20	37 - 60
Trace element	[illegible]	[illegible]	[illegible]		[illegible]

On the report

- Fertilization recommendations (nutrients)
  - Among others Phosphorus **Example I**
- Extra information
  - CEC **Example II**
  - Organic matter balance **Example III**
  - Soil structure
  - Water retention curve **Example IV**
  - Soil type

Example I
Phosphorus

Phoshporus (P)

Recommendations based on:
- Plant Available P

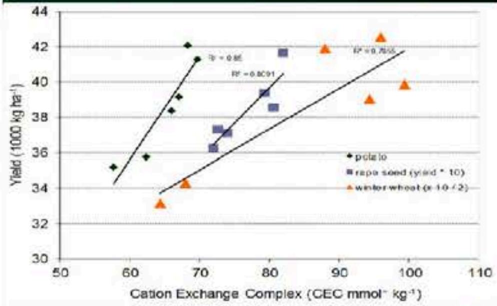
  as well as on
- Soil supplying capacity

Improved root development:
better uptake of nutrients
and less drought sensitive

Example II

CEC

CEC and yield potential



CEC can be improved by:

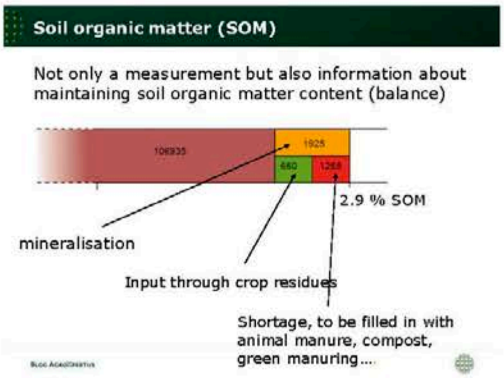
Effective CEC improved by pH improvements

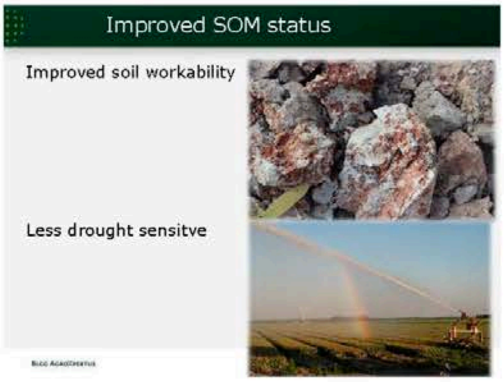
CEC improved by input organic matter

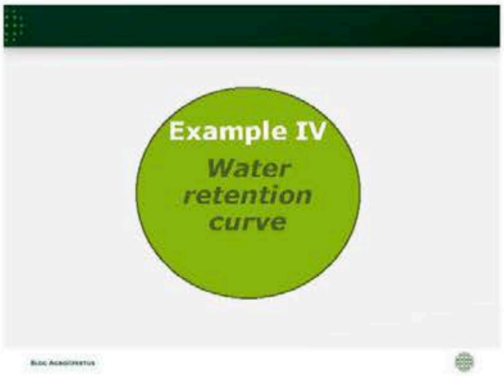
- Crop residues
- Compost
- Animal manure
- Green manuring
- Organic fertilizer

