Susceptibility to Chlorosis of grass seed varieties and soybean

Master thesis on a screening of 18 different grass varieties of different species for iron-induced chlorosis

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Master's Thesis

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Sustainable Development: Environmental Change and Ecosystems
45 ECTS
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Summary

A screening of 18 different varieties of graminaceous plants (rye, oats, and upland rice) was done based on their susceptibility to iron deficiency-induced chlorosis. Graminaceous plants reduce or prevent chlorosis using Strategy II, which is based on phytosiderophore release that can reduce inaccessible soil iron to iron accessible for plants in the form of Fe-phytosiderophore complexes. The plants were grown in a greenhouse in a quartz sand soil. A separate experiment was performed that examined the susceptibility of soybean (*Glycine max*) to iron deficiency-induced chlorosis. Soybean is a non-graminaceous plant that does not use Strategy II. Soybean was grown in growth chambers under low and high light regimes. In both experiments, the following parameters were studied: weekly water use of the plants, dry weight of above and belowground biomass, and leaf chlorophyll content measured using a SPAD meter. Additionally, different parameters of the revised Fe-binding assay protocol by Reichman and Parker (2007) were tested to examine whether their results could be reproduced and whether, subsequently, the method could be used to measure the fourth parameter—the concentration of phytosiderophores released by the plants. However, consistently reproducible results could not be obtained with the above assay protocol, and the fourth parameter was not used in the study. On the basis of the results obtained, the 18 screened varieties were ranked from the most susceptible to least susceptible to chlorosis. Rice varieties were found to be the most susceptible, followed by oat varieties. Rye varieties were the least susceptible, and most varieties did not show any susceptibility to chlorosis. Additionally, soybean plants showed extreme susceptibility to chlorosis in comparison with the 18 grass varieties, which indicated that plants using Strategy II are better able to withstand iron limitation. Light intensity did not significantly affect the susceptibility to chlorosis in soybean.

1. Introduction

1.1 Problem outline

Grass species are the primary crops for food production worldwide. Grains are part of the diet of billions of people, among which rice, wheat, barley, oats, and maize are the most widely used. Problems that reduce the yield of these crops can have direct and significant consequences for both the health of people that depend on them and the economic security for people that grow or distribute them. Micronutrient deficiencies causing reduced plant growth and lower crop yields are, therefore, major problems. Iron is one of the main micronutrients; sufficient iron uptake is essential for both the growth of a plant itself and the nutritional value of plant products.

Iron deficiency in plant species is called chlorosis. A characteristic indicator of chlorosis is yellowing of plant leaves and reduced growth (Gruber & Kosegarten, 2002). The yield of plant species affected by chlorosis is generally lower, and extreme cases of chlorosis have been known to lead to crop failure. In general, chlorosis caused by iron deficiency is not due to a lack of iron in the soil on which the plants grow. On the contrary, iron is abundant in most soils, and the amount needed for sufficient plant growth is amply present. However, most of the iron is not readily available for plant uptake, especially in alkaline and calcareous soils found in both arid and semi-arid areas of the world. This leads to chlorosis in plants grown on soil in approximately one-third of the world (Ma & Nomoto, 1996; Jeong & Guerinot, 2009). Chlorosis occurs if plants are unable to absorb sufficient iron and allocate them to the plant parts that require it.

To prevent reduced growth due to iron deficiency, grasses have developed a mechanism consisting of releasing chelating molecules that form complexes with iron and allowing them to be transported into the roots. Using this mechanism allows more soil iron to become available to the plants. The effectiveness of the mechanism differs among grass species. It is essential to understand and map the effectiveness of the mechanism for grass species, specifically species grown for human consumption that affect both human health and economy when chlorosis affects them. Iron acquisition by species prone to chlorosis can be facilitated through application of additives to the soil to prevent chlorosis.

1.2 Scientific background

1.2.1 Functions of iron

Iron (Fe) is one of the main micronutrients for plant species. It is used in the heme enzyme system used in plant respiration and photosynthesis (Uchida, 2000). Furthermore, iron is used in proteins like ferredoxin, required for the reduction of nitrate and sulfate. The third major use of iron is synthesis and maintenance of plant chlorophyll, which is central to the present thesis.

1.2.2 Phytosiderophores

Plants have developed specific strategies for acquiring Fe from the soil. Most plants use the so-called Strategy I mechanism, which involves both the acidification of the rhizosphere and enhancement of rates of Fe (III) reduction (Marschner & Römheld, 1986). These reactions make it easier for plants to absorb iron; however, it is not sufficient in iron-deficient soils. In contrast, grasses apply Strategy II, which involves the formation of phytosiderophores—non-proteinaceous amino acids—that form chelates with Fe (III), called Fe-phytosiderophore complexes (Lu et al., 2007). These complexes can be absorbed by graminaceous plants. Strategy II plants are more efficient in Fe acquisition than Strategy I plants (Römheld & Marschner, 1986). Therefore, Strategy II plants are more resistant to chlorosis. The presence of phytosiderophores was discovered by Takemoto et al. in 1978; mugineic acid (MA) was the first identified phytosiderophore able to form chelates with iron. Figure 1 shows a schematic view of both strategies described above. The letters in the ovals show the different transporters and enzymes used in the processes (Kobayashi & Nishizawa, 2012).

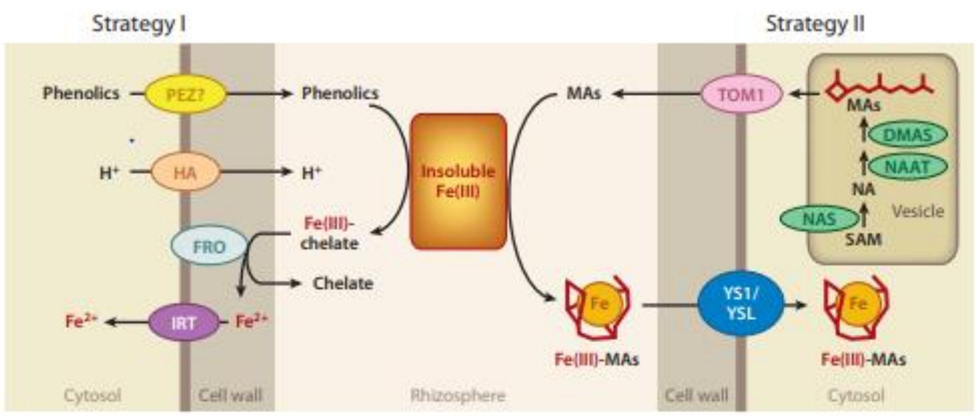

Figure 1: Overview of the two iron uptake strategies in plants (Kobayashi & Nishizawa, 2012).

1.2.3 Iron deficiency

Iron deficiency chlorosis in plants is caused by insufficient synthesis of chlorophyll (Schenkeveld, 2010). Fe is used in the formation of thylakoid membranes, where chlorophyll is located. Insufficient iron uptake, therefore, leads to a lower amount of chlorophyll. Chlorophyll is responsible for the green colour of plant leaves, and the lack thereof causes the plant and, especially, the leaves to become yellow (Koca et al., 2007). Newly grown leaves are more prone to chlorosis because Fe is not transported to them from roots—where it is absorbed from the soil—but it is relocated from older parts of the plant (Kim & Guerinot, 2007). Iron is also required for DNA synthesis in plant cells and therefore, an iron deficiency further reduces plant growth as DNA is required for growth (Reichard, 1993). Another plant response to chlorosis is the formation of a more elaborate root structure, which enables the plant to encounter more iron in the soil to overcome iron deficiency (Römheld & Marschner, 1981). Chlorosis is found more often in plants grown in calcareous soils owing to the typical pH of these soils, which is between 7 and 8.5 (Mengel, 1994; Schenkeveld, 2010) because the amount of iron in solution that can be absorbed by plant roots is the lowest in this pH range. Plants require a higher amount of iron in solution than that found at these pH levels (see also figure 2).

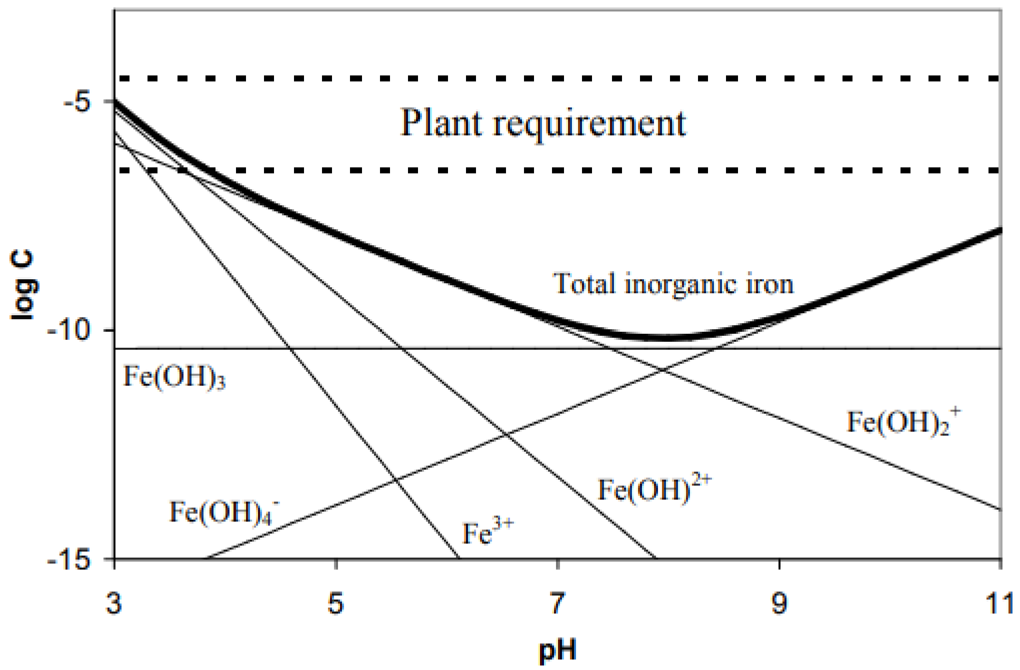

Figure 2: Representation of the total inorganic iron in equilibrium with soil Fe(hydr)oxide mineral phases as a function of pH (Schenkeveld, 2010; Lindsay, 1979).

1.3 Knowledge gap

Research on release of phytosiderophores in response to iron deficiency and chlorosis in grass species is limited. Most research that has been done was published before or shortly after 2000 and is therefore often not up to date with the varieties currently used in agriculture. This is because of the rapid turnover caused by breeding of new varieties. Literature search showed that there are no scientific publications about either iron uptake or iron deficiency in most grass varieties. More data are available on a species level, but differences among varieties of a species are significant (Jahn et al., 2011). On the basis of the general overview provided by the literature, the amount of phytosiderophore produced and therefore the iron efficiency of grasses can be ranked as follows: barley > wheat > oats > rye > corn > sorghum > rice (Römheld & Marschner, 1986; Lytle & Jolley, 1991). From this list of crops, corn and sorghum were not further considered in the proposed research because they are C4 grasses and because the focus of the present research is on C3 plants. Barley and wheat produce the highest quantities of phytosiderophores and are therefore not prone to chlorosis. These two species were not included in the proposed research, because iron-inefficient grass species are the focus of this research as they show reduced growth and crop yield when grown in iron-deficient conditions. More extensive literature research has been done on iron inefficiency in the remaining three species. Studies on iron inefficiency have been previously done in rice (Pereira et al., 2014; Kobayashi et al., 2014; Liu et al., 2015) and oats (Mench & Fargues, 1994; Hansen & Jolley, 1995; Jolley et al., 2004). Studies on rice species concluded that they were able to use both Strategy I and II. Iron deficiency was present among all tested varieties, but the dominant strategy used to reduce the effects of iron deficiency differed. Studies on oats indicated substantial differences among oat varieties with induced iron deficiency. Most varieties showed symptoms of chlorosis, whereas others were not affected. The affected species were found to have increased levels of not only Fe but also other metals like Zn and Ni in the rhizosphere. Most previous studies have been done on single varieties of these species, and assessments of groups of seed varieties of grass species are rare.

1.4 Research aim

The present master thesis project aims to close the existing knowledge gap regarding the limited research on iron deficiency in rice, oat, and rye varieties. The thesis focuses on phytosiderophore release in varieties that have not been previously studied. Knowledge of the effects of iron deficiency on growth, water use, and chlorophyll content in specific varieties of grass species was obtained through a screening experiment, which included a large-scale test of 18 different varieties of rice (8), oat (5), and rye (5). The 18 varieties were tested regarding their response to induced iron deficiency and subsequent chlorosis and ranked based on their susceptibility to chlorosis were the variety that is most susceptible is at the top of the list. Furthermore, to compare Strategy II plants (using phytosiderophore release) with Strategy I plants, a separate experiment was conducted in which iron deficiency was induced in a Strategy I plant. A soybean (*Glycine max*) variety was grown under iron-deficient conditions, allowing a comparison between strategy I and strategy II plants (18 grass varieties) with respect to their response to iron limitation and subsequent chlorosis. The difference between the two types of strategies, that is, release of phytosiderophores, was then indirectly quantified. The 18 grass varieties screened were ranked on the basis of their response to iron limitation. The ordered list thus obtained is potentially useful in future research or in agriculture, to determine which varieties would benefit the most from soil additives to improve iron acquisition or to determine novel techniques focusing on fixation of metals other than iron to increase the effectiveness of the amount of phytosiderophores in iron acquisition when chlorosis occurs. Thus, the present research aims to generate a knowledge base around iron acquisition in 18 different grass varieties, which is currently non-existent for the chosen varieties.

1.5 Research questions

In order to investigate plant response to chlorosis in 18 grass seed varieties and rank them accordingly, the following research question is proposed:

How do different grass varieties from rice, oat and rye species and soybean plants respond to induced iron deficiency with respect to leaf chlorophyll content?

To answer the main research question, the following sub-questions needed to be answered:

How do soybean and different varieties of rice, oats, rye respond to induced iron deficiency with respect to weekly water use?

The plants of both experiments are monitored on their weekly water use. The control and experimental groups of plants of both experiments are analysed to see if significant differences are present when chlorosis due to iron deficiency is induced.

How do soybean and different varieties of rice, oats, rye respond to induced iron deficiency with respect to leaf chlorophyll content?

The plants were closely monitored during the pot growth phase of the screening experiment. These measurements were then statistically analysed to find significant differences in chlorophyll content between the control and experimental groups of each seed variety over time. Subsequently, the 18 different grass seed varieties were compared on the basis of their chlorophyll content. Additionally, the results were compared with soil-plant analyses development (SPAD) measurements of soybean plants, which do not possess a mechanism of phytosiderophore release to resolve iron limitation, grown under iron-deficient conditions.

How does the biomass of soybean and different varieties of rice, oat, and rye differ in response to induced iron deficiency?

Iron acquisition ability of the grass varieties in response to induced iron deficiency was indirectly measured and compared using above and belowground dry weight and plant height. Additionally, the ratio of the aboveground and belowground weight of the screened plant varieties was compared with the same ratio in soybean to examine whether the ability to release phytosiderophores has a significant benefit. Different light regimes among soybean plants were additionally compared to examine whether the low light regime presents a confounding factor in the screening experiment because light exposure was limited in addition to the iron limitation.

How does phytosiderophore release in different seed varieties of rice, oat, and rye differ?

The revised Fe-binding assay by Reichman and Parker (2007) was tested extensively to establish whether it was a viable option for quantifying phytosiderophore release among the screened seed varieties. The tests included validating different steps in the protocol by changing the parameters. Reichman and Parker (2007) used the ligand hydroxyethyl ethylenediamine triacetic acid (HEDTA) to verify their method. In the present research, the same ligand was used to confirm whether their findings could be reproduced. Root exudates harvested from the screened plants were then analysed and compared between varieties.

These four sub-questions examine different indicators and consequences of chlorosis induced by iron deficiency and the answers to these sub-questions, together, would provide a solid knowledge base regarding iron acquisition among the 18 grass seed varieties studied.

1.6 Research framework

The framework of the research is found in figure 3. It gives a representation of the different phases and steps in the research.

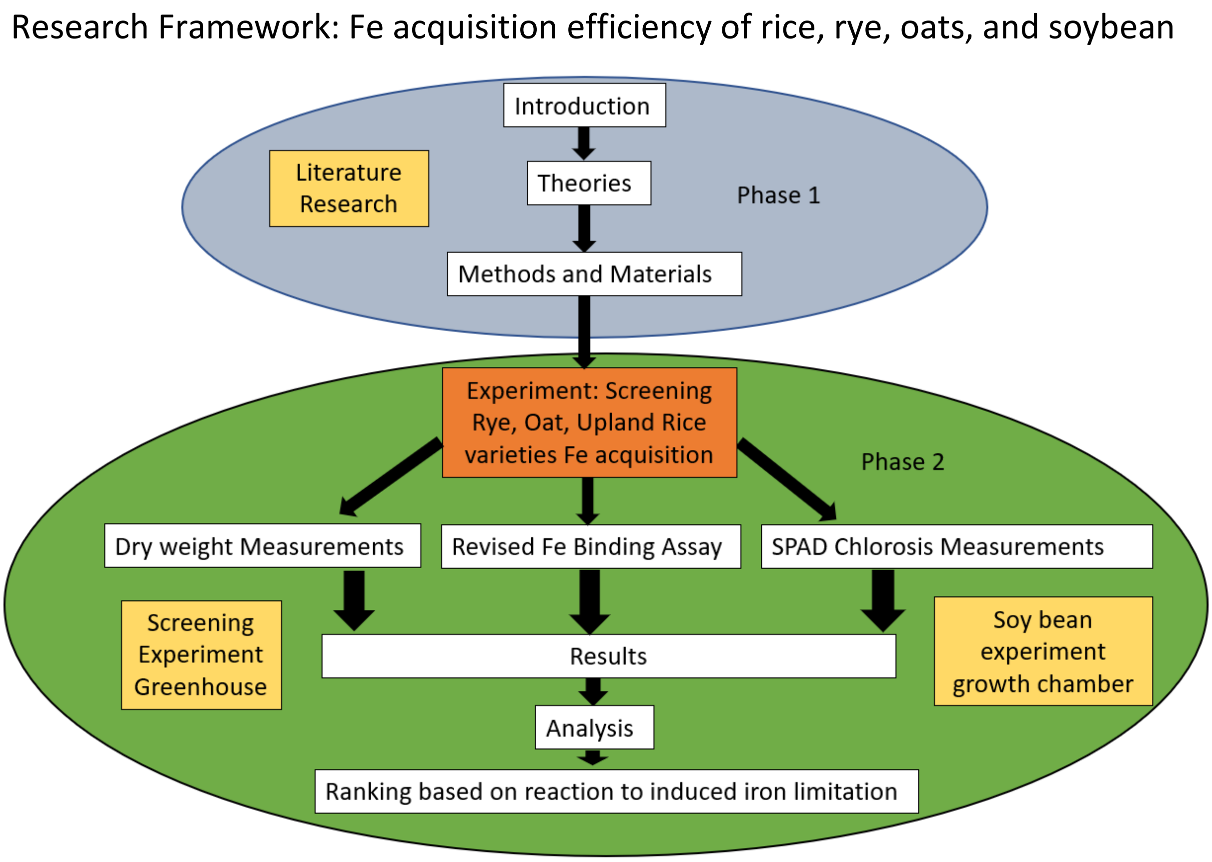

Figure 3: Research framework of the stepwise approach of identifying iron inefficiency in grass species, resulting in a ranking based on Fe acquisition ability of different grass seed varieties

1.7 Research relevance

The results of this master thesis research can be used for different types of follow-up research. The screening experiment provides previously unknown detailed information on iron deficiency in 18 different varieties of rice, oats, and rye. The thesis presents data regarding seed germination in the 18 grass varieties and the soybean variety and detailed information on induced chlorosis and above and belowground biomass in the different varieties under induced iron deficiency. Overall, the thesis creates a solid knowledge base regarding plant responses to induced iron deficiency. The data on water use, dry weight of above and belowground biomass, and chlorophyll content in iron-deficient plants over 4–5 weeks can be used by other researchers as a basis for research to identify grass varieties that do or do not cope well with iron deficiency or research on soil additives to ensure prevention of chlorosis in varieties with low phytosiderophore release. The screening data from this thesis can be used in the agricultural sector with respect to large-scale food production. The thesis results can be used to determine which variety would grow best in iron-deficient soils. If a specific variety from the 18 screened varieties needs to be grown, a comparison of the soil with the soil used in this thesis can determine whether iron additives are required.

Several of the varieties screened in this research are already used in agriculture, and this research can be used to improve the yield of these crops, primarily when people or animals depend on the crop yield for their survival. The research is, therefore, both relevant form a purely scientific and a societal point of view.

1.7.1 Research outline

The thesis work accounted for 45 points ECTS. First, during the set-up phase and analysis phase, the plant seed varieties of interest were selected through a literature research. Then, the seeds were acquired from different seed banks, for which a long communication period was required due to regulations. Because little was known about the germination period of these seed varieties, a range of tests were carried out. Soil was analysed using diethylenetriaminepentaacetic acid (DTPA) analysis to determine iron content and other elements of importance such as metals that could interact with phytosiderophores to form complexes. Next, literature search regarding a suitable method to quantify phytosiderophores at the end of the experiment was carried out. Lastly, nutrients required to be added to the soil on which the plants were grown were researched and acquired, and the soil was prepared for use in pots.

After the preparatory phase, the soybean experiment commenced, within three days of seed germination and 6 weeks of plant growth. The plants were watered four times per week, and SPAD measurements were taken three times per week for 4 weeks. Plant destruction of a little less than half the plants took place after 3 weeks and the final destruction after 6 weeks. Subsequently, dry weight of above and belowground biomass was measured.

The second experiment was carried out for 7 weeks, with 1.5 weeks for seed germination and seed transfer. In the following weeks, the plants were watered four times per week, and SPAD measurements were taken three times per week after the first visible symptoms of chlorosis. After approximately 7 weeks of growth, plant root exudates were collected, and the plants were separated into above and belowground biomass and dried for dry weight measurements. During and after the second experiment, the method chosen to quantify phytosiderophores was tested extensively.

2. Theory

2.1 Theoretical concepts

2.1.1 Plant response

The research in the present thesis is centred around plant response and soil chemistry. In the screening experiment, iron deficiency was induced in a group of varieties of three grass species. This experiment is focused on plant response to low iron uptake by roots, which induces chlorosis. This chlorosis was assessed using a Minolta-502 SPAD meter, which quantifies chlorophyll based on leaf colour.

The screening experiment examined the specific stress-induced response of grass species to chlorosis, that is, the release of phytosiderophores to bind and transport Fe (III), thereby increasing the amount of available iron among roots and relieving the iron deficiency stress. The amount of phytosiderophores produced by grass species is different for each variety (Römheld & Marschner, 1990). Additionally, the types of phytosiderophores produced may also differ (Ueno et al., 2007). Varieties that produce a lower amount of phytosiderophores show more chlorosis symptoms than those that produce larger amounts, which may not show any chlorosis symptoms (Kukier & Chaney, 2004); this was established using SPAD meter measurements to quantify phytosiderophores produced (Cesco et al., 2006). The SPAD meter is used as an indirect indicator of the quantity of phytosiderophores exuded by plants.

2.1.2 Soil chemistry

Most soil iron is present in a form inaccessible to plants. In Strategy I plants, Fe needs to be reduced to its ferrous form, which can be transported through the root cell membrane (Schmidt, 2003). However, Strategy II plants can transport the non-reduced form of iron as it forms complexes with phytosiderophores that can be transported through the plasma membrane. The amount of available soil iron can be increased using certain methods, for example, iron fertilization with synthetic chelates added to the soil (Calliskan et al., 2008; Rodríguez-Lucena et al., 2010). These chelates can convert and maintain the iron in a soluble form (Schenkeveld et al., 2017).

2.2 Hypotheses

It was hypothesised that screening different grass seed varieties would identify a variety of rice seeds that show the most symptoms of chlorosis and, therefore, the lowest iron acquisition ability. The screening was based on the list of grass species studied with respect to iron deficiency by different researchers over time (Römheld & Marschner, 1986; Lytle & Jolley, 1991). The amount of phytosiderophores released is lower in rice than in rye varieties, whereas oat species show the most significant amount of phytosiderophores released and, subsequently, highest iron acquisition. However, there is also evidence that rice can use part of the mechanism used by Strategy I plants to absorb Fe (II) (Ishimaru et al., 2006). Therefore, it is worth investigating whether this other mechanism, which the other grass species under study (rye and oats) do not use, affects their susceptibility to chlorosis.

It was further hypothesised that dry weights of above and belowground biomass would show substantial interspecies differences and significant differences in between plants of each variety grown with and without added Fe (control group and experimental group, respectively). In plants with iron deficiency, plant growth is inhibited even before leaf chlorosis occurs (Gruber & Kosegarten, 2002), resulting in low aboveground biomass. However, in Strategy I plants, the belowground biomass (plant roots) increases with low Fe levels (Forde & Lorenzo, 2001; de LaGuardia & Alcántara, 2002), which could result in high belowground biomass even when aboveground biomass is low owing to reduced photosynthesis. In addition, increased root biomass combined with increased root width and length would facilitate both release of phytosiderophores from and absorption of Fe-phytosiderophore complexes into the roots. Plants cannot afford to invest in aboveground biomass (shoot growth) as usual because of iron deficiency, and therefore, they invest in root growth to accumulate more iron to finally attain healthy growth after chlorosis is overcome.

SPAD measurements show substantial differences in leaf chlorophyll content over time. Moreover, leaf thickness also affects SPAD measurements; however, its effects were significantly offset in the present study because SPAD measurements from four leaves from the same plant were averaged. Initially, the plants continue to use all nutrients from their seeds and thus show no chlorosis. Subsequently, the plants use soil nutrients, and soon after, the iron deficiency results in low SPAD measurements as chlorosis starts. This continues for a period with consequent low SPAD measurements, until eventually, the plants either overcome chlorosis and show standard SPAD measurements (Bernards et al., 2002) or remain affected until the end of their growth phase.

Soybean plants do not exhibit a mechanism based on phytosiderophore release to overcome chlorosis. It was hypothesized that soybean has significantly lower growth owing to chlorosis under iron-deficient conditions than grass seed varieties. Owing to an absence of phytosiderophores like in

Strategy II plants, chlorosis from induced iron deficiency cannot be reduced or overcome in the soybean plant. Therefore, a comparison could be made between soybean (Strategy I plant) and the grass seed varieties (Strategy II plants). Soybean was grown under low and high light regimes, assuming that the light regimes do not significantly affect chlorosis but possibly significantly affect dry weight owing to increased growth.

3. Methods

3.1 Materials

3.1.1 Soil characteristics and nutrient addition

In the screening experiment, quartz sand was used because it contained low iron. The soil was subjected to DTPA extraction to verify the low iron percentage and quantify other metals that could react with phytosiderophores (table 1). The numbers in red indicate values below the detection limit and are therefore not valid. The DTPA-extractable content of Fe and other trace nutrients in the sand and Santomera soil as was low indicating that they were a suitable substrate to offer Fe limitation. Other deficiencies (such as Zn and Mn) could be prevented using additives. To prevent soil acidification resulting from plant growth and nutrient use over time, a buffer was added to the quartz soil. Lime was used to keep the pH sufficiently high (Anderson et al., 2013); it maintained the pH at slightly above 8 at the start of the experiment and 7 at the end of the experiment. The final soil composition for the screening experiment comprised 980 g of quartz sand and 20 g of lime. Appendix 8.9 contains pictures of the actual soil preparation.

Table 1: DTPA extractable metal content of quartz sand, Santomera soil and a mix of quartz sand and Santomera soil, all in duplicate.

			Element (mg/kg-1)			
Sample	Co	Cu	Fe	Mn	Ni	Zn
Quartz sand sample 1	-0.001	0.039	0.041	0.005	0.001	0.018
Quartz sand sample 2	-0.001	0.034	0.051	0.006	0.001	0.016
Santomera soil sampl 1	0.004	0.159	0.496	0.861	0.041	0.071
Santomera soil sample 2	0.004	0.177	0.507	0.952	0.045	0.053
Mix Quartz + Santomera sample 1	0.005	0.268	0.607	1.512	0.077	0.075
Mix Quartz + Santomera sample 2	0.005	0.274	0.608	1.509	0.076	0.082

The water-holding capacity of quartz sand was found to be 278 mL/kg. To prevent water limitation, 60% of 278 mL (167 mL, which was rounded down to 165 mL) was added to each pot.

The sand was further enriched by adding nutrient solutions. Table 2 shows the micronutrients and macronutrients that were added to the soil. The macronutrients to be added were determined by taking half of the nutrient amounts from the specific soil preparation by Schenkeveld et al., 2010. This amount was deemed enough for growth without limitation of these nutrients. Additional micronutrients were provided using Hoagland solution widely used for grass growth experiments (Holaday et al., 2015; Nackley et al., 2017). The control group received iron supplementation in the form of $FeCl_3$. The following dissolved salts were applied to prevent deficiency of nutrients other than Fe:

Table 2: Nutrients added to the pot soil in mol and gram/pot during the screening experiment. Nutrients used according to halve the macronutrients of Schenkeveld et al., 2010 and micronutrients of the widely used Hoagland Solution.

Name	**Substance**	**Mol/pot**	**Gram/pot**
Zinc Sulfate Heptahydrate	ZnSO4•7H2O	1.91E-07	0.000055
Manganese Chloride Tetrahydrate	MnCl2•4H2O	2.29E-06	0.000453
Copper Sulfate Pentahydrate	CuSO4•5H2O	8.01E-08	0.000020
Ammoniunitrate	NH4NO3	0.003333	0.268300
Kaliumwaterstoffosfaat	K2HPO4	0.002083	0.362875
Calciumchloride	CaCl2	0.001667	0.184967
Magnesiumsulfate	MgSO4•7H2O	0.000833	0.205400
Boric Acid	H3BO3	4.17E-05	0.002576
Ammonium Molybdate Tetrahydrate	(NH4)6Mo7O24•4H2O	3.13E-07	0.000386
Ijzer(III)chloride	FeCl3	0.00008	0.012976

The nutrient solutions were prepared in such a manner that portions of 4 mL per nutrient per pot could be made and added separately. Nine and ten nutrients, respectively, were added to the soil for the experimental and control groups, and therefore, 36 and 40 mL of dissolved nutrients, respectively, was added to the soil. Nutrients were added in a sufficiently large amount to prevent them from becoming limiting factors that could interfere with the induced iron deficiency. To bring up the volume to 165 mL (60% of the water-holding capacity), demineralized water was added.

The soil of the soybean experiment was prepared by combining 500 g of the quartz sand as was used in the screening experiment and 500 g of Santomera clay soil known to be low on iron. This soil was used before in soybean experiments by Schenkeveld, (2010). The water holding capacity of this soil was determined and nutrients and water were added to bring the moisture content up to 60%, the same as in the screening experiment. The nutrients in table 3 were then added according to Schenkeveld, (2010). Hydroxylbenzyl ethylenediamine acid (HBED) is added in the form of Fe-HBED as source for iron in the control group.

Table 3: Nutrients added to the pot soil in mol and gram /pot during the soybean experiment. Nutrients and HBED added according to Schenkeveld et al., 2010.

Name	**Substance**	**Mol/pot**	**Gram/pot**
Ammoniunitrate	NH4NO3	0.003333333	0.2683
Kaliumwaterstoffosfaat	K2HPO4	0.002083333	0.362875
Calciumchloride	CaCl2	0.001666667	0.184967
Magnesiumsulfate	MgSO4•7H2O	0.000833333	0.2054
Boric Acid	H3BO3	4.16667E-05	0.002576
Ammonium Molybdate Tetrahydrate	(NH4)6Mo7O24•4H2O	3.125E-07	0.000386
HBED	HBED HCL H2O	3.0303E-06	0.001342

3.1.2 Seed varieties

Upland rice varieties were provided by The African Rice Center, which is a part of the International Rice Research Institute (IRRI). From their database, eight varieties comparable regarding their drought resistance and use on the African continent were chosen. The list of upland rice varieties contains various varieties of New Rice for Africa (NERICA) seeds developed by cross-breeding different Asian rice species known for their high yield with African rice species known for their adaptivity (Diagne, 2006). NERICA seeds were developed by the African Rice Center, which made it possible to acquire them from the source. NERICA varieties have been adopted widely on the African continent to increase crop production and decrease food scarcity (Kijima et al., 2011). Because the NERICA varieties were developed less than two decades ago, phytosiderophore release in these varieties has not yet been examined. This factor, together with the widespread use of these seeds for a large population and the literature found on the low iron acquisition ability of rice varieties in general, made these rice varieties good candidates for the screening. The other upland rice varieties were chosen in order to compare them with the NERICA varieties and to increase variety in African rice seeds used in the research to give a more representable view of the the African continent.

The oat and rye varieties were kindly provided by the Swiss seed bank (Eidgenössisches Volkswirtschaftsdepartement, Forschungsanstalt Agroscope Changins-Wädenswil). This seed bank wants to conserve plant genetic resources and contains seeds of numerous grass and non-grass species (https://www.bdn.ch). The rye and oat varieties used in this experiment come from the category of major crops used in Swiss regions and can be stored for long periods. Using seeds from different regions leads to an in-depth look at grass varieties from a significant part of Swiss regions. The list of seed varieties and their country of origin is presented in table 4.

*Table 4: Grass seed varieties of rye, oat, and upland rice chosen for screening (*https://www.bdn.ch).

