Thesis topics (January 2019)

Group Horticulture & Product Physiology (HPP)



Students....

Students are welcome to do their BSc- and MSc-thesis research with one of the staff members, postdocs and/or PhD-students of the chairgroup HPP of Wageningen University (read the requirements you have to meet, which are presented on the HPP-webpage:
http://www.wur.eu/hpp >> *Education* >> *MSc- and BSc-thesis subjects HPP and Internships*).
The BSc- and MSc-thesis topics of HPP are spread over themes encompassing pre-harvest environmental plant physiology to post-harvest product physiology, and are connected to horticultural production world-wide. The emphasis is on, *but not restricted to*, modern glasshouse production.
Yearly, many students participate via BSc- and MSc-thesis's. During their research period MSc-thesis students enroll a community of students and staff (known as STAIR [**ST**udents **A**ctive **I**n **R**esearch]), which facilitates the development of important research related skills such as proposal writing and presenting, progress presentations and research discussions.

Topics are *example* topics....

In this document you will find a list of possible actual topics. The list gives you an impression of the subjects we are working on. The actual definition of subjects is always affected by interests of students, equipment and facilities available and other students already working on the same project. If you have some ideas or proposals by yourself we can always discuss them.

For BSc- and MSc-students......

Most proposed topics in the list are primarily described as MSc-thesis topic. In general, parts of many of the described topics can also be done as BSc-thesis.

Interested? Always contact the coordinator.....

If you want to participate in a student-research-proposal at HPP, **always** contact the coordinator of the student-research-projects (Dr. Ep Heuvelink).

ep.heuvelink@wur.nl tel. 4 83679

Make sure you do this in time:
Many of the listed topics require some preparation and certainly early planning from the student and researchers involved. This also takes time and may cause study delays if not initiated in time.

Although this document contains an extensive list of topics, it is not complete and may continuously be subject to changes.
For the latest version check our website: http://www.wur.eu/hpp >> Education

Pre-harvest topics

New fertilization concepts for improved nitrogen use efficiency in horticultural systems

Supervisor(s):

Dr ir Sander van Delden (daily supervisor)

Description:

Nitrogen (N) is an essential element for crop growth, development and subsequently product quality. Roughly 1 to 5% of total plant dry matter consists of N, which is an integral constituent of proteins, (co-)enzymes, nucleic acids, chlorophyll, phytohormones and secondary metabolites. Therefore plant nitrogen supply is an important cultivation factor. Not only the dose of nitrogen matters for crop production, also the form in which it is supplied (NH_4^+ and NO_3^- ratio) can affect crop growth and quality via several mechanisms. In nature, crops can take up nitrogen in three general forms: organic (e.g. urea, amino acids), ammonium (NH_4^+) and nitrate (NO_3^-).
In hydroponic systems mainly NH_4^+ and NO_3^- are supplied (generally in 1 to 10 ratio). NH_4^+ uptake acidifies the nutrient solution, NO_3^- uptake alkalizes the nutrient solution. At a molecular level NH_4^+ has lower energy costs for uptake and assimilation than NO_3^-, but high NH_4^+ dose causes cell damage. Additional to dose and nitrogen form, timing of nitrogen supply, that is moment of the day and developmental stage, can also enhance nitrogen efficiency.
The objective of this thesis is gaining novel insights in plant N efficiency by experimentally integrating findings on dynamic N supply and N form (NH_4^+ : NO_3^- ratio) and timing.

There is room for personal interest and insights, i.e. specific research questions can be formulated by the student.

BSc/MSc and ECTS:

MSc-thesis: 24-36 ECTS

Type of work:

Green house, growth cabinets, preparing nutrient solutions, lab experiments and analysis.

Plant(s): *Lettuce*

Methods:

Measuring several morphological and physiological parameters (biomass, leave number, transpiration, Fv/Fm, mineral content)

Planning:

Start September 2018

Predicting plant N demand

Supervisor(s):
Dr ir Sander van Delden (daily supervisor)

Description:
Plant nitrogen supply is an important cultivation factor. Suboptimal N fertilization in terms of dose, timing, and form can decrease crop commercial value, impact the environment and reduce crop health benefits for humans. Therefore optimal N fertilization in horticultural systems by continuously monitoring and predicting diurnal and seasonal plant N demand would be beneficial on many levels. Accordingly, this research gives emphasis to development of a dynamic model quantifying and predicting plant N demand.

There is room for personal interest and insights, i.e. specific research questions can be formulated by the student.

BSc/MSc and ECTS:
MSc-thesis: 24-36 ECTS

Type of work:
Model work preferably in MATLAB

Methods:
Literature study, testing existing models and writing new model code.

Planning:
Start September 2018

Capturing architectural plasticity in a tomato plant canopy using 3D scanning and assessing the influence on light interception and photosynthesis using a 3D tomato functional-structural plant model

Supervisor(s):

M. Verhoog (MSc) and Prof. Dr. Leo Marcelis

Description:

Tomato plants are modular organisms build-up of individual organs (leaves, internodes, fruits). Each organ perceives its own light microclimate (light intensity, light quality) by photoreceptors and responds accordingly. The resulting plant architecture is plastic and changes with environment. The environment itself is affected by neighbor competition, which means that individual plant architectures is also variable within a canopy.

Architectural models are used to capture the effects of neighbour competition on light interception and photosynthesis. However, quite often if not always, compromises are made on time spent to capture and implement plant architecture. The influence of these compromises on model simulation results (i.e. light interception and photosynthesis) is difficult to assess. One way is through a sensitivity analysis, which is often limited by initial compromises on architecture.

In this research, the goal is to perform an elaborate architecture sensitivity analysis in a 3D tomato functional-structural plant model. For this, variability in tomato plant architecture has to be captured as it is inside a tomato plant canopy. Following this, the variability will need to be implemented inside a 3D functional structural tomato plant model to assess its impact on light interception and photosynthesis.

BSc/MSc and ECTS:

MSc-thesis: 36 ECTS

Type of work:

Work involves selecting, testing and using a 3D scanner (explorative work) with associated software to capture individual tomato plant architecture in a plant canopy (practical work). This data would then need to be processed and analysed for model input into the 3D functional-structural plant model (platform: GroIMP). With this, a dedicated sensitivity analysis will be performed through model simulations (coding).

Planning:

Start at January 2019 onwards

Does photosynthesis determine yield? A case study in tomato

Supervisor(s):
Yutaka Tsutsumi (PhD-candidate) and Dr. Ep Heuvelink

Description:
Photosynthesis is the basic process for plant growth, and it is believed that improving photosynthesis will improve yield. However, many studies have focused on genetic differences in photosynthesis at leaf level without determining the association between leaf photosynthesis and yield. It is not clear to what extend a genotype with a high leaf photosynthesis level will also have a high yield. This is not obvious, as there are many processes in between like crop light interception and biomass partitioning.
In this project, high, middle and low yielding tomato genotypes (10 genotypes in total) were selected from 350 recombinant inbred lines by QTL analysis and genomic prediction. We want to know whether the yield level is explained by leaf photosynthesis. Students are expected to measure photosynthesis at least at the leaf level. It is also possible to measure the photosynthesis for whole canopy and/or photosynthesis under fluctuating light.
The aim of this study is to elucidate the association between yield and photosynthesis.

BSc/MSc and ECTS:
MSc thesis: 24-36 ECTS

Type of work:
Performing leaf photosynthesis measurements using a gas exchange and chlorophyll fluorescence system (LI-6400 and/or HexPAM (determines fluorescence with six measuring heads)).
Association study between yield and photosynthesis.

Planning:
Measurements will be possible from March to August 2019
(Preferably, measurements will be done before summer as we have better greenhouse climate)

Location:
Plants are grown in a commercial tomato greenhouse in Kwintsheul

Does salt stress affect dynamic photosynthesis through osmotic or ionic stress?

Supervisor(s):

Yuqi Zhang (PhD Candidate), Dr. Elias Kaiser (Max Planck Institute) and Prof. Dr. Leo Marcelis

Description:

In nature, plants are often subjected to rapidly alternating periods of sun and shade (sunflecks) and plants often experience suboptimal conditions, such as abiotic stresses, concomitantly with light fluctuations. Soil salinization is a growing challenge for agriculture worldwide and photosynthesis is among the primary processes that are affected most strongly by salinity.
The effects of salt stress on photosynthesis involves two different types of stresses: osmotic and ionic stress. Osmotic stress results from the reduction of the osmotic potential (i.e. reduced water availability to the plant due to the effect of high salt concentration in the soil/nutrient solution) at the root surface. Ionic tress results from the uptake and accumulation of sodium and chloride in the cells of photosynthetic tissues which are toxic.

In previous research, we found that short-term salt stress led to lower photosynthetic induction rate after dark-adapted leaves had been illuminated and decreased photosynthesis by 12-42% under fluctuating light intensities. However, because of the complex responses of plants to salinity, it is still unclear which factor (osmotic or ionic, or both) affects photosynthesis under fluctuating light.
To answer that question, this project will measure and analyse dynamic gas exchange on tomato leaves, which are subjected to three different treatments: non-stress, salt stress and only osmotic stress.

BSc/MSc and ECTS:

MSc-thesis: -36 ECTS

Type of work:

Investigating current literature on dynamic photosynthesis and the role of salt stress in photosynthesis.
Conducting a growth chamber experiment with tomato plants.
Measuring photosynthesis rate using a gas exchange system (LI-6400).

Planning:

To be scheduled after consulting with the supervisors.