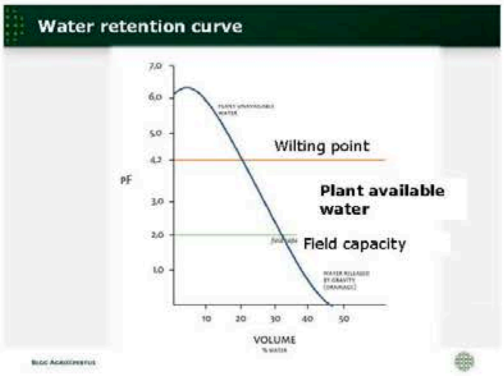
Example III

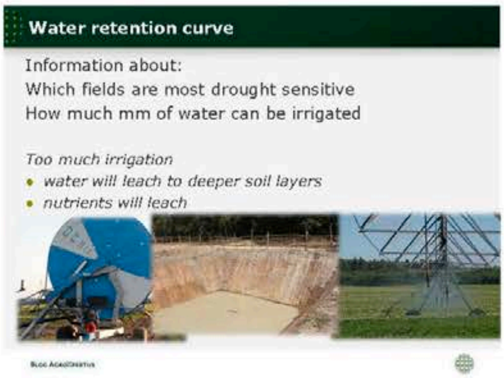
Organic matter


Soil organic matter (SOM)
Not only a measurement but also information about maintaining soil organic matter content (balance)
106935
1925
660
2.9 % SOM
mineralisation
Input through crop residues
Shortage, to be filled in with animal manure, compost, green manuring....


Improved SOM status
Improved soil workability
Less drought sensitve


Example IV
Water retention curve

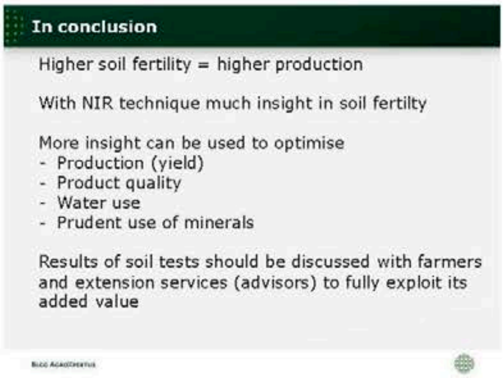

Water retention curve
7,0
6,0
5,0
4,2
3,0
2,0
1,0
PF
Wilting point
Plant available water
Field capacity
10
20
30
40
50
VOLUME

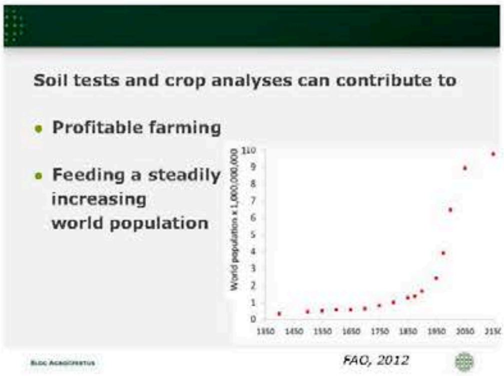

Water retention curve
Information about:
Which fields are most drought sensitive
How much mm of water can be irrigated
Too much irrigation
• water will leach to deeper soil layers
• nutrients will leach


Petiole sampling (crop analyses)


Finally


Sampling sites
NIR stations could be established everywhere (worldwide)


In conclusion
Higher soil fertility = higher production
With NIR technique much insight in soil fertilty
More insight can be used to optimise
- Production (yield)
- Product quality
- Water use
- Prudent use of minerals
Results of soil tests should be discussed with farmers and extension services (advisors) to fully exploit its added value


Soil tests and crop analyses can contribute to
Profitable farming
Feeding a steadily increasing world population
World population x 1,000,000,000
FAO, 2012


Questions?

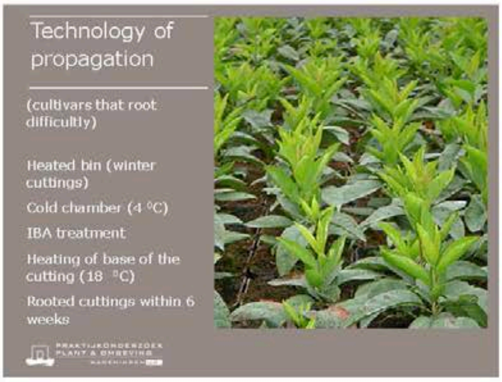

Support and consultation mission for the Agricultural Scientific – Research Center,
Fruit production
28th Oktober 2014, Marc Ravesloot
PRAKTIJKONDERZOEK PLANT & OMGEVING
WAGENINGEN UR