Plant Species	Seed variety	Country of origin
Rye	Beka	Swiss
Rye	CADI	Swiss
Rye	RIED LOETSCHENTALL	Swiss
Rye	Walliser Roggen Binnega	Swiss
Rye	Val Peccia GT-711	Swiss
Oat	Adliker	Swiss
Oat	Brune de Mont-calme	Swiss
Oat	Ebene	Swiss
Oat	Expander	Swiss
Oat	Hative des Alpes	Swiss
Upland Rice	NERICA 3	Sierra Leone
Upland Rice	NERICA 4	Sierra Leone
Upland Rice	NERICA 6	Sierra Leone
Upland Rice	NERICA 15	Sierra Leone
Upland Rice	NERICA 16	Sierra Leone
Upland Rice	NERICA 18	Sierra Leone
Upland Rice	CNAX 3031-78-2-1-1	Mali
Upland Rice	WAB 95-B-B-40-HB	Guinee

3.2 Research areas

The screening experiment took place in the Botanical Gardens in The Uithof, Utrecht. The plants were grown in a large greenhouse in which plants in other experiments were growing simultaneously. The pots were placed 1 m above the ground on a metal table. No measures for additional warming or cooling were used during the experiment. Temperature depended on the sun and was further increased by the plastic structure of the greenhouse. The greenhouse experiment was protected against precipitation, which means that the only source of water was manual watering of the plants. The greenhouse was closed on three sides and had a 1 m high opening on one side. To prevent wind from affecting the experiment, a screen was placed in front of the open parts of the greenhouse.

Both the soybean experiment and seed germination for the screening experiment were carried out in growth chambers in the Phytotron building on the Uithof, Utrecht. Temperature, humidity, and light intensity in these growth chambers were regulated. The preparation of pots and transfer of germinated seeds for the screening experiment were carried out in the greenhouse and in the Phytotron. Drying of biomass after harvest and subsequent weighing of the above and belowground biomass was done in the Phytotron building.

Nutrient solutions and reagent solutions required for the soil and plant analyses were prepared in the laboratory of the Vening Meinesz building in Utrecht. Root exudate analyses and revised Fe-binding assay tests were done in the same laboratory.

3.3 Germination phase

The screening experiment started with seed germination. The rye and oat seeds were germinated in boxes containing quartz sand saturated to 60% of its water-holding capacity with demineralized water. A plastic cap was placed over the sand boxes to ensure humidity close to 100%. No nutrients were added to the sand. Rice seeds were germinated on plastic beads floating on the surface of the water; in this manner, the seeds remain in contact with water most of the time, which increases germination rates. This method of germination, together with high humidity and sufficient light for germination, was preferred in studies done on these seed varieties by Abedin and Meharg, 2002 and Köhl, 2015. A plastic cap was placed over the plastic beads to ensure humidity was close to 100%. All seeds were germinated in a regulated growth chamber with 70% humidity at 21°C and light: dark cycles of 18:6 h. The humidity was not allowed to rise above 70% because of variability in the growth chamber and adverse effects of condensation on equipment placed in the growth chamber. All seeds were hydrated in demineralized water for 5 min before placing them either in the sand or on the plastic beads. Conditions for oat germination included high humidity, sufficient light, and seed moistening before germination, as per studies done by Willenborg et al., 2005 and Mickelson and Grey, 2006. For rye germination, conditions of high humidity, high light availability, and seed moistening before germination were used, following the studies by Snapp et al., 2008 and Wilson et al., 2013. A sufficiently large part of the seed was placed in the soil to ensure successful rooting of germinated seeds. Appendix 8.10 contains pictures of the germination and transfer phase

Small-scale testing of germination rates of the oat and rye seed varieties indicated that the rates differed among seed varieties. In oat and rye seeds, between 50% and 90% germinated within a week after experiments started, whereas rice needed 2 weeks to reach germination rates between 50% and 75%. Differences were also found between different varieties of rice, oats, and rye which indicated that transferring seedlings of the different varieties on the same day was not feasible and would have to be carried out over the period of a week. To reduce the time between seedling transfer of different varieties, 30–40 seeds were germinated, which amounted to 2.5–3.5 times the number of seeds needed in the pot experiment (n = 12). Of the 12 seeds grown for each variety, 4 were control pots with added iron and 8 were experimental pots with no added iron. The number of replicates was chosen according to the handbook of standardised measurements of plant functions by Peìrez-Harguindeguy, (Peìrez-Harguindeguy et al., 2013).

Seedlings were selected for transfer to pots on the basis of root growth and shoot length as well as a growth rate comparable to that of other seeds of the same variety, in order to exclude outliers. During seedling transfer of some seed varieties, more than the required 12 germinated seeds were transferred. Especially for rice, spare seedlings were transferred to pots because rice seedlings were expected to have the most difficulty surviving in iron-deficient conditions and showed lower root and shoot length than rye and oat seedlings.

Soybean seeds were germinated in the same manner as rye and oat seeds on moist quartz sand saturated to 60% of its water-holding capacity. Preliminary tests showed germination rates of 75% to 90%. Seedling transfer was done 4 days after germination. In total, 56 germinated seeds were divided into two groups of 28 pots placed in growth chambers with either a low light regime or a high light regime. Of the 28 in each growth chamber, 14 were control to which iron was added and 14 were experimental without iron addition.

Table 5 shows differences in germination rates among seed varieties. In general, rice required a longer germination time. Brune de Monte-calme oats were grown in the same tray as Beka rye, and because Beka rye needed longer time for sufficient germination, the Brune de Monte-calme oat seedlings were transferred after 11 days although they could have been transferred after 7 days.

Table 5: Germination rates and duration of germination before transfer of the grass seed varieties in the screening experiment

Plant Species	Seed variety	Germination rate at transfer (%)	Final germination rate (%)	Duration of germination until transfer (days)
Rye	Beka	30	35	11
Rye	CADI	45	65	9
Rye	RIED LOETSCHENTALL	98	98	7
Rye	Walliser Roggen Binnega	55	95	7
Rye	Val Peccia GT-711	53	85	7
Oat	Adliker	90	95	7
Oat	Brune de Mont-calme	75	95	11
Oat	Ebene	33	50	9
Oat	Expander	65	85	9
Oat	Hative des Alpes	93	98	7
Upland Rice	NERICA 3	68	75	10
Upland Rice	NERICA 4	68	80	10
Upland Rice	NERICA 6	75	85	11
Upland Rice	NERICA 15	80	90	10
Upland Rice	NERICA 16	78	85	11
Upland Rice	NERICA 18	68	75	11
Upland Rice	CNAX 3031-78-2-1-1	70	85	9
Upland Rice	WAB 95-B-B-40-HB	35	40	14

3.4 Growth phase

After successful transfer of seedlings, the pots were placed in a randomized order over the 10 m long metal work table. To prevent plants from touching each other, the plants were placed 20–30 cm from each other. Each pot contained one seedling in 1000 g of substrate to prevent competition for nutrients between different seeds and to provide sufficient space for growth. The dimensions of the pots used were 11 × 11 × 12 cm. The plants were watered three to four times a week depending on their daily water use and after watering, the plants were again placed randomly over the table. There were openings on the underside of the pots to let water through and prevent anaerobic conditions. Underneath the pots, a water dish was placed to capture the water that percolated through the soil. During the experiment, this dish was almost unused because water would be absorbed by the soil before it was able to reach the bottom of the pots. At the bottom of each pot, a piece of cloth was placed to prevent soil from passing through the openings on the pot base. The cloth was able to let water through if necessary.

Soybean plants were grown in growth chambers under controlled conditions. The light conditions were set (Light: dark cycles of 18:6 h), and temperature and moisture were maintained at constant levels.

During the plant growth phase of both experiments, abnormalities such as dry leaf tips were documented. Plants were watered with demineralized water. Initial pot weight at the start of the experiment was maintained throughout the growth phase. The weight was recorded on the pot, and weight (g) lost through evapotranspiration and plant growth was supplemented by adding water (ml).

3.5 Harvesting phase

The harvesting period of plants from the screening experiment was determined by the onset of chlorosis in most seed varieties of a plant species. Chlorosis was established as a significant difference in SPAD measurements between the experimental and control groups of seed varieties. If significant differences were found over time, the plants would be harvested. Accordingly, harvesting was carried out first in oat plants, then in rice plants, and lastly in rye plants. The plants were harvested to obtain root exudates first and then wet biomass that could be processed further to obtain dry biomass measurements. Roots (belowground biomass) of the plants from the screening experiment were washed before oven drying, to remove sand from clinging to the roots and affecting the dry weight.

Harvesting was done in steps. First, the plants were carefully washed by hand to remove any soil from the roots, taking care not to damage the roots. The plants were then placed into containers with unique codes that linked them to specific plants. Each container was then filled with 50 mL demineralized water, and all roots were kept submerged to provide the most suitable conditions for phytosiderophore release. The timing of the harvesting steps was of great importance. The harvesting was started 2 h after the onset of the light period (Reichman & Parker, 2007[a]) to fully utilise the period during which the roots release most of their daily amount of phytosiderophores (Reichman & Parker, 2007[b]; Oburger et al., 2014). Phytosiderophores were collected over a 3 h period (Zuchi et al., 2012), after which the solutions containing the root exudates were filtered to remove any plant residues, using a 0.45 µm polyethersulfone SY25TF Minisart syringe filter (Sartorius). Because a number of plants were harvested simultaneously, the exudates were filtered in the exact order in which the plants were placed into the containers. Next, Micropur was added to the filtered root exudates to prevent microbiological degradation of phytosiderophores (Erenoglu et al., 2000; Oburger et al., 2014). Finally, the exudates were stored at -20°C until further use. Appendix 8.11 contains pictures of the actual harvesting phase.

In the soybean experiment, 24 plants were harvested at the halfway point of the experiment and 32 were harvested at the end. After separating the above and belowground biomass, the belowground biomass was washed to remove soil, and the plant material was oven dried at 70°C.

3.6 Measurements

3.6.1 SPAD measurements

The measurements of chlorosis in both experiments were done with a Minolta-502 SPAD meter. This measurement device is used for evaluating the leaf chlorophyll content of (Loh et al., 2002; Schenkeveld, 2010) as it measures the relative chlorophyll content of plant leaves (Alvarez-Fernandez et al., 2004; Banuls et al., 2003). Before measurements, device calibration was done according to Markwell et al., 1995. Measurements were taken three times per week with a day without measurements between them. For the soybean plants, two youngest leaves and two leaves from the second youngest trifoliate were measured. Over time, this resulted in the measurement of different leaves as the plants grew new trifoliates. The youngest leaves were chosen because they are more susceptible to leaf chlorosis and would show symptoms first (Zhou et al., 2013). The measurements of the youngest and second youngest leaves (figure 4) were then averaged separately for each pot, following the method used by Schenkeveld, 2010.

The grass varieties from the screening experiment had completely different growth patterns compared with soybean; therefore, a different method had to be used. The method used for grass species by Zuchi et al., 2012 was further modified by taking not the youngest leaf but three youngest leaves that were sufficiently large for SPAD measurements. The placement of the SPAD meter on the leaves was the same as with the soybean plants. The measurements of the three youngest leaves were averaged to obtain a single value. On subsequent measurement days, newly grown leaves were monitored and, when possible, measured by the SPAD meter to assure that measurements were always taken on the three youngest possible leaves.

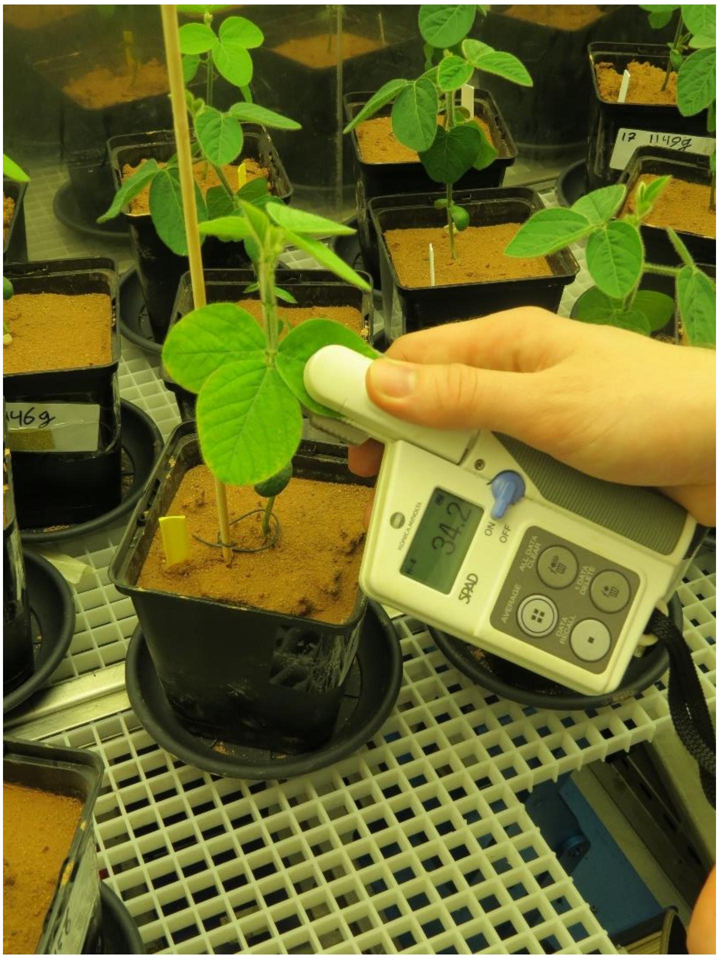

Figure 4: Minolta-502 SPAD measurement device

3.6.2 Dry weight measurements

Dry weights of soybean and grass varieties were determined by separating above and belowground biomass. These plant parts were oven dried (70°C) separately for 3 days. Subsequently, dry weight was measured and recorded for further analysis.

3.7 Revised Fe-binding assay

Root exudates collected and stored during the harvesting phase were further analysed to quantify phytosiderophores. Methods commonly used to analyse phytosiderophore concentration are complex and involve equipment that requires extensive specific knowledge and time. An indirect, more practical method to determine phytosiderophore concentration is the Fe-binding assay, first published by Gries and Runge in 1995 and revised by Reichman and Parker in 2007. The adaptation that was made concerns the use of a different filter and refinement of the concentration range that the assay can measure correctly. This method quantifies phytosiderophores by formation of soluble Fe-phytosiderophore complexes and removal of excess Fe that precipitates as Fe(hydr)oxide minerals. A detailed explanation of the protocol follows. Additionally, a list with pictures of the specific equipment used in this research during the revised Fe-binding assay is added in appendix 8.8. Appendix 8.12 contains a list of the substances used in the revised Fe-binding assay.

3.7.1 Revised Fe-binding assay protocol

- To 10 mL of exudate collected during the harvest phase, 0.5 mL of 0.6 mM $FeCl_3$ is added, to allow the formation of Fe complexes with all phytosiderophores.

- The mixture is shaken for 15 min in an end-over-end shaker to ensure that all phytosiderophores form complexes with Fe.
- Next, 1 mL 1 M Na-acetate buffer is added to increase the pH to 7 and maintain it.
- The solution is shaken again for 10 min to achieve complete precipitation of Fe.
- The solution is filtered through a 0.2 µm Whatman GF/F filter to remove excess Fe.
- Then, 0.25 mL of 6 M HCl is added, and afterwards, 0.5 mL of 80 g/L hydroxylamine hydrochloride is added to reduce Fe^{3+} to Fe^{2+}.
- The solution is placed in an oven for 30 min at 60°C to achieve complete reduction.
- Next, 0.25 mL of 2.5 g/L ferrozine is added, and afterwards, 1 mL of 2 M Na-acetate buffer is added to reduce the pH to 4.7 and buffer the solution. Reducing the pH facilitates the formation of Fe (II)-ferrozine complexes with a purple colour. The colour intensity is proportional to the initial phytosiderophore concentration.
- After 5 min of shaking by hand, absorbance of the solution at 562 nm is determined using the UB-1800 Shimadzu spectrophotometric measurement device (figure 5).
- Measured absorbance values are then used to determine the phytosiderophore concentration, using the Lambert-Beer law: $A = \varepsilon \times c \times l$, where A is the absorbance measured at 562 nm, ε is the molar extinction coefficient of the Fe (II)-ferrozine complex (1/0.000045 L mol^{-1} cm^{-1})(Reichman & Parker, 2007), c is the concentration of phytosiderophores, and l is the length of the path that the light has travelled through the cuvette in the spectrophotometric measurement device.

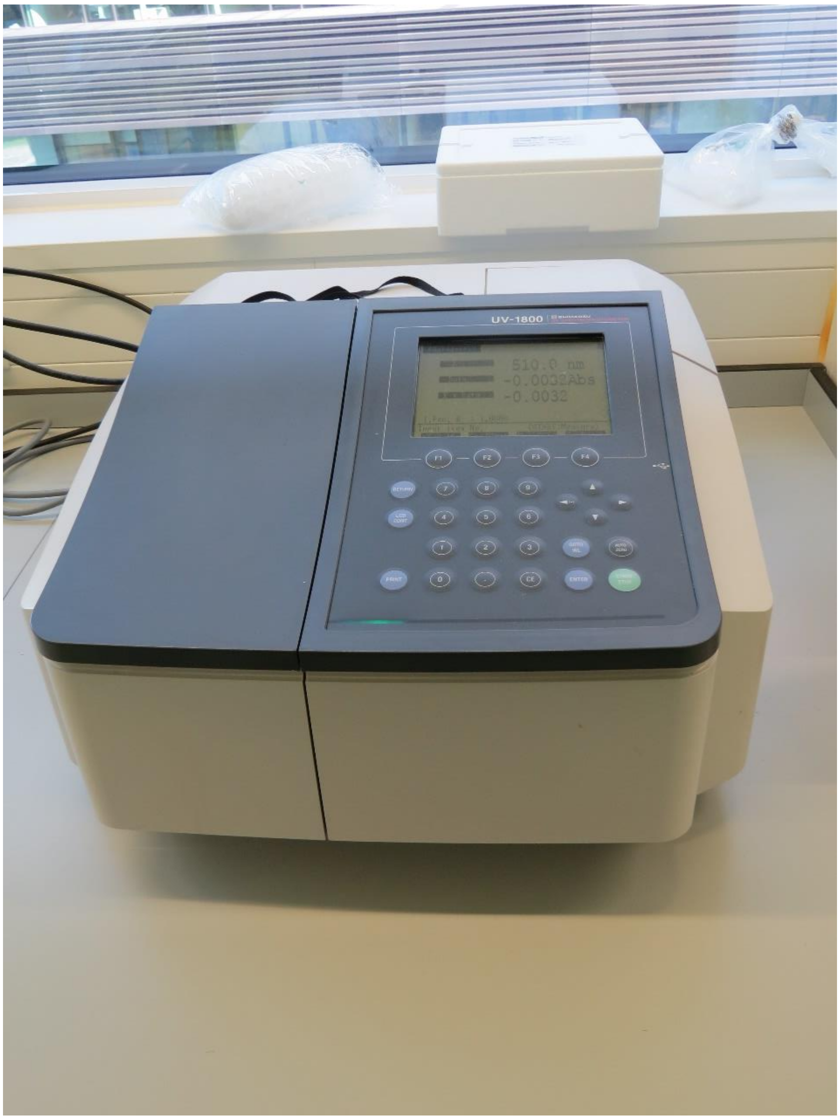

Figure 5: UV-1800 SHIMADZU Spectrophotometric device used at 562 nm.

3.7.2 Devised tests of the revised Fe-binding assay

The protocol of the revised Fe-binding assay is not widely used and has a couple of crucial steps that could be wrongly executed. A series of tests were proposed to validate the different steps of the protocol and to determine whether the assay could be used to analyse the root exudates.

All tests were done in duplicate to validate the results and control samples in duplicate were used for each test. HEDTA was used as a synthetic substitute of phytosiderophores in all tests. In the study in which the revised Fe-binding assay was reported, HEDTA was found to give reproducible results up to 20 µmol. All tests specified below differed from the standard protocol only on the specified step to ensure that results obtained were due to the particular deviation from the protocol. The following tests were executed:

- The amount of ***$FeCl_3$*** added was doubled, in order to validate that the amount in the protocol was indeed able to form complexes with the entire amount of phytosiderophores and additionally to test the filter that is expected to remove all excess Fe.

- Control samples ***without HEDTA and added Fe*** were used, which would show a phytosiderophore concentration of 0.

- Control samples ***without HEDTA but with added Fe*** were used, which would show a concentration of 0 because no Fe-binding would occur and all excess iron would be filtered out.

- A dilution series of a stock solution of 50 µmol of HEDTA was used. Because Reichman and Parker had used the HEDTA ligand in their study on the revised Fe-binding assay to validate their method, it was used in the present study in an attempt to reproduce their results. The dilution series ranged from 2.5 µmol (0.5 mL stock and 9.5 mL demineralized water) to 20 µmol (in increments of 2.5 µmol) which was the range that provided representative results in the study by Reichman and Parker, 2007.

- Addition ***of double the amount of HCL*** (0.5 mL instead of 0.25 mL) to see if the pH becomes too low for the buffering that occurs in a later step.

- A ***different filter was used***. Because a 0.2 µm Whatman GF/F filter preferred for the assay could not be acquired, a grey SY25GN 0.2 µm filter was used as a replacement for most tests. Reichman and Parker found that the filter was a crucial factor, and it was therefore extensively tested by them. Apart from the grey SY25GN 0.2 µm filter, two more filters (blue SY25NN 0.2 µm Nylon-66 Modi filter and yellow Sartorius polyethersulfone Ca 0.45 µm filter) were tested. Because preliminary tests found concentrations higher than the starting concentration, it was hypothesized that part of the excess iron was filtered through and not removed. Therefore, additional tests were done with the filters, for which the time allowed for formation of Fe-HEDTA complexes was increased from 10 min to 120 min. Solutions that followed the protocol in this respect and solutions that stood for 120 min were both filtered through different filters mentioned above.

- ***Solutions were placed in the oven for 15 min instead of 30 min.*** In this step, Fe^{3+} is reduced to Fe^{2+}; therefore, allowing the solutions to be in the oven for a shorter time tests whether complete reduction occurred during the period.

- ***Using the harvested exudates*** to find if the concentrations that were found are in the range of possible concentrations based on literature. Randomized samples from oat, rye, and rice plants were used, including samples from control groups, which were expected to contain low phytosiderophore concentrations owing to soil iron supplementation.

3.8 Statistical analysis

Water measurements of the difference in water use between the control and experimental groups of soybean and the screening varieties were analysed using two-tailed t-tests with equal variance ($p = 0.05$). This test was suitable because for each experiment, two groups (experimental and control) were analysed on one variable (water use).

SPAD measurements of the difference in chlorophyll content between the control and experimental groups of the screening and soybean experiments were analysed using two-tailed t-tests with equal variance ($p = 0.05$). This test was suitable because for each experiment, two groups (experimental and control) were analysed on one variable (chlorophyll content).

A two-tailed t-test of equal variance was used for the differences in SPAD measurements between different light regimes since there were two groups (low and high light) that were analysed on one variable (chlorophyll content).

Dry weight measurements of the difference in the above and belowground biomass of control and experimental groups of the screening and soybean experiments were analysed using two-tailed t-tests with equal variance ($p = 0.05$). This test was suitable because for each experiment, two groups (experimental and control) were analysed on one variable (either above or belowground biomass dry weight).

Equal variance was assumed since all the two-tailed t-tests with unequal variance were almost precisely the same as the tests with equal variance. A one-tailed t-test was not suitable in each analysis because the possible differences between control and experimental groups based on chlorophyll content, water use, and above/belowground biomass could be positive and negative.

One-Way ANOVAs ($p = 0.05$) were done for the differences in the ratio of above to belowground biomass between the screening varieties of rye, oat and rice. This test was suitable because more than two groups (either 5 oat groups, 5 rye groups or 8 rice groups) were analysed on one variable (ratio of above to belowground biomass). When significant differences were found between groups, a Tukey post-hoc test was done to determine which groups were significantly different.

The revised Fe-binding assay test data were analysed by comparing the duplicates with each other and comparing HEDTA concentrations at the start of the assay with the concentrations at the end of the assay.

4. Results

4.1 Water Measurements

4.1.1 Water measurements soybean

Table 6 shows the data of one week of measurements of weight loss due to water use in soybean plants. This is a part of the complete list of measurements that can be found in appendix 8.1. The week average in the latest column gives the average water use of the plant sample each measurement day. A separation is made between experimental (14 replicates) samples without FeHBED and the control group (14 replicates) with FeHBED. Another separation is made based on growing under a low (140 PAR) or higher (240 PAR) light regime to find if light influences water loss significantly in this research. A distinct difference cannot yet be seen from table 6 and is analyzed in more detail in table 7 and figure 6.

Table 6: Weight (g) of soybean plants over a general week of measurements. Week average gives the average weight loss (g) of each measurement day.

Sample	Light	FeHBED (Yes/No)	28-2-2019 start weight (g)	23-3-2019 (g)	25-3-2019 (g)	26-3-2019 (g)	27-3-2019 (g)	29-3-2019 (g)	Week average (g)
1	High	No	1144	1123	1123	1109	1131		**23**
2	High	No	1154	1135	1125	1138	1130	1130	**22**
3	High	No	1143	1119	1113	1133	1119	1115	**23**
4	High	No	1149	1133	1122	1133	1126	1128	**21**
5	High	No	1159	1126	1135	1141	1133	1132	**26**
6	High	No	1160	1133	1129	1144	1133		**25**
7	High	No	1150	1127	1126	1136	1130	1129	**20**
8	High	No	1147	1124	1113	1135	1129		**22**
9	High	No	1146	1135	1124	1133	1130	1124	**17**
10	High	No	1156	1127	1126	1127	1143		**25**
11	High	No	1152	1122	1128	1140	1132	1127	**22**
12	High	No	1156	1128	1128	1143	1134	1128	**24**
13	High	No	1146	1124	1121	1129	1126		**21**
14	High	No	1161	1146	1135	1148	1136		**20**
15	High	Yes	1152	1120	1129	1141	1125	1129	**23**
16	High	Yes	1153	1131	1123	1124	1145		**22**
17	High	Yes	1149	1131	1122	1140	1128	1103	**24**
18	High	Yes	1153	1129	1126	1138	1127	1121	**25**
19	High	Yes	1153	1125	1117	1114	1133		**31**
20	High	Yes	1152	1125	1131	1142	1130	1131	**20**
21	High	Yes	1157	1131	1131	1141	1136	1130	**23**
22	High	Yes	1154	1127	1124	1125	1144		**24**
23	High	Yes	1151	1127	1122	1140	1125	1127	**23**
24	High	Yes	1155	1126	1130	1135	1135		**24**
25	High	Yes	1138	1111	1109	1126	1112	1110	**24**
26	High	Yes	1143	1117	1113	1130	1123		**22**
27	High	Yes	1156	1133	1131	1129	1127		**26**
28	High	Yes	1139	1106	1112	1128	1116	1112	**24**
29	Low	No	1141	1130	1113	1118	1126		**19**
30	Low	No	1140	1124	1108	1129	1112		**22**
31	Low	No	1145	1131	1112	1136	1121	1130	**19**
32	Low	No	1162	1137	1134	1149	1139	1138	**23**
33	Low	No	1158	1142	1123	1149	1129	1134	**23**
34	Low	No	1157	1141	1130	1147	1129		**20**
35	Low	No	1152	1137	1117	1146	1124	1131	**21**
36	Low	No	1159	1142	1129	1156	1137	1144	**17**
37	Low	No	1162	1148	1131	1153	1143	1143	**18**
38	Low	No	1156	1137	1125	1138	1146		**20**

39	Low	No	1151	1141	1113	1146	1125	1127	**21**
40	Low	No	1149	1126	1103	1142	1124		**25**
41	Low	No	1154	1141	1117	1146	1128		**21**
42	Low	No	1156	1146	1123	1146	1126	1130	**22**
43	Low	Yes	1145	1132	1118	1130	1116	1126	**21**
44	Low	Yes	1144	1130	1113	1132	1123		**20**
45	Low	Yes	1141	1123	1113	1131	1116		**20**
46	Low	Yes	1148	1136	1112	1125	1136		**21**
47	Low	Yes	1143	1131	1110	1134	1117	1118	**21**
48	Low	Yes	1150	1132	1122	1141	1127	1130	**20**
49	Low	Yes	1145	1128	1116	1132	1118	1119	**22**
50	Low	Yes	1154	1141	1123	1132	1145		**19**
51	Low	Yes	1155	1129	1123	1140	1130		**25**
52	Low	Yes	1155	1136	1125	1146	1128	1125	**23**
53	Low	Yes	1160	1151	1128	1134	1130		**24**
54	Low	Yes	1156	1135	1123	1151	1136	1135	**20**
55	Low	Yes	1155	1135	1129	1138	1138	1128	**21**
56	Low	Yes	1158	1134	1125	1150	1132	1137	**22**

Table 7 shows the analyzes of the average water use over time of a measurement day between experimental and control groups under either low or high light regimes. The test used for this analyzes was a two-tailed t-test with equal variance. Analyzing the results over time made it possible to find out if the experimental group used more, or less water when undergoing chlorosis. The results of this research indicate that there are no significant differences between the experimental and control group over time of soybean plants under a low light regime.

There seems to be a significant difference between plants of the control group compared to the experimental group under the high light regime in the first and third week of measurements. This difference meant a slightly higher water use of the control group (see appendix 8.1 for further reference). However, the plants did not yet show signs of chlorosis in the first week of measurements and only part of the plants showed signs of chlorosis in the third week (see appendix 8.3 for further reference). It is therefore not possible to conclude that water use is different either under low or high light regimes between soybean plants that undergo chlorosis and those that do not. The reason that the plants showed a significant difference in the first and third week of measurements under high light could not be concluded.

Table 7: Two-tailed tests over time of the weekly average water use in gram of the soybean plants. The difference between experimental and control groups of low and high light regimes is analyzed. (p=0.05).

	Between experimental and control low light	Between experimental and control high light
Week 1 two-tailed equal variance t-test significance (p=0.05)	0.651	0.009
Week 2 two-tailed equal variance t-test significance (p=0.05)	0.265	0.098
Week 3 two-tailed equal variance t-test significance (p=0.05)	0.659	0.019
Week 4 two-tailed equal variance t-test significance (p=0.05)	0.433	0.058
Week 5 two-tailed equal variance t-test significance (p=0.05)	0.767	0.167
Week 6 two-tailed equal variance t-test significance (p=0.05)	0.974	0.105
Week 7 two-tailed equal variance t-test significance (p=0,05)	0.852	0.246

Figure 6 shows a representation of the average water use of a measurement day over time between the control and experimental groups of soybean plants under high light. It is clear from the error bars that the results of the control and experimental groups fall in each other error bar range and are mostly not significant.

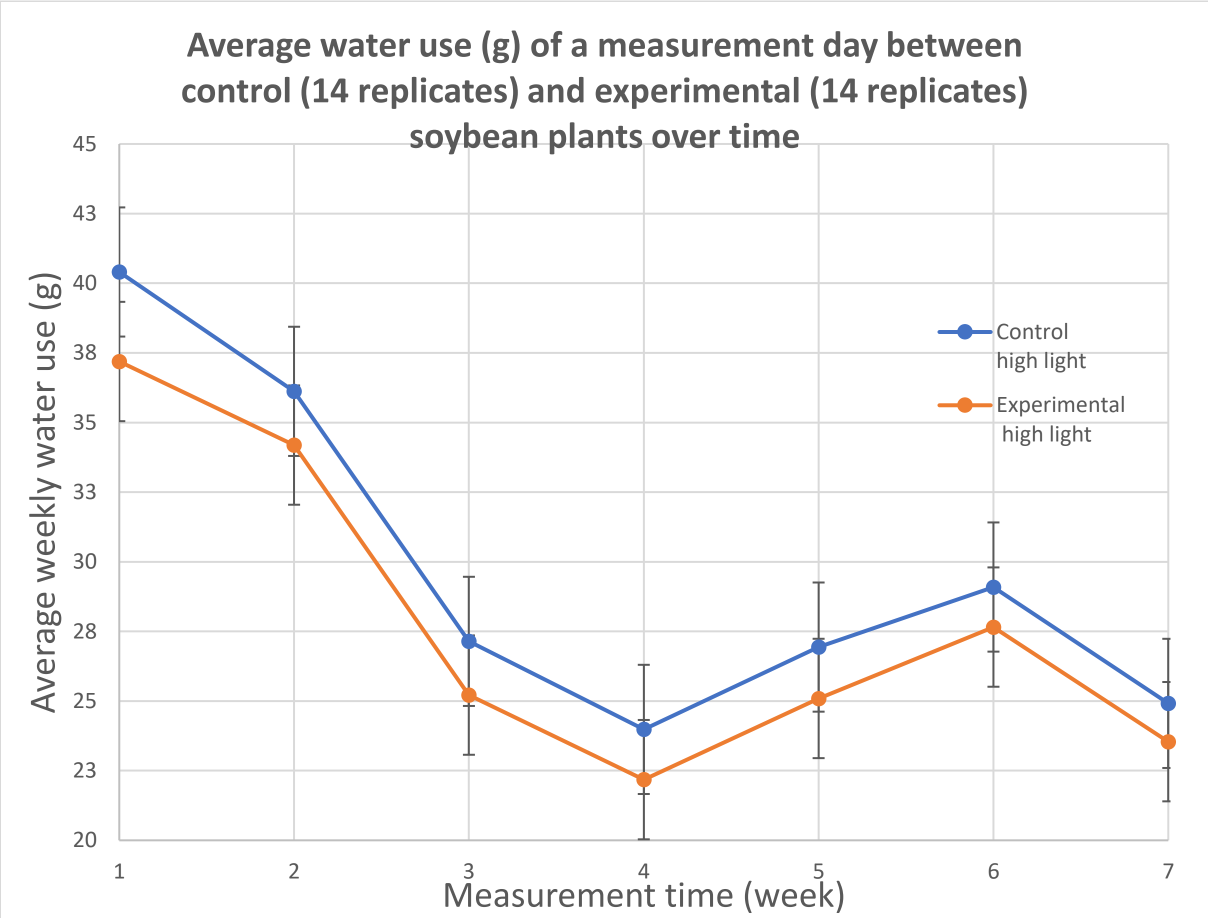

Figure 6: Average water use (g) of a measurement day over time. The differences between the control and experimental group of soybean plants grown under high light are analyzed.