Location:

Wageningen

Contact:

Yuqi Zhang (yuqi.zhang@wur.nl)

Estimation of growth and maintenance respiration in tomato

Supervisor(s):
Dr. Ep Heuvelink, Dr. Anne Elings (Wageningen UR Greenhouse Horticulture)

Description:
Growth and maintenance respiration are important sinks that have priority over dry matter increase of plant organs. Therefore, their quantification is important for a correct analysis of crop growth and production, e.g., through the use of a crop growth model. Much work on this has been done in the ’70 and ’80 of the 20th century, however, reliable and detailed information on modern high-wire greenhouse crops is lacking. Recently, Wageningen UR Greenhouse Horticulture has collected experimental information on the constitution of tomato plant organs ((hemi-)cellulose, sugars, lipids, etc.). With a biochemical approach this information can be used to derive respiration coefficients for application in growth analysis.

BSc/MSc and ECTS:
MSc-thesis: 24-36 ECTS

Type of work:
Data are largely available. A biosynthesis model is found in literature and applied to the data. This will yield maintenance coefficients for a modern high-wire tomato variety. Apply this in a crop growth simulation model to quantify the respiration processes at the crop level. Expected output: 1) a biosynthesis model, for instance in the form of a spreadsheet, 2) maintenance coefficients, 3) quantification of crop respiration.
Crop: tomato.
Literature: E.g., Penning de Vries et al., 1983.

Methods:
Desk study.

Planning:
Flexible.

Impact of silicon on tomato and cucumber growth and defense

Supervisor(s):

Dr Ep Heuvelink and Prof. dr ir. Gerlinde De Deyn (Dept. of Environmental Sciences – Soil Quality)

Description:

Tomato and cucumber are two major crops of horticultural systems in The Netherlands. These crops are typically grown on mineral wool in order to avoid soil-borne diseases as well as to enable efficient fertilizer management. However, also plants grown on mineral wool still need to defend the plant tissues against damage by herbivores and pathogens as these plants do not grow in sterile conditions. Plants can defend themselves by making tougher leaves and roots through increasing tissue density. Such strategy has the downside that it often trades-off with plant investment in growth as specific leaf area and specific root length decrease as leaf and root tissue densities increase.

Plants growing in soil take up essential and non-essential elements from the weathered soil and decomposted organic material. Silicon (Si) is one of the non-essential elements that is abundant in soil and is taken up by plants in varying quantities. Initially the role of Si in plants did not receive much attention but more recently it has been shown that Si can promote plant defenses both by increased plant tissue strength as well as via induced resistance above- and belowground (Chérif et al. 1994; Ma & Yamaji 2006; Ryalls et al. 2017). Plants grown in mineral wool receive all their nutrients from the nutrient solution that plant growers supply. Currently Si is typically not included in the nutrient solution, despite some recent work showing that also in soilless cultivation Si can provide benefits by increasing plant defenses and even nutritious value of the crop as shown in bean (Montesano et al. 2016). This thesis topic aims at exploring the uptake and impact of Si on growth and defense in tomato and cucumber grown on mineral wool.

Chérif, M., Asselin, A. & Bélanger, R. Defense responses induced by soluble silicon in cucumber roots infected by Pythium spp. *Phytopathology* **84,** 236–242 (1994).

Ma, J. & Yamaji, N. Silicon uptake and accumulation in higher plants. *Trends Plant Sci.* **11,** 392–397 (2006).

Montesano, F. F., D'Imperio, M., Parente, A., Cardinali, A., Renna, M., & Serio, F. Green bean biofortification for Si through soilless cultivation: plant response and Si bioaccessibility in pods. *Sci. Rep.* **6**(31662), 1–9 (2016).

Ryalls, J.M., Hartley, S.E., Johnson, S.N. Impacts of silicon-based grass defences across trophic levels under both current and future atmospheric CO_2 scenarios. *Biology Letters* Mar. **13**(3), (2017) doi: 10.1098/rsbl.2016.0912.

BSc/MSc and ECTS:

MSc-thesis: 36 ECTS

Type of work:

- investigate current literature on the role of silicon in plant defense (in tomato/cucumber)
- get acquainted with **TOMSIM** model for tomato growth and yield
- conduct a greenhouse experiment with tomato and cucumber in order to test Si uptake and its impact on plant phenotypic traits related to growth and defense
- gather experimental data that can be used for model development, calibration and/or validation.

Planning: flexible - In consultation with the supervisors.

Role of photoreceptors (PhyA, PhyB and Cry1&2) in flowering of chrysanthemum via PCR gene expression studies.

Supervisor(s):

Sharath Malleshaiah, Dr. Wim van Ieperen

Description:

We recently found out that flowering in the short-day (SD) plant Chrysanthemum can be induced during long-days when light quality is adjusted to pure blue light during the last hours of the (long) day-period. However, the success of this strategy also seems to depend on the spectral composition of the first hours of the day period.

How and if this fits into the currently accepted coincidence model for flower induction in SD-plants is not clear.

This research aims to elucidate the diurnal role of the light spectrum and associated photoreceptors (PhyA, PhyB and Cry1&2) on flower induction via gene expression studies.

BSc/MSc and ECTS:

MSc-thesis: 24-36 ECTS

Type of work:

Climate chamber experiment with LED's with chrysanthemum

Measurements: spectral light composition, flower induction (microscopic), gene expression studies.

Planning:

Start: In consultation with supervisors

Is Far-Red driving the circadian clock for photoperiodic time keeping in Chrysanthemum flowering.

Supervisor(s):

Sharath Malleshaiah, Dr. Wim van Ieperen

Description:

In a recent study we observed that flowering in short-day plant (SDP) chrysanthemum can be induced during longday (15h) provided with 11hours of red-blue(RB) spectrum and extended with 4hours of blue (B) spectrum. However, RB spectrum added with far-red (FR) spectrum with extended 4hours of B spectrum failed to induce flower. This contrasting results indicate, not only the duration of night period but also the spectral composition of the first 11 hours of daylight matters to induce flowering in chrysanthemum. Hence FR during 11hours of daylight is a logical suspect for inhibiting flowering. For many years physiologists indicated FR spectrum drives the photoconversion of phytochromes from their activated (P_{fr}) to their de-activated (P_{r}) state.

Hypothetically we are interested to study how *Far-Red can influence circadian clock for photoperiodic time keeping in Chrysanthemum* by studying the circadian clock and phytochrome genes in relation to the expression pattern of chrysanthemum florigen (*CmFTL3)* and anti-florigen (*CsAFT* and *CsTFL1*) genes.

BSc/MSc and ECTS:

MSc-thesis: 24-36 ECTS

Type of work:

Lab work qPCR to study gene expression studies.

Planning:

Start: from now on but in consulting with supervisors

FR-induced increase of fruit sink strength in tomato: how does it work?

Supervisor(s):

Dr. Ep Heuvelink, Yongran Ji (daily supervisor)

Description:

Recent research has shown a promotional effect of additional FR (Far-Red) in fruit growth and development in greenhouse tomato production. More interestingly, we recently discovered a strong increase of assimilate partitioning towards fruits under additional FR and we are curious about the mechanism behind it.

In this research, we would like to study the effect of additional FR on key regulators of fruit sink strength, which is one of the components that influences the assimilate partitioning to fruits.
This study will aim to identify key physiological and molecular processes that determines the capacity of fruits to compete for assimilates (fruit sink strength).
Further, we will examine how additional FR during growth can influence these processes and quantify how such influences impacts the fruit sink strength.

BSc/MSc thesis:

MSc thesis 24-36 ECTS

Type of work:

Greenhouse/climate chamber, plant morphology and anatomy, gene expression

Plant(s): *tomato*

Planning:

Start February 2019 (flexible)

The use of short term LED lighting before harvest to improve quality of Lettuce

Supervisor(s):

Qianxixi (Xixi) Min, Prof. Dr. Ernst Woltering

Description:

In recent years, vertical farming (plant factory) has been fast developed and the its concept has been spread worldwide. Lettuce, as one of the major crop grown in vertical farming has become a model plant in experimental research. Lettuce is a perishable leafy vegetable that generally has a short shelf life. Thus, beside the production yield, longer shelf life and better postharvest performance has become a hot topic in lettuce cultivation under controlled environment.

The undesirable conditions in processing, storage and transport are the reasons limits the shelf life of lettuce. A series of visual\sensorial disorders will show up along the storage, such as tissue browning, pinking, yellowing and wilting. These visual quality disorders became the limits of consumer acceptance and shelf life. Vitamin C and carbohydrates play an important role in inhibiting the mentioned quality disorders. Thus the products with high level of vitamin C and carbohydrates are reported also have longer shelf life and better visual quality performance.
The biosynthesis and\or accumulation of vitamin C and carbohydrates has been reported to rapidly respond to light treatments. This make it possible to produce lettuce with high level of vitamin C and carbohydrate by give a short-term light treatment just before harvest, in such a way extend the shelf life of lettuce products. This short-term pre-harvest lighting can be easily applied in vertical farming system, and became a strategy for vertical farming to produce vegetables with good quality.

Our research is focused on the effects of short term pre-harvest lighting on the quality of lettuce. Short term pre-harvest lighting may be different combinations of light intensity, light sum, spectrum, and photoperiod that is applied about 1 week before harvest. Quality of the harvested product is defined by vitamin C and carbohydrates content in the lettuce before and after harvest and by postharvest visual quality and shelf life.

Type of work:

Crops: Lettuce
Measurements:

- Measurements in climate chamber on lettuce (morphological and physiological parameters) and climate conditions in vertical farming system (Light condition, temperature);
- Quality measurements during postharvest storage (lab analysis of chlorophyll, vitamin C, carbohydrate, visual quality and shelf life);
- Data analysis (basic statistics, or sensory data analysis)

Experiments might take place in Philips city farming at Eindhoven. Some traveling is to be expected between Wageningen and Eindhoven. Lab work will take place in HPP lab.