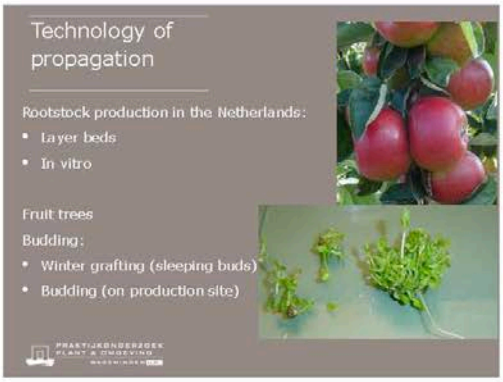

Introduction
Most fruit cultivars do not reproduce true from seed (apimixis)
So unique and valuable seedlings or hybrids should be propagated by vegetative way
Fortunately, closely related plant species can be grafted
Starting point for reseach on varieties and rootstocks
PRAKTIJKONDERZOEK PLANT & OMGEVING
WAGENINGEN UR


Technology of propagation
History
Confusions in names
Absence of good botanical descriptions
Lack of comparative experiments
Scientific efforts: 1912, UK East Malling
1. Methods of classification
2. Detailed descriptions
3. Judge their merits
PRAKTIJKONDERZOEK PLANT & OMGEVING
WAGENINGEN UR


Technology of propagation
Used in the Netherlands
Apple: M9 (Elstar/Golden)
Pear: MC (Conference)
Cherry: Gisela 5 (Kordia/Lapins)
Plumb: WA-1 (Prunus spinosa S766) St. Julian A (Opal/Victoria)
No production of peach, almond, nectarine.....
PRAKTIJKONDERZOEK PLANT & OMGEVING
WAGENINGEN UR


Technology of propagation
Layer bed rootstock production
You tube: film Kriellaars Nurseries
https://www.youtube.com/watch?v=Q1G_H3t45_o&feature=youtu.be


Technology of propagation
(cultivars that root difficultly)
Heated bin (winter cuttings)
Cold chamber (4 °C)
IBA treatment
Heating of base of the cutting (18 °C)
Rooted cuttings within 6 weeks


Technology of propagation
Rootstock production in the Netherlands:
• Layer beds
• In vitro
Fruit trees
Budding:
• Winter grafting (sleeping buds)
• Budding (on production site)

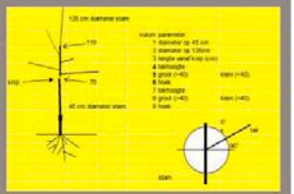

Identification of suitable equipment
• Difficult to prepare
• Find out what is the exact demand
• List of questions to find out
• Preparing answers at a later stage

Feathering technology

- Induction of lateral side-shoot formation
- "How to make one year old feathered apple trees"
- Reduction of appical dominance

Feathering technology

- Started '70-'90: promalin/paturil
- Apple and Pear
- 4-8 times
- Pure chemical approach in the '90
- Later, approach to decreasing labor costs

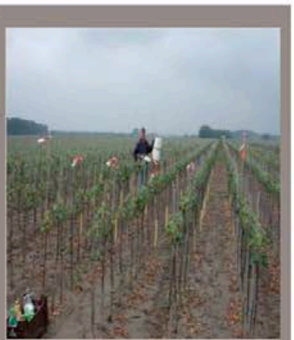


Feathering technology

- Starting:
- Height of 65 cm or
- when 9 full grown leaves

Feathering technology

- Pinching in combination with BA treatments give good results for a wide range of apple varieties
- Treatments depends on:
- Climate (RH / soil temperature)
- Variety (easy and difficult CV's)




Feathering technology
Difficulty of pinching
Meristeme
Best results when women do this job


Approach of evaluation
International network
International membership
ISHS
Working groups
Join or lead a working group
Network
Literature
ISHS


Approach of evaluation
Simple and effective
Collect plant material from international breading programs
Material transfer agreement (MTA)
Test cultivars under own climate conditions
Market introduction
Appelcam2.wmv


Approach of evaluation
Evaluation of fruits (basic)
Strict selection (focus)
5 trees
First fase evaluation (2-4 years)
Half of the normal crop protection
Secondly: small orchards
Finding interested business partners
UPOF guidelines

Planting material standards

- Classification:
- AA >6-7 branches
- A 3-5 branches
- B just a few branches
- "snoeren" trees without good placed branches