4.1.2 Water measurements screening

Table 8 shows the data of one week of measurements of weight loss due to water use in three screening varieties (RPI= rye variety Walliser Binnega, OOR= oat variety Adliker and UGR= upland rice variety NERICA 15). These varieties were chosen at random to give an example of the way measurements were done. It gives a representation of the different water uses of the three plant species and makes it possible to visually compare control and experimental groups of plants. This is a small part of the complete list of measurements that can be found in appendix 8.2. The week average in the latest column gives the average water use of the plant sample each measurement day. A separation is made between experimental samples (8 replicates) without iron in the form of $FeCl_3$ added and the control group (4 replicates) with $FeCl_3$. A distinct difference cannot yet be seen from table 8 and is analyzed in more detail in table 9 and figure 7.

Table 8: Weight (g) of rye variety Walliser Binnega (RPI), oat variety Adliker (OOR) and upland rice variety NERICA 15 (UGR) over a general week of measurements. Week average gives the average weight loss (g) each measurement day.

Sample	Control	Plant code	Start weight (g) 28-2-2019	10-6-2019 (g)	12-6-2019 (g)	14-6-2019 (g)	Week Average (g)
13	No	RPI	1142	1050	1067	1089	**73**
14	No	RPI	1144	1041	1097	1117	**59**
15	No	RPI	1140	1042	1080	1078	**73**
16	No	RPI	1139	1043	1081	1082	**70**
17	No	RPI	1143	1034	1077	1076	**81**
18	No	RPI	1145	1051	1082	1086	**72**
19	No	RPI	1146	1048	1093	1099	**66**
20	No	RPI	1147	1037	1082	1077	**82**
21	Yes	RPI	1148	1040	1078	1080	**82**
22	Yes	RPI	1141	1046	1092	1100	**62**
23	Yes	RPI	1148	1048	1092	1084	**73**
24	Yes	RPI	1140	1047	1085	1081	**69**
73	No	OOR	1155	1058	1109	1108	**63**
74	No	OOR	1135	1037	1088	1089	**64**
75	No	OOR	1152	1050	1093	1092	**74**
76	No	OOR	1140	1052	1084	1090	**65**
77	No	OOR	1136	1064	1086	1088	**57**
78	No	OOR	1135	1047	1089	1100	**56**
79	No	OOR	1138	1061	1099	1113	**47**
80	No	OOR	1141	1053	1092	1087	**64**
81	Yes	OOR	1142	1072	1102	1103	**50**
82	Yes	OOR	1140	1057	1095	1101	**56**
83	Yes	OOR	1139	1045	1087	1093	**64**
84	Yes	OOR	1137	1044	1095	1085	**62**
145	No	UGR	1146	1077	1111	1120	**43**
146	No	UGR	1146	1070	1104	1111	**51**
147	No	UGR	1145	1068	1099	1111	**52**
148	No	UGR	1136	1066	1095	1097	**50**
149	No	UGR	1139	1077	1091	1103	**49**
150	No	UGR	1138	1064	1098	1109	**48**
151	No	UGR	1143	1074	1100	1107	**49**
152	No	UGR	1142	1077	1100	1103	**49**
153	Yes	UGR	1143	1066	1096	1105	**54**
154	Yes	UGR	1138	1068	1100	1101	**48**
155	Yes	UGR	1141	1055	1100	1113	**52**
156	Yes	UGR	1140	1078	1105	1107	**43**

Table 9 shows the analyzes of the average water use over time of a measurement day between experimental and control groups. The test used for this analysis was a two-tailed t-test with equal variance. Analyzing the results over time made it possible to find out if the experimental group used more, or less water when undergoing chlorosis. The results of this research indicate that there are no significant differences between the experimental and control group over time of rye varieties. There seems to be a significant difference between oat plants of the control group compared to the experimental group over time in the fourth and fifth week of measurements. This difference meant a slightly higher water use of the control group (see appendix 8.2 for further reference). This difference over time is around the time that these oat varieties OOR (Adliker) and OYE (Hative des Alpes) also showed signs of chlorosis in their chlorophyll content of the SPAD measurements (see appendix 8.4). From these results it can be indicated that these varieties show decreased water use under chlorosis effects. This slight increase in water use over time by the control group is also found with the rice variety UBE (NERICA 18). Chlorosis could not be measured with SPAD measurements for the rice varieties because their leaves were too small in most cases and the number of plants that could be measured did not form a large enough sample size for analysis. It is therefore not possible to conclude that water use is different due to chlorosis for this variety of rice. The significant results between control and experimental groups of the rice varieties UGR, URE and UYE (respectively: NERICA 15, CNAX and NERICA 16), were found at the start of the measurements and could therefore not be tributed to chlorosis. The reason the control group used more water (see appendix 8.2) compared to the experimental group could not be concluded from the research.

Table 9: Two-tailed tests over time of the weekly average water use in gram of the screening varieties. The difference between experimental and control groups over time is analyzed. (p=0.05).

Average water measurement days week (12 replicates) (g)	**Week 2 two-tailed equal variance t-test significance (p=0.05)**	**Week 3 two-tailed equal variance t-test significance (p=0.05)**	**Week 4 two-tailed equal variance t-test significance (p=0.05)**	**Week 5 two-tailed equal variance t-test significance (p=0.05)**	**Week 6 two-tailed equal variance t-test significance (p=0.05)**
Between experimental and control RBL	0.568	0.094	0.528	0.277	0.343
Between experimental and control RPI	0.790	0.790	0.366	0.071	0.089
Between experimental and control RPU	0.963	0.686	0.359	0.813	0.446
Between experimental and control RRE	0.869	0.776	0.336	0.966	0.355
Between experimental and control RBR	0.163	0.350	0.970	0.309	0.103
Between experimental and control OGR	0.235	0.539	0.688	0.795	
Between experimental and control OOR	0.114	0.293	0.027	0.017	
Between experimental and control OYE	0.176	0.848	0.143	0.030	
Between experimental and control OBE	0.757	0.834	0.953	0.681	
Between experimental and control OPU	0.295	0.268	0.625	0.449	
Between experimental and control UBE	0.210	0.627	0.505	0.006	
Between experimental and control UOR	0.725	0.697	0.074	0.444	
Between experimental and control UGR	0.029	0.060	0.233	0.129	
Between experimental and control UPI	0.401	0.537	0.390	0.556	
Between experimental and control UBL	0.230	0.083	0.825	0.406	
Between experimental and control URE	0.036	0.963	0.667	0.174	
Between experimental and control UPU	0.516	0.501	0.352	0.290	
Between experimental and control UYE	0.045	0.616	0.117	0.693	

Figure 7 shows a representation of the average water use over time in gram of a measurement day between the control and experimental groups of the Adliker variety of oat. This variety was chosen because table 9 showed this variety to have increased water use in the control group compared to the experimental group over time. This is visualized in weeks 4 and 5 in the figure when looked at the error bars.

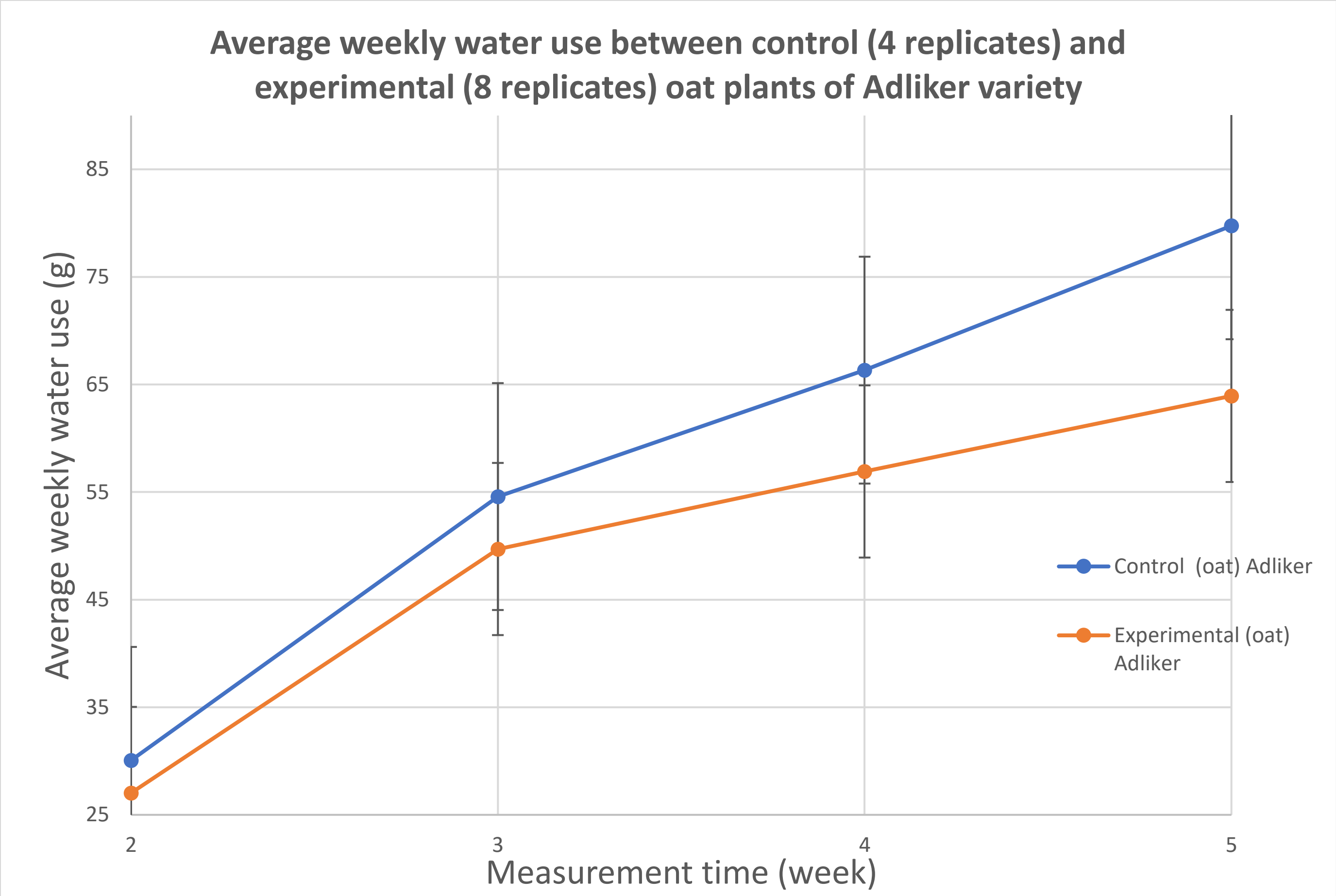

Figure 7: Average water use (g) of a measurement day over time of the Adliker oat variety. The differences between the control and experimental group are analyzed. Significant differences found in the tests is seen in the last two weeks.

4.2 SPAD Measurements

The following tables show the results of the SPAD measurements from the soybean and screening experiment. The full list of measurements can be found in appendices 8.3 and 8.4.

4.2.1 Results Soybean variety

Table 10 shows the SPAD data of a randomized measurement day for all soybean plants (full dataset found in appendix 8.3). It gives an indication of the way the raw data was gathered and digitalized. The table shows the four different SPAD measurements, two from the youngest trifoliate and two from the trifoliate that is second to youngest. The column FeHBED indicates if FeHBED is added to the soil, making the plant sample either a control sample or experimental sample. When the chlorophyll content of the samples with FeHBED are compared to those without, the numbers indicate that chlorosis could be present on this measurement day. To analyze if this difference in chlorophyll content was significant and could be used to answer the research question, table 11 was made.

Table 10: SPAD measurements of chlorophyll content in soybean plants over a general day of measurements. Two leaves from the youngest and second to youngest leaves are measured and averaged for use in further analysis.

			27-3-2019					
Samples	**FeHBED**	**Light**	**Old**		**Average**	**New**		**Average**
1	No	High	31.4	32.1	**31.75**	28.6	28	**28.3**
2	No	High	33.4	32.6	**33**	31.6	34.5	**33.05**
3	No	High	35.4	33.6	**34.5**	31.6	27.4	**29.5**
4	No	High	38.4	37.5	**37.95**	32	30.1	**31.05**
5	No	High	34.4	29.1	**31.75**	27.9	27.7	**27.8**
6	No	High	32.3	33.4	**32.85**	24.4	28.5	**26.45**
7	No	High	31.2	30.1	**30.65**	27.7	28.5	**28.1**
8	No	High	37.5	36.3	**36.9**	33.4	32.5	**32.95**
9	No	High	33.5	27	**30.25**	25.9	24.9	**25.4**
10	No	High	31.4	21.7	**26.55**	25.9	29.3	**27.6**
11	No	High	30.5	31.3	**30.9**	30.6	32.8	**31.7**
12	No	High	35.1	34.6	**34.85**	29	29.4	**29.2**
13	No	High	29.6	31.7	**30.65**	23	25.3	**24.15**
14	No	High	34.9	34.7	**34.8**	32.1	32.4	**32.25**
15	Yes	High	41.8	41	**41.4**	36.4	36.2	**36.3**
16	Yes	High	48.7	46.5	**47.6**	40.2	42.3	**41.25**
17	Yes	High	52.4	50.1	**51.25**	41.8	42.5	**42.15**
18	Yes	High	49.8	47.3	**48.55**	42	42.6	**42.3**
19	Yes	High	51.9	51.2	**51.55**	41.3	39.1	**40.2**
20	Yes	High	47.6	48.8	**48.2**	42.8	40.4	**41.6**
21	Yes	High	49	50.2	**49.6**	43.8	40.5	**42.15**
22	Yes	High	48	50.7	**49.35**	40.6	42.7	**41.65**
23	Yes	High	51.3	49.6	**50.45**	45.5	42.5	**44**
24	Yes	High	45.1	49.8	**47.45**	40.8	37.6	**39.2**

25	Yes	High	48.7	48.5	**48.6**	42.7	43.9	**43.3**
26	Yes	High	54	46.5	**50.25**	40.1	40.1	**40.1**
27	Yes	High	48.3	43.2	**45.75**	38	40.9	**39.45**
28	Yes	High	46.8	47.7	**47.25**	41.7	39.8	**40.75**
29	No	Low	46.8	47.5	**47.15**	35.9	35.9	**35.9**
30	No	Low	26.5	28.8	**27.65**	29.2	31.2	**30.2**
31	No	Low	30.1	30	**30.05**	31	30.4	**30.7**
32	No	Low	32.5	31.9	**32.2**	33.3	32.5	**32.9**
33	No	Low	27.5	29.8	**28.65**	29.3	27.9	**28.6**
34	No	Low	17.4	15.7	**16.55**	15.3	13.2	**14.25**
35	No	Low	15.9	19	**17.45**	23.1	23.8	**23.45**
36	No	Low	28.6	28.1	**28.35**	29.1	26.9	**28**
37	No	Low	21.1	22.3	**21.7**	23.4	22.2	**22.8**
38	No	Low	19.8	23.5	**21.65**	25.2	21.5	**23.35**
39	No	Low	37.4	38	**37.7**	33.8	35.9	**34.85**
40	No	Low	29.6	30.8	**30.2**	26.7	29.8	**28.25**
41	No	Low	31.3	33.5	**32.4**	30	25.8	**27.9**
42	No	Low	29.7	25.6	**27.65**	19.6	22.1	**20.85**
43	Yes	Low	48.8	46.6	**47.7**	38.4	40	**39.2**
44	Yes	Low	46.3	41	**43.65**	45.5	40.6	**43.05**
45	Yes	Low	47.9	53.9	**50.9**	40.9	40.7	**40.8**
46	Yes	Low	50.5	50.2	**50.35**	47.3	45.4	**46.35**
47	Yes	Low	46	46.8	**46.4**	39.6	40.7	**40.15**
48	Yes	Low	47.8	50.3	**49.05**	38.7	42.6	**40.65**
49	Yes	Low	49.5	50.9	**50.2**	41	42.5	**41.75**
50	Yes	Low	47.9	47.3	**47.6**	39.3	39.6	**39.45**
51	Yes	Low	49.4	46	**47.7**	40.7	40.9	**40.8**
52	Yes	Low	44.9	44.6	**44.75**	38.5	42	**40.25**
53	Yes	Low	40.1	39.8	**39.95**	50.7	48.7	**49.7**
54	Yes	Low	49.2	49	**49.1**	41.4	41.7	**41.55**
55	Yes	Low	46	41.8	**43.9**	36.1	36.4	**36.25**
56	Yes	Low	47.2	49	**48.1**	40.5	39.9	**40.2**

Table 11 shows the results of the SPAD measurements over time between control and experimental groups of soybeans under either high or low light. Two-tailed t-tests of equal variance were done using the average SPAD-measurements of each measurement day. The two columns represent the two different growth chambers that were used (high and low light) but no comparison is yet made based on their light regime.

The results of table 11 show that on each measurement day, the difference between the control group and experimental soybean groups were significant, indicating that chlorosis by iron limitation was induced which was the only factor on which control and experimental groups differed. The control plants with FeHBED all had a higher chlorophyll content compared to the untreated plants.

Looking at the results over time shows that the significance of the difference between the control and experimental group became slightly less significant as the lower differences between the SPAD values of the soybean over time make clear (see appendix 8.3). This indicates that the chlorophyll content levels of the control and experimental group slowly became the same, possibly indicating that the plants were overcoming chlorosis. Chlorosis was however still present on all measurement days. Figure 8 shows a visualization of the chlorosis that was found between the control and experimental groups.

Table 11: Two-tailed t-test with equal variance around the differences between the SPAD chlorophyll content of the control (14 replicates) and experimental (14 replicates) group of soybean plants on either high or low light regime. Significance is found at $p = <0.05$ and given in green.

Measurement date	Control/experimental high light	Control/experimental low light
18-3-2019	8.8E-14	2.3E-11
20-3-2019	2.2E-14	7.6E-13
22-3-2019	5.2E-09	7.2E-08
25-3-2019	7.8E-13	3.2E-08
27-3-2019	1.0E-14	2.7E-09
29-3-2019	4.2E-08	6.1E-08
1-4-2019	2.2E-06	9.0E-08
3-4-2019	8.1E-07	1.1E-06
5-4-2019	1.1E-05	5.3E-06
8-4-2019	8.7E-06	1.3E-04
10-4-2019	2.0E-06	1.6E-04
12-4-2019	1.4E-06	1.1E-04
15-4-2019	6.0E-07	1.1E-04
17-4-2019	4.1E-06	5.0E-04

Table 12 shows the results of the SPAD measurements over time between low and high light regimes. These results specifically show if there was a significant difference between soybean plants grown under low or high light on a specific measurement day. The results were found using two-tailed t-tests of equal variance. All comparisons based on light regime showed no significant difference in chlorophyll content between different light regimes. This difference in light regime did therefore not affect the chlorophyll content of soybean in this research. Larger differences in light regimes could have a significant effect but more tests around different light regimes were not done in this research. This makes clear that light was not a limiting factor affecting chlorophyll content. This makes the results of the other tests more valid since there is only one-factor affecting chlorosis which is iron addition to the soil or no iron addition.

Table 12: Two-tailed t-test with equal variance around the differences between the SPAD chlorophyll content of the high (28 replicates) and low (28 replicates) light regime groups of soybean plants. Significance is found at p= <0.05 and given in green when significant or red when not significant.

Measurement date	High light/ low light
18-3-2019	0.174
20-3-2019	0.107
22-3-2019	0.054
25-3-2019	0.213
27-3-2019	0.460
29-3-2019	0.626
1-4-2019	0.847
3-4-2019	0.373
5-4-2019	0.200
8-4-2019	0.422
10-4-2019	0.286
12-4-2019	0.561
15-4-2019	0.569
17-4-2019	0.416

Figure 8: Visualization of two representative soybean plants taken from the control and experimental group. Chlorosis is visible in the youngest leaves.

4.2.2 Results grass seed varieties

Table 13 shows the data of one randomized day of measurements of chlorophyll content in three screening varieties (RPI= rye variety Walliser Binnega, OOR= oat variety Adliker and UGR= upland rice variety NERICA 15). These varieties were chosen at random to give an example of the way measurements were done. It is also able to give a representation of the different chlorophyll contents of the three plant species and makes it possible to visually compare control and experimental groups of plants. When the section of table 13 around the upland rice variety UGR is considered, it indicates large differences in SPAD measurements between the control and experimental samples. However, the many empty data points in the table and a smaller list of measured samples indicate that SPAD measurements could not be done on all plants and even when possible, not often on all three leaves. This occurred in all rice varieties. The data in this table is a small part of the complete list of measurements that can be found in appendix 8.4. The average in the latest column gives the average SPAD measurement of chlorophyll content of the plant sample at the specific measurement day. A separation is made between experimental samples (8 replicates) without iron in the form of $FeCl_3$ added and the control group (4 replicates) with $FeCl_3$. A distinct difference cannot yet be seen from table 13 and is analyzed in more detail in table 14.

Table 13: SPAD measurements of chlorophyll content of rye variety Walliser Binnega (RPI), oat variety Adliker (OOR) and upland rice variety NERICA 15 (UGR) plants over a general day of measurements. The three youngest leaves measurable by the SPAD meter are measured and averaged for use in further analysis.

Sample	Code	Blank	Young 1 10-6-19	Young 2 10-6-19	Young 3 10-6-19	Average 10-6-19
13	RPI	Yes	28.7	28.7	26.7	28.0
14	RPI	Yes	33.8	31.9	28.5	31.4
15	RPI	Yes	30.4	27.6	25.3	27.8
16	RPI	Yes	25.2	25.9	29.5	26.9
17	RPI	No	26.7	33.3	28.5	29.5
18	RPI	No	22.1	24.4	22.4	23.0
19	RPI	No	28.3	29.9	27.9	28.7
20	RPI	No	26.7	22.1	26.5	25.1
21	RPI	No	28.9	24.1	20.5	24.5
22	RPI	No	22.9	25.1	22.5	23.5
23	RPI	No	26.9	28.4	22.8	26.0
24	RPI	No	26.7	28.9	29.1	28.2
73	OOR	Yes	38.2	36.3	42.5	39.0
74	OOR	Yes	34.3	39.5	33.7	35.8
75	OOR	Yes	32.8	35.1	37.4	35.1
76	OOR	Yes	36.1	52.1	43.0	43.7
77	OOR	No	41.6	37.8	40.3	39.9
78	OOR	No	35.3	34.3	28.0	32.5
79	OOR	No	18.0			18.0
80	OOR	No	30.2	31.0	39.7	33.6
81	OOR	No	33.2	26.3	40.8	33.4
82	OOR	No	32.5	22.5	31.1	28.7
83	OOR	No	31.2	45.6	32.3	36.4
84	OOR	No	40.9	29.6	41.0	37.2

145	UGR	Yes	25.8	35.8		30.8
146	UGR	Yes	31.5	29.7	36.8	32.7
147	UGR	Yes				
148	UGR	Yes	28.7	20.3		24.5
149	UGR	No	9.3	8.3		8.8
150	UGR	No	15.6			15.6
151	UGR	No				
152	UGR	No	13.7	8.1		10.9
154	UGR	No	13.4			13.4
156	UGR	No	19	9.8		14.4

Table 14 shows the results of statistical analysis on the SPAD data over time of the different measurement days of the screening varieties. The statistical analysis was done using a two-tailed t-test with equal variance (p= 0.05). The tests were done based on the average of the measurements of the three youngest leaves of all replicates of a variety. The results of table 14 indicate the significance between the differences of the control and experimental groups of the variety.

Table 14 shows that there are significant differences over time in chlorophyll content for the oat species between the control and experimental groups. The database (appendix 8.4) shows that these differences are based on higher chlorophyll content in the control group compared to the experimental group. These differences indicate chloroses in all five oat species over time. However, table 14 also shows that the significance is not present anymore in all but one oat variety (Adliker) on 12-6-19 the last measurement day before harvesting. The chlorophyll content of the experimental group is by then increased towards the control group (appendix 8.4) and not significantly different anymore, indicating a possible overcome of the chloroses or recovery from diminished chlorophyll content due to chlorosis.

The rye varieties show no significant difference in chlorophyll content over time except for the variety Val Peccia and a single measurement day of both Ried Loetschentall and Walliser Binnega. These last two indeed show lower chlorophyll content in the experimental group compared to the control group (appendix 8.4), but these results could not be reproduced over time and are therefore not attributed to be caused by chlorosis in this research. Val Peccia however, does show a larger period in time where the difference in chlorophyll content is significant and based on lower chlorophyll content in the experimental group compared to the control group.

The results from table 14 together with the chlorophyll content data in the SPAD database indicate that iron deficiency induced chlorosis took place and that Val Peccia is more prone to chlorosis than the other rye varieties. The oat variety of Ebene is the most susceptible to chlorosis and the Expander variety is least susceptible to chlorosis. Figure 9 shows a visual comparison of leaves from an experimental and control plant of Ebene oat. Chlorosis is visible in the lighter color and the stripes of darker and lighter green along with the leaf. From the rye seeds varieties, only Val Peccia and Wallisser Binnega showed significant differences more than once and tended to become chlorotic later compared to oat although they have been planted around the same time. Beka and CADI did not show significant differences throughout the experiment and are therefore more resistant to chlorosis.

SPAD- measurements of the rice varieties were done when possible, but due to their delayed and reduced growth, only a few measurement days were possible and much later compared to oat and rye. Additionally, the sample size of the rice plants that could be measured was half or less compared to oat and rye and therefore not large enough to do viable t-tests. The data around rice varieties was instead analyzed through water use and dry weight measurements of above and belowground biomass.

Comparing the results of table 14 on the screening varieties, table 11 on the soybean plants and the databases around chlorophyll content found in appendices 8.3 and 8.4, shows the effect of phytosiderophores release. Oat and rye plants showed fewer signs of chlorosis compared to soybean and later in their growth (the fourth week of growth for screening varieties compared to third week for oat varieties).

Table 14: Two-tailed t-test with equal variance around the differences over time between the SPAD chlorophyll content of the control (4 replicates) and experimental (8 replicates) group of screening varieties. Significance is found at p= <0.05 and given in green. Insignificant differences are given in red.

Seed Variety	27-5-2019	29-5-2019	3-6-2019	5-6-2019	7-6-2019	10-6-2019	12-6-2019	14-6-2019	17-6-2019	21-6-2019
Val Peccia (Rye)	0.963	0.446	0.007	0.285	0.297	0.365	0.033	0.019	0.014	0.116
Walliser Binnega (Rye)	0.938	0.613	0.276	0.024	0.816	0.118	0.099	0.342	0.350	0.136
Ried Loetschentall (Rye)	0.491	0.015	0.639	0.996	0.940	0.752	0.936	0.910	0.242	0.360
Beka (Rye)	0.466	0.684	0.738	0.195	0.812	0.530	0.782	0.894	0.450	0.189
CADI (Rye)	0.350	0.368	0.754	0.675	0.792	0.839	0.103	0.721	0.376	0.718
Ebene (Oat)	0.777	0.014	0.021	0.000	0.013	0.000	0.070			
Adliker (Oat)	0.633	0.120	0.573	0.013	0.026	0.139	0.041			
Hative des Alpes (Oat)	0.077	0.925	0.019	0.001	0.004	0.002	0.283			
Brune de Mont-calme (Oat)	0.784	0.057	0.316	0.001	0.005	0.001	0.416			
Expander (Oat)	0.483	0.805	0.002	0.012	0.812	0.719	0.135			

Figure 9: Visual representation of chlorosis in the Ebene oat variety. Difference between a plant with (left leaf) and without (right leaf) iron limitation.

4.3 Above/Belowground Biomass Measurements

The following tables show the results of the above and belowground biomass measurements from the soybean and screening experiment. The full list of measurements can be found in appendices 8.6 and 8.7.

4.3.1 Soybean

Tables 15 and 16 show the dry weight in gram of the soybean plants of both destructions. The lighter rows contain the above and belowground biomass of the experimental group without FeHBED while the other rows contain the above and belowground biomass of the control group with FeHBED. A slightly higher weight seems to be present in the control group which is further analyzed in tables 17 and 18.

Table 15: Dry weight (g) above and belowground biomass of all soybean plants of the first destruction. The table categorizes if the plant belongs to the control group (with FeHBEd) or the experimental group (without FeHBED) and under which light regime (high or low) the plant grew up. The last column contains the ratio of above to belowground biomass.

Plant sample	FeHBED	Light condition	Aboveground (g)	Belowground (g)	Ratio above to belowground biomass
1	No	High	0.570	0.203	2.809
6	No	High	0.469	0.283	1.658
8	No	High	0.372	0.170	2.184
10	No	High	0.647	0.207	3.132
13	No	High	0.393	0.135	2.905
14	No	High	0.635	0.241	2.631
29	No	Low	0.312	0.118	2.652
30	No	Low	0.367	0.200	1.834
34	No	Low	0.471	0.170	2.767
38	No	Low	0.366	0.118	3.105
40	No	Low	0.509	0.237	2.146
41	No	Low	0.518	0.186	2.786
16	Yes	High	0.674	0.309	2.183
19	Yes	High	0.762	0.289	2.640
22	Yes	High	0.674	0.237	2.843
24	Yes	High	0.644	0.315	2.042
26	Yes	High	0.587	0.252	2.332
27	Yes	High	0.565	0.216	2.613
44	Yes	Low	0.662	0.238	2.780
45	Yes	Low	0.537	0.183	2.930
46	Yes	Low	0.665	0.270	2.462
50	Yes	Low	0.557	0.205	2.715
51	Yes	Low	0.861	0.279	3.086
53	Yes	Low	0.502	0.222	2.267

Table 16: Dry weight (g) above and belowground biomass of all soybean plants of the second destruction. The table categorizes if the plant belongs to the control group (with FeHBEd) or the experimental group (without FeHBED) and under which light regime (high or low) the plant grew up. The last column contains the ratio of above to belowground biomass.

Plant sample	FeHBED	Light condition	Aboveground (g)	Belowground (g)	Ratio above to belowground biomass
2	No	High	1.347	0.415	3.250
3	No	High	0.982	0.323	3.037
4	No	High	1.151	0.362	3.180
5	No	High	1.555	0.368	4.223
7	No	High	0.637	0.202	3.158
9	No	High	0.499	0.140	3.572
11	No	High	1.184	0.350	3.386
12	No	High	0.954	0.372	2.563
31	No	Low	0.890	0.222	4.009
32	No	Low	1.099	0.290	3.793
33	No	Low	1.043	0.228	4.573
35	No	Low	0.917	0.230	3.985
36	No	Low	0.818	0.268	3.056
37	No	Low	0.771	0.207	3.722
39	No	Low	1.097	0.264	4.157
42	No	Low	1.062	0.232	4.579
15	Yes	High	0.944	0.322	2.933
17	Yes	High	1.418	0.597	2.376
18	Yes	High	1.634	0.456	3.585
20	Yes	High	1.344	0.405	3.319
21	Yes	High	1.319	0.390	3.384
23	Yes	High	1.502	0.446	3.371
25	Yes	High	1.657	0.526	3.148
28	Yes	High	1.336	0.435	3.070
43	Yes	Low	1.270	0.514	2.472
47	Yes	Low	0.900	0.246	3.657
48	Yes	Low	1.009	0.242	4.163
49	Yes	Low	1.088	0.238	4.580
52	Yes	Low	1.073	0.275	3.909
54	Yes	Low	1.024	0.404	2.534
55	Yes	Low	0.910	0.255	3.573
56	Yes	Low	0.901	0.218	4.135

The results from the statistical analysis of the aboveground and belowground biomass of the soybean plants are presented in tables 17 and 18. The tables show the results of the two-tailed t-tests of qual variance that has been done of the aboveground (table 17) and belowground (table 18) biomass. The t-tests analyze the significance of the differences between the above and belowground biomass of the control and experimental group of soybean plants of the first and second destruction. The tables also contain tests of the differences in above and belowground biomass of the control of the first destruction that took place with he soybean plants and the control of the second destruction. The difference between the experimental groups of the first and second destruction is analyzed in the same way.

Additionally, the differences between the above and belowground biomass weight of the experimental groups under high and low light of the first destruction are statistically analyzed. This analysis was repeated for the second destruction phase. The same analyzes were done for the control groups under high and low light.

The results from the statistical analysis on aboveground biomass (table 17) show that the difference between control and experimental groups is significantly different both after 3 weeks (first destruction) and 6 weeks (second destruction). The control group with iron had a larger dry weight compared to the plants in the treatment without iron application. These results show that chlorosis inhibits plant growth.

Significant differences were also found between the controls of the first and second destruction as well as the experimental groups of both destructions. This is attributed to increased growth of the plant over time.

The only significant difference between the aboveground biomass of the different light regimes is found when the control groups of the second destruction are compared. This shows that plants that are not limited by nutrients (iron) produce less biomass due to a limitation of light (see tables 15 and 16 for further reference about the dry weights).

Table 17: Two-tailed equal variance t-tests (p=0.05) of aboveground biomass dry weight measurements of soybean. The difference in aboveground biomass dry weight is analyzed between the control and experimental groups of different light regimes and different destruction phases.