Requirements

Highly motivated team members with the interests products quality. Skilful in data analysis and statistics are preferred

BSc/MSc thesis:

MSc thesis 36 ECTS

Planning:

From July-August 2018 onwards

Lettuce growth model 2.0 – Investigating the limits of crop productivity

Supervisor(s):

Dr. ir. Ep Heuvelink (Plant Sciences), Dr. Cecilia Stanghellini and Ilias Tsafaras (Greenhouse Horticulture)

Description:

The expansion of the urban population has resulted in an ever increasing interest in urban food production. Urban farming is considered a promising development in the light of societal challenges regarding food security and urbanization, and sustainable crop production (FAO 2011, Colding & Barthe 2013). Substantial attention is given to production in closed plant production systems, or so-called plant factories and vertical farms, which rely solely on artificial illumination.

These plant factories and vertical farms currently focus on the production of leafy greens. These types of closed plant production systems typically combine high-density crop production, a limited volume and lack of natural ventilation. This induces a high demand for cooling and vapour removal. Preferably, production temperatures would be increased, to minimise said cooling load. The existing lettuce growth models (Van Henten, 1994; Van Henten et al., 1994) have not been calibrated for production at such elevated temperatures (Graamans et al., 2018). Additionally, the effects of root zone temperature (He et al., 1998b, 1998a; Thompson et al., 1998; Frantz et al., 2004) and high daily light integrals have not been taken into account.

This research features numerous experiments focusing on the effects of air temperature, root zone temperature, and light intensity on the production of lettuce. This data can be used to increase the precision and applicability of existing lettuce growth models for plant factories. These models can then be used to optimise the production of lettuce in plant factories for energy use efficiency.

Type of work (for a number of students, one could focus more on experimental work or more on modelling):

- make a research plan;
- get acquainted with crop models and their programming;
- analyse existing lettuce models with respect to temperature, light and other production factors;
- program a structural growth model for lettuce, which is able to simulate light absorption, crop photosynthesis, leaf growth and plant development; and
- conduct numerous lettuce production experiments in order to gather experimental data that can be used for model development, calibration and/or validation.

BSc/MSc thesis:

MSc thesis 36 ECTS

Planning:

Flexible - In consultation with the supervisors. Experiments will start around 1 October 2018

Note: The project will be available from 1 August 2018.

Light coming from two sides: how does a leaf acclimate to light direction?

Supervisor(s):

Rachel Schipper (MSc.) and Prof. dr. Leo Marcelis

Description:

Lighting strategies in greenhouses no longer only depend on light coming from the top, but interlighting is becoming more common. However, it is not clear how the plant adapts to a new kind of light strategy. With interlighting, more light is received by the bottom leaves of the canopy. Another side effect is the capture of light by the lower side of the leaf, which might lead to acclimation on leaf level. An experiment was conducted with tomato plants grown with either 100% light from above or 50% light from above and 50% light from below. It is not clear what the acclimation of the leaves entails, this is your job to find out! We will start by analysing the stomatal features of the acclimated leaves, as stomatal imprints were made during the experiment.

Type of work:

Microscopy analysis in laboratory, data analysis and literature research

Requirements:

A motivated and creative student who is interested in LED lighting and photosynthesis

BSc/MSc thesis:

BSc thesis of 18 ECTS. However, it can also be transformed into a MSc thesis of 24 or 36 ECTS

Planning:

From February 2019 onwards (in consultation with supervisor)

LED lighting strategies in tomato: modelling photosynthesis with a Functional-Structural Plant Model (FSPM)

Supervisor(s):

Rachel Schipper (MSc.) and Prof. dr. Leo Marcelis

Description:

This project is part of the 'LED it be 50%' project. The 50% stands for the aimed reduction of energy usage in horticulture. The use of energy for lighting is the main bottleneck to decrease energy use in the horticultural sector. By using LED lighting in a smart way, the use of energy could be reduced tremendously. For smart and optimal use of LED light, the light and heat distribution through the canopy should be as optimal as possible. But what is optimal exactly?

This project will use a model on 3D light simulation and a Functional-Structural Plant Model (FSPM) to predict to (1) create a more homogeneous LED light distribution in the crop, resulting in a more efficient use of light energy and (2) reduce light losses to ground and sky. It helps us to find a most optimal LED lighting strategy.

A static FSPM of tomato is developed to enable simulations of different plant architectures and LED lighting positions. An experiment was conducted to estimate the acclimation of leaf photosynthesis to light coming from different directions. Now the bi-lateral interception of light needs to be incorporated into the FSPM.

Are you interested in light and photosynthesis modelling, LED application in tomato crop production, or functional-structural plant modelling? And would you like to combine experimental data analysis with modelling? Feel free to contact the coordinator or the supervisors, and we can discuss the options and your interests. There are always many possibilities!

Type of work:

Programming with FSPM, development of conceptual model of leaf photosynthesis, radiative transfer modelling, parameterization of photosynthesis responses, literature research.

Requirements:

A creative and motivated student who is up for a challenging project! We are looking for someone with experience in modelling (eg. FSPM), with affinity for photosynthesis.

BSc/MSc thesis:

MSc thesis 24 or 36 ECTS; part of this work can also be conducted as BSc thesis (18 ECTS)

Planning:

From February 2019 onwards (in consultation with supervisor)

Yield gap analysis for greenhouse production in Japan

Supervisor(s):
Dr. Ep Heuvelink

Description:
Japanese agriculture is small-scale and farmers are on average older than 65. The Japanese government wants to stimulate modern large-scale production in greenhouses. Therefore, on 10 locations such large-scale greenhouses have been built and selected for detailed recommendations to improve yield and quality. Wageningen UR Greenhouse Horticulture together with WU-HPP is giving advise (via NARO, the Japanese NATIONAL AGRICULTURE AND FOOD RESEARCH ORGANIZATION) for 4 locations on how to do this. NARO researchers collect greenhouse climate, crop growth and yield data. These are shared with Wageningen researchers, who will a.o. analyse in detail the difference between potential and actual yield (yield gap analysis). WU will improve model forecasts for potential and actual yield under various conditions in Japan.

Within this project 1 or 2 thesis students can participate..

MSc and ECTS:
MSc-thesis: 24-36 ECTS

Type of work:
Obtaining greenhouse climate and yield data via email contacts (part of the data is already available in Wageningen), conducting simulations with a crop growth model, detailed analysis of differences between potential and actual yield.
Crops: tomato, strawberries, cucumber and sweet pepper

Methods:
Desk study.

Planning:
In consultation with supervisor(s)

How high temperature delays photoperiodic floral induction in Chrysanthemum

Supervisor(s):

Sharath Malleshaiah and Dr. Ep Heuvelink

Description:

Chrysanthemums are one of the most valuable ornamental commodity of floriculture sector to use as cut flowers and potted plants owing to their colourful 'capitulum'. Production of this ornamental beauties is quite challenging due to their largely depend on day length (photoperiod) and temperature. Chrysanthemum is an obligate short day plant demanding long hours of darkness for floral induction and development. For year round cut-flower production of chrysanthemum, greenhouse growers regulate light by bringing photoperiod closer by shading with blackout screens or extended further by night breaks with artificial lighting. However these blackout screens poses extra anomaly by rising the temperature under the blackout screens which results into delayed flowering (Heat delay).
We are interested in elucidation of influence of how high temperature influence physiological mechanisms which cause delay in flowering using molecular biology techniques.

We will use different heat sensitive and tolerant chrysanthemum genotypes to study how higher temperature delay flowering both in terms of physiological and molecular mechanisms. And to determine the extent of heat delay in chrysanthemum we like to investigate the effect of high temperature on set of florigen (CmFTL3) and anti-florigen (CsAFT and CsTFL1) genes in influencing flowering trait and along with other phenotypic traits involved in the floral transition.

MSc and ECTS:

MSc-thesis: 24-36 ECTS

Type of work:

This work is executed by climate chamber experiments and the candidate is expected to conduct the experiments and performing measurements of physiological and morphological parameters, along with gene expression analysis using qPCR.

Planning:

Start: In consultation with supervisors

Sucrose as a *Florigen* for floral induction in Chrysanthemum

Supervisor(s):
Sharath Malleshaiah, Dr. Wim van Ieperen and Dr. Ep Heuvelink

Description:
Sugars are involved in diverse physiological functions and their roles in signal transduction in plants have become apparent, disaccharides like sucrose molecules mediate plant responses to stresses, growth and development. Sugar signalling in plants is crucial to distribute available energy and respond appropriately to energy deprivation induced by biotic and abiotic factors. Sucrose being predominant sugar in plants has involved in the regulation of diverse developmental process such as flowering. The transition of shoot apical meristem from the vegetative to flowering involves a complex network of physiological and molecular signalling that integrates a range of environmental and endogenous factors. One such endogenous factor is sucrose that might participate in long-distance signalling for flowering by acting on FT with direct effects on its expression.

Chrysanthemum being an popular ornamental plant, its flowering largely depends strictly on inductive SD photoperiod but the role of endogenous factors like sugars and its signalling pathway are still in infancy. But the preliminary study with exogenous application of sucrose on chrysanthemum indicated flowering acceleration with increased level of cmFTL2 transcription in the leaf under both LD and SD (Sun et. al 2017).
In the context of this MSc project, we will investigate further the idea of sucrose as signalling molecule to act as florigen for floral transition in chrysanthemum.

MSc and ECTS:
MSc-thesis: 24-36 ECTS

Type of work:
Climate chamber experiments for a characterisation of FT genes and their expressions. These experiments will involve the use of various phenotypic and molecular analyses. This will help to generate new information on the flowering signal in chrysanthemum.

Planning:
To be scheduled after consulting the supervisors.