PRAKTIJKONDERZOEK PLANT & OMGEVING WAGENINGEN UR

Planting material standards

- But, "for every quality a client"
- So: different producers make their own classification
- AA+
- AA
- A+
- B
- "snoeren"

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Planting material standards

- a. planting system
- b. investment space
- c. best possible fruit trees shapes

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Equipment pomological lab

Control room for post harvest research

- Storage protocols for new cultivars
- Best picking moment
- New storage innovations 1-MCP

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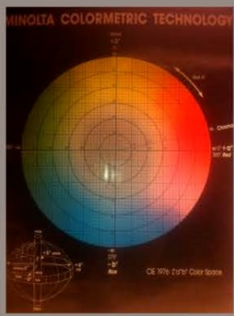
Equipment pomological lab

Brix
Refractometer

Equipment

Color
Background color



Equipment

Starch/sugar ripening process

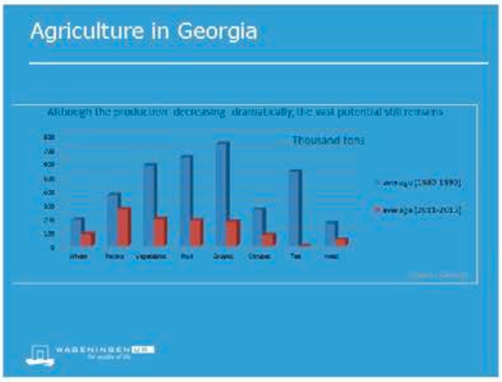
Sugar content

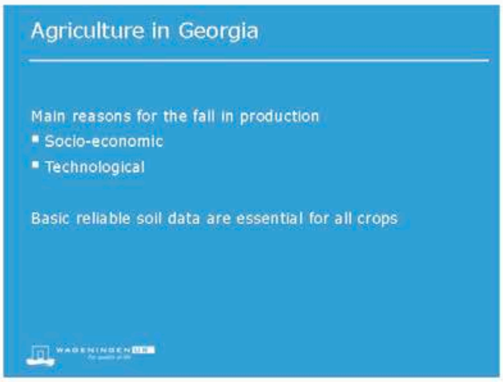
Acid content

Thank you for attention

Time for questions and discussion


Recommendations and discussion
Support and consultation mission for the Agricultural Scientific – Research Center, Tbilisi, Georgia
31 October 2014


Agriculture in Georgia
Thousand tons


Agriculture in Georgia
Main reasons for the fall in production
▪ Socio-economic
▪ Technological
Basic reliable soil data are essential for all crops


Agriculture in Georgia
▪ Role of the LEPL Agricutural Scientific-Research Centre
▪ Laboratory for Soil and Plant analysis

Soil testing

- Higher soil fertilty = higher production

Soil testing

- Good soil fertilty = less problems with crop quality

How to implement soil testing: *prerequisites*

- Georgian government wants to invest in agriculture to get agricultural production on a higher level
- Agricultural Research Centre will be building a soil laboratory
- Establishment of extension services 1.5 year ago in 54 (all) districts

So...the basis seems very good!

(from University – Agricultural Research Centre – Advisors to Farmers)

Introducing soil testing

Objective?!

In 10 years?, every farm will have a soil test result (0-20 and 20-40)

40.000 farms /10 years = 4000 samples per year x 2 layers = 8.000 samples per year

---

Extension service is supported by the government

Soil tests also subsidized by the government ?

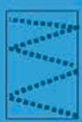
and let it be part of the task of the extension services to 'explain' the soil test results

---

Soil sampling

- Material: soil cores



- Instructions for the soil sample takers
  - Future: regional soil sample collectors
- Transporting (small boxes, bags)
- Instructions for the laboratory (which analyes/crops)

Soil analyses

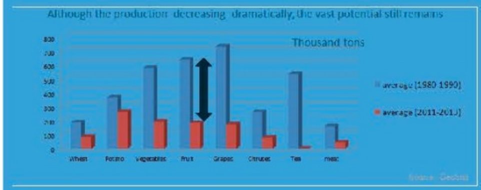
- Pretreatment: drying/ sieving
- Usual methods or alternative methods?
  - Multi nutrient methods
  - NIR possibilities
  - Cost efficient
  - Research needed

- Create data base (store soil and plant samples)

Interpretations

- Soil based: target values
  - Yield response trials
- Development of fertilization guidelines for various crops
- From hand-based to computer-based interpretations

Fruit production



Main challenge

How can the actual fruit production be increased in a sustainable way?