Aboveground biomass soybean	**Two-tailed equal variance t-test (p= 0.05)**
Between control/ experimental of the first destruction	**6.5E-04**
Between control/ experimental of the second destruction	**3.1E-02**
Between control of first and control of the second destruction	**1.4E-07**
Between experimental of first and experimental of the second destruction	**4.6E-07**
Between experimental of High and Low light first destruction	1.7E-01
Between control of High and Low light first destruction	7.5E-01
Between experimental of High and Low light second destruction	5.7E-01
Between control of High and Low light second destruction	**1.1E-03**

Table 12 of belowground biomass shows comparable results as for aboveground biomass. Both above and belowground biomass is inhibited by Fe deficiency. The expected difference between plants of the first and second destructions was found again.

A significant effect of light intensity regime was found only when the belowground biomass of the control groups of the high light regime of the second destruction was compared to the control group of the low light regime of the second destruction. The control group under the high light regime had significantly more weight than the control group under the low light regime (see table 16 for further reference). It can be concluded that the light regimes of 140 PAR (low) to 240 PAR (high) were not enough to give significant differences in weight in most analyses. An additional table with two-tailed equal variance t-tests around the ratio of above to belowground biomass of the soybean experiment can be found in appendix 8.5.

Table 18: Two-tailed equal variance t-tests (p=0.05) of belowground biomass dry weight measurements of soybean. The difference in aboveground biomass dry weight is analyzed between the control and experimental groups of different light regimes and different destruction phases.

Belowground biomass soybean	**Two-tailed equal variance t-test (p= 0.05)**
Between control/ experimental of the first destruction	**3.4E-03**
Between control/ experimental of the second destruction	**1.3E-02**
Between control of first and control of the second destruction	**2.4E-03**
Between experimental of first and experimental of the second destruction	**1.7E-03**
Between experimental of High and Low light first destruction	2.5E-01
Between control of High and Low light first destruction	1.3E-01
Between experimental of High and Low light second destruction	5.3E-02
Between control of High and Low light second destruction	**7.5E-03**

4.3.2 Screening experiment

The dry weight measurements of above and belowground biomass that were weighted after three days of drying in the oven at 70°C are represented in table 19. It shows a randomized variety of rye, oat and rice. It is not visible from the data if the control (4 replicates) and experimental group (8 replicates) of the rye and oat variety that are shown have a difference in weight or ratio. The rice variety UGR (NERICA 15) does seem to have a visible difference. The data is statistically analysed in tables 20 and 21.

Table 19: Dry weight measurements (g) of above and belowground biomass and ratio of above to belowground biomass of the rye variety Walliser Binnega (RPI), oat variety Adliker (OOR) and upland rice variety NERICA 15 (UGR).

Sample	Fe added	Aboveground weight (g)	Belowground weight (g)	Ratio above to belowground biomass
14 RPI	Yes	0.654	1.184	0.553
15 RPI	Yes	1.404	3.008	0.467
16 RPI	Yes	1.647	2.142	0.769
17 RPI	No	1.207	2.795	0.432
18 RPI	No	1.456	2.016	0.722
19 RPI	No	0.990	1.934	0.512
20 RPI	No	1.475	2.465	0.598
21 RPI	No	1.611	2.378	0.678
22 RPI	No	1.328	1.929	0.688
23 RPI	No	1.457	2.139	0.681
24 RPI	No	1.469	1.583	0.928
73 OOR	Yes	0.490	1.278	0.383
74 OOR	Yes	1.050	2.047	0.513
75 OOR	Yes	0.980	2.691	0.364
76 OOR	Yes	0.499	1.562	0.319
77 OOR	No	0.700	1.680	0.417
78 OOR	No	0.695	1.313	0.529
80 OOR	No	0.959	1.187	0.808
81 OOR	No	0.564	1.251	0.451
82 OOR	No	0.484	1.201	0.403
83 OOR	No	1.103	2.749	0.401
84 OOR	No	0.614	1.708	0.359
145 UGR	Yes	0.076	0.351	0.217
146 UGR	Yes	0.094	0.255	0.370
148 UGR	Yes	0.071	0.305	0.232
217 UGR	Yes	0.076	0.196	0.388
230 UGR	Yes	0.042	0.146	0.286
232 UGR	Yes	0.057	0.103	0.554
149 UGR	No	0.013	0.015	0.860
151 UGR	No	0.011	0.015	0.693
152 UGR	No	0.015	0.027	0.542
154 UGR	No	0.011	0.014	0.754
156 UGR	No	0.014	0.023	0.631

Table 20 shows the results from the two-tailed t-tests of equal variance around the aboveground biomass of the different grass varieties used in the screening. The results show that there were no significant differences between the control and experimental group of any rye and oat variety. This is in contrast to the results of the soybean experiment were chlorosis affected the dry weight of above and belowground biomass greatly. Since the soybean plants do not release phytosiderophores like the grass seed varieties, it implies that the absence of this mechanism could be the cause of the difference in the results.

The differences between the dry weight of the aboveground biomass of every upland rice variety except UYE (NERICA 16) was significant. The weights in the database show that the aboveground dry weights were all higher in the control group compared to the experimental group as is also present in table 19 for the variety UGR and in appendix 8.7 for the other rice varieties. These differences were also apparent in most groups by sight as is seen in figure 10 where a photo of the UBE (NERICA 18) is shown. It was not possible to test all varieties of rice since most of the plants of three (CNAX, WAB 95 and NERICA 6) varieties had died-off or were in the last stages of it.

Figure 10: Differences in growth between control (left) and experimental (right) plants of the UBE (NERICA 18) upland rice variety.

Table 20: Two-tailed tests of equal variance of the differences in dry weight of aboveground biomass of the screening varieties. The difference between experimental and control groups is analyzed. (p=0.05)

Aboveground biomass	**Two-tailed equal variance t-test (p= 0.05)**
Between experimental and control RBL	2.9E-01
Between experimental and control RPI	4.5E-01
Between experimental and control RPU	3.6E-01
Between experimental and control RRE	7.9E-01
Between experimental and control RBR	2.5E-01
Between experimental and control OGR	4.5E-01
Between experimental and control OOR	8.9E-01
Between experimental and control OYE	6.1E-01
Between experimental and control OBE	5.2E-01
Between experimental and control OPU	3.2E-01
Between experimental and control UBE	**2.4E-02**
Between experimental and control UOR	**1.7E-04**
Between experimental and control UGR	**6.7E-05**
Between experimental and control UPU	**2.3E-03**
Between experimental and control UYE	1.2E-01

The results from the statistical analysis on belowground biomass presented in table 21 are comparable to those presented in table 20 on aboveground biomass. No difference in biomass between control and experimental treatments were observed for most oat and rye varieties. The hypotheses that the experimental group invests in root growth during chlorosis to be able to exude more phytosiderophores and further into the ground is rejected based on these results.

Significant differences between the belowground biomass of the control and experimental groups were found between three upland rice varieties (NERICA 4, NERICA 15 and NERICA 3). The differences between the other two upland rice varieties were not significant. The belowground biomass dry weights in appendix 8.7 indicate that the control groups had more weight compared to the experimental groups. Based on the results of the above and belowground biomass, chlorosis seems to affect rice varieties more than oat and rye varieties.

Table 21: Two-tailed tests of equal variance of the differences in dry weight of belowground biomass of the screening varieties. The difference between experimental and control groups is analyzed. (p=0.05)

Belowground biomass	**Two-tailed equal variance t-test (p= 0.05)**
Between experimental and control RBL	6.0E-01
Between experimental and control RPI	5.8E-01
Between experimental and control RPU	7.6E-01
Between experimental and control RRE	8.3E-01
Between experimental and control RBR	7.4E-01
Between experimental and control OGR	4.4E-01
Between experimental and control OOR	4.1E-01
Between experimental and control OYE	6.1E-01
Between experimental and control OBE	**9.4E-04**
Between experimental and control OPU	8.6E-01
Between experimental and control UBE	1.5E-01
Between experimental and control UOR	**1.6E-04**
Between experimental and control UGR	**9.4E-04**
Between experimental and control UPU	**2.0E-03**
Between experimental and control UYE	2.2E-01

One-Way ANOVAs with an alfa of 0,05 of the screening varieties on the ratio of above to belowground biomass were made (appendix 8.13). The F value was higher than the critical F value and the p-value was much lower than the alfa in all ANOVAs which indicates that the null-hypothesizes (no significant difference between the ratios) can be rejected for all three ANOVAs and significant differences are present.

Figure 11 shows the result of the Tukey post-hoc test of the one-Way ANOVA of the rye varieties. The Studentized Range q is 4,072 (5 groups df=34 p=0.05). This q was placed in the figure as an orange line indicating the critical q value. The bars that are higher than the orange line show group combinations were a significant result is found. The numbers on the x-axis in the figure correspondent to the numbers in table 22. The differences between the ratios of above to belowground biomass of Valer Peccia and Beka compared with the other rye varieties are significant. These were also the two out of five rye species that showed upward growth with few stems in contrast to growing broader with many stems and staying low in height. Figures 12 and 13 show these visible differences. The difference in growth strategy was only found for rye varieties.

Table 22: Rye variety group combination. Combination number correspondents to combination number in figure 11. Green cells have a significantly larger ratio of above to belowground biomass than the variety of the other group in the combination. Red cells have no difference in the ratio of above to belowground biomass between the groups in the combination.

Rye Variety Combination	Rye Group 1	Rye Group 2
1	Valer Peccia	Wallisser Binnega
2	Valer Peccia	Ried Loetschentall
3	Valer Peccia	Beka
4	Valer Peccia	CADI
5	Wallisser Binnega	Ried Loetschentall
6	Wallisser Binnega	Beka
7	Wallisser Binnega	CADI
8	Ried Loetschentall	Beka
9	Ried Loetschentall	CADI
10	Beka	CADI

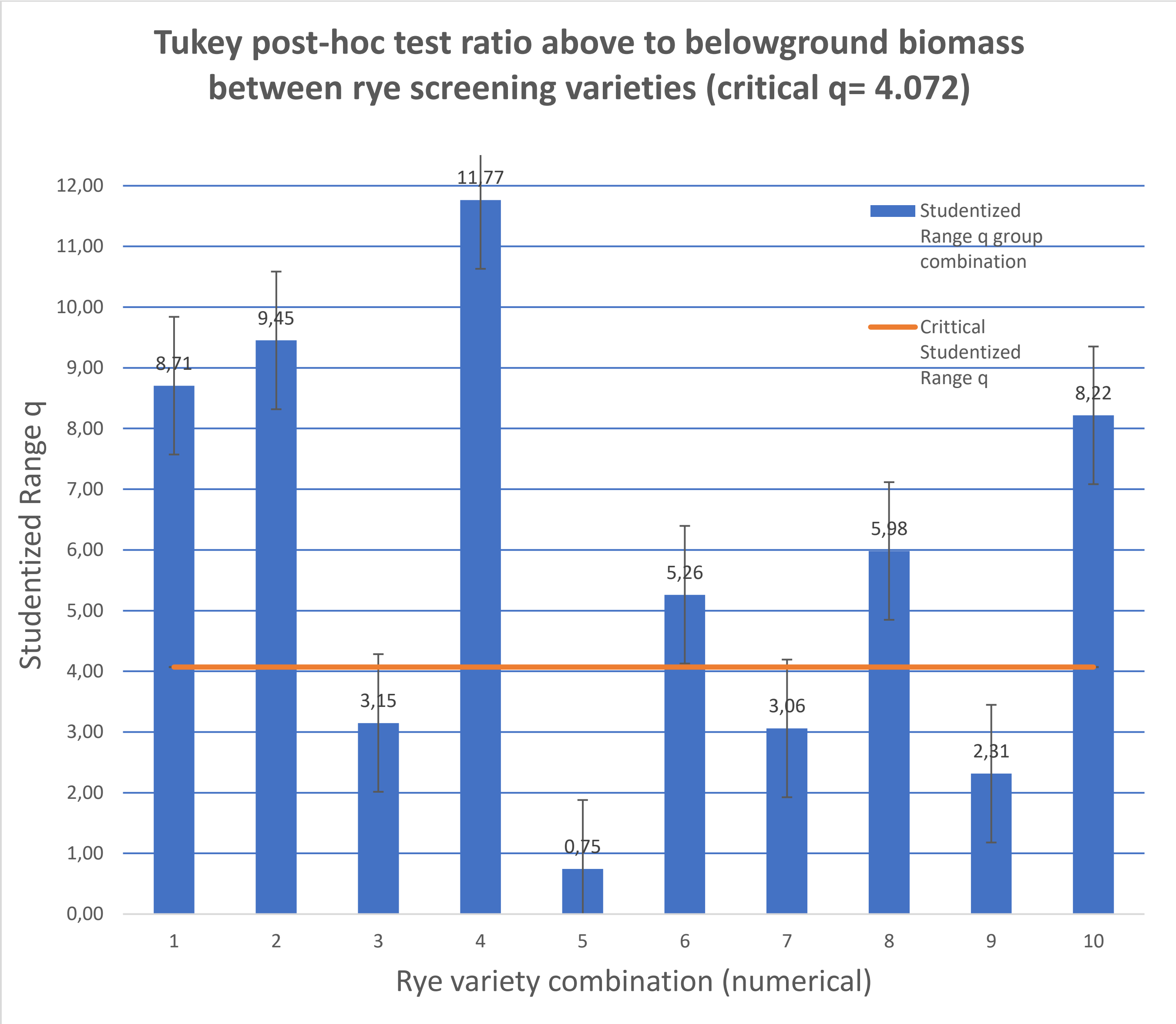

Figure 11: Results Tukey post-hoc test ratio above to belowground biomass rye varieties. The numbers on the x-axis correspond to the rye group combinations in table 22. Bars above the orange line (critical Studentized Range q) represent significant differences.

Figure 12: Rye variety CADI (RBR) growing many stems and staying low in height.

Figure 13: Rye variety Beka (RRE) showing growth of only a few stems and investing in height instead of broadness.

Figure 14 shows the one-way ANOVA results of the oat varieties. The Studentized Range q is 4,066 (5 groups df=35 p=0,05). This q was placed in the figure as an orange line indicating the critical q value. The bars that are higher than the orange line show group combinations were a significant result is found. The numbers on the x-axis in the figure correspondent to the numbers in table 23

The results of this table combined with the values for the ratios of above to belowground dry weight biomass in appendix 8.7 show that the Hative des Alpes variety has the largest ratio of above to belowground dry weight biomass and Ebene the lowest. Oat species growth followed the same pattern for all varieties: a few stems that grew increasingly into height instead of width. Additional leaves sprouted from the top part of the stem. Figure 15 shows a representative example of this growth pattern.

Table 23: Oat variety group combination. Combination number correspondents to combination number in figure 14. Green cells have a significantly larger ratio of above to belowground biomass than the variety of the other group in the combination. Red cells have no difference in the ratio of above to belowground biomass between the groups in the combination.

Oat Variety Combination	Oat Group 1	Oat Group 2
1	Ebene	Adliker
2	Ebene	Hative des Alpes
3	Ebene	Brune de Mont-calme
4	Ebene	Expander
5	Adliker	Hative des Alpes
6	Adliker	Brune de Mont-calme
7	Adliker	Expander
8	Hative des Alpes	Brune de Mont-calme
9	Hative des Alpes	Expander
10	Brune de Mont-calme	Expander

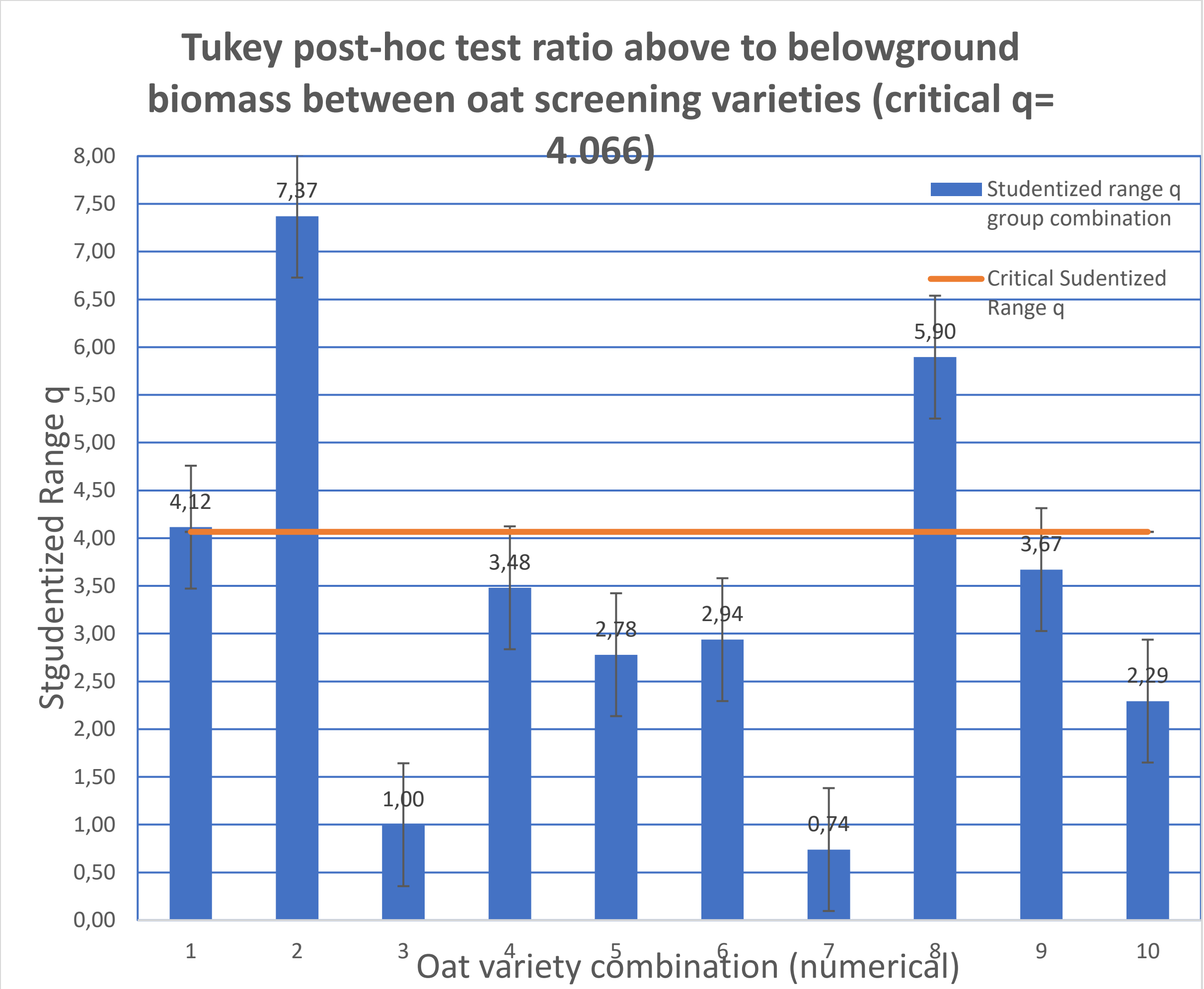

Figure 14: Results Tukey post-hoc test ratio above to belowground biomass oat varieties. The numbers on the x-axis correspond to the oat group combinations in table 23. Bars above the orange line (critical Studentized Range q) represent significant differences.

Figure 15: Oat variety Expander (OPU). Two stems are investing growth into height.

Figure 16 shows the one-way ANOVA results of the rice varieties. The Studentized Range q is 4,524 (6 groups df=17 p=0,05). This q was placed in the figure as an orange line indicating the critical q value. The bars that are higher than the orange line show group combinations were a significant result is found. The numbers on the x-axis in the figure correspondent to the numbers in table 24. The figure shows that the differences in the groups were small. Only NERICA 4 seems to be significantly the largest. The small differences could be the result of the seeds being mainly of the NERICA variant making their genetics comparable to a more significant point compared to the different rye or oat seeds.

Table 24: Rice variety group combination. Combination number correspondents to combination number in figure 16. Green cells have a significantly larger ratio of above to belowground biomass than the variety of the other group in the combination. Red cells have no difference in the ratio of above to belowground biomass between the groups in the combination.

Rice Variety Combination	Rice Group 1	Rice Group 2
1	NERICA 18	NERICA 4
2	NERICA 18	NERICA 15
3	NERICA 18	CNAX
4	NERICA 18	NERICA 3
5	NERICA 18	NERICA 16
6	NERICA 4	NERICA 15
7	NERICA 4	CNAX
8	NERICA 4	NERICA 3
9	NERICA 4	NERICA 16
10	NERICA 15	CNAX
11	NERICA 15	NERICA 3
12	NERICA 15	NERICA 16
13	CNAX	NERICA 3
14	CNAX	NERICA 16
15	NERICA 3	NERICA 16

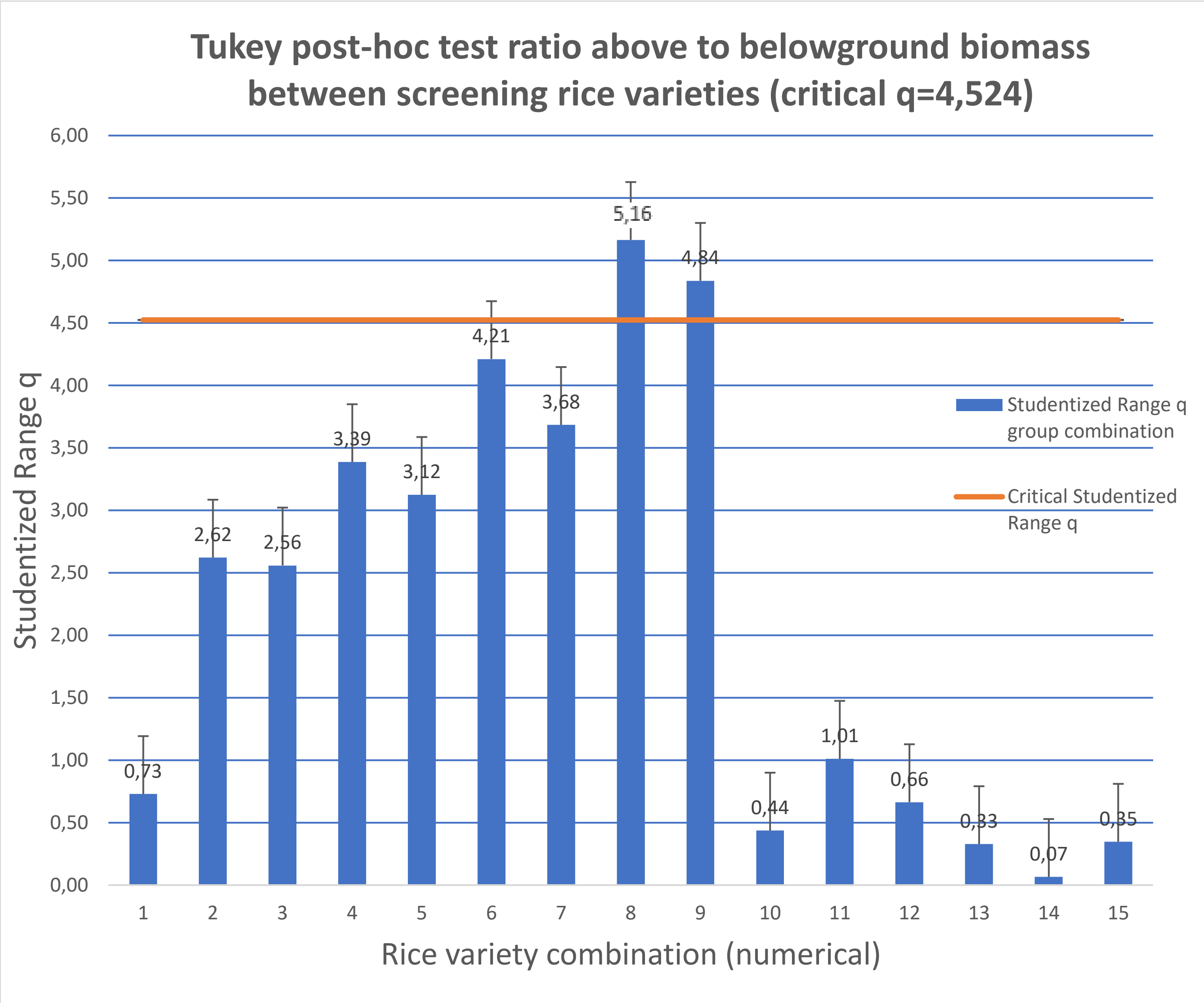

Figure 16: Results Tukey post-hoc test ratio above to belowground biomass rice varieties. The numbers on the x-axis correspond to the rice group combinations in table 24. Bars above the orange line (critical Studentized Range q) represent significant differences.

4.4 Testing Revised Fe Binding Assay

Table 25 shows the results from the first test done with the revised Fe binding assay. Diluted samples of randomly chosen root exudates were tested. The absorbance column shows the results of the spectrophotometrical analysis. The correction factor is calculated by 10:13.5. This is done to correct for the additional ml of reagent solutions that were added during the assay. Another correction based on the total volume of root exudate needs to be done because only the concentration of 10 ml of the total exudate was measured. To calculate the number of phytosiderophores, the concentrations had to be multiplied with the volume. The final column shows the number of phytosiderophores after all corrections. It is clear that the test results show that problems occurred during the protocol. The diluted amounts 1:49 should be one-fifth of the 1:9 which is not found. The control sample should also be closer to zero. Results in table 23 with the same color can be compared since they are different dilutions of the same exudate. It did not become clear were possible mistakes or changed had to be made and on the basis of these results, additional tests of the protocol were devised. Note that sample 4-10 had accidental addition of double the amount of HCl and are therefore not usable.

Table 25: Results of the first test of Fe binding assay with small amounts of the collected root exudates in different dillutions. A correction factor for the difference between the starting volume and volume at the end. Is used as well as a correction for total exudate.

Concentration phytosiderophores in µmol of 9 collected exudate in two dilutions

Sample	Absorbance	Correction factor	Total exudate (l)	Concentration phytosiderophores in exudate (µmol)
1 Control sample	0.101	0.741	0.04	**0.246**
2 RPU 25B 1:9 ratio exudate to water	0.671	0.741	0.04	**1.629**
3 RPU 30 1:9 ratio exudate to water	0.629	0.741	0.04	**1.529**
4 RRE 45 1:9 ratio exudate to water	0.056	0.741	0.04	**0.137**
5 OGR 61B 1:9 ratio exudate to water	0.065	0.741	0.04	**0.159**
6 OGR 69 1:9 ratio exudate to water	0.055	0.741	0.04	**0.134**
7 OOR 81 1:9 ratio exudate to water	0.065	0.741	0.04	**0.159**
8 UBE 131 1:9 ratio exudate to water	0.055	0.741	0.04	**0.133**
9 UOR 134B 1:9 ratio exudate to water	0.056	0.741	0.04	**0.135**
10 UOR 139 1:9 ratio exudate to water	0.056	0.741	0.04	**0.137**
11 RPU 25B 1:49 ratio exudate to water	0.420	0.741	0.04	**1.021**
12 RPU 30 1:49 ratio exudate to water	0.207	0.741	0.04	**0.503**
13 RRE 45 1:49 ratio exudate to water	0.112	0.741	0.04	**0.272**
14 OGR 61B 1:49 ratio exudate to water	0.373	0.741	0.04	**0.905**
15 OGR 69 1:49 ratio exudate to water	0.590	0.741	0.04	**1.434**
16 OOR 81 1:49 ratio exudate to water	0.328	0.741	0.04	**0.797**
17 UBE 131 1:49 ratio exudate to water	0.097	0.741	0.04	**0.236**
18 UOR 134B 1:49 ratio exudate to water	0.084	0.741	0.04	**0.205**
19 UOR 139 1:49 ratio exudate to water	0.108	0.741	0.04	**0.263**

Table 26 shows the result of the second test with the Fe binding assay. The different steps of the protocol were tested in duplicate. The control sample should have resulted in a concentration close to zero and the results make clear that contamination has taken place. Possibly because of equipment that was not appropriately cleaned, or contamination from non-control samples. The concentration from the samples using the normal protocol is quite close to the desired concentration and reproducible in duplicates. Samples with double the amount of Fe resulted in concentrations close to the expected concentrations which seems to make clear that the required amount was either not in excess or much likelier, the formation of Fe-HEDTA complexes was not entirely finished in the time designated for complex formation that was described in the protocol.

Doubling the amount of HCl seems to have prevented the formation of HEDTA-complexes due to the extremely acidic (pH around 0) of the HCl. This also makes clear why the results of the earlier test showed a comparatively low number of phytosiderophores-complexes for sample 4-10. In these samples the HCl amount was accidentally doubled. This makes clear that the amount of HCl that is added is a crucial step where small changes make the results useless.

The results of the different filters that were used make clear that the extensive research by Reichman & Parker when they revised the Fe binding assay was indeed crucial. The difference between filters is significant. It is expected that the samples that were given a longer time before filtering would result in a lower final concentration. This is caused by the more substantial amount of Fe that is filtered out because it had time to precipitate. This is true for the blue and yellow filters but not for the grey filter which was used for most tests. It is not clear how this result could be explained, especially since it is reproducible.

A shorter time in the oven resulted in a higher concentration. The reduction of Fe(lll) to Fe(ll) by hydroxylamine chloride was potentially interrupted in this step which should have led to a lower Fe(II) ferrozine complex concentration when ferrozine was added. The duplicates were not reproducible when compared, reducing their validity, which makes it challenging to interpret these results.

When the ratio of HEDTA to water was doubled to 2:8 instead of 1:9, the resulting expected concentration should have been around 9 or 12 when compared to the 1:9 results. Since the results were around 27, it was determined that a dilution series would need to be the main focus of an additional test.

Table 26: Protocol testing of Fe binding assay. A correction factor for the difference between the starting volume and volume at the end. The expected concentration HEDTA is compared with the resulting concentration of HEDTA.

Results revised Fe-binding assay tests with HEDTA around steps in the normal protocol

Sample code	Expected concentration (µmol)	Absorbance	Correction factor	Concentration HEDTA (µmol)
1 Control sample	0	0.046	0.74	2.79
2 Normal protocol	4.5	0.100	0.74	6.10
3 Normal protocol	4.5	0.107	0.74	6.51
4 Normal protocol	4.5	0.119	0.74	7.20
5 Double amounts of Fe	4.5	0.066	0.71	4.13
6 Double amounts of Fe	4.5	0.068	0.71	4.28
7 Double amounts of HCL	4.5	-0.002	0.73	-0.14
8 Double amounts of HCL	4.5	-0.002	0.73	-0.14
9 Blue SY25NN 0,2 um Nylon-66 Modi filter	4.5	0.201	0.74	12.18
10 Blue SY25NN 0,2 um Nylon-66 Modi filter	4.5	0.211	0.74	12.82
11 Blue SY25NN 0,2 um Nylon-66 Modi filter two hours wait before filtering	4.5	0.166	0.74	10.10
12 Blue SY25NN 0,2 um Nylon-66 Modi filter two hours wait before filtering	4.5	0.175	0.74	10.61
13 Yellow Sartorius Ca 0,45 um filter	4.5	0.349	0.74	21.18
14 Yellow Sartorius Ca 0,45 um filter	4.5	0.342	0.74	20.76
15 Yellow Sartorius Ca 0,45 um filter two hours wait before filtering	4.5	0.287	0.74	17.46
16 Yellow Sartorius Ca 0,45 um filter two hours wait before filtering	4.5	0.360	0.74	21.85
17Gray SY25GN 0,2um filter two hours wait before filtering	4.5	0.289	0.74	17.56
18 Gray SY25GN 0,2um filter two hours wait before filtering	4.5	0.302	0.74	18.34
19 Taken out of Oven after 15 minutes instead of 30 minutes	4.5	0.217	0.74	13.18
20 Taken out of Oven after 15 minutes instead of 30 minutes	4.5	0.335	0.74	20.35
21 Double amounts of HEDTA added	9	0.444	0.74	26.97
22 Double amounts of HEDTA added	9	0.454	0.74	27.56

The two main focusses of the third and final test around the revised Fe binding assay were centered both on achieving control samples that were zero or close to zero by preventing contaminations and on an extensive dilution series to see if the results of Reichman & Parker could be replicated. Figure 17 shows the results of this test. The controls are all zero or close to zero indicating that contamination was largely prevented. The results with Fe show a small concentration compared to controls without Fe which would indicate that not all Fe was filtered out and the filter that was used results in concentrations higher than expected. This filter effect was found to be consistent with a large part of the results, but it is difficult to interpret these results right without a comparison of the filter with the exact filter that was used by Reichman & Parker (this filter was sadly not available during this master thesis).

The dilution series shows a high reproducibility between the samples with the same added concentration of HEDTA. However, the increase in the concentration of 2.5 µmol in between samples was not found in most results and more disturbingly, the concentration at the start of the series was already far above the expected concentration of 2.5 µmol. Higher initial concentrations resulted in concentrations as expected leading to the possible explanation that the assay had difficulties with the low concentrations. This should not be the case because the work by Reichman & Parker showed that HEDTA could be used in the assay between 3 and 20 µmol.

Although the tests that were executed were extensive and able to validate most of the steps used in the protocol and resulted in a better feel for the method, they did not result in a validated assay. Additional tests were not possible due to time constraints. It was therefore chosen to store the gathered root exudates for later use when either the revised Fe binding assay was wholly validated and used successfully on more than the few occasions found in the results of the tests, or another method had been chosen.