Interactions of Fe concentrations, root development, growing medium and irrigation strategy

Supervisor(s):

Wim Voogt (WUR Plant Sciences, Bleiswijk), Ep Heuvelink

Description:

This experiment is part of a project which aims to develop a prototype of a dynamic model for monitoring and surveillance of nutrient concentrations in substrate systems. This model will be based on relevant parameters related to crop and cropping system, and dynamic changes during cultivation. Experiments are carried out to fill the knowledge gaps in order to develop the model.
The experiment will focus on the question: what is the effect of root condition and root morphology on the uptake and distribution of Fe by the plant, and what are the consequences for target values in the nutrient solution supplied and the drainage.

MSc and ECTS:

MSc-thesis: 24-36 ECTS
(also available as Internship)

Type of work:

Experimental: conducting the trials, routine measurements of the parameters of the water- and nutrient balance (EC, pH nutrients, drainage, water use), as well as determination of yields/biomass, sampling plant tissue. A search for methods to determine Fe-stress (by enzymatic reactions) will be part of the task.
Plant(s): *tomato, grafted on various rootstocks*

Methods:

Plant material grafted on rootstocks varying in growth power will be exposed to various Fe-concentrations and chelate types. The effect on growth and development and Fe-chlorosis will be observed, as well as the Fe-content of tissue.

Two approaches: 1) short trial in the propagation phase, with a broad range of rootstocks and Fe-concentrations and 2) a 6 months production trial with a selection of the variables of the initial trial.

Planning:

In consultation with supervisor(s)
Note: the experiments will be executed in Bleiswijk, candidates are expected to work at least 4 days/week in Bleiswijk during the experimental period.

Signaling of stomata closure – interaction between CO_2 and NO

Supervisor(s):

Dr. Wim van Ieperen, *Priscilla Malcolm Matamoros (PhD-student)*

Description:

Stomata are pores that make the uptake of CO_2 possible, the substrate of photosynthesis. At the same time, water vapour will leave the plant via the stomata. To optimize photosynthesis, while at the same time preventing excessive water loss, stomata control their opening by a signaling network of pathways that respond to signals from the plant as well as to environmental conditions such as light and darkness, air humidity, temperature, CO_2, and ethylene. These signals result in changes of turgor pressure of the guard cells, resulting in stomatal opening or closure. Understanding the signaling pathways is of crucial importance to understand effects of climate change and also of conditions in greenhouses.

In general stomata close in response to an increase in the level of the hormone abscisic acid (ABA). In many of ABA-regulated processes, nitric oxide (NO), a gaseous compound, is a downstream mediator of ABA signaling. Also in the control of stomata closure, it is thought that NO is a key compound. However, there are some controversial findings about the role of NO as an important second messenger in stomatal closure. For example, stomata of a mutant, that has impaired NO biosynthesis, were more responsive to ABA than the stomata of the wild-type plants. The mutant also showed a strong resistance to drought. Another example is, that we did not find any effect of NO on stomatal closure when applied to epidermal leaf strips, while ABA caused closure of these stomata. However, when NO was applied to leaf discs, cut leaves or intact plants it induced stomatal closure. The difference in used plant material is that epidermal strips miss mesophyll. Measurements of kinetics in leaves of photosynthesis, stomatal closure, and internal CO_2 concentration (in stomatal cavity) suggest that NO inhibits very fast photosynthesis resulting in an increase in internal CO_2, followed by stomatal closure. The question is why several previous researchers found a closing effect of NO in epidermal strips. It cannot just be an artifact, because scavengers that removed NO in epidermal strips inhibited stomatal closure by ABA application. A possible explanation could be that NO-signaling needs the presence of CO_2: we used degassed solutions in our experiments with epidermal strips, while it is not clear if that was done by previous authors.

The objective of this project is to evaluate a possible interaction between CO_2 and NO in the signaling pathway of stomata closure. Understanding this signaling pathway is important to understand (and control) plant vulnerability to stresses.

BSc/MSc and ECTS:

Bsc thesis (18 ECTS)
MSc-thesis: 24-36 ECTS

Type of work:

Crop: beans
Measurements: studying stomata opening and closure in epidermal strips, while applying different combinations of CO_2, NO, SNP (NO-donor), and ABA. This can be combined with treatments to inhibit respiration and/or photosynthesis. Measuring stomata opening by microscopy.

Planning:

Can start now, but later is also possible (in consultation with the supervisor)

Effects of light quality on plant water relations, leaf development and stem elongation

Supervisor(s):

Dr. Wim van Ieperen & PhD student or Postdoc

Description:

Several topics can be studied within the framework of a PhD project on the effects of light quality on plant water relations, and 2 postdoc projects, one on the effect of light quality on leaf development, and one on the effect of light quality on stem elongation. These projects are of fundament scientific interest, as not much is known yet about the role of light quality during plant development on water relations and the underlying (molecular) mechanisms of light quality effects on leaf development and stem elongation. It is also of practical interest for horticulture e.g. because (1) the use of LEDs might enable the control of hardening of young plants before transplanting and (2) the use of LEDs might enable the production of compact potplants in greenhouses without the use of growth regulators.

BSc/MSc and ECTS:

Bsc thesis (18 ECTS)
MSc-thesis: 24-36 ECTS

Type of work:

Crop: tomato
Measurements: these topics include building and development of methodology, growing plants under different light qualities, measurements of physiological (e.g. photosynthesis and transpiration) and morphological parameters.

Requirements

Planning:

Start in consultation with Dr. Wim van Ieperen

Thermal imaging for high throughput stomata phenotyping in tomato

Supervisor(s):

Prof. Dr. Leo Marcelis

Description:

The capability to non-destructively capture plant traits is a key advance in high-throughput phenotyping. Stomatal regulation is an important indicator of plant photosynthesis and water relations. Stomatal responses to light is of critical importance and rapidly captured responses will provide insight into the plant growth status. The dynamic changes in stomatal conductance in response to a change in light intensity and the variation of the response among different genotypes will be characterized in this study. Out of a core collection of 40 genotypes, contrasting genotypes (in stomatal responses) will be selected. Plants will be adapted to either high or low light intensity, and then placed in the other environment. During these changes in light intensity, thermal imaging will be used to assess dynamic stomatal responses in a controlled environment with red and blue LED lighting. A thermal index (I_G) will be calculated from thermal imagery and evaluated for suitability for screening of dynamic stomatal conductance and compared to parallel stomatal conductance measurements using a porometer. The results will be discussed in relation to their potential for high throughput plant phenotyping applications.

The main objective of this work will be to develop a methodology for use of IR thermography for high throughput phenotyping of stomatal conductance and to assess dynamic opening and closing of stomata in response to light intensity stimulus.

BSc/MSc and ECTS:

MSc-thesis: 24-36 ECTS; also BSc thesis possible (18 ECTS)

Type of work:

Climate chamber experiments
Crops: tomato plants
Measurements: Thermal imaging, porometry

Planning:

Can start from February 2017 (in consultation with the supervisors)

Understanding and predicting the Phenotype of Phalaenopsis Orchids in different environments

Supervisor(s):

Evelien van Tongerlo (PhD-student), Dr. Wim van Ieperen

Description:

Phalaenopsis is one of the most economically important ornamental crops. Selection of new varieties is often done by manual assessment of colour, shape and number of flowers. Important cultivation characteristics, such as growth duration and responses to the greenhouse climate are not taken into account. Consequently, rates of growth and development may later appear to be disappointing. Breeders are lacking (early) selection criteria for production and product quality. Therefore failure of new varieties is often only known after several years.

The aim of this project is to develop reliable phenotyping techniques for Phalaenopsis, which takes into account the cultivation performance in modern greenhouse environments in relation to the climate. To do so, we will investigate the interactions between temperature, light intensity, light spectrum and genotypes on the processes of growth and development. Besides that, we'll look at the effects on photosynthesis and carbon budgets.
Photosynthesis is the primary source for carbohydrates in plants. Phalaenopsis employs Crassulacean Acid Metabolism (CAM) photosynthesis. This implies that CO_2 is taken up at night and stored as free malate in vacuoles. In CAM plants, stomata are closed during the largest part of the light period and opened during the dark. Nocturnal and diurnal CO_2-uptake can readily be obtained by gas exchange measurements. However, measuring gas exchange is not suitable for large scale phenotyping. It will also not provide information about instantaneous CAM photosynthesis rates during the light period, though it can be used to measure shifts between CAM and C3 in the light in dedicated experiments. However, measuring gas exchange is not suitable for large scale phenotyping. Chlorophyll fluorescence (CF) has already been applied successfully as a tool for screening of genotypes of C3 crops, but large-scale chlorophyll fluorescence protocols still need to be developed for CAM plants such as Phalaenopsis.

BSc/MSc and ECTS:

Bsc thesis (18 ECTS)
MSc-thesis: 24-36 ECTS

Type of work:

Crop: Phalaenopsis
Measurements: Plant growth measurements, gas exchange, chlorophyll fluorescence

Planning:

Any time, but if you are interested contact the supervisors as soon as possible because of long-term planning

Water stress and light quality: Coordination of Leaf hydraulic conductance and stomatal conductance at different light qualities (i.e. under LEDs and Sun-light)

Supervisor(s):
Dr. Wim van Ieperen

Description:
When leaves adapt to environmental conditions they apparently show coordinated responses with respect to photosynthesis and water relations. This requires some kind of internal organisation, which might possibly be under the control of an environmental factor. Recently we showed that the conductance for water transport in the leaf lamina (K_{leaf}) and stomatal conductance (g_s) are highly correlated, even when plants are grown under distinct different light qualities (Savvides et al., *Journal of Experimental Botany, 2012*) which might point to a specific role for some photoreceptors (i.e. phytochromes, cryptochromes etc). This topic is of fundament scientific interest, as not much is known yet about the role of light quality during plant development on water relations. It is also of practical interest for horticulture e.g. because the use of LEDs might enables the control of hardening of young plants before transplanting.