- People
- Planet
- Profit

Technological

- Planting material — high quality and suitable for local conditions
- Soil suitability and land preparation
- Plant density
- Management — fertilization, scouting, spraying, pruning
- Harvest — right moment
- Post harvest — storage
- Soil chemical and physical data

Introduction

- Goal:
  - "look for ways to increase fruit yield and quality"
- Very big challenge after just a few days and meetings
- Apologize in advance if I am completely wrong from your point of view

Observations

- Production of young fruit trees
- Preserving collection of varieties
- Pruning
- Plant systems and habitus
- Gravelly soils
  - Difficult tillage
- Processing Class III fruit
- No time to visit production orchards

Discussed

- Price & market
- Education
- Politics

Main topics - phases

- Pre-planting
- Planting
- Growth and production
- Pre-harvest
- Harvest
- Post harvest

Yield and quality

		Increase yield	Quality	Ranking
Pre-planting	considerations when selecting an orchard site			
	availability of irrigation water	++	+	
	attention for cropping history, soiltype/structure/nutrient holding capacity,...	+	0	
Planting	uniformity of starting plant material (budding height...)	+	+	
	conditions in the chain before planting (prevention of dehydration)	+++		
	spring or autumn planting	++		NL spring better bud formation
	improving shelter for winds (combined hedges)		+	interesting IPM
Growth and production	improving light interception	+++	+++	
	1 Pruning	+++	+++	
	2 Bending	+++	+++	
	3 Thinning (flower & after June drop)	++	++++	
	considering inter stems	++		
	tree density	+++++	?	
	tree shape and mechanical pruning	++++	++	
Pre harvest	modernisation prediction (Streif method)		+++	
Harvest	prevention of losses		+	
Post-harvest	modernization post harvest management		++++	

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Summary

- Middle term process and approach
- Achievable and realistic (focus)
- On-farm: improve yield of existing orchards
  - Adding new (best) practices aiming at
    - Reducing percentage of 2-3 class fruit
    - Increase percentage 1 class fruit
- Institute: introduction of new techniques

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Homework

After-care

- Equipment pomological lab
- Feathering/branching (products, concentrations, timing/Regalis)
- Experimental design
- Strategy for introducing new varieties

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Socio- economic

Participatory approach

- Farmers that are interested and willing to improve their fruit production
- Formulating the goal(s)
- Demonstrations
  - Location – Research station or ?

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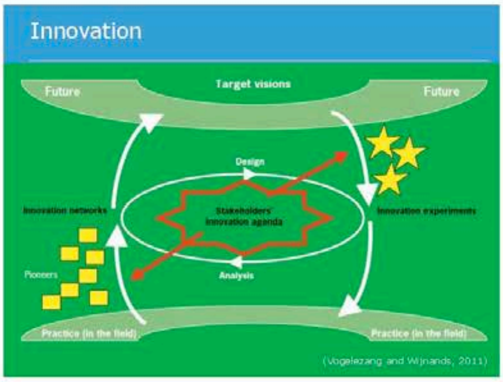
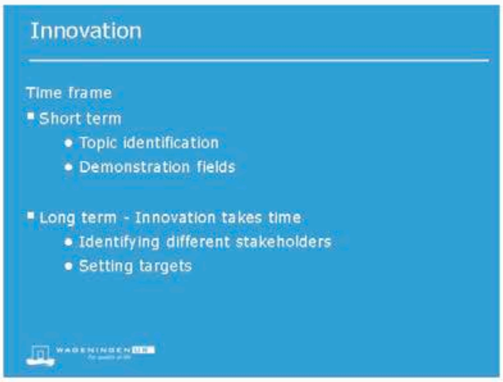
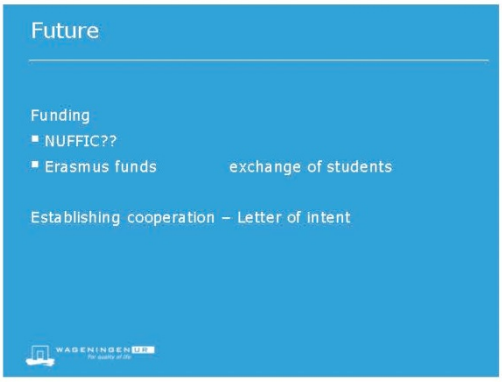