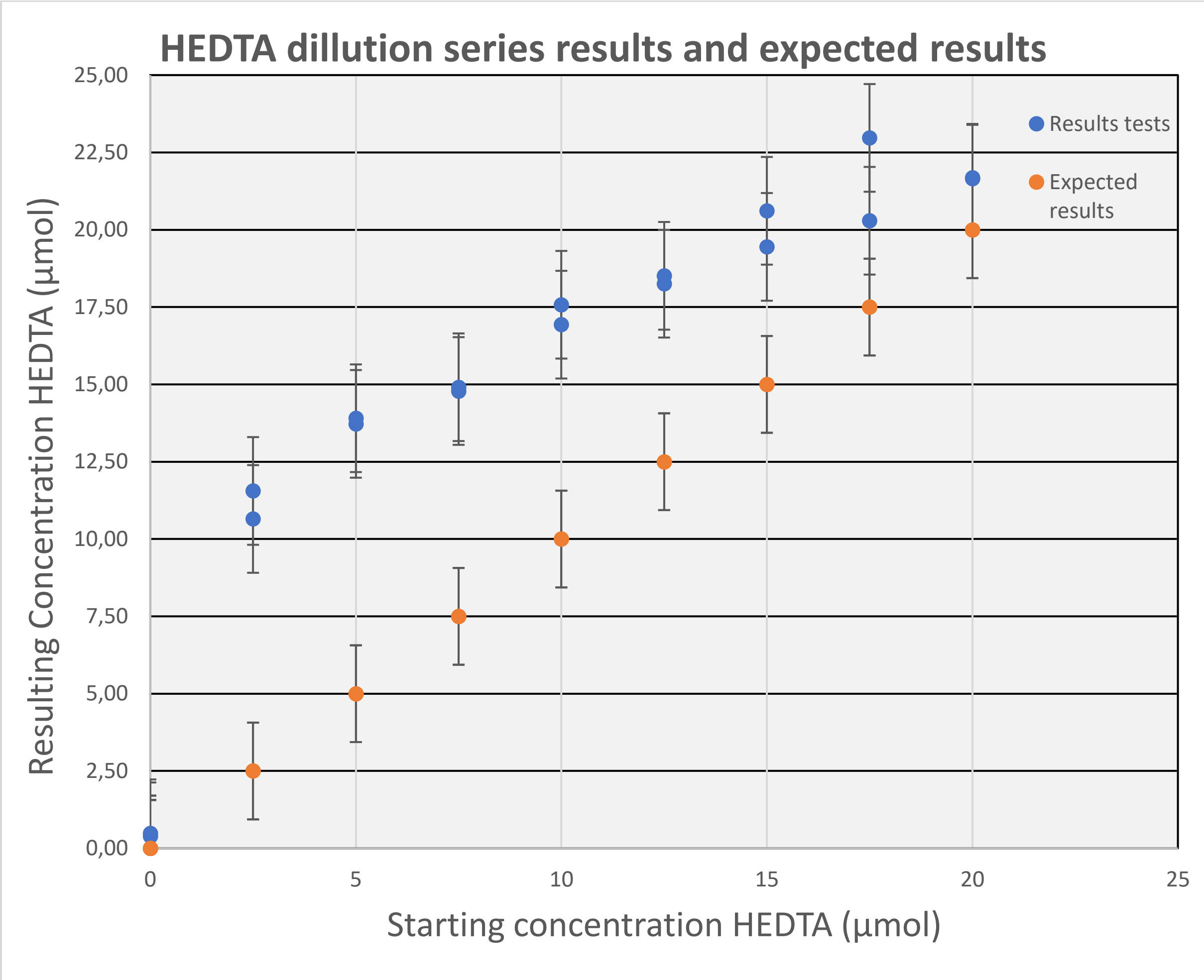

Figure 17: HEDTA dilution series. The orange results show the expected HEDTA concentrations based on the concentration added at the start of the tests. The blue results show the concentrations found at the end of the tests.

5. Discussion

5.1 Limitations

5.1.1 Phytosiderophore complexes

Phytosiderophores released by plant roots form complexes with not only Fe but also other metals, specifically Cu (Schenkeveld et al., 2014); the amount of Cu-phytosiderophore complexes formed in the soil can be higher than that of Fe-phytosiderophores. When the amount of Fe-phytosiderophore complexes is sufficiently reduced owing to the presence of other metal complexes, the efficiency of phytosiderophores in relieving iron deficiency stress is reduced, which results in plants showing more severe symptoms of chlorosis or showing symptoms earlier than expected. To prevent this from happening, in the present research, quartz sand with low copper was chosen, and the only copper added to prevent copper limitation was in the form of micronutrients. The formation of Cu-phytosiderophore complexes has been studied by Schenkeveld et al., the results of which are presented in Figure 18. The figure demonstrates metal mobilization from a Spanish calcareous clay soil upon addition of 30 µM of phytosiderophores (2'-deoxymugineic acid or DMA) as a function of time on the x-axis. Sodium azide was added to minimize microbiological activity that would otherwise break down the phytosiderophores complexes.

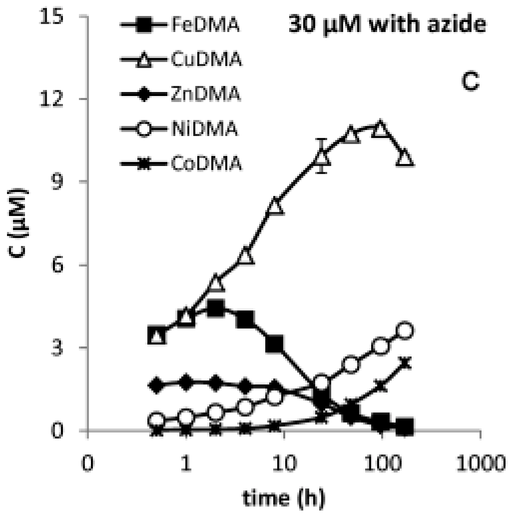

Figure 18: Metal mobilization of different metals in the soil as a function of time (Schenkeveld et al., 2014).

5.1.2 Seed varieties

The varieties of seeds selected for the screening experiment belonged to grass species in which phytosiderophore release had not previously been studied and species that are known, in general, to release lower amounts of phytosiderophores than other grass species. However, practicality was also an essential factor because it is challenging to acquire seeds suitable for use in a scientific experiment. The number of different varieties chosen for the screening experiment was larger at the beginning, but certain varieties were not available. Further difficulties arose with legislative issues regarding African seed varieties because of the potential risk of introducing diseases known to be present in Africa to Europe. Seeds easily available in from general stores were not considered because they could, for example, be contaminated with unknown disease-causing organisms. A screening experiment of grass seeds should ideally present a large variety of species that together represent most global regions. Because the seeds included in the present screening originated from only two continents and four countries, it could be perceived as a very limited range. However, the chosen varieties represented varieties from two countries (Swiss and Sierra Leone) in depth.

Moreover, most of the African upland rice varieties are bred in Sierra Leone but used in large parts of Africa, and their use is increasing over time.

5.1.3 Germination phase

The germination phase for all seed varieties in the screening experiment was started simultaneously; however, the varieties showed significant differences in the time required for the seedlings to be sufficiently large for potting. This led to a difference of a few days between potting of the seed varieties. Consequently, certain varieties had fewer days of growth in the quartz sand supplemented with nutrients needed for growth. However, plants in the early growth phase do subsist mostly on the nutrients available in the seeds, which should reduce potential differences in nutrient availability because potted seedlings were still growing mostly on their seeds (Rengel & Graham, 1995).

Rice seeds required more time to germinate than oat and rye seeds. Owing to time constraints, the germination of all seeds was started simultaneously instead of a week earlier for the rice seeds. In some previous studies on rice seeds, a seed incubator was used in addition to the plastic floating beads used for germination. However, the present study did not use a seed incubator, which resulted in a slower-than-expected growth of the germinated rice seeds. Seeds were potted over when their roots showed growth that was deemed sufficient for successful potting. However, a substantial number of seedlings died within 2 weeks after transfer. Afterwards, their root length was determined to be too small for successful transfer of germinated seedlings. Reserve pots were made to compensate for the loss to a certain extent but in follow-up research, rice seeds should be germinated either for an extended period or in a seed incubator. Oat and rye seeds were sufficiently germinated such that deaths of potted plants were prevented in all but a few cases.

5.1.4 Study area

The screening experiment was carried out on an iron working table placed in a greenhouse. A part of the working table surface would be in the shade for part of the day, resulting in differences in light received during daytime for different parts of the table. In an attempt to overcome this inconsistency, pots were placed randomly three to four times each week. Additionally, one side of the working table was next to the greenhouse wall through which the wind could enter. Again, potential differences in growth due to this factor were tried to be overcome using random pot placement and no placement on the surface closest to incoming wind. In addition, most pots in the screening experiment were placed at a considerable distance from each other to prevent leaves from touching each other and plants growing in very close proximity from each other. However, several plant pots were being placed in relatively close proximity (up to 10 cm). This distance was not ideal because it could affect the results, for example, owing to shadow spots with lesser light intensity caused by a high and/or wide plant standing in close proximity to small plants (Gilbert et al., 2001).

The above examples demonstrate the difference between the soybean plants grown in a growth chamber with regulated conditions, with no effect of the wind. However, a greenhouse provides conditions more similar to real-life growth conditions, with changing temperatures on sunny or cloudy days and high light availability.

5.1.5 Data collection

The SPAD measurement device was extensively used to monitor chlorophyll levels in both experiments. There was a distinct difference in the ease with which SPAD values of soybean, oat, rye and rice leaves could be measured. For growing soybean and rice plants, it was evident which leaves were the youngest.

Measuring SPAD values in oat plants was more difficult because as secondary tillers started to grow, it became more difficult to determine which leaves from which tiller were the youngest.

Taking measurements was even more difficult in three out of the five rye varieties. These varieties often had six or more tillers protruding from the ground that continued to grow new leaves. Care was taken to measure the appropriate leaves, but with more than 120 plants of oat and rye being measured thrice a week for many weeks, the possibility of minor errors, which could induce false differences between control and experimental groups, cannot be excluded.

SPAD measurements were taken on specific positions on the leaves and measuring a different part of the leaf could cause significant differences in measurements. Comparable to the measurement of a wrong leaf, measurements at a position higher or lower along the length of a leaf could also have affected the results. Measurements were done in a pair which introduced extra control on taking the measurements correctly.

The SPAD measurement device requires a sufficiently large leaf area to be placed in the clamp. However, the leaf area of the youngest leaves, on which measurements were taken, was smaller than that of older leaves. Thus, the device detects low levels of chlorophyll because the whole measurement area of the SPAD meter does not come in contact with the leaf. In the present study, lower SPAD readings in the experimental group plants than in the control plants indicated chlorosis in the experimental plants. However, if a large number of leaves that are too small for SPAD measurements is used, it could lead to a false assumption that the plants are chlorotic. Care was taken only to measure large enough leaves; however, over many thousands of measurements, the possibility of minor errors cannot be excluded.

Differences between leaf colour of control and experimental groups of oat and rye seed varieties were tested using t-tests. Symptoms of chlorosis in experimental plants are more discernible when control plants have dark green leaves. However, oat and rye control plants had considerably light green leaves, making changes caused by chlorosis more difficult to distinguish and potentially reducing the difference in SPAD values between the control and experimental groups, thus lowering the likelihood of obtaining significant results. The light green leaf colour was even more pronounced in rye seed varieties. Therefore, establishing chlorosis in rye plants was difficult with SPAD measurements alone, where small differences are indicative of chlorosis but are too small to be statistically significant ($p = 0.05$).

Dry biomass weight is susceptible to keeping the biomass out of the oven for long periods of time because the water in the air increases the biomass weight. To prevent rehydration, the weighing procedure was divided into parts such that only a few plant samples were removed from the oven at a time to be weighed. Accurate weighing of belowground biomass was difficult because of soil residues adhered to the roots. Most belowground plant samples were sufficiently cleaned to remove any sand or soil residues, but rye and oat roots were especially difficult to clean because of high root density. Therefore, certain dry weight values in varieties from oat and rye may have had a slightly lower actual weight than that measured.

5.1.6 Harvesting root exudates

Timing is a critical factor in the method used to collect root exudates. The start and end of the period during which the roots must be submerged in demineralized water to release phytosiderophores is crucial to be able to compare between samples. The procedure was carried out well with rye and rice exudates, but difficulties in timing arose with the oat exudates. This was caused by delays in filtration of the exudates to remove plant fragments from the exudates. The fragments blocked the filters, owing to which two filters had to be used instead of one to filter each exudate. The delay resulted in approximately half of the exudates standing 1 h longer than the 3 h used in the previous studies. The final phytosiderophore concentration in the oat samples was corrected for a longer time period (4 h instead of 3 h) than that used for rye and rice.

Oat and rye were harvested under comparable temperatures in the greenhouse, whereas rice was harvested on a cloudy morning. Light reduces the release of phytosiderophores and harvesting of rice under lower light conditions than those during the harvesting of rye and oat could potentially affect the final concentration of phytosiderophores being released (Reichman & Parker, 2007[b]).

5.2 Follow-up research

The ranking of different varieties of grass species based on the effect of induced iron deficiency on onset of chlorosis can be used as a reference for further research regarding individual seed varieties. Future research could focus on limiting nutrients other than iron to examine whether a specific variety is equally susceptible to deficiency of a different nutrient.

Unfortunately, the Fe-binding assay revised by Reichman and Parker could not be used in the present research. The revised Fe-binding assay was thoroughly tested in this study but still showed some unexplained results regarding certain parts of the protocol. Additional research on this revised assay, which is not yet extensively used, is needed before the root exudates collected in this research can be analysed. These analyses would further elucidate the susceptibility of the seed varieties to chlorosis through examination of phytosiderophore concentrations in their root exudates and, therefore, their iron acquisition rates.

Another application of the results from this study could be in research on the effectiveness of the phytosiderophores released by the grass varieties. The tendency to form phytosiderophore complexes with metals other than Fe has been researched in the past, but solutions to this limitation have not yet been proposed. For instance, the use of a substance that fixes certain metals making them inaccessible for phytosiderophore complex formation could be tested. Previously, research on one such substance called Triethylenetetramine (TETA), which can fix Cu in the soil, was conducted by my supervisor Walter Schenkeveld. Triethylenetetramine has been successfully used in human medicine against Wilson's disease characterised by copper accumulation in the body (Nazer et al., 1986; Chen et al., 2015). The copper is complexed by TETA and can then be excreted from the body. Experiments in the present study could be repeated using only seed varieties that were most affected by chlorosis and showed the lowest phytosiderophore concentration. The only modifications in this screening experiment would be the use of TETA and a source of Cu as a soil additive. Comparing the results of this follow-up experiment with the results from this thesis would indicate if using TETA is a potential method to reduce the adverse effects of chlorosis on plant growth in iron-deficient soils.

6. Conclusion

The thesis focused on answering the following research question:

How do different grass varieties from rice, oat, and rye species and soybean plants respond to induced iron deficiency with respect to leaf chlorophyll content?

The water use of soybean plants did not differ significantly over time under low light. Increased water use in the control group of soybean plans under high light was found, but these differences could not be coupled to chlorosis.

The water use of the screening varieties did not differ significantly for rye varieties. The oat varieties Adliker and Hative des Alpes showed increased water use in the control group compared to the experimental group during chlorosis.

Increases in water use between various control and experimental groups of rice seeds were found significant but these differences could not be attributed to chlorosis.

Soybean plants from the experimental group of plants showed a significantly lower biomass weight than the control group. Plants grown in a different light regime did not show any difference in dry weight of above and belowground biomass weight, which for this experiment indicated that it was solely caused by the iron limitation imposed on the experimental group. Additional tests with light different light regimes would have to be done to conclude more about the effect on the biomass of soybean plants.

Dry weight above and belowground biomass of the grass varieties did not differ significantly between the experimental and control groups. Rice seed varieties did show significant differences between control and experimental groups, indicating that the rice varieties were more susceptible to chlorosis compared to the rye and oat varieties.

SPAD measurements of chlorophyll content of soybean showed chlorosis symptoms early on in their growth (3rd week) and only slowly recovered over time. Full recovery was not observed because the difference between the experimental and control groups stayed significant in the last few days before destruction. Contrary to expectations, light did not have a significant effect on the chlorophyll content.

Oat varieties showed more pronounced chlorosis symptoms and earlier in development than rye varieties. Certain rye varieties did not show significant chlorosis symptoms. Overall the rye varieties were the least affected by chlorosis.

Sufficient SPAD data could not be obtained for the rice varieties. Dry biomass weight data indicated that these varieties were more susceptible to chlorosis than oat and rye varieties, and their growth was often disrupted owing to chlorosis, causing insufficient leaf growth, which prevented SPAD measurements.

Tests of the revised Fe-binding assay method of Reichman and Parker were sufficiently extensive to test and validate most steps of the protocol. However, the test including a dilution series of pre-known concentrations of HEDTA did not show expected results, and therefore, the method could not be used to analyse the root exudates collected during the study. Therefore, susceptibility to chlorosis was measured using three of the four factors initially proposed (water use, dry biomass weight and chlorophyll content, but not phytosiderophore release).

Table 27 shows a ranked list of the studied grass varieties according to susceptibility to chlorosis (from high to low) determined based on water use, dry weight and SPAD measurements. Susceptibility to chlorosis could not be determined for the rice varieties using SPAD readings. Therefore, dry weight and weekly average water use were used as indicators to rank the rice varieties.

Table 27: Ranking of grass seed varieties based on susceptibility to iron deficiency-induced chlorosis.

Rank	Seed variety
1	CNAX 3031-78-2-1-1 (Rice)
2	WAB 95-B-B-40-HB (Rice)
3	NERICA 6 (Rice)
4	NERICA 15 (Rice)
5	NERICA 4 (Rice)
6	NERICA 3 (Rice)
7	NERICA 18 (Rice)
8	NERICA 16 (Rice)
9	Ebene (Oat)
10	Hative des Alpes (Oat)
11	Brune de Mont-calme (Oat)
12	Adliker (Oat)
13	Expander (Oat)
14	Val Peccia GT-711 (Rye)
15	Walliser Roggen Binnega (Rye)
16	RIED LOETSCHENTALL (Rye)
17	Beka (Rye)
18	CADI (Rye)

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8. Appendix

8.1 Water use of soybean

Weight of the soybean pots in grams with the weekly average water use in g

Sample	Light	FeHBED (Yes/No)	28-2-2019 startweight (g)	4-3-2019 (g)	6-3-2019 (g)	8-3-2019 (g)	Week average (g)
1	High	No	1144	1101	1105	1105	**34**
2	High	No	1154	1110	1121	1110	**40**
3	High	No	1143	1101	1107	1108	**38**
4	High	No	1149	1110	1118	1100	**40**
5	High	No	1159	1118	1121	1117	**40**
6	High	No	1160	1108	1122	1119	**44**
7	High	No	1150	1112	1115	1118	**35**
8	High	No	1147	1118	1118	1111	**31**
9	High	No	1146	1116	1118	1112	**31**
10	High	No	1156	1115	1121	1121	**37**
11	High	No	1152	1119	1123	1109	**35**
12	High	No	1156	1114	1123	1113	**39**
13	High	No	1146	1102	1115	1106	**38**
14	High	No	1161	1122	1126	1119	**39**
15	High	Yes	1152	1112	1118	1109	**39**
16	High	Yes	1153	1110	1119	1115	**38**
17	High	Yes	1149	1107	1120	1107	**38**
18	High	Yes	1153	1114	1119	1112	**38**
19	High	Yes	1153	1111	1117	1119	**37**
20	High	Yes	1152	1110	1120	1105	**40**
21	High	Yes	1157	1105	1124	1113	**43**
22	High	Yes	1154	1100	1122	1114	**42**
23	High	Yes	1151	1103	1118	1099	**44**
24	High	Yes	1155	1105	1120	1113	**42**
25	High	Yes	1138	1086	1100	1105	**41**
26	High	Yes	1143	1094	1107	1104	**41**
27	High	Yes	1156	1111	1114	1119	**41**
28	High	Yes	1139	1093	1108	1097	**40**
29	Low	No	1141	1113	1113	1114	**28**
30	Low	No	1140	1104	1107	1109	**33**
31	Low	No	1145	1110	1099	1123	**34**
32	Low	No	1162	1117	1115	1134	**40**
33	Low	No	1158	1115	1118	1122	**40**
34	Low	No	1157	1107	1124	1124	**39**
35	Low	No	1152	1105	1114	1123	**38**
36	Low	No	1159	1114	1121	1128	**38**
37	Low	No	1162	1112	1121	1134	**40**

38	Low	No	1156	1112	1114	1128	**38**
39	Low	No	1151	1107	1105	1117	**41**
40	Low	No	1149	1106	1108	1114	**40**
41	Low	No	1154	1105	1120	1120	**39**
42	Low	No	1156	1098	1117	1130	**41**
43	Low	Yes	1145	1098	1094	1124	**40**
44	Low	Yes	1144	1100	1114	1102	**39**
45	Low	Yes	1141	1101	1098	1118	**35**
46	Low	Yes	1148	1110	1103	1123	**36**
47	Low	Yes	1143	1103	1107	1099	**40**
48	Low	Yes	1150	1110	1109	1128	**34**
49	Low	Yes	1145	1102	1113	1123	**32**
50	Low	Yes	1154	1114	1109	1129	**37**
51	Low	Yes	1155	1112	1112	1130	**37**
52	Low	Yes	1155	1114	1109	1129	**38**
53	Low	Yes	1160	1119	1112	1137	**37**
54	Low	Yes	1156	1116	1108	1122	**41**
55	Low	Yes	1155	1122	1111	1129	**34**
56	Low	Yes	1158	1117	1110	1125	**41**

Sample	**Light**	**FeHBED (Yes/No)**	**28-2-2019 startweight (g)**	**11-3-2019 (g)**	**13-3-2019 (g)**	**15-3-2019 (g)**	**Week average (g)**
1	High	No	1144	1102	1099	1130	**34**
2	High	No	1154	1119	1115	1133	**32**
3	High	No	1143	1102	1107	1108	**37**
4	High	No	1149	1108	1112	1123	**35**
5	High	No	1159	1110	1126	1130	**37**
6	High	No	1160	1111	1123	1134	**37**
7	High	No	1150	1105	1118	1115	**37**
8	High	No	1147	1116	1111	1119	**32**
9	High	No	1146	1110	1115	1126	**29**
10	High	No	1156	1126	1115	1127	**33**
11	High	No	1152	1116	1112	1134	**31**
12	High	No	1156	1118	1125	1115	**37**

13	High	No	1146	1096	1119	1120	**34**
14	High	No	1161	1118	1126	1139	**33**
15	High	Yes	1152	1113	1112	1119	**37**
16	High	Yes	1153	1110	1106	1124	**40**
17	High	Yes	1149	1107	1125	1126	**30**
18	High	Yes	1153	1106	1105	1132	**39**
19	High	Yes	1153	1108	1113	1132	**35**
20	High	Yes	1152	1117	1118	1115	**35**
21	High	Yes	1157	1118	1115	1124	**38**
22	High	Yes	1154	1109	1105	1128	**40**
23	High	Yes	1151	1118	1107	1129	**33**
24	High	Yes	1155	1119	1116	1110	**40**
25	High	Yes	1138	1097	1101	1108	**36**
26	High	Yes	1143	1094	1103	1119	**38**
27	High	Yes	1156	1117	1127	1125	**33**
28	High	Yes	1139	1101	1100	1120	**32**
29	Low	No	1141	1097	1112	1108	**35**
30	Low	No	1140	1095	1105	1109	**37**
31	Low	No	1145	1102	1110	1117	**35**
32	Low	No	1162	1111	1130	1119	**42**
33	Low	No	1158	1094	1126	1128	**42**
34	Low	No	1157	1099	1125	1129	**39**
35	Low	No	1152	1102	1113	1118	**41**
36	Low	No	1159	1099	1131	1129	**39**
37	Low	No	1162	1117	1122	1138	**36**
38	Low	No	1156	1105	1121	1132	**37**
39	Low	No	1151	1105	1115	1113	**40**
40	Low	No	1149	1101	1109	1103	**45**
41	Low	No	1154	1100	1115	1129	**39**
42	Low	No	1156	1108	1115	1128	**39**
43	Low	Yes	1145	1090	1119	1110	**39**
44	Low	Yes	1144	1105	1105	1110	**37**
45	Low	Yes	1141	1086	1116	1096	**42**
46	Low	Yes	1148	1102	1109	1116	**39**
47	Low	Yes	1143	1105	1116	1098	**37**
48	Low	Yes	1150	1102	1117	1122	**36**
49	Low	Yes	1145	1093	1112	1113	**39**
50	Low	Yes	1154	1113	1123	1123	**34**
51	Low	Yes	1155	1103	1122	1119	**40**
52	Low	Yes	1155	1107	1136	1119	**34**
53	Low	Yes	1160	1111	1117	1122	**43**
54	Low	Yes	1156	1105	1120	1118	**42**
55	Low	Yes	1155	1113	1114	1131	**36**
56	Low	Yes	1158	1120	1130	1135	**30**

Sample	Light	FeHBED (Yes/No)	28-2-2019 startweight (g)	18-3-2019 (g)	19-3-2019 (g)	20-3-2019 (g)	22-3-2019 (g)	Week average (g)
1	High	No	1144	1101	1120	1133	1118	**26**
2	High	No	1154	1109	1133	1142	1128	**26**
3	High	No	1143	1095	1122	1129	1126	**25**
4	High	No	1149	1102	1125	1134	1124	**28**
5	High	No	1159	1113	1138	1138	1133	**29**
6	High	No	1160	1111	1136	1143	1138	**28**
7	High	No	1150	1100	1129	1143	1127	**25**
8	High	No	1147	1111	1124	1139	1122	**23**
9	High	No	1146	1113	1122	1140	1114	**24**
10	High	No	1156	1112	1136	1148	1138	**23**
11	High	No	1152	1111	1130	1142	1129	**24**
12	High	No	1156	1108	1138	1141	1139	**25**
13	High	No	1146	1104	1131	1132	1123	**24**
14	High	No	1161	1111	1139	1152	1141	**25**
15	High	Yes	1152	1106	1129	1148	1132	**23**
16	High	Yes	1153	1103	1131	1145	1121	**28**
17	High	Yes	1149	1106	1123	1129	1121	**29**
18	High	Yes	1153	1106	1135	1134	1133	**26**
19	High	Yes	1153	1106	1129	1137	1126	**29**
20	High	Yes	1152	1102	1128	1136	1130	**28**
21	High	Yes	1157	1097	1135	1144	1136	**29**
22	High	Yes	1154	1099	1131	1139	1120	**32**
23	High	Yes	1151	1103	1130	1137	1128	**27**
24	High	Yes	1155	1106	1130	1142	1131	**28**
25	High	Yes	1138	1090	1121	1121	1117	**26**
26	High	Yes	1143	1098	1115	1135	1119	**26**
27	High	Yes	1156	1115	1131	1148	1133	**24**
28	High	Yes	1139	1080	1121	1133	1119	**26**
29	Low	No	1141	1106	1119	1125	1121	**23**
30	Low	No	1140	1099	1116	1123	1113	**27**
31	Low	No	1145	1108	1124	1120	1120	**27**
32	Low	No	1162	1116	1149	1150	1133	**25**
33	Low	No	1158	1108	1149	1130	1124	**30**
34	Low	No	1157	1111	1137	1147	1125	**27**
35	Low	No	1152	1107	1137	1135	1119	**28**
36	Low	No	1159	1109	1135	1145	1141	**27**
37	Low	No	1162	1114	1135	1139	1137	**31**
38	Low	No	1156	1108	1143	1147	1127	**25**
39	Low	No	1151	1106	1137	1127	1125	**27**
40	Low	No	1149	1106	1126	1123	1130	**28**
41	Low	No	1154	1104	1134	1139	1130	**27**
42	Low	No	1156	1105	1131	1140	1137	**28**

43	Low	Yes	1145	1096	1128	1133	1120	**26**
44	Low	Yes	1144	1108	1111	1127	1116	**29**
45	Low	Yes	1141	1104	1123	1125	1114	**25**
46	Low	Yes	1148	1096	1136	1122	1123	**29**
47	Low	Yes	1143	1110	1116	1130	1115	**25**
48	Low	Yes	1150	1105	1135	1135	1117	**27**
49	Low	Yes	1145	1101	1121	1141	1110	**27**
50	Low	Yes	1154	1107	1140	1135	1126	**27**
51	Low	Yes	1155	1111	1129	1133	1130	**29**
52	Low	Yes	1155	1112	1139	1135	1130	**26**
53	Low	Yes	1160	1112	1150	1143	1125	**28**
54	Low	Yes	1156	1106	1150	1136	1127	**26**
55	Low	Yes	1155	1117	1132	1142	1120	**27**
56	Low	Yes	1158	1121	1136	1136	1137	**26**

Sample	**Light**	**FeHBED (Yes/No)**	**28-2-2019 startweight (g)**	**23-3-2019 (g)**	**25-3-2019 (g)**	**26-3-2019 (g)**	**27-3-2019 (g)**	**29-3-2019 (g)**	**Week average (g)**
1	High	No	1144	1123	1123	1109	1131		**23**
2	High	No	1154	1135	1125	1138	1130	1130	**22**
3	High	No	1143	1119	1113	1133	1119	1115	**23**
4	High	No	1149	1133	1122	1133	1126	1128	**21**
5	High	No	1159	1126	1135	1141	1133	1132	**26**
6	High	No	1160	1133	1129	1144	1133		**25**
7	High	No	1150	1127	1126	1136	1130	1129	**20**
8	High	No	1147	1124	1113	1135	1129		**22**
9	High	No	1146	1135	1124	1133	1130	1124	**17**
10	High	No	1156	1127	1126	1127	1143		**25**
11	High	No	1152	1122	1128	1140	1132	1127	**22**
12	High	No	1156	1128	1128	1143	1134	1128	**24**
13	High	No	1146	1124	1121	1129	1126		**21**
14	High	No	1161	1146	1135	1148	1136		**20**
15	High	Yes	1152	1120	1129	1141	1125	1129	**23**
16	High	Yes	1153	1131	1123	1124	1145		**22**
17	High	Yes	1149	1131	1122	1140	1128	1103	**24**
18	High	Yes	1153	1129	1126	1138	1127	1121	**25**
19	High	Yes	1153	1125	1117	1114	1133		**31**
20	High	Yes	1152	1125	1131	1142	1130	1131	**20**
21	High	Yes	1157	1131	1131	1141	1136	1130	**23**
22	High	Yes	1154	1127	1124	1125	1144		**24**
23	High	Yes	1151	1127	1122	1140	1125	1127	**23**
24	High	Yes	1155	1126	1130	1135	1135		**24**
25	High	Yes	1138	1111	1109	1126	1112	1110	**24**

26	High	Yes	1143	1117	1113	1130	1123		**22**
27	High	Yes	1156	1133	1131	1129	1127		**26**
28	High	Yes	1139	1106	1112	1128	1116	1112	**24**
29	Low	No	1141	1130	1113	1118	1126		**19**
30	Low	No	1140	1124	1108	1129	1112		**22**
31	Low	No	1145	1131	1112	1136	1121	1130	**19**
32	Low	No	1162	1137	1134	1149	1139	1138	**23**
33	Low	No	1158	1142	1123	1149	1129	1134	**23**
34	Low	No	1157	1141	1130	1147	1129		**20**
35	Low	No	1152	1137	1117	1146	1124	1131	**21**
36	Low	No	1159	1142	1129	1156	1137	1144	**17**
37	Low	No	1162	1148	1131	1153	1143	1143	**18**
38	Low	No	1156	1137	1125	1138	1146		**20**
39	Low	No	1151	1141	1113	1146	1125	1127	**21**
40	Low	No	1149	1126	1103	1142	1124		**25**
41	Low	No	1154	1141	1117	1146	1128		**21**
42	Low	No	1156	1146	1123	1146	1126	1130	**22**
43	Low	Yes	1145	1132	1118	1130	1116	1126	**21**
44	Low	Yes	1144	1130	1113	1132	1123		**20**
45	Low	Yes	1141	1123	1113	1131	1116		**20**
46	Low	Yes	1148	1136	1112	1125	1136		**21**
47	Low	Yes	1143	1131	1110	1134	1117	1118	**21**
48	Low	Yes	1150	1132	1122	1141	1127	1130	**20**
49	Low	Yes	1145	1128	1116	1132	1118	1119	**22**
50	Low	Yes	1154	1141	1123	1132	1145		**19**
51	Low	Yes	1155	1129	1123	1140	1130		**25**
52	Low	Yes	1155	1136	1125	1146	1128	1125	**23**
53	Low	Yes	1160	1151	1128	1134	1130		**24**
54	Low	Yes	1156	1135	1123	1151	1136	1135	**20**
55	Low	Yes	1155	1135	1129	1138	1138	1128	**21**
56	Low	Yes	1158	1134	1125	1150	1132	1137	**22**

Sample	**Light**	**FeHBED (Yes/No)**	**28-2-2019 startweight (g)**	**1-4-2019 (g)**	**2-4-2019 (g)**	**3-4-2019 (g)**	**5-4-2019 (g)**	**Week average (g)**
1	High	No	1144					
2	High	No	1154	1111	1130	1140	1123	**28**
3	High	No	1143	1107	1126	1131	1119	**22**
4	High	No	1149	1107	1128	1136	1123	**26**
5	High	No	1159	1108	1139	1141	1128	**30**
6	High	No	1160					
7	High	No	1150	1112	1133	1135	1130	**23**
8	High	No	1147					
9	High	No	1146	1113	1125	1130	1126	**23**