BSc/MSc and ECTS:
MSc-thesis: 24-36 ECTS

Type of work:
Crops: tomato, cucumber
Measurements: the topic includes building and development of methodology, growing plants under different light qualities, measurements of K-leaf, stomatal conductance and stomatal -aperture, -size and -densities. Measurements of photosynthesis and transpiration and biomass accumulation

Planning:
Start in consultation with supervisor
For this MSc-project basic technical skills are required (further info: wim.vanieperen@wur.nl)

UV as regulator of developmental processes in plants

Supervisor(s):
Dr. Wim van Ieperen

Description:
Recently, a UV-B photoreceptor has been discovered. It is assumed to influence a broad range of physiological processes, but details are lacking. Many greenhouses filter UV-B from solar light spectrum. It is unclear what impact this has on processes such as: flower induction, elongation, stress tolerance, leaf initiation and development. In the scientific literature some suggestions have been made but not much is clear yet.

BSc/MSc thesis:
Several BSc thesis's and possibly an MSc-thesis

Type of work:
Literature study
Short Climate chamber and or in vitro experiments with UV has light factor

Planning:
To be scheduled after consulting the supervisor

Improving homogeneity in cut chrysanthemum production

Supervisor(s):

Dr. Jochem Evers (CSA – Crop System Analysis) – Dr. Ep Heuvelink (HPP)

Description

Chrysanthemum is one of the most important horticultural ornamental crops worldwide. Much research has been done on the response of chrysanthemum to environmental factors such as temperature, light, and their interaction. This research is being used to optimize chrysanthemum production. However, the single most persistent issue in production of this ornamental crop is the variation within the product: individual chrysanthemum plants grown simultaneously in the same conditions differ from one another in terms of stem extension, branching, leaf area, biomass, and flower number and size. Adding to this complexity is the rapid introduction of new varieties, each with their own particular responses to environmental signals.

This MSc thesis topic aims at improving the homogeneity of chrysanthemum production by finding optimal plant traits for production. This entails mapping the suit of responses chrysanthemum shows to environmental signals (notably light), quantifying those responses, and formulating management protocols as well as directions for chrysanthemum breeding. This research will be done in collaboration with Deliflor, the largest chrysanthemum breeder worldwide (www.deliflor.nl).

Types of work

This study will include one or more of the following components: measurements in current chrysanthemum production situations, performing small-scale experiments to quantify crop responses to manipulation of environmental variables, and integration of new and existing knowledge in a simulation model of chrysanthemum growth and development based on the principles of functional-structural plant modelling. The exact contents of the work can be tailored towards the learning goals of the student to a certain extent.

Location

Wageningen (WUR Crop Systems Analysis; WUR Horticulture and Product Physiology)
Maasdijk (Deliflor)

Contacts:

Jochem Evers (jochem.evers@wur.nl)
Ep Heuvelink (ep.heuvelink@wur.nl)

Planning:

Start in consultation with supervisor

Analysis of realistic ‘genotype by environment’ interactions simulated using a crop growth model with a large number of physiological parameters

Supervisor(s):

Dr. Ep Heuvelink and Prof.Dr. Fred van Eeuwijk (WUR Biometris)

Description:

A different response of genotypes across environments is frequent in multi-location trials and is known as genotype by environment interaction (GxE). The study and understanding of these interactions is a major challenge for breeders and agronomic researchers.

To better understand the GxE a simulation study may be conducted using a crop growth model with a large number of physiological parameters, to obtain yields for different genotypes in different environmental conditions. Yields of different genotypes across environments should be analysed with some of the standard techniques to study GxE (e.g. AMMI models, mixed linear models, etc.) in order to answer questions such as:

- (i) are the GxE interactions significantly important? (e.g. are crossovers present in the data?);
- (ii) which kind of parameters make the GxE stronger?
- (iii) which characteristics (regarding parameter specification) should have the genotypes to have higher yield in a particular environment?
- (iv) which parameters are the most important to explain the final yield?

BSc/MSc and ECTS:

MSc-thesis: 24 or 36 ECTS

Type of work:

Desk study thesis on modelling/simulation/analysis.

Requirements:

Interest in quantitative methods. Some knowledge of crop growth models and good statistical knowledge, preferably including multivariate methods.

Planning:

In consultation with the supervisor(s).

Source-sink ratio and negative feedback of low sink strength on crop photosynthesis

Supervisor(s):

Dr. Ep Heuvelink and Prof. Dr. Leo Marcelis

Description:

Light is the most important growth factor determining crop yield in greenhouses. In northern regions including The Netherlands, low light levels limit photosynthesis and consequently growth during a large part of the year. On the other hand in summer time there are periods with too high intensities, which may lead to photo-damage or reduction of the quality of produce.

The overall objective of this project is to identify and quantify possibilities for increasing Light Use Efficiency (LUE; g per MJ intercepted PAR) in greenhouse crops. The MSc thesis work will focus on the reduction in LUE which may result from a limitation by sink demand. Occurrence of feedback inhibition of photosynthesis may limit LUE. In this project the importance of sink demand for LUE will be investigated in tomato cultivars with different fruit sizes (sink strengths).

BSc/MSc and ECTS:

MSc-thesis: 24 or 36 ECTS

Type of work:

Determine the source-sink ratio for several tomato cultivars.

Determine whether tomato cultivars differ in their feedback inhibition of plant growth.

Greenhouse experiment and laboratory measurements, including leaf photosynthetic properties, stomatal conductance, content of carbohydrates, leaf area expansion and orientation.

Planning:

In consultation with the supervisor(s)

Viability of broad-spectrum LED lighting in greenhouse tomato

Supervisor(s):

Dr. Ep Heuvelink

Description:

Vine crops, specifically tomatoes, represent one of the largest segments for electric lighting in horticultural applications. Furthermore, cultivators are constrained by inadequate lighting conditions during winter months and high operating costs for traditional lighting systems. LED lighting systems are becoming increasingly efficient and cost-effective, yet understanding of spectral effectiveness within PAR and beyond requires further investigation. In this study we aim to assess the effectiveness of three light recipes; (1) Traditional HPS, (2) Broad spectrum LED, within the PAR range, and (3) Broad spectrum LED with Far Red 730nm. The objective of this study is to evaluate the viability of broad-spectrum LED fixtures as a substitute for HPS fixtures in greenhouse tomato production.

MSc-thesis: 24 or 36 ECTS

Type of work:

A greenhouse experiment is conducted. Several students can participate, with focus on:
Growth and yield component analysis – destructive harvests
Photosynthesis and light interception
Fruit quality – sugar content, shelf life

Planning:

Start in January 2019

A Functional Structural Plant Model (FSPM) for lettuce growth in urban horticultural production systems

Supervisor(s):
Wenqing Jin (Ph.D candidate) and Prof. dr. Leo Marcelis

Description:
3D simulation of plant function and structure is a vital and a growing international scientific research field. The last decade the methodologies for 3D simulation of plants have improved enormously. 3D simulation of plant function and structure enables researchers to address very interesting scientific questions as well as practical questions in horticulture. For instance understanding the consequences of different distributions of light in canopies for leaf and crop photosynthesis, which is being applied in the development of light diffusing materials and LED lighting systems.

'Urban farming' is food production in and around the city. Urban farming is considered a promising development in the light of societal challenges regarding food security and urbanization, and sustainable crop production (FAO 2011, Colding & Barthe 2013). Growing vegetables in multilayers in buildings without solar light is a form of urban farming, attracting a lot of attention worldwide. Experiments by Philips with Light-emitting Diode (LED) systems for multilayer cropping facilities indicate that the growing of crops in multistorey warehouses close to the point of consumption is technically feasible and promising. To make these systems economical profitable the growth process needs to be fully optimised. Models can help to guide in order to find the most optimal production system.

BSc/MSc and ECTS:
MSc-thesis: 36 ECTS

Type of work:
- make a research plan
- get acquainted with **FSPM** models and Groimp (see http://www.grogra.de/)
- make a survey of existing lettuce models
- program an **FSPM** for lettuce able to simulate light absorption, crop photosynthesis, leaf growth and plant development
- A lettuce experiment can be conducted in order to gather experimental data that can be used for model development, calibration and/or validation.

Planning:
flexible - In consultation with the supervisors.

Nutrient solutions for the cultivation of Arabidopsis

Supervisor(s):

Dr J Harbinson, Dr Sander van Delden

Description:

In WUR we grow huge numbers of Arabidopsis plants for research purposes. For this we use a standard recipe of a hydroponic nutrient solution often with rockwool as a substrate. It is not at all certain, however, that this standard recipe and method is optimal, and some evidence points to it being, in fact, not the best nutrient mix. We would like, therefore, to research the optimality of the nutrient mix we use for the rockwool cultivation system to determine if it is optimal. This would involve exploring the nutrient mix use in the hydroponic cultivation system, changes that occur in the rockwool system, and depending on progress, naturally occurring variability amongst Arabidopsis ecotypes. As a fast growing plant it is feasible to conduct this kind of research on Arabidopsis within the timeframe of a Master's project.

BSc/MSc and ECTS:

MSc-thesis: 36 ECTS

Type of work:

Working with plant nutrition, plant growth, chlorophyll fluorescence imaging, and possibly naturally occurring variation in plant nutrition responses. This would require some competence in the chemical formulation of nutrient mixes and the analysis of chemical changes in a rockwool growing system (eg pH).

Planning:

In consultation with the supervisor.

The responses of Arabidopsis to different artificial light-sources

Supervisor(s):

Dr J Harbinson, Dr W van Ieperen.