Innovation
Future
Target visions
Future
Design
Innovation networks
Stakeholders' innovation agenda
Innovation experiments
Pioneers
Analysis
Practice (in the field)
Practice (in the field)
(Vogelezang and Wijnands, 2011)

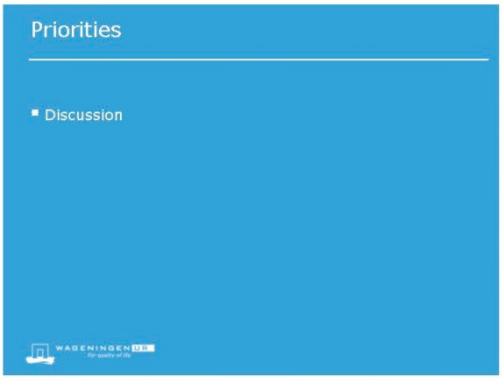

Innovation
Topics for demonstration
Differences between treatments very clear
Economic benefits must also be very clear
Communication
How to reach impact?


Innovation
Time frame
Short term
Topic identification
Demonstration fields
Long term - Innovation takes time
Identifying different stakeholders
Setting targets


Commitment
Cartoons
Films
....


Commitment
Machines always attract attention of Dutch growers
e.g. Root pruning


Future
Funding
NUFFIC??
Erasmus funds
exchange of students
Establishing cooperation – Letter of intent


Priorities
Discussion

A more trustworthy
P recommendation
by implementing the
intensity,
buffering capacity,
quantity concept
into agricultural practice

Arjan Reijneveld

BLGG AgroXpertus

Introduction

BLGG AgroXpertus

Introduction (back then)

- P fertilization recommendations for agricultural crops are based on soil tests from ~ 1900 onwards
- Already at that time, it was suggested that two or more soil P test would give more insight in soil processes and improve recommendations
- However, mostly for reason of costs, this was not implemented

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Introduction (nowadays)

- Modern soil analysis methods (costs decreased)
- Optimal crop yield and quality increasingly important (world food)
- Environmental protection has become a topic
- P resources are exhaustible
- Legislative restrictions for P-fertilization
- Farmers value soil P tests, doubt the current recommendations, and are interested in improved allotment of P

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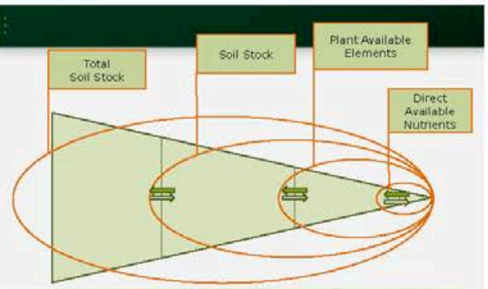
So, there seems room for a more trustworthy P recommendation