10	High	No	1156						
11	High	No	1152	1114	1132	1132	1132	**25**
12	High	No	1156	1119	1133	1140	1130	**26**
13	High	No	1146					
14	High	No	1161					
15	High	Yes	1152	1109	1124	1144	1131	**25**
16	High	Yes	1153					
17	High	Yes	1149	1107	1129	1141	1123	**24**
18	High	Yes	1153	1108	1132	1135	1130	**27**
19	High	Yes	1153					
20	High	Yes	1152	1115	1110	1136	1124	**31**
21	High	Yes	1157	1120	1138	1142	1126	**26**
22	High	Yes	1154					
23	High	Yes	1151	1107	1130	1130	1120	**29**
24	High	Yes	1155					
25	High	Yes	1138	1094	1116	1126	1109	**27**
26	High	Yes	1143					
27	High	Yes	1156					
28	High	Yes	1139	1090	1126	1118	1112	**28**
29	Low	No	1141					
30	Low	No	1140					
31	Low	No	1145	1103	1135	1132	1123	**22**
32	Low	No	1162	1117	1137	1157	1142	**24**
33	Low	No	1158	1106	1136	1143	1129	**30**
34	Low	No	1157					
35	Low	No	1152	1107	1125	1149	1128	**25**
36	Low	No	1159	1115	1138	1142	1137	**26**
37	Low	No	1162	1115	1136	1155	1136	**27**
38	Low	No	1156					
39	Low	No	1151	1113	1132	1139	1131	**22**
40	Low	No	1149					
41	Low	No	1154					
42	Low	No	1156	1106	1140	1139	1130	**27**
43	Low	Yes	1145	1096	1120	1135	1121	**27**
44	Low	Yes	1144					
45	Low	Yes	1141					
46	Low	Yes	1148					
47	Low	Yes	1143	1104	1123	1131	1127	**22**
48	Low	Yes	1150	1099	1132	1138	1124	**27**
49	Low	Yes	1145	1097	1128	1135	1123	**24**
50	Low	Yes	1154					
51	Low	Yes	1155					
52	Low	Yes	1155	1109	1133	1140	1131	**27**
53	Low	Yes	1160					
54	Low	Yes	1156	1113	1144	1137	1131	**25**

55	Low	Yes	1155	1114	1130	1142	1130	**26**
56	Low	Yes	1158	1107	1137	1151	1128	**27**

Sample	**Light**	**FeHBED (Yes/No)**	**28-2-2019 startweight (g)**	**8-4-2019 (g)**	**9-4-2019 (g)**	**10-4-2019 (g)**	**12-4-2019 (g)**	**Week average (g)**
1	High	No	1144					
2	High	No	1154	1109	1132	1124	1134	**29**
3	High	No	1143	1103	1117	1117	1126	**27**
4	High	No	1149	1105	1132	1121	1125	**28**
5	High	No	1159	1112	1134	1132	1136	**31**
6	High	No	1160					
7	High	No	1150	1107	1130	1128	1131	**26**
8	High	No	1147					
9	High	No	1146	1110	1127	1122	1126	**25**
10	High	No	1156					
11	High	No	1152	1110	1134	1124	1131	**27**
12	High	No	1156	1115	1135	1129	1133	**28**
13	High	No	1146					
14	High	No	1161					
15	High	Yes	1152	1109	1135	1125	1136	**26**
16	High	Yes	1153					
17	High	Yes	1149	1099	1129	1124	1126	**30**
18	High	Yes	1153	1105	1138	1122	1130	**29**
19	High	Yes	1153					
20	High	Yes	1152	1106	1134	1125	1126	**29**
21	High	Yes	1157	1108	1138	1130	1130	**31**
22	High	Yes	1154					
23	High	Yes	1151	1105	1130	1124	1127	**30**
24	High	Yes	1155					
25	High	Yes	1138	1090	1122	1113	1113	**29**
26	High	Yes	1143					
27	High	Yes	1156					
28	High	Yes	1139	1094	1121	1103	1116	**31**
29	Low	No	1141					
30	Low	No	1140					
31	Low	No	1145	1110	1127	1126	1126	**23**
32	Low	No	1162	1124	1138	1144	1139	**26**
33	Low	No	1158	1117	1139	1129	1140	**27**
34	Low	No	1157					
35	Low	No	1152	1112	1126	1133	1132	**26**
36	Low	No	1159	1120	1134	1140	1134	**27**
37	Low	No	1162	1119	1138	1143	1140	**27**
38	Low	No	1156					

39	Low	No	1151	1108	1126	1134	1132	**26**
40	Low	No	1149					
41	Low	No	1154					
42	Low	No	1156	1114	1136	1135	1124	**29**
43	Low	Yes	1145	1104	1120	1130	1125	**25**
44	Low	Yes	1144					
45	Low	Yes	1141					
46	Low	Yes	1148					
47	Low	Yes	1143	1101	1120	1124	1111	**29**
48	Low	Yes	1150	1112	1128	1127	1128	**26**
49	Low	Yes	1145	1109	1123	1129	1130	**22**
50	Low	Yes	1154					
51	Low	Yes	1155					
52	Low	Yes	1155	1113	1132	1135	1135	**26**
53	Low	Yes	1160					
54	Low	Yes	1156	1114	1131	1143	1127	**27**
55	Low	Yes	1155	1114	1135	1135	1132	**26**
56	Low	Yes	1158	1109	1133	1138	1139	**28**

Sample	**Light**	**FeHBED (Yes/No)**	**28-2-2019 startweight (g)**	**15-4-2019 (g)**	**16-4-2019 (g)**	**17-4-2019 (g)**	**Week average (g)**
1	High	No	1144				
2	High	No	1154	1114	1140	1128	**27**
3	High	No	1143	1101	1131	1127	**23**
4	High	No	1149	1111	1132	1124	**27**
5	High	No	1159	1119	1147	1142	**23**
6	High	No	1160				
7	High	No	1150	1121	1140	1128	**20**
8	High	No	1147				
9	High	No	1146	1111	1137	1128	**21**
10	High	No	1156				
11	High	No	1152	1120	1139	1127	**23**
12	High	No	1156	1117	1145	1133	**24**
13	High	No	1146				

14	High	No	1161				
15	High	Yes	1152	1112	1135	1133	**25**
16	High	Yes	1153				
17	High	Yes	1149	1113	1137	1125	**24**
18	High	Yes	1153	1117	1143	1134	**22**
19	High	Yes	1153				
20	High	Yes	1152	1119	1135	1128	**25**
21	High	Yes	1157	1124	1140	1127	**27**
22	High	Yes	1154				
23	High	Yes	1151	1116	1142	1128	**22**
24	High	Yes	1155				
25	High	Yes	1138	1095	1125	1112	**27**
26	High	Yes	1143				
27	High	Yes	1156				
28	High	Yes	1139	1098	1123	1114	**27**
29	Low	No	1141				
30	Low	No	1140				
31	Low	No	1145	1116	1133	1124	**21**
32	Low	No	1162	1130	1146	1142	**23**
33	Low	No	1158	1119	1143	1129	**28**
34	Low	No	1157				
35	Low	No	1152	1127	1140	1128	**20**
36	Low	No	1159	1128	1145	1134	**23**
37	Low	No	1162	1139	1149	1134	**21**
38	Low	No	1156				
39	Low	No	1151	1110	1136	1129	**26**
40	Low	No	1149				
41	Low	No	1154				
42	Low	No	1156	1133	1139	1133	**21**
43	Low	Yes	1145	1113	1130	1116	**25**
44	Low	Yes	1144				
45	Low	Yes	1141				
46	Low	Yes	1148				
47	Low	Yes	1143	1121	1132	1117	**20**
48	Low	Yes	1150	1115	1139	1124	**24**
49	Low	Yes	1145	1115	1130	1121	**23**
50	Low	Yes	1154				
51	Low	Yes	1155				
52	Low	Yes	1155	1125	1142	1132	**22**
53	Low	Yes	1160				
54	Low	Yes	1156	1131	1147	1129	**20**
55	Low	Yes	1155	1126	1139	1131	**23**
56	Low	Yes	1158	1116	1141	1134	**28**

8.2 Water use of screening varieties

Weight of the screening pots in grams with the weekly average water use in g

Sample	Plant code	Start weight (g) 28-2-2019	14-5-2019 (g)	15-5-2019 (g)	16-5-2019 (g)	17-5-2019 (g)	**Week Average (g)**
1	RBL	1148		1140	1117	1130	**19**
2	RBL	1141		1125	1104	1117	**26**
3	RBL	1141		1114	1119	1115	**25**
4	RBL	1141		1119	1109	1119	**25**
5	RBL	1145		1122	1120	1124	**23**
6	RBL	1140		1119	1104	1118	**26**
7	RBL	1143		1127	1108	1117	**26**
8	RBL	1144		1120	1112	1124	**25**
9	RBL	1144		1123	1110	1123	**25**
10	RBL	1140		1114	1105	1119	**27**
11	RBL	1140		1125	1115	1120	**20**
12	RBL	1139		1116	1111	1112	**26**
13	RPI	1142	1114	1120	1117	1118	**25**
14	RPI	1144	1121	1131	1117	1124	**21**
15	RPI	1140	1120	1121	1112	1120	**22**
16	RPI	1139	1115	1121	1111	1109	**25**
17	RPI	1143	1140	1119	1115	1119	**20**
18	RPI	1145	1122	1117	1109	1122	**28**
19	RPI	1146	1122	1124	1117	1123	**25**
20	RPI	1147	1124	1122	1113	1123	**27**
21	RPI	1148	1123	1129	1119	1116	**26**
22	RPI	1141	1119	1116	1111	1115	**26**
23	RPI	1148	1135	1128	1119	1128	**21**
24	RPI	1140	1116	1119	1110	1117	**25**
25	RPU	1151	1132	1140	1131	1127	**19**
26	RPU	1140	1117	1122	1134	1122	**16**
27	RPU	1150	1128	1122	1119	1130	**25**
28	RPU	1145	1126	1123	1117	1129	**21**
29	RPU	1138	1116	1113	1107	1119	**24**
30	RPU	1146	1122	1120	1113	1124	**26**
31	RPU	1138	1126	1116	1102	1113	**24**
32	RPU	1141	1129	1128	1107	1124	**19**
33	RPU	1146	1126	1122	1114	1123	**25**
34	RPU	1143	1134	1128	1109	1125	**19**
35	RPU	1144	1123	1118	1113	1125	**24**
36	RPU	1144	1140	1117	1112	1124	**21**
37	RRE	1129					
38	RRE	1149					

39	RRE	1138					
40	RRE	1143					
41	RRE	1145					
42	RRE	1135					
43	RRE	1148					
44	RRE	1146					
45	RRE	1137					
46	RRE	1147					
47	RRE	1146					
48	RRE	1145					
49	RBR	1145			1119	1121	**25**
50	RBR	1141			1115	1112	**28**
51	RBR	1144			1113	1127	**24**
52	RBR	1139			1108	1116	**27**
53	RBR	1143			1111	1116	**30**
54	RBR	1145			1116	1120	**27**
55	RBR	1148			1112	1124	**30**
56	RBR	1145			1113	1124	**27**
57	RBR	1144			1112	1127	**25**
58	RBR	1145			1109	1123	**29**
59	RBR	1143			1107	1127	**26**
60	RBR	1147			1113	1120	**31**
61	OGR	1136		1108	1109	1109	**27**
62	OGR	1145		1117	1115	1118	**28**
63	OGR	1143		1120	1113	1119	**26**
64	OGR	1141		1114	1107	1117	**28**
65	OGR	1135		1109	1106	1118	**24**
66	OGR	1142		1114	1113	1120	**26**
67	OGR	1150		1123	1114	1133	**27**
68	OGR	1133		1119	1108	1110	**21**
69	OGR	1141		1112	1107	1121	**28**
70	OGR	1139		1112	1115	1117	**24**
71	OGR	1134		1109	1108	1116	**23**
72	OGR	1135		1111	1114	1110	**23**
73	OOR	1155	1133	1132	1121	1129	**26**
74	OOR	1135	1116	1111	1102	1114	**24**
75	OOR	1152	1131	1120	1120	1131	**27**
76	OOR	1140	1122	1112	1107	1114	**26**
77	OOR	1136	1116	1118	1103	1115	**23**
78	OOR	1135	1113	1115	1106	1112	**24**
79	OOR	1138	1122	1120	1109	1118	**21**
80	OOR	1141	1133	1118	1112	1126	**19**
81	OOR	1142	1128	1122	1115	1121	**21**
82	OOR	1140	1121	1119	1112	1118	**23**
83	OOR	1139	1116	1117	1105	1113	**26**

84	OOR	1137	1118	1113	1102	1109	**27**
85	OYE	1136	1119	1109	1099	1116	**25**
86	OYE	1145	1122	1120	1108	1119	**28**
87	OYE	1143	1121	1117	1108	1127	**25**
88	OYE	1141	1116	1112	1105	1115	**29**
89	OYE	1144	1122	1120	1112	1123	**25**
90	OYE	1139	1127	1114	1105	1120	**23**
91	OYE	1140	1119	1115	1108	1116	**26**
92	OYE	1144	1121	1119	1110	1118	**27**
93	OYE	1144	1138	1120	1109	1120	**22**
94	OYE	1140	1126	1113	1101	1116	**26**
95	OYE	1143	1120	1127	1115	1114	**24**
96	OYE	1141	1117	1116	1112	1118	**25**
97	OBE	1155					
98	OBE	1135					
99	OBE	1152					
100	OBE	1145					
101	OBE	1141					
102	OBE	1139					
103	OBE	1139					
104	OBE	1140					
105	OBE	1143					
106	OBE	1141					
107	OBE	1138					
108	OBE	1139					
109	OPU	1148			1120	1128	**24**
110	OPU	1145			1111	1120	**30**
111	OPU	1148			1116	1126	**27**
112	OPU	1141			1126	1131	**13**
113	OPU	1139			1113	1118	**24**
114	OPU	1140			1106	1118	**28**
115	OPU	1141			1110	1120	**26**
116	OPU	1141			1123	1121	**19**
117	OPU	1141			1111	1118	**27**
118	OPU	1139			1112	1116	**25**
119	OPU	1139			1114	1117	**24**
120	OPU	1139			1115	1110	**27**
121	UBE	1137					
122	UBE	1157					
123	UBE	1141					
124	UBE	1147					
125	UBE	1140					
126	UBE	1142					
127	UBE	1143					
128	UBE	1139					

129	UBE	1139					
130	UBE	1142					
131	UBE	1144					
132	UBE	1142					
133	UOR	1140				1120	**20**
134	UOR	1143				1122	**21**
135	UOR	1142				1125	**17**
136	UOR	1143				1129	**14**
137	UOR	1138				1127	**11**
138	UOR	1140				1120	**20**
139	UOR	1143				1126	**17**
140	UOR	1142				1130	**12**
141	UOR	1141				1117	**24**
142	UOR	1142				1139	**3**
143	UOR	1140				1117	**23**
144	UOR	1138				1120	**18**
145	UGR	1146				1124	**22**
146	UGR	1146				1126	**20**
147	UGR	1145				1125	**20**
148	UGR	1136				1116	**20**
149	UGR	1139				1115	**24**
150	UGR	1138				1114	**24**
151	UGR	1143				1117	**26**
152	UGR	1142				1120	**22**
153	UGR	1143				1132	**11**
154	UGR	1138				1120	**18**
155	UGR	1141				1117	**24**
156	UGR	1140				1118	**22**
157	UPI	1144					
158	UPI	1143					
159	UPI	1144					
160	UPI	1144					
161	UPI	1140					
162	UPI	1136					
163	UPI	1140					
164	UPI	1143					
165	UPI	1140					
166	UPI	1142					
167	UPI	1139					
168	UPI	1140					
169	UBL	1140					
170	UBL	1144					
171	UBL	1139					
172	UBL	1136					
173	UBL	1141					

174	UBL	1138					
175	UBL	1143					
176	UBL	1140					
177	UBL	1141					
178	UBL	1140					
179	UBL	1143					
180	UBL	1142					
181	URE	1136			1113	1115	**22**
182	URE	1143			1110	1117	**30**
183	URE	1143			1108	1116	**31**
184	URE	1144			1112	1119	**29**
185	URE	1144			1112	1121	**28**
186	URE	1140			1109	1117	**27**
187	URE	1139			1112	1120	**23**
188	URE	1141			1112	1120	**25**
189	URE	1138			1109	1117	**25**
190	URE	1142			1118	1119	**24**
191	UPU	1139			1112	1120	**23**
192	UPU	1141			1115	1137	**15**
193	UPU	1145				1122	**23**
194	UPU	1144				1122	**22**
195	UPU	1138				1120	**18**
196	UPU	1141				1136	**5**
197	UPU	1137				1123	**14**
198	UPU	1137				1126	**11**
199	UPU	1141				1117	**24**
200	UPU	1141				1117	**24**
201	UPU	1140				1114	**26**
202	UPU	1143				1120	**23**
203	UPU	1142				1121	**21**
204	UPU	1142				1120	**22**
205	UYE	1142					
206	UYE	1138					
207	UYE	1137					
208	UYE	1137					
209	UYE	1141					
210	UYE	1140					
211	UYE	1140					
212	UYE	1140					
213	UYE	1142					
214	UYE	1140					
215	UYE	1144					
216	UYE	1141					
217	UGR	1141				1139	**2**
218	UBE	1140					

219	UBL	1142					
220	UPI	1141					
221	UOR	1140				1117	**23**
222	UPU	1141				1119	**22**
223	UOR	1143				1122	**21**
224	RBR	1143			1104	1116	**33**
225	UYE	1138					
226	URE	1144					
227	URE	1142					
228	UBL	1140					
229	UPU	1140				1120	**20**
230	UGR	1143				1126	**17**
231	UYE	1139					
232	UGR	1137					
233	UBE	1144					
234	URE	1144					
235	URE	1140					
236	URE	1137					
237	OGR	1141		1117	1106	1123	**26**
238	UPI	1141					
239	OYE	1143	1118	1122	1104	1122	**27**

Sample	Plant code	Start weight (g) 28-2-2019	20-5-2019 (g)	21-5-2019 (g)	23-5-2019 (g)	24-5-2019 (g)	**Week Average (g)**
1	RBL	1148	1097	1137	1111	1120	**32**
2	RBL	1141	1092	1132	1116	1114	**28**
3	RBL	1141	1092	1138	1112	1111	**28**
4	RBL	1141	1092	1135	1111	1115	**28**
5	RBL	1145	1092	1135	1113	1108	**33**
6	RBL	1140	1094	1131	1108	1107	**30**
7	RBL	1143	1088	1135	1114	1108	**32**
8	RBL	1144	1101	1132	1111	1117	**29**
9	RBL	1144	1094	1138	1113	1115	**29**
10	RBL	1140	1100	1134	1105	1112	**27**
11	RBL	1140	1094	1134	1115	1112	**26**
12	RBL	1139	1086	1130	1114	1107	**30**
13	RPI	1142	1084	1132	1110	1113	**32**
14	RPI	1144	1091	1136	1116	1112	**30**

15	RPI	1140	1085	1130	1109	1108	**32**
16	RPI	1139	1084	1130	1104	1108	**33**
17	RPI	1143	1088	1141	1112	1116	**29**
18	RPI	1145	1093	1135	1119	1107	**32**
19	RPI	1146	1086	1140	1113	1109	**34**
20	RPI	1147	1089	1140	1113	1120	**32**
21	RPI	1148	1084	1144	1114	1117	**33**
22	RPI	1141	1096	1132	1107	1109	**30**
23	RPI	1148	1089	1143	1120	1113	**32**
24	RPI	1140	1084	1130	1108	1113	**31**
25	RPU	1151	1101	1135	1117	1120	**33**
26	RPU	1140	1084	1136	1112	1103	**31**
27	RPU	1150	1092	1142	1111	1117	**35**
28	RPU	1145	1083	1138	1115	1109	**34**
29	RPU	1138	1097	1132	1103	1102	**30**
30	RPU	1146	1091	1141	1112	1105	**34**
31	RPU	1138	1080	1126	1098	1104	**36**
32	RPU	1141	1096	1134	1110	1105	**30**
33	RPU	1146	1085	1134	1115	1113	**34**
34	RPU	1143	1092	1133	1113	1101	**33**
35	RPU	1144	1086	1137	1109	1115	**32**
36	RPU	1144	1082	1135	1107	1111	**35**
37	RRE	1129	1089	1125	1107	1103	**23**
38	RRE	1149	1103	1145	1120	1119	**27**
39	RRE	1138	1088	1132	1110	1113	**27**
40	RRE	1143	1095	1132	1112	1122	**28**
41	RRE	1145	1094	1135	1116	1123	**28**
42	RRE	1135	1096	1132	1109	1109	**24**
43	RRE	1148	1107	1145	1120	1118	**26**
44	RRE	1146	1097	1138	1125	1115	**27**
45	RRE	1137	1097	1130	1111	1111	**25**
46	RRE	1147	1114	1130	1121	1122	**25**
47	RRE	1146	1096	1141	1120	1116	**28**
48	RRE	1145	1096	1140	1125	1111	**27**
49	RBR	1145	1093	1143	1126	1119	**25**
50	RBR	1141	1092	1131	1117	1105	**30**
51	RBR	1144	1089	1138	1115	1105	**32**
52	RBR	1139	1086	1131	1115	1118	**27**
53	RBR	1143	1093	1139	1116	1112	**28**
54	RBR	1145	1093	1140	1110	1122	**29**
55	RBR	1148	1092	1135	1113	1125	**32**
56	RBR	1145	1086	1137	1119	1107	**33**
57	RBR	1144	1092	1137	1116	1116	**29**
58	RBR	1145	1093	1137	1120	1111	**30**
59	RBR	1143	1085	1136	1115	1113	**31**

60	RBR	1147	1092	1136	1113	1117	**33**
61	OGR	1136	1136	1130	1108	1103	**17**
62	OGR	1145	1092	1143	1119	1111	**29**
63	OGR	1143	1093	1142	1112	1113	**28**
64	OGR	1141	1093	1139	1113	1107	**28**
65	OGR	1135	1092	1128	1113	1098	**27**
66	OGR	1142	1092	1138	1111	1110	**29**
67	OGR	1150	1099	1138	1127	1136	**25**
68	OGR	1133	1093	1122	1101	1110	**27**
69	OGR	1141	1090	1129	1111	1108	**32**
70	OGR	1139	1095	1136	1106	1115	**26**
71	OGR	1134	1088	1130	1101	1107	**28**
72	OGR	1135	1086	1128	1107	1106	**28**
73	OOR	1155	1097	1152	1124	1121	**32**
74	OOR	1135	1081	1124	1104	1106	**31**
75	OOR	1152	1100	1146	1124	1118	**30**
76	OOR	1140	1089	1137	1112	1112	**28**
77	OOR	1136	1097	1130	1112	1107	**25**
78	OOR	1135	1108	1132	1110	1099	**23**
79	OOR	1138	1095	1132	1114	1105	**27**
80	OOR	1141	1091	1132	1111	1113	**29**
81	OOR	1142	1101	1140	1120	1112	**24**
82	OOR	1140	1095	1132	1103	1116	**29**
83	OOR	1139	1094	1135	1109	1102	**29**
84	OOR	1137	1086	1128	1108	1098	**32**
85	OYE	1136	1080	1127	1105	1103	**32**
86	OYE	1145	1085	1139	1115	1111	**33**
87	OYE	1143	1086	1134	1109	1117	**32**
88	OYE	1141	1085	1134	1115	1106	**31**
89	OYE	1144	1108	1134	1119	1115	**25**
90	OYE	1139	1090	1127	1108	1107	**31**
91	OYE	1140	1088	1134	1114	1108	**29**
92	OYE	1144	1089	1135	1115	1107	**33**
93	OYE	1144	1090	1136	1115	1115	**30**
94	OYE	1140	1093	1134	1110	1115	**27**
95	OYE	1143	1093	1132	1109	1115	**31**
96	OYE	1141	1095	1131	1116	1108	**29**
97	OBE	1155	1103	1148	1123	1117	**32**
98	OBE	1135	1084	1132	1107	1111	**27**
99	OBE	1152	1100	1145	1122	1116	**31**
100	OBE	1145	1121	1143	1128	1125	**16**
101	OBE	1141	1095	1135	1113	1110	**28**
102	OBE	1139	1099	1137	1105	1109	**27**
103	OBE	1139	1098	1128	1116	1108	**27**
104	OBE	1140	1104	1138	1117	1107	**24**

105	OBE	1143	1099	1140	1124	1118	**23**
106	OBE	1141	1095	1138	1122	1123	**22**
107	OBE	1138	1097	1131	1107	1105	**28**
108	OBE	1139	1097	1134	1113	1101	**28**
109	OPU	1148	1088	1144	1124	1116	**30**
110	OPU	1145	1098	1131	1111	1125	**29**
111	OPU	1148	1092	1138	1109	1122	**33**
112	OPU	1141	1116	1137	1124	1127	**15**
113	OPU	1139	1015	1132	1103	1111	**49**
114	OPU	1140	1092	1138	1116	1106	**27**
115	OPU	1141	1087	1133	1108	1113	**31**
116	OPU	1141	1088	1134	1105	1116	**30**
117	OPU	1141	1092	1138	1112	1104	**30**
118	OPU	1139	1093	1134	1106	1114	**27**
119	OPU	1139	1085	1130	1113	1105	**31**
120	OPU	1139	1097	1128	1111	1106	**29**
121	UBE	1137	1082	1130	1111	1105	**30**
122	UBE	1157	1100	1149	1126	1128	**31**
123	UBE	1141	1085	1136	1109	1125	**27**
124	UBE	1147	1103	1131	1115	1118	**30**
125	UBE	1140	1091	1132	1116	1109	**28**
126	UBE	1142	1095	1134	1116	1109	**29**
127	UBE	1143	1097	1138	1111	1118	**27**
128	UBE	1139	1096	1135	1106	1119	**25**
129	UBE	1139	1091	1134	1115	1108	**27**
130	UBE	1142	1098	1135	1116	1113	**27**
131	UBE	1144	1095	1138	1117	1116	**28**
132	UBE	1142	1096	1131	1112	1115	**29**
133	UOR	1140	1091	1134	1114	1113	**27**
134	UOR	1143	1093	1132	1112	1118	**29**
135	UOR	1142	1092	1135	1115	1111	**29**
136	UOR	1143	1093	1133	1109	1117	**30**
137	UOR	1138	1086	1131	1109	1109	**29**
138	UOR	1140	1087	1132	1114	1111	**29**
139	UOR	1143	1103	1131	1113	1117	**27**
140	UOR	1142	1092	1138	1112	1111	**29**
141	UOR	1141	1091	1137	1108	1115	**28**
142	UOR	1142	1093	1135	1116	1111	**28**
143	UOR	1140	1093	1126	1115	1108	**30**
144	UOR	1138	1084	1132	1116	1104	**29**
145	UGR	1146	1086	1141	1117	1109	**33**
146	UGR	1146	1098	1142	1114	1117	**28**
147	UGR	1145	1095	1134	1115	1119	**29**
148	UGR	1136	1083	1127	1110	1105	**30**
149	UGR	1139	1094	1132	1111	1113	**27**

150	UGR	1138	1095	1130	1108	1113	**27**
151	UGR	1143	1093	1134	1118	1110	**29**
152	UGR	1142	1097	1140	1112	1116	**26**
153	UGR	1143	1092	1134	1111	1116	**30**
154	UGR	1138	1096	1122	1104	1115	**29**
155	UGR	1141	1090	1132	1111	1111	**30**
156	UGR	1140	1100	1136	1108	1116	**25**
157	UPI	1144		1128	1105	1116	**28**
158	UPI	1143		1134	1119	1119	**19**
159	UPI	1144		1142	1105	1122	**21**
160	UPI	1144		1134	1113	1116	**23**
161	UPI	1140		1129	1127	1111	**18**
162	UPI	1136		1132	1130	1130	**5**
163	UPI	1140		1130	1108	1117	**22**
164	UPI	1143		1135	1109	1119	**22**
165	UPI	1140		1131	1114	1112	**21**
166	UPI	1142		1127	1110	1124	**22**
167	UPI	1139		1137	1110	1111	**20**
168	UPI	1140		1127	1104	1116	**24**
169	UBL	1140	1109	1133	1113	1111	**24**
170	UBL	1144	1082	1140	1115	1116	**31**
171	UBL	1139	1085	1135	1113	1104	**30**
172	UBL	1136	1090	1129	1099	1116	**28**
173	UBL	1141	1096	1132	1115	1112	**27**
174	UBL	1138	1089	1128	1112	1109	**29**
175	UBL	1143	1088	1135	1109	1115	**31**
176	UBL	1140	1088	1130	1109	1115	**30**
177	UBL	1141	1080	1138	1119	1110	**29**
178	UBL	1140	1089	1136	1104	1112	**30**
179	UBL	1143	1088	1140	1116	1111	**29**
180	UBL	1142	1089	1136	1112	1113	**30**
181	URE	1136	1085	1130	1113	1107	**27**
182	URE	1143	1083	1137	1109	1115	**32**
183	URE	1143	1098	1134	1110	1111	**30**
184	URE	1144	1090	1136	1114	1112	**31**
185	URE	1144	1089	1138	1120	1116	**28**
186	URE	1140	1093	1129	1113	1103	**31**
187	URE	1139	1086	1132	1110	1122	**27**
188	URE	1141	1092	1138	1126	1108	**25**
189	URE	1138	1091	1131	1112	1108	**28**
190	URE	1142	1105	1125	1107	1112	**30**
191	UPU	1139	1085	1136	1115	1106	**29**
192	UPU	1141	1090	1133	1115	1113	**28**
193	UPU	1145	1093	1139	1123	1112	**28**
194	UPU	1144	1089	1134	1115	1115	**31**

195	UPU	1138	1096	1122	1108	1111	**29**
196	UPU	1141	1136	1136	1138	1135	**5**
197	UPU	1137	1086	1132	1115	1109	**27**
198	UPU	1137	1086	1134	1108	1108	**28**
199	UPU	1141	1098	1132	1110	1113	**28**
200	UPU	1141	1085	1134	1117	1112	**29**
201	UPU	1140	1092	1136	1103	1114	**29**
202	UPU	1143	1093	1137	1112	1114	**29**
203	UPU	1142	1092	1135	1113	1111	**29**
204	UPU	1142	1088	1132	1117	1113	**30**
205	UYE	1142	1109	1133	1116	1115	**24**
206	UYE	1138	1097	1134	1108	1111	**26**
207	UYE	1137	1096	1128	1112	1107	**26**
208	UYE	1137	1086	1134	1104	1110	**29**
209	UYE	1141	1092	1134	1117	1109	**28**
210	UYE	1140	1083	1126	1110	1112	**32**
211	UYE	1140	1076	1136	1111	1108	**32**
212	UYE	1140	1090	1134	1109	1108	**30**
213	UYE	1142	1097	1140	1115	1116	**25**
214	UYE	1140	1081	1132	1107	1114	**32**
215	UYE	1144	1094	1135	1111	1116	**30**
216	UYE	1141	1088	1135	1109	1114	**30**
217	UGR	1141	1091	1131	1109	1116	**29**
218	UBE	1140	1095	1139	1108	1122	**24**
219	UBL	1142	1098	1136	1113	1113	**27**
220	UPI	1141	1100	1136	1119	1115	**24**
221	UOR	1140	1091	1135	1112	1106	**29**
222	UPU	1141	1089	1136	1115	1114	**28**
223	UOR	1143	1095	1138	1114	1115	**28**
224	RBR	1143	1091	1134	1111	1115	**30**
225	UYE	1138	1080	1128	1107	1112	**31**
226	URE	1144	1100	1135	1114	1115	**28**
227	URE	1142	1100	1137	1109	1116	**27**
228	UBL	1140	1097	1136	1111	1107	**27**
229	UPU	1140	1096	1136	1110	1112	**27**
230	UGR	1143	1093	1131	1118	1110	**30**
231	UYE	1139	1079	1136	1112	1107	**31**
232	UGR	1137	1100	1100	1100	1100	**37**
233	UBE	1144	1099	1140	1113	1120	**26**
234	URE	1144	1100	1134	1116	1111	**29**
235	URE	1140	1100	1135	1120	1105	**25**
236	URE	1137	1100	1129	1111	1105	**26**
237	OGR	1141	1088	1140	1104	1106	**32**
238	UPI	1141	1100	1132	1103	1116	**28**
239	OYE	1143	1091	1133	1110	1102	**34**

Sample	Plant code	Start weight (g) 28-2-2019	27-5-2019 (g)	29-5-2019 (g)	31-5-2019 (g)	**Week Average (g)**
1	RBL	1148	1073	1106	1075	**63**
2	RBL	1141	1075	1103	1085	**53**
3	RBL	1141	1070	1104	1090	**53**
4	RBL	1141	1073	1108	1104	**46**
5	RBL	1145	1079	1109	1105	**47**
6	RBL	1140	1070	1103	1084	**54**
7	RBL	1143	1080	1111	1104	**45**
8	RBL	1144	1076	1113	1098	**48**
9	RBL	1144	1082	1116	1080	**51**
10	RBL	1140	1073	1108	1100	**46**
11	RBL	1140	1082	1100	1092	**49**
12	RBL	1139	1081	1104	1087	**48**
13	RPI	1142	1077	1100	1081	**56**
14	RPI	1144	1073	1098	1078	**61**
15	RPI	1140	1077	1103	1084	**52**
16	RPI	1139	1070	1103	1081	**54**
17	RPI	1143	1076	1104	1081	**56**
18	RPI	1145	1074	1105	1098	**53**
19	RPI	1146	1072	1105	1078	**61**
20	RPI	1147	1071	1109	1086	**58**
21	RPI	1148	1066	1113	1095	**57**
22	RPI	1141	1064	1101	1066	**64**
23	RPI	1148	1075	1113	1077	**60**
24	RPI	1140	1072	1111	1101	**45**
25	RPU	1151	1077	1107	1078	**64**
26	RPU	1140	1062	1095	1082	**60**
27	RPU	1150	1067	1107	1086	**63**
28	RPU	1145	1069	1104	1079	**61**
29	RPU	1138	1059	1091	1072	**64**
30	RPU	1146	1066	1101	1073	**66**
31	RPU	1138	1057	1089	1061	**69**
32	RPU	1141	1065	1097	1071	**63**
33	RPU	1146	1071	1111	1084	**57**
34	RPU	1143	1067	1097	1088	**59**
35	RPU	1144	1073	1105	1077	**59**
36	RPU	1144	1066	1097	1070	**66**
37	RRE	1129	1067	1100	1082	**46**
38	RRE	1149	1088	1119	1108	**44**
39	RRE	1138	1068	1104	1089	**51**