Description:

In WUR we make extensive use Arabidopsis as a model plant. It is common practice to grow the plant in growth cabinets using fluorescent tubes as a light-source, but in the future this light light-source will be phased out in favour of LED lighting systems. There is therefore considerable interest in understanding how different LED light-sources influence in the growth of Arabidopsis, and how these responses compare to those achieved under an LED-based artificial daylight spectrum, and an LED-based artificial fluorescent tube-light spectrum. In the end we need to know how we can best replace our fluorescent tube systems. Arabidopsis is also a widely distributed (from Africa to Northern Europe) plant which even though it is a sun plants can be expected to have adapted to a range of light-environments. We would also like to explore naturally occurring variation in the responses of Arabidopsis to different light-sources.

BSc/MSc and ECTS:

MSc-thesis: 36 ECTS

Type of work:

This project combines plant-light responses and plant lighting technology and control, along with evolution and biodiversity. It would suit someone interested in these topics. The work would include not only the measurement of the light environment but the characterisation of plant responses to the spectrum and intensity.

Planning:

In consultation with the supervisor.

State Transitions in photosynthesis

Supervisor(s):

Dr J Harbinson

Description:

A low irradiances (within the light-limited region and slightly above) the LHC of PSII (LHCII) becomes phosphorylated when the excitation of PSII exceeds that of PSI, resulting in the reduction of the PQ pool. As a result of this phosphorylation, LHCII detaches from PSII, decreasing the cross-section for light absorption by PSII. Once detached, this phosphorylated LHCII is generally believed to at least partly attach to PSI, so increasing the cross-section for PSI light absorption. This should result in an increased While this 'detachment from PSII, attachment to PSI' model is generally believed, some measurements of assimilation during a state-transition show no change in light-use efficiency for assimilation, which contradicts the role of state-transitions as a means for increasing photosynthetic light-use efficiency. We have recently built a system for measuring state-transitions and assimilation, and shown that in tomato state-transitions do result in an increase in the light-use efficiency of assimilation. This instrument also allows state transitions (amongst other things) to be relatively easily monitored, allowing state transitions to be more generally investigated. Within this project it is expected that state transitions would be investigated in different plants to investigate their extent, their speed, and if, indeed, the extent to which they generally result in an increase in leaf light-use efficiency for assimilation.

BSc/MSc and ECTS:

MSc-thesis: 36 ECTS

Type of work:

Manage the operation of the instrumentation required for measuring state-transitions.
Select species/genotypes/mutants for investigation (to be decided after discussion with student).
Measure state transitions at the leaf level using a combination of gas exchange, biophysical measurements, and – depending on the detailed research plan – correlate with properties or processes.

Planning:

In consultation with the supervisor.

Spectral dependency of the light-limited quantum yield of photosynthesis

Supervisor(s):
Dr J Harbinson

Description:
Under light-limited conditions the relationship between assimilation and irradiance (either incident or absorbed irradiance can be used) is predominantly linear. The gradient of this relationship is called the light-limited quantum yield of photosynthesis and is determined by the basic biophysics and biochemistry of photosynthesis. The light-limited quantum yield is wavelength dependent, reflecting the wavelength dependency of various photosynthetic and non-photosynthetic processes that influence the quantum yield for photosynthesis. We have recently built an instrument that allows the more or less routine measurement of the light-limited quantum yield, allowing it to be more readily measured than before. Not much systematic research has been done on this topic, and it would be valuable to look at the diversity of light-limited yields in plants, and how mutations in various photosynthetic processes affect the spectral dependency of quantum yield. The choice of material to be investigated is large and the final choice would depend on the interests and expertise of the student

BSc/MSc and ECTS:
MSc-thesis: 36 ECTS

Type of work:
Manage the operation of the instrumentation required for measuring light-limited quantum yield and possibly modify this equipment.
Select species/genotypes/mutants for investigation (to be decided after discussion with student).
Measure light-limited quantum yields under different conditions at the leaf level using a combination of gas exchange, biophysical measurements.
Correlate these data with other measurements of leaf physiology or organisation.

Planning:
In consultation with the supervisor.

Modelling the light-use efficiency of photosynthesis

Supervisor(s):

Dr J Harbinson (HPP) and Dr Xinyou Yin (CSA)

Description:

We have recently devised a basic mechanistic model of photosynthetic light-use efficiency that is based on the biophysics of photosynthetic electron transport and the redox state of P700. Even with only minor modification, this thylakoid level model can be used to simulate and fit light-response curves of assimilation. We would like to further develop this model, integrating into other photosynthesis models, and further explore its use. This would require a student with some modelling and numerical aptitude because of the need to work with mathematical models and apply them to the analysis of data and simulation of processes. Within the broad scope outlined, there are many opportunities to develop more specific projects to suit the interests and experience of suitable candidates

BSc/MSc and ECTS:

MSc-thesis: 36 ECTS

Type of work:

Working with and developing mathematical models and applying them to real-world data and using them to simulate physiological processes in leaves and canopies.

Planning:

In consultation with the supervisor.

Developing instrumentation, based on Arduino, custom made electronics and LEDs, to measure photosynthetic biophysical processes in leaves

Supervisor(s):

Dr J Harbinson

Description:

Photosynthesis research depends on instrumentation and associated measurement procedures to measure the activity and regulation of physiological processes occurring deep in leaves and other photosynthetic organs. We build much of our own instrumentation, and we are always seeking to improve the performance and usability of the equipment and improve the measurement procedures/techniques. For candidates with the appropriate background and experience, developing improved protocols and improving instrumentation in other similar ways, would be possible thesis topics. Our systems are increasingly based on Arduino microcontrollers, so knowledge of this (or similar) platform would be essential to undertake a thesis of this kind.

BSc/MSc and ECTS:

MSc-thesis: 36 ECTS

Type of work:

Developing instrumentation improvements based on electronics and microcontroller programming

Planning:

In consultation with the supervisor.

Photosynthetic properties of extremophiles

Supervisor(s):
Dr J Harbinson

Description:
Many plants grown as ornamentals are extremophiles or at least grow in unusual environments or have unusual physiological properties compared to typical crop plants (both field and greenhouse crops). For example, many orchids and bromeliads use the CAM photosynthetic metabolic pathway, many bromeliads can tolerate high light while possessing only limited photosynthetic capacity, and many foliage ornamentals are capable of adapting to extreme shade. The photosynthetic properties of these plants are often unusual and interesting, and important in terms of understanding the flexibility of plant photosynthesis. Measuring the photosynthetic properties of the extremophile or otherwise interesting ornamentals would be a challenging project for someone who wants to understand some of the more challenging aspects of photosynthesis.

BSc/MSc and ECTS:
MSc-thesis: 36 ECTS

Type of work:
Working with unusual plants, which display unusual physiological or ecological properties. The physiological measurements required would be diverse and often challenging – in some cases novel approaches would need to be developed given the unusual nature of these plants both morphologically and physiologically. The data obtained will also require thoughtful analysis.

Planning:
In consultation with the supervisor.

MEDICAL CANNABIS

Supervisor(s):

Prof.dr. Leo Marcelis

Description:

The global market for medical cannabis is rapidly growing and some countries have now also legalised the recreational use of cannabis. Multiple medical benefits for cannabis have been described (Hill et al. 2015; Whiting et al 2015). The major compounds of medical interest are cannaboids. The plant produces over 100 cannaboids, of which tetrahydrocannabinol (THC), Cannabidiol (CBD) tetrahydrocannabinol (THC), and Cannabidiol (CBD) are the most abundant compounds of interest, but other compounds might also be very important. These cannaboids are produced in glandular trichomes, which are most abundant in floral buds of cannabis plants. Also terpenes produced in the plant are relevant and they may synergistically interact with the medical effects on cannaboids (from website Bedrocan).

Application of cannabis compounds for medical purposes requires that the production meets standards of the farmaceutical industry. Amongst others this implies that the production process is completely controlled and that absolutely no pesticides are used. A high level of control can be realised in greenhouses, but even better in indoor farms without solar light.

BSc/MSc and ECTS:

MSc-thesis: 24-36 ECTS

Type of work:

In this research we will perform a number of experiments in climate chambers to study effects of LED Lighting on different growth stages of the cannabis plant (propagation, development, morphology, flower induction and content of cannaboids; per student project one of these topics will be studied).

For more info on this exciting topic contact Leo Marcelis (Leo.Marcelis@wur.nl)

Planning:

In consultation with the supervisor.

Pre- to Postharvest Topics

Anthocyanin Discolouration in Purple Pepper Fruits.

Supervisor(s):

Ying Liu (PhD candidate) and Dr. Rob Schouten, Prof.dr. Leo Marcelis and Dr. Arnaud Bovy (Plant Breeding)

Description:

- Anthocyanins, plant secondary metabolism, are suggested to have health-promoting effects for human. They also facilitate plant reproduction and protect plants from various biotic and abiotic stresses. In pepper (Capsicum. Spp.), there are many purple-fruited genotypes, whose purple colour is imparted by anthocyanins. However, during fruit ripening anthocyanin gradually disappears which results in a lack of mature purple pepper fruits on the market. Besides developmental regulation, anthocyanin metabolism is regulated by environmental factors such as light and temperature.
- Anthocyanin discolouration could be attributed by two aspects, namely reduced biosynthesis and increased degradation.
- We want to study the environmental regulation on anthocyanin biosynthesis and degradation during fruit development and storage processes.