Material & Methods

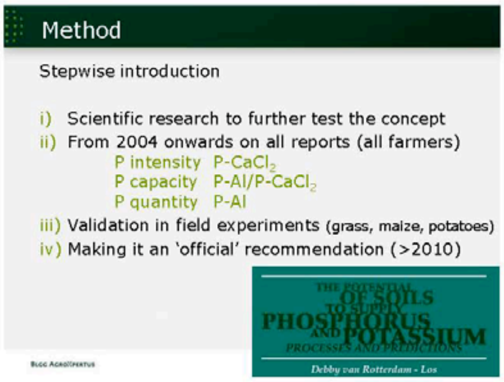
Material

Literature: Throughout 20th century combination of soil tests was promoted

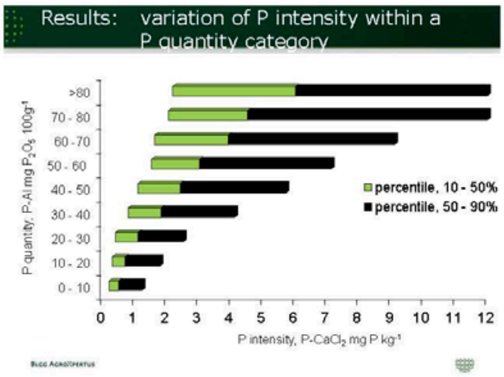
- P intensity = *plant available P*
- P buffering capacity = *capacity to replenish plant available P when P is taken up by crops*
- P quantity = *total capacity for P replenishment*

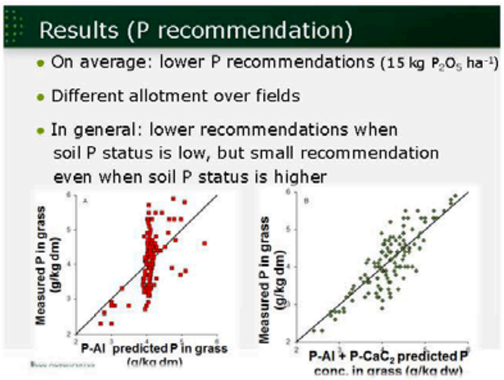


Methods	P-total or P-oxalate	P-Al or P-CAL or P-Olsen	P-$CaCl_2$	P-water
Metaphor	Basement	Kitchen	Table	Plate
Kg P ha^{-1}	3400	545	4.7	2.5
	Soil Quantity		**Soil Intensity**	


Method
Stepwise introduction
i) Scientific research to further test the concept
ii) From 2004 onwards on all reports (all farmers)
P intensity P-$CaCl_2$
P capacity P-Al/P-$CaCl_2$
P quantity P-Al
iii) Validation in field experiments (grass, maize, potatoes)
iv) Making it an 'official' recommendation (>2010)
THE POTENTIAL OF SOILS TO SUPPLY PHOSPHORUS AND POTASSIUM
PROCESSES AND PREDICTIONS
Debby van Rotterdam - Los


Results


Results: variation of P intensity within a P quantity category
P quantity, P-Al mg P_2O_5 $100g^{-1}$
>80
70 - 80
60 - 70
50 - 60
40 - 50
30 - 40
20 - 30
10 - 20
0 - 10
0 1 2 3 4 5 6 7 8 9 10 11 12
P intensity, P-$CaCl_2$ mg P kg^{-1}
percentile, 10 - 50%
percentile, 50 - 90%


Results (P recommendation)
On average: lower P recommendations (15 kg P_2O_5 ha^{-1})
Different allotment over fields
In general: lower recommendations when soil P status is low, but small recommendation even when soil P status is higher
Measured P in grass (g/kg dm)
P-Al predicted P in grass (g/kg dm)
Measured P in grass (g/kg dm)
P-Al + P-CaC_2 predicted P conc. in grass (g/kg dw)

Discussion

Discussion: improvements

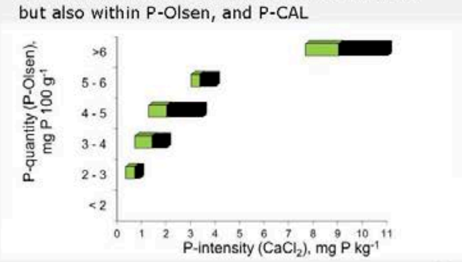
Buffering capacity is represented by ratio P-Al/P-$CaCl_2$

Recommendations could be improved by measuring **Fe, Al,** and **Ca** on routine basis (to establish Fe-P, Al-P, and Ca-P binding)

Risk of leaching can be established

Discussion: international (P-Olsen)

A lot of variation in plant available P within P-Al, but also within P-Olsen, and P-CAL



Discussion: other nutrients

Concept can also be used for other nutrients:

For example:
- K plant available (K-$CaCl_2$)
- K soil stock (K-CEC)

Discussion: legislation

Soil P status of a soil is established by one soil P test

Government in the Netherlands has the intention the use quantity and intensity characteristics to classify soils and establish P applications from 2015 onwards.