40	RRE	1143	1074	1109	1100	**49**
41	RRE	1145	1083	1112	1092	**49**
42	RRE	1135	1074	1105	1105	**40**
43	RRE	1148	1073	1113	1104	**51**
44	RRE	1146	1084	1114	1098	**47**
45	RRE	1137	1066	1104	1084	**52**
46	RRE	1147	1076	1113	1097	**52**
47	RRE	1146	1080	1120	1099	**46**
48	RRE	1145	1081	1119	1097	**46**
49	RBR	1145	1076	1109	1095	**52**
50	RBR	1141	1077	1104	1093	**50**
51	RBR	1144	1071	1108	1077	**59**
52	RBR	1139	1078	1099	1086	**51**
53	RBR	1143	1074	1117	1093	**48**
54	RBR	1145	1076	1112	1090	**52**
55	RBR	1148	1076	1111	1092	**55**
56	RBR	1145	1076	1111	1095	**51**
57	RBR	1144	1076	1120	1084	**51**
58	RBR	1145	1081	1123	1108	**41**
59	RBR	1143	1075	1116	1096	**47**
60	RBR	1147	1073	1109	1094	**55**
61	OGR	1136	1064	1103	1073	**56**
62	OGR	1145	1072	1104	1097	**54**
63	OGR	1143	1073	1107	1089	**53**
64	OGR	1141	1072	1115	1099	**46**
65	OGR	1135	1076	1098	1050	**60**
66	OGR	1142	1078	1108	1100	**47**
67	OGR	1150	1085	1118	1109	**46**
68	OGR	1133	1080	1104	1088	**42**
69	OGR	1141	1077	1101	1085	**53**
70	OGR	1139	1074	1098	1087	**53**
71	OGR	1134	1075	1104	1084	**46**
72	OGR	1135	1081	1111	1084	**43**
73	OOR	1155	1076	1115	1095	**60**
74	OOR	1135	1065	1097	1066	**59**
75	OOR	1152	1088	1116	1095	**52**
76	OOR	1140	1076	1112	1090	**47**
77	OOR	1136	1084	1104	1082	**46**
78	OOR	1135	1069	1100	1076	**53**
79	OOR	1138	1081	1105	1092	**45**
80	OOR	1141	1076	1104	1081	**54**
81	OOR	1142	1087	1117	1105	**39**
82	OOR	1140	1082	1112	1100	**42**
83	OOR	1139	1068	1101	1069	**60**
84	OOR	1137	1064	1094	1078	**58**

85	OYE	1136	1068	1102	1077	**54**
86	OYE	1145	1070	1106	1096	**54**
87	OYE	1143	1073	1111	1089	**52**
88	OYE	1141	1068	1105	1086	**55**
89	OYE	1144	1081	1105	1085	**54**
90	OYE	1139	1081	1104	1080	**51**
91	OYE	1140	1071	1101	1083	**55**
92	OYE	1144	1072	1105	1095	**53**
93	OYE	1144	1067	1111	1091	**54**
94	OYE	1140	1080	1109	1095	**45**
95	OYE	1143	1077	1108	1084	**53**
96	OYE	1141	1081	1107	1085	**50**
97	OBE	1155	1079	1116	1092	**59**
98	OBE	1135	1070	1109	1086	**47**
99	OBE	1152	1076	1113	1102	**55**
100	OBE	1145	1112	1130	1120	**24**
101	OBE	1141	1072	1107	1084	**53**
102	OBE	1139	1074	1107	1088	**49**
103	OBE	1139	1078	1108	1099	**44**
104	OBE	1140	1078	1107	1094	**47**
105	OBE	1143	1084	1107	1095	**48**
106	OBE	1141	1083	1107	1093	**47**
107	OBE	1138	1082	1100	1091	**47**
108	OBE	1139	1078	1104	1100	**45**
109	OPU	1148	1076	1112	1085	**57**
110	OPU	1145	1074	1115	1092	**51**
111	OPU	1148	1081	1122	1092	**50**
112	OPU	1141	1115	1130	1117	**20**
113	OPU	1139	1077	1100	1088	**51**
114	OPU	1140	1079	1109	1095	**46**
115	OPU	1141	1077	1105	1089	**51**
116	OPU	1141	1074	1105	1084	**53**
117	OPU	1141	1075	1106	1082	**53**
118	OPU	1139	1073	1104	1089	**50**
119	OPU	1139	1067	1108	1086	**52**
120	OPU	1139	1070	1105	1080	**54**
121	UBE	1137	1074	1104	1101	**44**
122	UBE	1157	1095	1129	1113	**45**
123	UBE	1141	1081	1112	1103	**42**
124	UBE	1147	1086	1123	1112	**40**
125	UBE	1140	1081	1112	1103	**41**
126	UBE	1142	1081	1118	1109	**39**
127	UBE	1143	1083	1116	1097	**44**
128	UBE	1139	1085	1111	1101	**40**
129	UBE	1139	1082	1114	1105	**39**

130	UBE	1142	1084	1108	1097	**46**
131	UBE	1144	1085	1122	1105	**40**
132	UBE	1142	1088	1116	1105	**39**
133	UOR	1140	1079	1110	1097	**45**
134	UOR	1143	1090	1116	1104	**40**
135	UOR	1142	1076	1112	1100	**46**
136	UOR	1143	1080	1119	1106	**41**
137	UOR	1138	1081	1112	1092	**43**
138	UOR	1140	1086	1113	1096	**42**
139	UOR	1143	1095	1118	1103	**38**
140	UOR	1142	1087	1116	1103	**40**
141	UOR	1141	1081	1117	1093	**44**
142	UOR	1142	1080	1112	1104	**43**
143	UOR	1140	1088	1112	1101	**40**
144	UOR	1138	1086	1109	1100	**40**
145	UGR	1146	1085	1109	1113	**44**
146	UGR	1146	1086	1122	1095	**45**
147	UGR	1145	1082	1111	1095	**49**
148	UGR	1136	1078	1104	1085	**47**
149	UGR	1139	1082	1116	1100	**40**
150	UGR	1138	1078	1112	1101	**41**
151	UGR	1143	1082	1115	1100	**44**
152	UGR	1142	1086	1117	1097	**42**
153	UGR	1143	1093	1111	1105	**40**
154	UGR	1138	1086	1110	1097	**40**
155	UGR	1141	1085	1114	1093	**44**
156	UGR	1140	1088	1119	1105	**36**
157	UPI	1144	1071	1115	1100	**49**
158	UPI	1143	1110	1140	1100	**26**
159	UPI	1144	1090	1117	1100	**42**
160	UPI	1144	1074	1115	1111	**44**
161	UPI	1140	1080	1113	1115	**37**
162	UPI	1136	1124	1120	1126	**13**
163	UPI	1140	1089	1108	1100	**41**
164	UPI	1143	1086	1120	1111	**37**
165	UPI	1140	1082	1112	1104	**41**
166	UPI	1142	1091	1113	1105	**39**
167	UPI	1139	1083	1110	1093	**44**
168	UPI	1140	1089	1114	1100	**39**
169	UBL	1140	1076	1115	1105	**41**
170	UBL	1144	1074	1113	1095	**50**
171	UBL	1139	1075	1112	1089	**47**
172	UBL	1136	1078	1108	1096	**42**
173	UBL	1141	1081	1114	1104	**41**
174	UBL	1138	1084	1107	1107	**39**

175	UBL	1143	1082	1118	1096	**44**
176	UBL	1140	1088	1114	1105	**38**
177	UBL	1141	1077	1115	1099	**44**
178	UBL	1140	1080	1115	1108	**39**
179	UBL	1143	1080	1113	1104	**44**
180	UBL	1142	1076	1110	1112	**43**
181	URE	1136	1093	1111	1103	**34**
182	URE	1143	1102	1115	1096	**39**
183	URE	1143	1081	1113	1099	**45**
184	URE	1144	1124	1109	1101	**33**
185	URE	1144	1085	1115	1096	**45**
186	URE	1140	1114	1113	1104	**30**
187	URE	1139	1107	1118	1100	**31**
188	URE	1141	1095	1112	1106	**37**
189	URE	1138	1087	1115	1098	**38**
190	URE	1142	1111	1114	1099	**34**
191	UPU	1139	1103	1110	1100	**35**
192	UPU	1141	1109	1111	1101	**34**
193	UPU	1145	1080	1116	1100	**46**
194	UPU	1144	1111	1112	1108	**34**
195	UPU	1138	1080	1113	1102	**40**
196	UPU	1141	1100	1120	1100	**34**
197	UPU	1137	1117	1120	1095	**26**
198	UPU	1137	1083	1113	1089	**42**
199	UPU	1141	1080	1116	1103	**41**
200	UPU	1141	1081	1112	1093	**46**
201	UPU	1140	1078	1115	1094	**44**
202	UPU	1143	1085	1117	1105	**41**
203	UPU	1142	1081	1112	1103	**43**
204	UPU	1142	1083	1113	1109	**40**
205	UYE	1142	1085	1108	1099	**45**
206	UYE	1138	1077	1113	1103	**40**
207	UYE	1137	1073	1109	1099	**43**
208	UYE	1137	1081	1112	1097	**40**
209	UYE	1141	1089	1117	1101	**39**
210	UYE	1140	1072	1112	1089	**49**
211	UYE	1140	1079	1111	1096	**45**
212	UYE	1140	1080	1116	1102	**41**
213	UYE	1142	1082	1113	1100	**44**
214	UYE	1140	1083	1115	1099	**41**
215	UYE	1144	1088	1122	1105	**39**
216	UYE	1141	1086	1112	1100	**42**
217	UGR	1141	1075	1119	1101	**43**
218	UBE	1140	1097	1128	1107	**29**
219	UBL	1142	1084	1114	1096	**44**

220	UPI	1141	1082	1115	1108	**39**
221	UOR	1140	1076	1107	1089	**49**
222	UPU	1141	1077	1115	1098	**44**
223	UOR	1143	1087	1112	1100	**43**
224	RBR	1143	1074	1110	1088	**52**
225	UYE	1138	1077	1107	1099	**44**
226	URE	1144	1086	1116	1105	**42**
227	URE	1142	1086	1116	1105	**40**
228	UBL	1140	1072	1109	1108	**44**
229	UPU	1140	1084	1113	1097	**42**
230	UGR	1143	1080	1113	1095	**47**
231	UYE	1139	1077	1115	1107	**39**
232	UGR	1137	1000	1087	1082	**81**
233	UBE	1144	1086	1115	1103	**43**
234	URE	1144	1084	1116	1095	**46**
235	URE	1140	1080	1113	1105	**41**
236	URE	1137	1114	1109	1099	**30**
237	OGR	1141	1066	1093	1088	**59**
238	UPI	1141	1084	1116	1101	**41**
239	OYE	1143	1073	1098	1069	**63**

Sample	Plant code	Start weight (g) 28-2-2019	3-6-2019 (g)	5-6-2019 (g)	7-6-2019 (g)	**Week Average (g)**
1	RBL	1148	1049	1112	1128	**52**
2	RBL	1141	1048	1089	1097	**63**
3	RBL	1141	1044	1091	1104	**61**
4	RBL	1141	1048	1086	1089	**67**
5	RBL	1145	1063	1080	1089	**68**
6	RBL	1140	1043	1091	1087	**66**
7	RBL	1143	1049	1086	1086	**69**
8	RBL	1144	1048	1074	1078	**77**
9	RBL	1144	1050	1093	1102	**62**
10	RBL	1140	1046	1076	1085	**71**
11	RBL	1140	1095	1097	1111	**39**
12	RBL	1139	1045	1090	1088	**65**
13	RPI	1142	1050	1067	1089	**73**
14	RPI	1144	1041	1097	1117	**59**

15	RPI	1140	1042	1080	1078	**73**
16	RPI	1139	1043	1081	1082	**70**
17	RPI	1143	1034	1077	1076	**81**
18	RPI	1145	1051	1082	1086	**72**
19	RPI	1146	1048	1093	1099	**66**
20	RPI	1147	1037	1082	1077	**82**
21	RPI	1148	1040	1078	1080	**82**
22	RPI	1141	1046	1092	1100	**62**
23	RPI	1148	1048	1092	1084	**73**
24	RPI	1140	1047	1085	1081	**69**
25	RPU	1151	1029	1108	1097	**73**
26	RPU	1140	1047	1086	1087	**67**
27	RPU	1150	1047	1086	1091	**75**
28	RPU	1145	1046	1095	1108	**62**
29	RPU	1138	1038	1095	1095	**62**
30	RPU	1146	1042	1086	1095	**72**
31	RPU	1138	1038	1093	1109	**58**
32	RPU	1141	1045	1091	1105	**61**
33	RPU	1146	1041	1103	1099	**65**
34	RPU	1143	1044	1080	1082	**74**
35	RPU	1144	1043	1094	1095	**67**
36	RPU	1144	1043	1091	1092	**69**
37	RRE	1129	1048	1084	1091	**55**
38	RRE	1149	1041	1092	1096	**73**
39	RRE	1138	1045	1092	1087	**63**
40	RRE	1143	1049	1080	1086	**71**
41	RRE	1145	1066	1107	1100	**54**
42	RRE	1135	1043	1095	1104	**54**
43	RRE	1148	1062	1081	1090	**70**
44	RRE	1146	1068	1103	1118	**50**
45	RRE	1137	1052	1087	1089	**61**
46	RRE	1147	1054	1089	1091	**69**
47	RRE	1146	1050	1092	1088	**69**
48	RRE	1145	1068	1101	1099	**56**
49	RBR	1145	1059	1085	1088	**68**
50	RBR	1141	1051	1089	1091	**64**
51	RBR	1144	1042	1089	1093	**69**
52	RBR	1139	1044	1096	1091	**62**
53	RBR	1143	1065	1085	1088	**64**
54	RBR	1145	1055	1080	1095	**68**
55	RBR	1148	1058			
56	RBR	1145	1050	1088	1085	**71**
57	RBR	1144	1047	1087	1085	**71**
58	RBR	1145	1082	1103	1112	**46**
59	RBR	1143	1052	1082	1089	**69**

60	RBR	1147	1051	1084	1096	**70**
61	OGR	1136	1042	1080	1094	**64**
62	OGR	1145	1052	1097	1095	**64**
63	OGR	1143	1047	1093	1093	**65**
64	OGR	1141	1051	1084	1083	**68**
65	OGR	1135	1000	1051	1075	**93**
66	OGR	1142	1048	1093	1093	**64**
67	OGR	1150	1064	1116	1109	**54**
68	OGR	1133	1053	1084	1088	**58**
69	OGR	1141	1051	1095	1111	**55**
70	OGR	1139	1054	1086	1097	**60**
71	OGR	1134	1050	1089	1092	**57**
72	OGR	1135	1055	1088	1094	**56**
73	OOR	1155	1058	1109	1108	**63**
74	OOR	1135	1037	1088	1089	**64**
75	OOR	1152	1050	1093	1092	**74**
76	OOR	1140	1052	1084	1090	**65**
77	OOR	1136	1064	1086	1088	**57**
78	OOR	1135	1047	1089	1100	**56**
79	OOR	1138	1061	1099	1113	**47**
80	OOR	1141	1053	1092	1087	**64**
81	OOR	1142	1072	1102	1103	**50**
82	OOR	1140	1057	1095	1101	**56**
83	OOR	1139	1045	1087	1093	**64**
84	OOR	1137	1044	1095	1085	**62**
85	OYE	1136	1041	1082	1090	**65**
86	OYE	1145	1042	1096	1095	**67**
87	OYE	1143	1047	1092	1103	**62**
88	OYE	1141	1023	1074	1070	**85**
89	OYE	1144	1061	1107	1103	**54**
90	OYE	1139	1059			
91	OYE	1140	1052	1089	1088	**64**
92	OYE	1144	1046	1089	1095	**67**
93	OYE	1144	1047	1084	1084	**72**
94	OYE	1140	1052	1085	1089	**65**
95	OYE	1143	1050	1110	1099	**57**
96	OYE	1141	1060	1089	1096	**59**
97	OBE	1155	1052	1104	1115	**65**
98	OBE	1135	1045	1085	1086	**63**
99	OBE	1152	1051	1085	1099	**74**
100	OBE	1145	1104	1121	1117	**31**
101	OBE	1141	1055	1091	1093	**61**
102	OBE	1139	1051	1085	1096	**62**
103	OBE	1139	1061	1095	1101	**53**
104	OBE	1140	1054	1091	1086	**63**

105	OBE	1143	1064	1091	1110	**55**
106	OBE	1141	1070	1104	1112	**46**
107	OBE	1138	1053	1086	1090	**62**
108	OBE	1139	1057	1088	1092	**60**
109	OPU	1148	1056	1085	1094	**70**
110	OPU	1145	1051	1091	1095	**66**
111	OPU	1148	1049	1091	1091	**71**
112	OPU	1141	1105	1117	1130	**24**
113	OPU	1139	1050	1081	1082	**68**
114	OPU	1140	1057	1091	1092	**60**
115	OPU	1141	1055	1095	1090	**61**
116	OPU	1141	1053	1091	1095	**61**
117	OPU	1141	1054	1092	1100	**59**
118	OPU	1139	1055	1095	1099	**56**
119	OPU	1139	1049	1083	1088	**66**
120	OPU	1139	1050	1088	1095	**61**
121	UBE	1137	1066	1100	1107	**46**
122	UBE	1157	1073	1111	1113	**58**
123	UBE	1141	1062	1100	1105	**52**
124	UBE	1147	1070	1109	1116	**49**
125	UBE	1140	1073	1095	1115	**46**
126	UBE	1142	1075	1109	1109	**44**
127	UBE	1143	1069	1100	1112	**49**
128	UBE	1139	1068	1097	1109	**48**
129	UBE	1139	1074	1105	1112	**42**
130	UBE	1142	1076	1100	1106	**48**
131	UBE	1144	1072	1106	1107	**49**
132	UBE	1142	1081	1098	1108	**46**
133	UOR	1140	1066	1098	1107	**50**
134	UOR	1143	1061	1100	1105	**54**
135	UOR	1142	1068	1091	1103	**55**
136	UOR	1143	1070	1106	1110	**48**
137	UOR	1138	1070	1097	1105	**47**
138	UOR	1140	1075	1100	1107	**46**
139	UOR	1143	1079	1108	1104	**46**
140	UOR	1142	1075	1106	1107	**46**
141	UOR	1141	1070	1108	1104	**47**
142	UOR	1142	1069	1101	1103	**51**
143	UOR	1140	1079	1100	1102	**46**
144	UOR	1138	1071	1109	1107	**42**
145	UGR	1146	1077	1111	1120	**43**
146	UGR	1146	1070	1104	1111	**51**
147	UGR	1145	1068	1099	1111	**52**
148	UGR	1136	1066	1095	1097	**50**
149	UGR	1139	1077	1091	1103	**49**

150	UGR	1138	1064	1098	1109	**48**
151	UGR	1143	1074	1100	1107	**49**
152	UGR	1142	1077	1100	1103	**49**
153	UGR	1143	1066	1096	1105	**54**
154	UGR	1138	1068	1100	1101	**48**
155	UGR	1141	1055	1100	1113	**52**
156	UGR	1140	1078	1105	1107	**43**
157	UPI	1144	1058	1100	1107	**56**
158	UPI	1143	1096	1109	1115	**36**
159	UPI	1144	1074	1101	1106	**50**
160	UPI	1144	1064	1102	1101	**55**
161	UPI	1140	1071	1100	1108	**47**
162	UPI	1136	1114	1129	1124	**14**
163	UPI	1140	1070	1100	1104	**49**
164	UPI	1143	1080	1099	1103	**49**
165	UPI	1140	1073	1098	1108	**47**
166	UPI	1142	1070	1105	1113	**46**
167	UPI	1139	1069	1099	1101	**49**
168	UPI	1140	1074	1102	1106	**46**
169	UBL	1140	1067	1107	1112	**45**
170	UBL	1144	1095	1104	1106	**42**
171	UBL	1139	1066	1100	1098	**51**
172	UBL	1136	1062	1091	1095	**53**
173	UBL	1141	1069	1097	1106	**50**
174	UBL	1138	1070	1100	1098	**49**
175	UBL	1143	1069	1097	1107	**52**
176	UBL	1140	1072	1107	1100	**47**
177	UBL	1141	1066	1105	1108	**48**
178	UBL	1140	1078	1111	1108	**41**
179	UBL	1143	1075	1100	1113	**47**
180	UBL	1142	1073	1105	1110	**46**
181	URE	1136	1067	1099	1104	**46**
182	URE	1143	1059	1100	1105	**55**
183	URE	1143	1069	1095	1111	**51**
184	URE	1144	1065	1108	1107	**51**
185	URE	1144	1074	1101	1109	**49**
186	URE	1140	1070	1107	1109	**45**
187	URE	1139	1067	1101	1109	**47**
188	URE	1141	1069	1098	1107	**50**
189	URE	1138	1069	1099	1106	**47**
190	URE	1142	1066	1095	1111	**51**
191	UPU	1139	1066	1100	1103	**49**
192	UPU	1141	1072	1096	1104	**50**
193	UPU	1145	1068	1104	1111	**51**
194	UPU	1144	1068	1104	1115	**48**

195	UPU	1138	1070	1101	1104	**46**
196	UPU	1141	1065	1089	1108	**54**
197	UPU	1137	1068	1104	1108	**44**
198	UPU	1137	1068	1100	1098	**48**
199	UPU	1141	1076	1101	1115	**44**
200	UPU	1141	1072	1101	1107	**48**
201	UPU	1140	1065	1097	1101	**52**
202	UPU	1143	1078	1104	1108	**46**
203	UPU	1142	1074	1095	1103	**51**
204	UPU	1142	1073	1100	1107	**49**
205	UYE	1142	1061	1098	1103	**55**
206	UYE	1138	1074	1109	1113	**39**
207	UYE	1137	1072	1106	1112	**40**
208	UYE	1137	1068	1096	1110	**46**
209	UYE	1141	1081	1109	1103	**43**
210	UYE	1140	1066	1103	1105	**49**
211	UYE	1140	1064	1089	1101	**55**
212	UYE	1140	1070	1093	1108	**50**
213	UYE	1142	1065	1103	1098	**53**
214	UYE	1140	1068	1097	1101	**51**
215	UYE	1144	1062	1094	1105	**57**
216	UYE	1141	1072	1102	1105	**48**
217	UGR	1141	1058	1096	1100	**56**
218	UBE	1140	1076	1109	1117	**39**
219	UBL	1142	1066	1098	1105	**52**
220	UPI	1141	1068	1101	1103	**50**
221	UOR	1140	1061	1091	1103	**55**
222	UPU	1141	1068	1104	1108	**48**
223	UOR	1143	1062	1104	1116	**49**
224	RBR	1143	1048	1091	1091	**66**
225	UYE	1138	1072	1096	1109	**46**
226	URE	1144	1067	1097	1103	**55**
227	URE	1142	1071	1096	1103	**52**
228	UBL	1140	1024	1094	1105	**66**
229	UPU	1140	1069	1096	1107	**49**
230	UGR	1143	1070	1107	1105	**49**
231	UYE	1139	1064	1101	1110	**47**
232	UGR	1137	1038	1087	1105	**60**
233	UBE	1144	1069	1100	1110	**51**
234	URE	1144	1069	1103	1107	**51**
235	URE	1140	1066	1095	1103	**52**
236	URE	1137	1068	1092	1098	**51**
237	OGR	1141	1044	1085	1091	**68**
238	UPI	1141	1063	1101	1103	**52**
239	OYE	1143	1049	1095	1095	**63**

Sample	Plant code	Start weight (g) 28-2-2019	10-6-2019 (g)	12-6-2019 (g)	14-6-2019 (g)	**Week Average (g)**
1	RBL	1148	1101	1109	1111	**41**
2	RBL	1141	1062	1078	1092	**64**
3	RBL	1141	1060	1071	1076	**72**
4	RBL	1141	1053	1076	1076	**73**
5	RBL	1145	1051	1070	1077	**79**
6	RBL	1140	1046	1074	1069	**77**
7	RBL	1143	1050	1064	1080	**78**
8	RBL	1144	1049	1071	1089	**74**
9	RBL	1144	1055	1075	1080	**74**
10	RBL	1140	1043	1068	1074	**78**
11	RBL	1140	1095	1095	1104	**42**
12	RBL	1139	1057	1069	1082	**70**
13	RPI	1142	1054	1074	1080	**73**
14	RPI	1144	1095	1084	1103	**50**
15	RPI	1140	1054	1066	1080	**73**
16	RPI	1139	1050	1074	1075	**73**
17	RPI	1143	1041	1058	1079	**84**
18	RPI	1145	1058	1073	1080	**75**
19	RPI	1146	1068	1074	1086	**70**
20	RPI	1147	1047	1065	1071	**86**
21	RPI	1148	1021	1074	1084	**88**
22	RPI	1141	1055	1081	1078	**70**
23	RPI	1148	1050	1076	1084	**78**
24	RPI	1140	1053	1074	1073	**73**
25	RPU	1151	1058	1088	1078	**76**
26	RPU	1140	1050	1077	1074	**73**
27	RPU	1150	1055	1069	1080	**82**
28	RPU	1145	1089	1098	1107	**47**
29	RPU	1138	1065	1080	1081	**63**
30	RPU	1146	1053	1081	1084	**73**
31	RPU	1138	1085	1082	1085	**54**
32	RPU	1141	1077	1087	1096	**54**
33	RPU	1146	1062	1077	1093	**69**
34	RPU	1143	1049	1074	1074	**77**
35	RPU	1144	1039	1082	1077	**78**
36	RPU	1144	1050	1074	1085	**74**
37	RRE	1129	1057	1080	1074	**59**
38	RRE	1149	1057	1084	1086	**73**
39	RRE	1138	1051	1065	1082	**72**

40	RRE	1143	1056	1073	1091	**70**
41	RRE	1145	1062	1089	1089	**65**
42	RRE	1135	1054	1069	1076	**69**
43	RRE	1148	1058	1081	1086	**73**
44	RRE	1146	1086	1086	1113	**51**
45	RRE	1137	1047	1072	1073	**73**
46	RRE	1147	1058	1079	1081	**74**
47	RRE	1146	1055	1074	1082	**76**
48	RRE	1145	1066	1082	1092	**65**
49	RBR	1145	1057	1076	1086	**72**
50	RBR	1141	1058	1080	1085	**67**
51	RBR	1144	1053	1071	1087	**74**
52	RBR	1139	1042	1068	1080	**76**
53	RBR	1143	1057	1070	1096	**69**
54	RBR	1145	1062	1085	1085	**68**
55	RBR	1148				
56	RBR	1145	1057	1084	1084	**70**
57	RBR	1144	1051	1074	1091	**72**
58	RBR	1145	1080	1097	1104	**51**
59	RBR	1143	1057	1080	1082	**70**
60	RBR	1147	1055	1085	1084	**72**
61	OGR	1136	1049	1065		**79**
62	OGR	1145	1052	1088		**75**
63	OGR	1143	1054	1085		**74**
64	OGR	1141	1059	1068		**78**
65	OGR	1135	1059	1044		**84**
66	OGR	1142	1061	1074		**75**
67	OGR	1150	1065	1073		**81**
68	OGR	1133	1058	1068		**70**
69	OGR	1141	1056	1077		**75**
70	OGR	1139	1055	1072		**76**
71	OGR	1134	1051	1079		**69**
72	OGR	1135	1053	1076		**71**
73	OOR	1155	1062	1092		**78**
74	OOR	1135	1043	1073		**77**
75	OOR	1152	1058	1074		**86**
76	OOR	1140	1054	1070		**78**
77	OOR	1136	1065	1084		**62**
78	OOR	1135	1057	1084		**65**
79	OOR	1138	1099	1093		**42**
80	OOR	1141	1057	1081		**72**
81	OOR	1142	1063	1079		**71**
82	OOR	1140	1084	1081		**58**
83	OOR	1139	1059	1080		**70**
84	OOR	1137	1054	1073		**74**

85	OYE	1136	1046	1064		**81**
86	OYE	1145	1063	1078		**75**
87	OYE	1143	1043	1068		**88**
88	OYE	1141	1028	1039		**108**
89	OYE	1144	1065	1086		**69**
90	OYE	1139				
91	OYE	1140	1050	1088		**71**
92	OYE	1144	1048	1070		**85**
93	OYE	1144	1051	1088		**75**
94	OYE	1140	1056	1072		**76**
95	OYE	1143	1065	1074		**74**
96	OYE	1141	1062	1086		**67**
97	OBE	1155	1067	1104		**70**
98	OBE	1135	1055	1071		**72**
99	OBE	1152	1061	1076		**84**
100	OBE	1145	1101	1115		**37**
101	OBE	1141	1057	1074		**76**
102	OBE	1139	1062	1077		**70**
103	OBE	1139	1058	1078		**71**
104	OBE	1140	1060	1091		**65**
105	OBE	1143	1065	1073		**74**
106	OBE	1141	1092	1098		**46**
107	OBE	1138	1034	1075		**84**
108	OBE	1139	1057	1082		**70**
109	OPU	1148	1058	1085		**77**
110	OPU	1145	1055	1088		**74**
111	OPU	1148	1055	1075		**83**
112	OPU	1141	1119	1119		**22**
113	OPU	1139	1054	1071		**77**
114	OPU	1140	1060	1079		**71**
115	OPU	1141	1061	1080		**71**
116	OPU	1141	1065	1062		**78**
117	OPU	1141	1058	1086		**69**
118	OPU	1139	1065	1085		**64**
119	OPU	1139	1064	1071		**72**
120	OPU	1139	1055	1080		**72**
121	UBE	1137	1071	1093	1103	**48**
122	UBE	1157	1081	1105	1116	**56**
123	UBE	1141	1074	1097	1107	**48**
124	UBE	1147	1077	1100	1109	**52**
125	UBE	1140	1082	1101	1107	**43**
126	UBE	1142	1084	1123	1115	**35**
127	UBE	1143	1085	1112	1109	**41**
128	UBE	1139	1078	1100	1104	**45**
129	UBE	1139	1078	1100	1107	**44**

130	UBE	1142	1087	1107	1107	**42**
131	UBE	1144	1093	1108	1116	**38**
132	UBE	1142	1086	1100	1107	**44**
133	UOR	1140	1081	1089	1113	**46**
134	UOR	1143	1078	1111	1119	**40**
135	UOR	1142	1075	1095	1109	**49**
136	UOR	1143	1074	1106	1107	**47**
137	UOR	1138	1084	1116	1130	**28**
138	UOR	1140	1081	1105	1112	**41**
139	UOR	1143	1085	1099	1112	**44**
140	UOR	1142	1086	1106	1103	**44**
141	UOR	1141	1082	1097	1109	**45**
142	UOR	1142	1073	1096	1107	**50**
143	UOR	1140	1082	1097	1108	**44**
144	UOR	1138	1078	1091	1113	**44**
145	UGR	1146	1077	1102	1113	**49**
146	UGR	1146	1084	1109	1110	**45**
147	UGR	1145	1094	1113	1117	**37**
148	UGR	1136	1072	1092	1100	**48**
149	UGR	1139	1084	1112	1109	**37**
150	UGR	1138	1073	1101	1115	**42**
151	UGR	1143	1081	1101	1112	**45**
152	UGR	1142	1084	1100	1110	**44**
153	UGR	1143	1085	1093	1107	**48**
154	UGR	1138	1078	1111	1110	**38**
155	UGR	1141	1082	1091	1109	**47**
156	UGR	1140	1091	1094	1117	**39**
157	UPI	1144	1082	1095	1118	**46**
158	UPI	1143	1099	1119	1120	**30**
159	UPI	1144	1084	1092	1109	**49**
160	UPI	1144	1076	1100	1107	**50**
161	UPI	1140	1081	1101	1114	**41**
162	UPI	1136	1120	1124	1130	**11**
163	UPI	1140	1078	1105	1110	**42**
164	UPI	1143	1094	1088	1112	**45**
165	UPI	1140	1081	1104	1111	**41**
166	UPI	1142	1081	1107	1107	**44**
167	UPI	1139	1079	1087	1113	**46**
168	UPI	1140	1081	1110	1104	**42**
169	UBL	1140	1078	1100	1107	**45**
170	UBL	1144	1080	1116	1114	**41**
171	UBL	1139	1076	1100	1112	**43**
172	UBL	1136	1070	1100	1104	**45**
173	UBL	1141	1078	1091	1113	**47**
174	UBL	1138	1087	1089	1108	**43**