BSc/MSc and ECTS:

MSc-thesis: 24-36 ECTS

Type of work:

Postharvest Biotech. Techniques:

- Molecular biology: DNA, RNA, RT-(q)PCR
- Metabolite analysis: HPLC, LC-MS
- Enzyme assays

Postharvest Phys. Techniques:

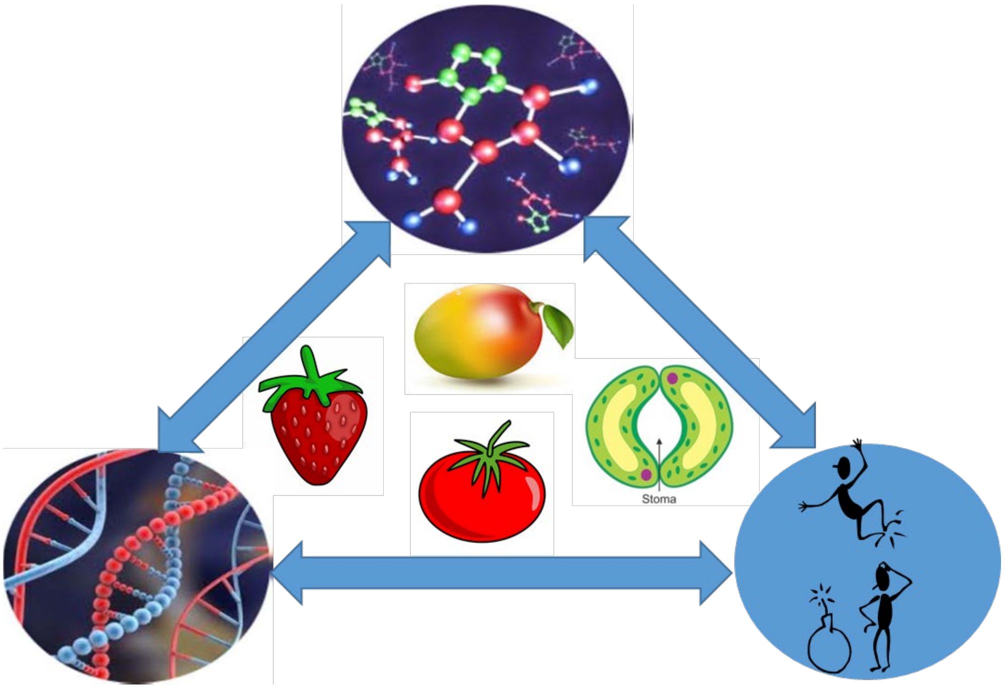
- Colour measurements to assess anthocyanin level
- Storage at varying light and temperatures

Planning:

Start in consultation with supervisor

Post-harvest topics

Post-harvest quality of fruits, flowers and vegetables



- **Influence of preharvest conditions**

  Chilling injury, LED lighting, vase-life, tree factor

- **Postharvest Physiology & Biotechnology techniques**

  Colour, firmness, HPLC, qPCR, GC-MS, CRISPR-Cas9, modelling

Supervisor(s):

Dr Rob Schouten, Dr Julian Verdonk, and Prof Dr Ernst Woltering

BSc/MSc and ECTS:

MSc-thesis: 24-36 ECTS.

Planning:

Flexible starting time.

Topics available:

Vase life of cut flowers

- Investigate the influence of preharvest conditions on postharvest quality, vase life. RH during preharvest has effect on quality (vase life). Stomata malfunction is caused by high humidity during preharvest, and is possibly genotype dependent. Bouvardia, Chrysanthemum, topics available.
- Transport of cut flowers can lead to quality problems. What is exactly happening and why is quality affected in some genotypes and not others. Chilling injury, sugar leakage, high humidity during transport. Chrysanthemum, Bouvardia, Gerbera, Rose topics available.
- Stomata functioning can be badly influenced by high RH during pre- and or post- harvest. Gene expression in good and bad lines, and observations using stomata analyses are part of this topic. Chrysanthemum and Rose topics available, as well as mere theoretical ones using Arabidopsis and bean.

Type of work:

Postharvest Phys. Techniques:

- Vase life measurements
- Stomata functioning
- Enzyme assays for chilling injury
- Transport/Storage simulations
- Postharvest treatments, LED lighting, cooling, humidity
- Bacterial counts

Postharvest Biotech. Techniques:

- Stomata functioning assays
- Molecular biology: DNA, RNA, RT-(q)PCR

Chilling injury in Tomato

- Tomato, as a (sub-) tropical fruit suffers from chilling injury (CI). CI occurs before or after harvest, in the field, during transport, storage and marketing. Symptoms are numerous, and include tissue browning, pitting and discoloration of the skin, uneven ripening, and increased disease susceptibility. We want to investigate the role of preharvest factors by growing plants of small tomato cultivars in growing cabinets and vary light and temperature. We also have projects that explore the potential of CA (Conditioned Atmosphere) to reduce CI incidence primarily by lowering the oxygen level during postharvest storage. Finally, we have projects that aim to develop volatile and enzymatic markers to screen fruit cultivars for their ability to benefit from CA and MAP (Modified Air Packaging).

Type of work:

Pre-Postharvest Phys. Techniques:

- Non-destructive measurements (firmness, colour)
- Enzyme assays
- Conditioned atmosphere storage
- Growing tomato plants under varying amounts of light and temperature stress

Postharvest Biotech. Techniques:

- Molecular biology: DNA, RNA, RT-(q)PCR
- HPLC, GC-MS

Tomato Lycopene Bioavailability

[Project together with Dr. Edoardo Capuano FQD (Food Quality and Design)]

- A very red tomato contains more lycopene than a light red tomato. However, the bioavailability (how much gets absorbed in your body) of lycopene, an important health-promoting compound, might be the same. Manipulation of tomatoes by postharvest cold and light treatments. We hypothesize that if we can create softer tomatoes with the same colour that we can drastically improve the bioavailability of lycopene. We will measure use bioavailability of lycopene by in vitro digestion.

Type of work:

Postharvest Phys. Techniques:

- Non-destructive measurements (firmness, pigment, etc.)
- Modelling
- HPLC analyses and bioavailability assays

LEDs grow Quality: Light conditions and the effect on quality related compounds

- Investigate the regulation and biosynthesis of specific classes of agronomically important secondary metabolites in species that are valued for their production of such compounds. We will grow plants under different light conditions to modulate these specific chemical pathways.
    - Glucosinolates in rucola, bimi and Arabidopsis
    - Volatile aroma compounds in the herbs basil, mint and cilantro
    - Lettuce and other leafy vegetables keeping quality
    - Biosynthesis of other quality related compounds: carotenoids, vitamin A, C, and E, phenylpropanoids, etc.

Type of work:

Postharvest Phys. Techniques:

- Shelf life
- Water loss
- Microscopy
- LED lighting

Postharvest Biotech. Techniques:

- Molecular biology: DNA, RNA, RT-(q)PCR
- HPLC, GC-MS
- Microscopy

Quality of processed lettuce, cucumber and tomato: what is translucency?

- Translucency (glassiness) is a serious problem in processed products, but up till now we don't understand the mechanism that leads to glassiness. We have found a number of clues, though. We can for instance transfer the glassiness that often happens in cut tomato to cut cucumber (that never shows this), and we can quantify the process. Can you come up with smart experiments that provide insight in the nature of this problem?

Type of work:

Postharvest Phys. Techniques:

- Translucency measurements
- Slicing (thickness, sharpness of the knifes)
- Microscopy
- Modelling
- Temperature treatments
- Ethylene treatments

Postharvest Biotech. Techniques:

- Enzyme assays
- Molecular biology: DNA, RNA, RT-(q)PCR
- HPLC
- Microscopy

CRISPR-Cas9 projects

- We have projects to design and test CRISPR-Cas9 approaches for the species below. It is the goal to test the constructs in transient expression systems like *Nicotiana benthamiana*, Tobacco or Petunia.
- The target gene will also be tested, for example during ripening, or growth conditions, using qPCR. It is also necessary to clone the target DNA in a binary vector.
- Co-transformation of a construct that contains the target gene or region of the species of interest and the CRISPR-Cas9 construct that will cut it, will give us an idea if it will work.
- This thesis will be a great way to learn the newest molecular biology tools. We will use Golden Gate, Gateway, and traditional restriction enzyme cloning. Also, qRT-PCR, and a lot of bioinformatics will be part of the thesis. Transient agrobacterium transformations, and the start of tissue culture to make real transgenic plants will all be part of your work.

Type of work:

Postharvest Biotech. Techniques:

- Tissue culture:
- Plant transformation: Stable, transient, protoplast transformation
- Molecular biology: DNA, RNA, RT-(q)PCR, Cloning (gateway, golden gate, traditional RE cloning)

Strawberry projects:

- We have projects to study the effect of preharvest conditions on postharvest quality, shelf life and flavour life.
- We have projects to study the link between strawberry colour, proanthocyanidin content and Botrytis incidence.
- We would like to identify genes and gene products that are involved with shelf life and postharvest quality. Once identified, we will characterize them, and if possible manipulate expression in plants to prove functionality.

Type of work:

Postharvest Phys. Techniques:

- Microscopy
- Shelf life
- Stomatal function
- Colour measurements
- LED lighting
- Modelling

Postharvest Biotech. Techniques:

- Molecular biology: DNA, RNA, RT-(q)PCR
- HPLC, GC-MS
- Microscopy
- Tissue culture, and transgenic plant production

Petunia scent and colour: Manipulate scent and/or colour in Petunia.