Conclusion

Conclusion

Improved allotment of P
useful for food, farmer and environment

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Thank you all!

Questions?

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Wim Bussink Wim.Bussink@nmi-agro.nl

Appendix 3 – Persons met

Embassy of the Kingdom of the Netherlands
Sheraton Metechi Palace Hotel
20, Telavi Street, Tbilisi 0103, Georgia
Tel. 995 32 227 62 00
Website: http://georgia.nlembassy.org/

Mr. Hans P.P.M. Hornbach – Ambassador tbi-cdp@minbuza.nl
Mrs. Maia Todria – Trade/Economic Officer maia.todria@minbuza.nl
Mrs. Sopko Kotiashvili – Fellowship Officer sopio.kotiashvili@minbuza.nl
Mr. Heine Lageveen – Economic Policy Officer (till Feb. 2015) heine.lageveen@minbuza.nl
Mr. Olav Hofland – Economic Policy Officer (till 15 Dec. 2014) olav.hofland@minbuza.nl

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Prof. Dr. Avantadil Korakhashvili, Academician akorakhashvili@yahoo.com
Assistant Prof. Dr. Giorgi Ghambashidze Soil scientist g.ghambashidze@agruni.edu.ge
Mobile +995 577 11 87 15 g.ghambashidze@gmail.com
Mrs. Nato Kakabadze, Head of department of Annual crops
Mr. Zyrab Khidesheli, Head of department of Plant Protection

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Tbilisi 0131, Georgia

Prof. Dr. Tengiz Urushadze, Director of the Mikheil Sabashvili Institute of Soil Science, Agrichemistry and Amelioration t_urushadze@yahoo.com
tengiz.urushadze@agruni.edu.ge
Mrs. Tamar Khitarishvili, Head of International Relations t.khitarishvili@agruni.edu.ge

Ministry of Agriculture
Marshal Gelovani Ave.
0159 Tbilisi, Georgia
www.moa.gov.ge

Mrs. Ekaterine Sanadze, Amelioration Policy Department, Head of Soil Management division
Mobile +995 599 14 14 10 ekasanadze@yahoo.com

Appendix 4 – Itinerary

Monday 27 October	Travel to Tbilisi, Georgia by KL 3108
Tuesday 28 October	Briefing at the Embassy of the Kingdom of the Netherlands Mr. Hans P.P.M. Hornbach – Ambassador Mrs. Maia Todria – Trade/Economic Officer Mrs. Sopko Kotiashvili – Fellowship Officer Mr. Heine Lageveen – Economic Policy Officer Mr. Olav Hofland – Economic Policy Officer Head Office of the LEPL Agricultural Scientific Research Center Associate Prof. Dr. Zviadi Bobokashvili Pomology Prof. Dr. Avantadil Korakhashvili Assistant Prof. Dr. Giorgi Ghambashidze Soil scientist Mrs. Nato Kakabadze, Head of department of Annual crops Mr. Zyrab Khidesheli, Head of department of Plant Protection
Wednesday 29 October	Fieldtrip with Prof. Zviadi Bobokashvili and Prof. Dr. Avantadil Korakhashvili Institute for Fruit growing at Saguramo Apple juice processing factory at Gori Mamuka Lomsadze, Head Consultation and information Centre
Thursday 30 October	Visit to the State Agricultural University accompanied by Mrs. Maia Todria and Mr. Olav Hofland, both of the Embassy of the Kingdom of the Netherlands Prof. Dr. Tengiz Urushadze, Director of the Mikheil Sabashvili Institute of Soil Science, Agrichemistry and Melioration Mrs. Tamar Khitarishvili, Head of International Relations Assistant Prof. Dr. Giorgi Ghambashidze Soil scientist
Friday 31 October	Discussion at Head Office of the LEPL Agricultural Scientific Research Center Prof. Zviadi Bobokashvili Dr. Giorgi Ghambashidze Mr. Akaki Mamaladze, Head of International Relations Mrs. Ekaterine Sanadze, Amelioration Policy Department, Head of Soil Management Division Mr. Olav Hofland Project team
Saturday 1 November	Travel to the Netherlands by KL 3109