- Investigate the biosynthetic pathway and regulatory elements of scent and colour production. Manipulate gene expression through overexpression, silencing or CRISPR-cas9
- Change the smell of petunia flowers. Introduce genes that produce volatiles that are not present in the headspace of wild type Petunia flowers. Additional, use inducible expression to switch it on when you want (dexamethasone/steroid inducible expression)

Type of work:

Postharvest Biotech. Techniques:

- Tissue culture:
- Plant transformation: Stable, transient, protoplast transformation
- Molecular biology: DNA, RNA, RT-(q)PCR, Cloning
- Metabolite analysis: HPLC, GC-MS
- Enzyme assays
- Cell biology: subcellular localization of compounds (Anthocyanins located in the vacuole, Carotenoids in the chromoplasts)

Marigold regulation of Carotenoid biosynthesis:

- Manipulate biosynthesis pathway in Marigold to change composition of carotenoids. Change colour or health benefits (Vitamin A).
- Golden Marigold. Introduce the golden rice construct to see the effects on marigold flowers.
- Study regulatory network of carotenoid biosynthesis. Investigate transcription factors that regulate colour, and study the effect of their manipulation on secondary metabolism (colour, scent, health related compounds).

Type of work:

Postharvest Biotech. Techniques:

- Tissue culture:
- Plant transformation: Stable, transient, protoplast transformation
- Molecular biology: DNA, RNA, RT-(q)PCR, Cloning
- Metabolite analysis: HPLC, GC-MS
- Enzyme assays
- Cell biology: subcellular localization of compounds (carotenoids loc. in the chromoplasts)

Tomato carotenoid manipulation:

- Tomato has a huge pool of lycopene; can this be used to produce lycopene breakdown products like lutein and or Astaxanthin? These compounds are highly valuable pigments and strong antioxidants.
- Manipulate biosynthesis pathway in tomato to change composition of carotenoids. Change colour or health benefits (Vitamin A).
- Golden tomato. Introduce the golden rice construct to see the effects on tomato fruit.
- Study regulatory network of carotenoid biosynthesis. Investigate transcription factors that regulate colour, and study the effect of their manipulation on secondary metabolism (colour, scent, health rel. compounds).

Type of work:

Postharvest Phys. Techniques:

- Colour measurements
- HPLC

Postharvest Biotech. Techniques:

- Tissue culture:
- Plant transformation: Stable, transient, protoplast transformation
- Molecular biology: DNA, RNA, RT-(q)PCR, Cloning
- Metabolite analysis: HPLC, GC-MS
- Enzyme assays
- Cell biology: subcellular localization of compounds (carotenoids loc. in the chromoplasts)

Tomato Stay Green:

- During tomato ripening, chlorophyll breakdown and lycopene biosynthesis coincide and are regulated by a Stay Green Protein (SGP). But not only colour, also firmness is regulated by this amazing protein family! This means that SGP are vital to tomato quality attributes such as colour and firmness behaviour.
- We want to study this regulation by manipulating of expression (CRISPR-cas9 and OX lines) , and study the effect on ripening processes.
- Stay Green proteins also affect firmness. We will study the link between SGR proteins and expression and activity of pectin breakdown enzymes with the aim to model the interactions.

Type of work:

Postharvest Biotech. Techniques:

- Tissue culture:
- Plant transformation: Stable, transient, protoplast transformation
- Molecular biology: DNA, RNA, RT-(q)PCR, Cloning
- Metabolite analysis: HPLC, GC-MS
- Enzyme assays

Postharvest Phys. Techniques:

- Colour measurements calibrated to assess chlorophyll and lycopene levels
- Non-destructive firmness measurements
- Storage at varying temperatures
- Modelling

Mango projects:

- Mangoes hardly ripens on tree, but quickly ripens after harvest. We want to identify the 'tree factor' compound in e.g. the milky white sap from the harvest wound. Also, we want to investigate the effect of e.g. removing leaves from mango branches in a Spanish orchard.
- Study the production of mango volatiles during development and ripening, and identify genes responsible for their production.
- For the study of processes in relation to quality and shelf life, we would like to identify genes and gene products involved with shelf life and postharvest quality. Once identified, we will characterize them, and if possible manipulate expression in plants to prove functionality.

Type of work:

Postharvest Biotech. Techniques:

- Molecular biology: DNA, RNA, RT-(q)PCR, Cloning
- Metabolite analysis: HPLC, GC-MS, LC-MS
- Enzyme assays

Postharvest Phys. Techniques:

- Non-destructive firmness measurements
- Storage at varying temperatures
- Ethylene treatments
- Preharvest treatments such as thinning, steam girdling

Potted plants (internships)

- Transport conditions reduce quality. Possible topics to study is the effect of darkness, ethylene, cold and mechanic damage. Effect of growing conditions (preharvest) on quality. Petunia, Chrysanthemum topics available. In collaboration with Syngenta, Dümen Orange, etc.
- Postharvest problems with transport of cuttings. Transport in plastic bags, cold and wet, some cultivars have problems rooting and show other quality problems afterwards. Poinsettia, Geranium topics available.

End of topics as grouped under title '*Post-harvest quality of fruits, flowers and vegetables*'

Post-harvest topics (continued)

Quality improvement of cut monocot flowers

Supervisor(s):
Supervisor(s): Prof. dr. Ernst Woltering (also Wageningen Food & Biobased Research - FBR)

Description:
Many monocot flowers (e.g. ginger, tulipa, iris) have a short vase life. The flower senescence in these flowers is not regulated by ethylene, so available solutions to block ethylene (STS, 1-MCP) generally have no impact in these flowers. In addition, in monocot flowers there is no problem with vascular blockage so solutions developed for this disorder (biocides, surfactants) have no impact in monocots.
The flower senescence in monocot flowers is generally thought to be related to the hormonal status, Especially plant hormones from the group cytokinins and gibberellins when applied to cut stems may positively affect the vase life.
To get more insight in the factors affecting the vase life of monocot species and to develop new pre-treatment solutions, we are in need of a literature study on:

- Physiology of senescence in monocot species
- Effect of plant hormones (and other compounds) on vase life and quality of monocot species

BSc/MSc and ECTS:
BSc-thesis: 18 ECTS

Type of work:
Literature study

Requirements:

Location:
Wageningen

Planning:
Can start anytime in consultation with supervisor.

Photosynthesis and respiration under low light conditions in fresh-cut lettuce

Supervisor(s):

Prof. Dr. Ernst Woltering (also FBR), Dr. Jeremy Harbinson and Dr. Wim van Ieperen.

Description:

In fresh cut lettuce stored at low temperature and low light intensity, there is significant sugar accumulation, this greatly improves the shelf life.. The light level applied is below the light compensation point for lettuce, which means that the sugar can, in theory, not be produced through photosynthesis. Currently it is not clear where the sugars come from. To solve this mystery we hypothesize that under these specific conditions photosynthetic activity may become more efficient than expected as e.g. the photorespiration may be suppressed or CO2 availability may be improved.
The aim of the research will be to determine the photosynthetic efficiency of lettuce leaf pieces under a variety of conditions of low light and low temperatures. This will give insight in the behaviour of the photosynthetic and respiratory systems under these conditions. In addition, the accumulation of carbohydrates (glucose, fructose, sucrose, starch) will be monitored and compared to the photosynthetic activities.

BSc/MSc and ECTS:

MSc-thesis: 24-36 ECTS

Type of work:

Crop(s): lettuce
Methods: LICOR for measurements of dark respiration and photosynthesis, light response curves; HPLC for measurements of carbohydrates; chlorophyll fluorescence imaging for determination PSII activity; microscopy to study stomata opening.

Planning:

Laboratory experiments that can be started in consultation with the supervisors; the exact nature of the experiments may change depending on start time.

Long-term storage of roses: its effect on xylem hydraulic conductance

Supervisor(s):
Prof. Dr. E. J. Woltering (also FBR) and Dr. Ir. Bastiaan Brouwer (FBR - Fresh Food & Chains)

Description:
We recently found that following long-term cold storage the stomata are less functional. It means that the flowers rapidly develop a negative water balance when placed in the vase (transpiration exceeds the uptake). Later during the vase life, the stomata become functional again, probably due to the developing water stress as xylem vessels become blocked. Also the xylem properties change during storage.
We want to develop an better understanding of the loss of xylem hydraulic conductance during long term storage and after flowers are put in vases. Loss of xylem hydraulic conductance can be due to changes in the vessel system, air embolisms, bacteria or wound-reactions.

BSc/MSc and ECTS:
MSc-thesis: 24-36 ECTS

Type of work:
We will work with roses, different cultivars, from Dutch growers, quality and vase life assessments, water uptake and transpiration, xylem resistance measurements, bacterial counting, ...
We will apply a variety of chemicals and technologies that are hypothesized to improve xylem hydraulic properties

Location:
Axis building, Food & Biobased research (Wageningen Campus)

Planning:
In consultation with supervisor

Avoiding the development of bitter taste in papaya

Supervisor(s):

Prof. Dr. E. J. Woltering also (FBR) and Dr. Ir. Bastiaan Brouwer (FBR - Fresh Food & Chains)

Description:

As part of a running project on papaya quality, we are interested in measuring the bitter flavour in papaya fruit flesh, what causes it and how it spreads through the papaya.
Ways of assessing the bitter flavour range from lab work to the use of highly specialized equipment.
The ultimate goal of the project will be to provide knowledge to understand under what conditions the bitter flavour occurs.

Goals:

1) Quantifiably measuring the bitter taste or its causing agents in papaya fruit flesh.
2) Prevent bitter flavour from developing in papaya fruit flesh.

BSc/MSc and ECTS:

MSc-thesis: 24-36 ECTS

Type of work:

- Literature study and setting-up trial plan
- Preparing experiments
- Learning how to work in the lab
- Performing measurements + quality measurements (firmness, colour, taste)
- Analyzing data
- Writing report

Planning:

- We expect this work to take up to a maximum of 6 Months (including introduction, setting up plan, designing experiments, performing them, analysing the data and writing report).
- Since papaya will not be available throughout the year, the starting date of the project will be discussed with the applicant.