175	UBL	1143	1076	1100	1106	**49**
176	UBL	1140	1077	1089	1112	**47**
177	UBL	1141	1074	1096	1104	**50**
178	UBL	1140	1100	1104	1108	**36**
179	UBL	1143	1079	1101	1106	**48**
180	UBL	1142	1080	1095	1111	**47**
181	URE	1136	1082	1092	1077	**52**
182	URE	1143	1079	1092	1114	**48**
183	URE	1143	1080	1094	1116	**46**
184	URE	1144	1081	1107	1109	**45**
185	URE	1144	1082	1093	1117	**47**
186	URE	1140	1082	1104	1112	**41**
187	URE	1139	1073	1100	1103	**47**
188	URE	1141	1080	1100	1106	**46**
189	URE	1138	1080	1101	1103	**43**
190	URE	1142	1080	1092	1119	**45**
191	UPU	1139	1081	1100	1111	**42**
192	UPU	1141	1087	1089	1117	**43**
193	UPU	1145	1085	1117	1115	**39**
194	UPU	1144	1087	1121	1113	**37**
195	UPU	1138	1079	1116	1120	**33**
196	UPU	1141	1072	1093	1104	**51**
197	UPU	1137	1076	1086	1104	**48**
198	UPU	1137	1085	1093	1109	**41**
199	UPU	1141	1083	1102	1105	**44**
200	UPU	1141	1082	1100	1117	**41**
201	UPU	1140	1078	1091	1113	**46**
202	UPU	1143	1085	1108	1111	**42**
203	UPU	1142	1081	1096	1116	**44**
204	UPU	1142	1079	1100	1107	**47**
205	UYE	1142	1078	1111	1108	**43**
206	UYE	1138	1071	1102	1106	**45**
207	UYE	1137	1074	1101	1100	**45**
208	UYE	1137	1073	1081	1103	**51**
209	UYE	1141	1088	1095	1116	**41**
210	UYE	1140	1084	1095	1109	**44**
211	UYE	1140	1079	1091	1107	**48**
212	UYE	1140	1076	1105	1104	**45**
213	UYE	1142	1075	1090	1120	**47**
214	UYE	1140	1083	1111	1113	**38**
215	UYE	1144	1072	1101	1108	**50**
216	UYE	1141	1086	1100	1116	**40**
217	UGR	1141	1070	1102	1108	**48**
218	UBE	1140	1084	1100	1108	**43**
219	UBL	1142	1077	1100	1113	**45**

220	UPI	1141	1081	1100	1117	**42**
221	UOR	1140	1086	1095	1108	**44**
222	UPU	1141	1080	1100	1116	**42**
223	UOR	1143	1081	1101	1115	**44**
224	RBR	1143	1052	1076	1086	**72**
225	UYE	1138	1077	1091	1099	**49**
226	URE	1144	1081	1100	1107	**48**
227	URE	1142	1082	1088	1109	**49**
228	UBL	1140	1081	1106	1105	**43**
229	UPU	1140	1078	1100	1109	**44**
230	UGR	1143	1076	1104	1109	**47**
231	UYE	1139	1081	1102	1104	**43**
232	UGR	1137	1087	1080	1096	**49**
233	UBE	1144	1081	1100	1116	**45**
234	URE	1144	1077	1100	1119	**45**
235	URE	1140	1077	1089	1109	**48**
236	URE	1137	1081	1088	1112	**43**
237	OGR	1141	1048	1073		**81**
238	UPI	1141	1084	1089	1111	**46**
239	OYE	1143	1058	1082		**73**

Sample	Plant code	Start weight (g) 28-2-2019	17-6-2019 (g)	18-6-2019 (g)	21-6-2019 (g)	**Week Average (g)**
1	RBL	1148	1089	1105	1084	**55**
2	RBL	1141	1053	1090	1070	**70**
3	RBL	1141	1055	1087	1058	**74**
4	RBL	1141	1058	1079	1059	**76**
5	RBL	1145	1051	1092	1058	**78**
6	RBL	1140	1054	1076	1051	**80**
7	RBL	1143	1050	1088	1050	**80**
8	RBL	1144	1054	1086	1058	**78**
9	RBL	1144	1060	1078	1065	**76**
10	RBL	1140	1053	1079	1049	**80**
11	RBL	1140	1084	1105	1073	**53**
12	RBL	1139	1053	1087	1063	**71**
13	RPI	1142	1057	1093	1053	**74**
14	RPI	1144	1063	1099	1060	**70**

15	RPI	1140	1050	1099	1054	**72**
16	RPI	1139	1054	1078	1053	**77**
17	RPI	1143	1040	1088	1047	**85**
18	RPI	1145	1056	1104	1058	**72**
19	RPI	1146	1061	1093	1055	**76**
20	RPI	1147	1048	1091	1048	**85**
21	RPI	1148	1051	1084	1046	**88**
22	RPI	1141	1055	1092	1054	**74**
23	RPI	1148	1054	1094	1058	**79**
24	RPI	1140	1057	1081	1055	**76**
25	RPU	1151	1065	1085	1064	**80**
26	RPU	1140	1054	1088	1061	**72**
27	RPU	1150	1055	1096	1055	**81**
28	RPU	1145	1076	1098	1084	**59**
29	RPU	1138	1055	1072	1054	**78**
30	RPU	1146	1060	1078	1059	**80**
31	RPU	1138	1053	1085	1047	**76**
32	RPU	1141	1069	1095	1065	**65**
33	RPU	1146	1050	1090	1054	**81**
34	RPU	1143	1058	1083	1055	**78**
35	RPU	1144	1059	1084	1055	**78**
36	RPU	1144	1055	1096	1053	**76**
37	RRE	1129	1051	1077	1051	**69**
38	RRE	1149	1070	1086	1060	**77**
39	RRE	1138	1049	1088	1054	**74**
40	RRE	1143	1061	1082	1061	**75**
41	RRE	1145	1066	1086	1064	**73**
42	RRE	1135	1051	1068	1043	**81**
43	RRE	1148	1070	1092	1060	**74**
44	RRE	1146	1086			
45	RRE	1137	1053	1086	1046	**75**
46	RRE	1147	1060	1091	1058	**77**
47	RRE	1146	1057	1085	1060	**79**
48	RRE	1145	1057	1099	1063	**72**
49	RBR	1145	1061	1095	1062	**72**
50	RBR	1141	1061	1092	1061	**70**
51	RBR	1144	1054	1084	1087	**69**
52	RBR	1139	1052	1083	1057	**75**
53	RBR	1143	1052	1094	1059	**75**
54	RBR	1145	1070	1091	1054	**73**
55	RBR	1148				
56	RBR	1145	1061	1092	1062	**73**
57	RBR	1144	1045	1099	1070	**73**
58	RBR	1145	1092			
59	RBR	1143	1066	1086	1061	**72**

60	RBR	1147	1061	1086	1064	**77**
61	OGR	1136				
62	OGR	1145				
63	OGR	1143				
64	OGR	1141				
65	OGR	1135				
66	OGR	1142				
67	OGR	1150				
68	OGR	1133				
69	OGR	1141				
70	OGR	1139				
71	OGR	1134				
72	OGR	1135				
73	OOR	1155				
74	OOR	1135				
75	OOR	1152				
76	OOR	1140				
77	OOR	1136				
78	OOR	1135				
79	OOR	1138				
80	OOR	1141				
81	OOR	1142				
82	OOR	1140				
83	OOR	1139				
84	OOR	1137				
85	OYE	1136				
86	OYE	1145				
87	OYE	1143				
88	OYE	1141				
89	OYE	1144				
90	OYE	1139				
91	OYE	1140				
92	OYE	1144				
93	OYE	1144				
94	OYE	1140				
95	OYE	1143				
96	OYE	1141				
97	OBE	1155				
98	OBE	1135				
99	OBE	1152				
100	OBE	1145				
101	OBE	1141				
102	OBE	1139				
103	OBE	1139				
104	OBE	1140				

105	OBE	1143				
106	OBE	1141				
107	OBE	1138				
108	OBE	1139				
109	OPU	1148				
110	OPU	1145				
111	OPU	1148				
112	OPU	1141				
113	OPU	1139				
114	OPU	1140				
115	OPU	1141				
116	OPU	1141				
117	OPU	1141				
118	OPU	1139				
119	OPU	1139				
120	OPU	1139				
121	UBE	1137	1074			
122	UBE	1157	1080			
123	UBE	1141	1081			
124	UBE	1147	1084			
125	UBE	1140	1088			
126	UBE	1142	1083			
127	UBE	1143	1057			
128	UBE	1139	1093			
129	UBE	1139	1094			
130	UBE	1142	1086			
131	UBE	1144	1099			
132	UBE	1142	1091			
133	UOR	1140	1082			
134	UOR	1143	1091			
135	UOR	1142	1082			
136	UOR	1143	1080			
137	UOR	1138	1085			
138	UOR	1140	1086			
139	UOR	1143	1097			
140	UOR	1142	1091			
141	UOR	1141	1085			
142	UOR	1142	1082			
143	UOR	1140	1086			
144	UOR	1138	1084			
145	UGR	1146	1085			
146	UGR	1146	1081			
147	UGR	1145	1097			
148	UGR	1136	1080			
149	UGR	1139	1111			

150	UGR	1138	1095			
151	UGR	1143	1091			
152	UGR	1142	1106			
153	UGR	1143	1082			
154	UGR	1138	1095			
155	UGR	1141	1088			
156	UGR	1140	1092			
157	UPI	1144	1082			
158	UPI	1143	1096			
159	UPI	1144	1088			
160	UPI	1144	1082			
161	UPI	1140	1081			
162	UPI	1136	1124			
163	UPI	1140	1086			
164	UPI	1143	1088			
165	UPI	1140	1095			
166	UPI	1142	1093			
167	UPI	1139	1085			
168	UPI	1140	1094			
169	UBL	1140	1093			
170	UBL	1144	1087			
171	UBL	1139	1082			
172	UBL	1136	1085			
173	UBL	1141	1082			
174	UBL	1138	1074			
175	UBL	1143	1091			
176	UBL	1140	1083			
177	UBL	1141	1087			
178	UBL	1140	1088			
179	UBL	1143	1092			
180	UBL	1142	1099			
181	URE	1136	1085			
182	URE	1143	1081			
183	URE	1143	1084			
184	URE	1144	1092			
185	URE	1144	1088			
186	URE	1140	1089			
187	URE	1139	1088			
188	URE	1141	1086			
189	URE	1138	1078			
190	URE	1142	1076			
191	UPU	1139	1085			
192	UPU	1141	1077			
193	UPU	1145	1091			
194	UPU	1144	1093			

195	UPU	1138	1084			
196	UPU	1141	1080			
197	UPU	1137	1076			
198	UPU	1137	1081			
199	UPU	1141	1091			
200	UPU	1141	1087			
201	UPU	1140	1079			
202	UPU	1143	1086			
203	UPU	1142	1088			
204	UPU	1142	1093			
205	UYE	1142	1099			
206	UYE	1138	1088			
207	UYE	1137	1088			
208	UYE	1137	1070			
209	UYE	1141	1088			
210	UYE	1140	1092			
211	UYE	1140	1093			
212	UYE	1140	1092			
213	UYE	1142	1078			
214	UYE	1140	1091			
215	UYE	1144	1084			
216	UYE	1141	1095			
217	UGR	1141	1076			
218	UBE	1140	1097			
219	UBL	1142	1099			
220	UPI	1141	1078			
221	UOR	1140	1094			
222	UPU	1141	1084			
223	UOR	1143	1094			
224	RBR	1143	1053	1084	1053	**80**
225	UYE	1138	1082			
226	URE	1144	1089			
227	URE	1142	1084			
228	UBL	1140	1081			
229	UPU	1140	1080			
230	UGR	1143	1089			
231	UYE	1139	1080			
232	UGR	1137	1068			
233	UBE	1144	1080			
234	URE	1144	1088			
235	URE	1140	1081			
236	URE	1137	1085			
237	OGR	1141				
238	UPI	1141	1077			
239	OYE	1143				

8.3 SPAD data soybean

Samples	FeHBED	Light	18-3-2019			20-3-2019		
			New		Gem.	New		Gem.
1	No	High	24.2	26.2	25.2	25.2	24.9	25.1
2	No	High	25.2	30	27.6	24.7	28.1	26.4
3	No	High	28.5	29.2	28.9	31.6	32.5	32.1
4	No	High	33.9	34	34.0	34.9	33.6	34.3
5	No	High	25.8	21.3	23.6	26.5	23.9	25.2
6	No	High	27	26	26.5	27.8	28.7	28.3
7	No	High	29.2	25.8	27.5	27.9	25.1	26.5
8	No	High	35.6	31.3	33.5	30.5	34.5	32.5
9	No	High	28.2	26	27.1	33.8	28.2	31
10	No	High	14.4	22.5	18.5	27.7	20.1	23.9
11	No	High	26.8	28.4	27.6	27.8	27.3	27.6
12	No	High	30.9	27.1	29	30.5	29.3	29.9
13	No	High	30.8	31.3	31.1	30	28.7	29.4
14	No	High	29.2	29.9	29.6	32.9	32.6	32.8
15	Yes	High	41.6	41.8	41.7	41.9	41.3	41.6
16	Yes	High	44	42.2	43.1	44.2	47	45.6
17	Yes	High	43.2	45.3	44.3	44.8	46	45.4
18	Yes	High	42.7	40.3	41.5	39.7	41.2	40.5
19	Yes	High	43.5	44	43.8	45.4	43	44.2
20	Yes	High	46.2	44.2	45.2	46.5	45.1	45.8
21	Yes	High	42.2	46.4	44.3	46.5	46.9	46.7
22	Yes	High	44.9	44.3	44.6	46.2	45.5	45.9
23	Yes	High	47.7	44.1	45.9	47.7	46.2	47.0
24	Yes	High	42	41.9	42.0	44.8	47	45.9
25	Yes	High	45.5	46.7	46.1	41.3	41	41.2
26	Yes	High	42.4	45.2	43.8	41.9	46.6	44.3
27	Yes	High	44.5	42.5	43.5	44.2	44.1	44.2
28	Yes	High	44.5	40.9	42.7	44.6	46	45.3
29	No	Low	33.5	33.8	33.7	32.9	31.9	32.4
30	No	Low	28.1	29	28.6	25.7	25.3	25.5
31	No	Low	22.5	24.5	23.5	24.9	22.1	23.5
32	No	Low	27.3	27.4	27.4	23.5	23.3	23.4
33	No	Low	21.2	20.9	21.1	23.5	21	22.3
34	No	Low	16.1	15.8	16.0	15.8	14.7	15.3
35	No	Low	15.2	13.1	14.2	11.6	12.4	12
36	No	Low	23.4	24.4	23.9	23.9	23.4	23.7
37	No	Low	21.5	22.4	22.0	20.9	18.5	19.7

38	No	Low	22.6	23.2	**22.9**	19.3	19.6	**19.5**
39	No	Low	28.7	30.4	**29.6**	27.1	28.4	**27.8**
40	No	Low	25.4	25.9	**25.7**	28.3	25	**26.7**
41	No	Low	18.9	18.5	**18.7**	21.1	18.8	**20.0**
42	No	Low	27.8	25.7	**26.8**	25.6	22.3	**24.0**
43	Yes	Low	37.3	37.5	**37.4**	38.4	39.4	**38.9**
44	Yes	Low	43.3	44.1	**43.7**	42.5	46.9	**44.7**
45	Yes	Low	40.3	42.1	**41.2**	45.1	45.7	**45.4**
46	Yes	Low	45.5	44.6	**45.1**	44.6	46.1	**45.4**
47	Yes	Low	37.2	37.9	**37.6**	38.2	38.8	**38.5**
48	Yes	Low	40.1	42.6	**41.4**	44	44.6	**44.3**
49	Yes	Low	41.2	40.7	**41.0**	45.3	44.8	**45.1**
50	Yes	Low	41.7	40.4	**41.1**	40.5	44.2	**42.4**
51	Yes	Low	41.8	44.3	**43.1**	42.5	42.1	**42.3**
52	Yes	Low	42.4	42.2	**42.3**	44.7	41	**42.9**
53	Yes	Low	41.5	40.6	**41.1**	43.5	44.2	**43.9**
54	Yes	Low	40.9	40.4	**40.7**	41.7	41.5	**41.6**
55	Yes	Low	40.9	40.4	**40.7**	38.6	40.7	**39.7**
56	Yes	Low	38.8	37.1	**38.0**	39.2	38.3	**38.8**

			22-3-2019					
Samples	**FeHBED**	**Light**	**Old**		**Gem.**	**New**		**Gem.**
1	No	High	29.5	29.7	**29.6**	27.7	26	**26.9**
2	No	High	31.9	29.4	**30.7**	28.3	23	**25.7**
3	No	High	44.4	44.2	**44.3**	32.8	33.2	**33**
4	No	High	48	44.9	**46.5**	35.1	35.6	**35.4**
5	No	High	31.9	29.2	**30.6**	26.2	24.8	**25.5**
6	No	High	41.1	41.2	**41.2**	29.7	26.9	**28.3**
7	No	High	42.7	39.1	**40.9**	36.9	28.2	**32.6**
8	No	High	42.6	38.5	**40.6**	35.6	30.5	**33.1**
9	No	High	36.5	39.7	**38.1**	27.2	21.6	**24.4**
10	No	High	33.8	36.6	**35.2**	30.1	22.3	**26.2**
11	No	High	28.4	37	**32.7**	29.3	27	**28.2**
12	No	High	45.9	42.2	**44.1**	32.6	32.6	**32.6**
13	No	High	37.7	40.4	**39.1**	31.3	30.2	**30.8**
14	No	High	32.3	33.5	**32.9**	29.6	31.1	**30.4**
15	Yes	High	49.2	47.7	**48.5**	38.6	41.6	**40.1**
16	Yes	High	43.1	46.5	**44.8**	45.3	42.3	**43.8**
17	Yes	High	46.2	46.2	**46.2**	40.2	41.8	**41**
18	Yes	High	47.9	47.5	**47.7**	40	41.3	**40.7**
19	Yes	High	45.4	46.7	**46.1**	41.2	40.9	**41.1**

20	Yes	High	47.6	46.4	**47**	38.5	41	**39.8**
21	Yes	High	44.8	47.2	**46**	37.9	39.7	**38.8**
22	Yes	High	46	48.3	**47.2**	39.1	39.2	**39.2**
23	Yes	High	50.3	43.3	**46.8**	42.2	41.8	**42**
24	Yes	High	45.3	48.4	**46.9**	40.4	40	**40.2**
25	Yes	High	49.7	45.8	**47.8**	41.7	41.2	**41.5**
26	Yes	High	43.4	46.6	**45**	41.3	39.6	**40.5**
27	Yes	High	46.5	45.3	**45.9**	38.2	40.1	**39.2**
28	Yes	High	50.9	50.7	**50.8**	46	46.7	**46.4**
29	No	Low	45.7	43.4	**44.6**	33.9	32.4	**33.2**
30	No	Low	35.7	34.4	**35.1**	23.6	25.4	**24.5**
31	No	Low	40.1	37.8	**39.0**	25.8	23.6	**24.7**
32	No	Low	42.4	42.5	**42.5**	26.5	26	**26.3**
33	No	Low	23	25.4	**24.2**	23.2	22.9	**23.1**
34	No	Low	14.5	13.8	**14.2**	8.5	14.3	**11.4**
35	No	Low	12.6	12	**12.3**	13.8	16.6	**15.2**
36	No	Low	40.3	41.1	**40.7**	25.9	22.8	**24.4**
37	No	Low	29.6	40.2	**34.9**	18.6	20.8	**19.7**
38	No	Low	17.5	16.6	**17.1**	8.2	11.9	**10.1**
39	No	Low	33.6	32	**32.8**	28.7	29.4	**29.1**
40	No	Low	27.3	28	**27.7**	19.2	23	**21.1**
41	No	Low	23.1	21.6	**22.4**	21.3	22	**21.7**
42	No	Low	25.8	23.1	**24.5**	14.9	15.2	**15.1**
43	Yes	Low	42.6	42.9	**42.8**	33	34.1	**33.6**
44	Yes	Low	45.1	45.7	**45.4**	40.4	39.9	**40.2**
45	Yes	Low	48.7	47.8	**48.3**	40.4	40.5	**40.5**
46	Yes	Low	49.4	48.2	**48.8**	43.7	42.5	**43.1**
47	Yes	Low	44.5	47.3	**45.9**	37.6	40.8	**39.2**
48	Yes	Low	44.7	45.3	**45**	42.5	40.9	**41.7**
49	Yes	Low	47.6	49.4	**48.5**	44.9	45.5	**45.2**
50	Yes	Low	43.3	44.7	**44**	43.1	41.6	**42.4**
51	Yes	Low	44.6	40.9	**42.8**	35.2	37.2	**36.2**
52	Yes	Low	42.6	44	**43.3**	42.3	43.1	**42.7**
53	Yes	Low	51.7	52.1	**51.9**	44.8	43.7	**44.3**
54	Yes	Low	44.4	46.3	**45.4**	41	42.7	**41.9**
55	Yes	Low	43.8	40	**41.9**	41	38.1	**39.6**
56	Yes	Low	40.3	43.2	**41.8**	33.9	33.5	**33.7**

			25-3-2019						
Samples	FeHBED	Light	Old		Gem.	New		Gem.
1	No	High	31.1	29.2	**30.2**	28.1	27.6	**27.9**
2	No	High	29.3	31.7	**30.5**	31.2	32.4	**31.8**
3	No	High	34.1	34.8	**34.5**	28.1	28.8	**28.5**
4	No	High	34.4	37.7	**36.1**	29.5	28.8	**29.2**
5	No	High	31.9	33	**32.5**	29.3	29.4	**29.4**
6	No	High	26.9	31.7	**29.3**	27.7	23.1	**25.4**
7	No	High	40.1	36.7	**38.4**	28.7	30.1	**29.4**
8	No	High	45	38.8	**41.9**	37.3	34.8	**36.1**
9	No	High	35.6	35	**35.3**	31.7	26.7	**29.2**
10	No	High	35.5	38.9	**37.2**	18.7	28.5	**23.6**
11	No	High	28.9	29.5	**29.2**	30.3	28.6	**29.5**
12	No	High	29.2	34.9	**32.1**	25.2	26.6	**25.9**
13	No	High	39.3	41.3	**40.3**	29.4	29.8	**29.6**
14	No	High	34.3	34.8	**34.6**	29.6	29.4	**29.5**
15	Yes	High	43.6	41.6	**42.6**	35.1	34.9	**35**
16	Yes	High	48.8	46.8	**47.8**	41.7	45.3	**43.5**
17	Yes	High	50.8	44.7	**47.8**	40.7	40.6	**40.7**
18	Yes	High	45.7	47.2	**46.5**	42.5	40.6	**41.6**
19	Yes	High	49.2	49.1	**49.2**	41.7	40.7	**41.2**
20	Yes	High	47.5	50	**48.8**	40.6	41.6	**41.1**
21	Yes	High	48.4	51.3	**49.9**	40.8	40.1	**40.5**
22	Yes	High	49.8	46.9	**48.4**	41.3	39.2	**40.3**
23	Yes	High	49.2	46	**47.6**	42.2	42.3	**42.3**
24	Yes	High	44.9	47.5	**46.2**	40	40.8	**40.4**
25	Yes	High	51.3	51.2	**51.3**	42.9	40.7	**41.8**
26	Yes	High	43.1	47.8	**45.5**	37.9	39.1	**38.5**
27	Yes	High	43.4	45.7	**44.6**	39.4	38.9	**39.2**
28	Yes	High	46.8	46.1	**46.5**	40.4	39.5	**40.0**
29	No	Low	45.5	46.6	**46.1**	35.3	33.2	**34.3**
30	No	Low	35.7	39	**37.4**	27	25.6	**26.3**
31	No	Low	41.6	36	**38.8**	28.5	27.1	**27.8**
32	No	Low	30.7	30	**30.4**	32.8	29.7	**31.3**
33	No	Low	25.4	27.9	**26.7**	27.2	25.6	**26.4**
34	No	Low	26.1	27.2	**26.7**	26.8	27.3	**27.1**
35	No	Low	11.8	10.7	**11.3**	18.2	22.6	**20.4**
36	No	Low	37.9	43.8	**40.9**	26	26.1	**26.1**
37	No	Low	21.6	18.5	**20.1**	16	18	**17**
38	No	Low	20.1	17.9	**19**	17.1	23.4	**20.3**
39	No	Low	33.8	33.7	**33.8**	31.8	33.1	**32.5**

40	No	Low	28.9	30.5	**29.7**	28.2	23.5	**25.9**
41	No	Low	27.8	23.9	**25.9**	25.8	27.2	**26.5**
42	No	Low	29.8	26.2	**28**	13.4	17	**15.2**
43	Yes	Low	43.5	44.8	**44.2**	36.3	38.6	**37.5**
44	Yes	Low	46.4	50.4	**48.4**	43.1	42.3	**42.7**
45	Yes	Low	51.1	51	**51.1**	38.9	37.6	**38.3**
46	Yes	Low	51.3	51.6	**51.5**	43.1	46.2	**44.7**
47	Yes	Low	41	43.7	**42.4**	39	36.3	**37.7**
48	Yes	Low	47.3	45.6	**46.5**	39.1	40.8	**40.0**
49	Yes	Low	46.2	49.8	**48**	39.1	38.1	**38.6**
50	Yes	Low	48.4	44.1	**46.3**	39.3	36	**37.7**
51	Yes	Low	44.2	42.6	**43.4**	40.3	38.9	**39.6**
52	Yes	Low	47.5	46.3	**46.9**	37.4	38.8	**38.1**
53	Yes	Low	49.2	47.3	**48.3**	40.1	40	**40.1**
54	Yes	Low	28.2	47.7	**38.0**	40	41	**40.5**
55	Yes	Low	44.4	43.6	**44**	34.4	35.7	**35.1**
56	Yes	Low	45.4	46.7	**46.1**	37.7	36.7	**37.2**

			27-3-2019					
Samples	**FeHBED**	**Light**	**Old**		**Gem.**	**New**		**Gem.**
1	No	High	31.4	32.1	**31.8**	28.6	28	**28.3**
2	No	High	33.4	32.6	**33**	31.6	34.5	**33.1**
3	No	High	35.4	33.6	**34.5**	31.6	27.4	**29.5**
4	No	High	38.4	37.5	**38.0**	32	30.1	**31.1**
5	No	High	34.4	29.1	**31.8**	27.9	27.7	**27.8**
6	No	High	32.3	33.4	**32.9**	24.4	28.5	**26.5**
7	No	High	31.2	30.1	**30.7**	27.7	28.5	**28.1**
8	No	High	37.5	36.3	**36.9**	33.4	32.5	**33.0**
9	No	High	33.5	27	**30.3**	25.9	24.9	**25.4**
10	No	High	31.4	21.7	**26.6**	25.9	29.3	**27.6**
11	No	High	30.5	31.3	**30.9**	30.6	32.8	**31.7**
12	No	High	35.1	34.6	**34.9**	29	29.4	**29.2**
13	No	High	29.6	31.7	**30.7**	23	25.3	**24.2**
14	No	High	34.9	34.7	**34.8**	32.1	32.4	**32.3**
15	Yes	High	41.8	41	**41.4**	36.4	36.2	**36.3**
16	Yes	High	48.7	46.5	**47.6**	40.2	42.3	**41.3**
17	Yes	High	52.4	50.1	**51.3**	41.8	42.5	**42.2**
18	Yes	High	49.8	47.3	**48.6**	42	42.6	**42.3**
19	Yes	High	51.9	51.2	**51.6**	41.3	39.1	**40.2**
20	Yes	High	47.6	48.8	**48.2**	42.8	40.4	**41.6**
21	Yes	High	49	50.2	**49.6**	43.8	40.5	**42.2**

22	Yes	High	48	50.7	**49.4**	40.6	42.7	**41.7**
23	Yes	High	51.3	49.6	**50.5**	45.5	42.5	**44**
24	Yes	High	45.1	49.8	**47.5**	40.8	37.6	**39.2**
25	Yes	High	48.7	48.5	**48.6**	42.7	43.9	**43.3**
26	Yes	High	54	46.5	**50.3**	40.1	40.1	**40.1**
27	Yes	High	48.3	43.2	**45.8**	38	40.9	**39.5**
28	Yes	High	46.8	47.7	**47.3**	41.7	39.8	**40.8**
29	No	Low	46.8	47.5	**47.2**	35.9	35.9	**35.9**
30	No	Low	26.5	28.8	**27.7**	29.2	31.2	**30.2**
31	No	Low	30.1	30	**30.1**	31	30.4	**30.7**
32	No	Low	32.5	31.9	**32.2**	33.3	32.5	**32.9**
33	No	Low	27.5	29.8	**28.7**	29.3	27.9	**28.6**
34	No	Low	17.4	15.7	**16.6**	15.3	13.2	**14.3**
35	No	Low	15.9	19	**17.5**	23.1	23.8	**23.5**
36	No	Low	28.6	28.1	**28.4**	29.1	26.9	**28**
37	No	Low	21.1	22.3	**21.7**	23.4	22.2	**22.8**
38	No	Low	19.8	23.5	**21.7**	25.2	21.5	**23.4**
39	No	Low	37.4	38	**37.7**	33.8	35.9	**34.9**
40	No	Low	29.6	30.8	**30.2**	26.7	29.8	**28.25**
41	No	Low	31.3	33.5	**32.4**	30	25.8	**27.9**
42	No	Low	29.7	25.6	**27.7**	19.6	22.1	**20.9**
43	Yes	Low	48.8	46.6	**47.7**	38.4	40	**39.2**
44	Yes	Low	46.3	41	**43.7**	45.5	40.6	**43.1**
45	Yes	Low	47.9	53.9	**50.9**	40.9	40.7	**40.8**
46	Yes	Low	50.5	50.2	**50.4**	47.3	45.4	**46.4**
47	Yes	Low	46	46.8	**46.4**	39.6	40.7	**40.2**
48	Yes	Low	47.8	50.3	**49.1**	38.7	42.6	**40.7**
49	Yes	Low	49.5	50.9	**50.2**	41	42.5	**41.8**
50	Yes	Low	47.9	47.3	**47.6**	39.3	39.6	**39.5**
51	Yes	Low	49.4	46	**47.7**	40.7	40.9	**40.8**
52	Yes	Low	44.9	44.6	**44.8**	38.5	42	**40.3**
53	Yes	Low	40.1	39.8	**40.0**	50.7	48.7	**49.7**
54	Yes	Low	49.2	49	**49.1**	41.4	41.7	**41.6**
55	Yes	Low	46	41.8	**43.9**	36.1	36.4	**36.3**
56	Yes	Low	47.2	49	**48.1**	40.5	39.9	**40.2**

			29-3-2019						
Samples	**FeHBED**	**Light**	**Old**		**Gem.**	**New**		**Gem.**	
1	No	High							
2	No	High	32.9	34.5	**33.7**	33.5	35.2	**34.4**	
3	No	High	35.8	35.6	**35.7**	28.6	29	**28.8**	
4	No	High	38.6	37.3	**38.0**	32.7	32.1	**32.4**	
5	No	High	34.8	30.1	**32.5**	30.6	28.4	**29.5**	
6	No	High							
7	No	High	31.9	30.7	**31.3**	29.4	29.3	**29.4**	
8	No	High							
9	No	High	31.7	24.9	**28.3**	29	28.4	**28.7**	
10	No	High							
11	No	High	31.9	31	**31.5**	30.7	32.2	**31.5**	
12	No	High	35.7	32.1	**33.9**	29.9	28.6	**29.3**	
13	No	High							
14	No	High							
15	Yes	High	41.1	42.8	**42.0**	35.3	35	**35.2**	
16	Yes	High							
17	Yes	High	49.7	48.3	**49**	40.5	43.5	**42**	
18	Yes	High	47.8	47.1	**47.5**	42.9	40.7	**41.8**	
19	Yes	High							
20	Yes	High	47.9	50.8	**49.4**	43.1	43.5	**43.3**	
21	Yes	High	50.3	52.2	**51.3**	43.5	41.3	**42.4**	
22	Yes	High							
23	Yes	High	51.4	48.3	**49.9**	44.3	44.5	**44.4**	
24	Yes	High							
25	Yes	High	51	49.2	**50.1**	43.4	46.1	**44.8**	
26	Yes	High							
27	Yes	High							
28	Yes	High	48.1	48	**48.1**	41.4	41.6	**41.5**	
29	No	Low							
30	No	Low							
31	No	Low	30.3	31.6	**31.0**	33.1	33.3	**33.2**	
32	No	Low	33.5	33.3	**33.4**	33.7	33.8	**33.8**	
33	No	Low	26.1	29.9	**28**	31.9	32.1	**32**	
34	No	Low							
35	No	Low	18.1	15.6	**16.9**	23.9	27.5	**25.7**	
36	No	Low	29	26.2	**27.6**	29.5	29.1	**29.3**	
37	No	Low	23.2	22.2	**22.7**	26.6	25.8	**26.2**	
38	No	Low							
39	No	Low	32.2	37.2	**34.7**	29.5	29.3	**29.4**	

40	No	Low						
41	No	Low						
42	No	Low	30.2	27.2	**28.7**	23.9	25.2	**24.6**
43	Yes	Low	46	48.2	**47.1**	41.9	41.6	**41.8**
44	Yes	Low						
45	Yes	Low						
46	Yes	Low						
47	Yes	Low	49.5	48.9	**49.2**	42.9	42.1	**42.5**
48	Yes	Low	52.8	51.2	**52**	39.3	43.2	**41.3**
49	Yes	Low	51.8	54.5	**53.2**	41.7	42.6	**42.2**
50	Yes	Low						
51	Yes	Low						
52	Yes	Low	48.1	52.9	**50.5**	41.4	41.8	**41.6**
53	Yes	Low						
54	Yes	Low	50.5	47.7	**49.1**	43.4	42.4	**42.9**
55	Yes	Low	45.7	45.1	**45.4**	37.9	37.3	**37.6**
56	Yes	Low	49.2	48.4	**48.8**	42.2	42.4	**42.3**

			1-4-2019					
Samples	**FeHBED**	**Light**	**Old**		**Gem.**	**New**		**Gem.**
1	No	High						
2	No	High	35.7	37	**36.4**	38.3	38	**38.2**
3	No	High	36.2	35.4	**35.8**	31.3	30.9	**31.1**
4	No	High	37.3	38.4	**37.9**	34.7	35	**34.9**
5	No	High	34.8	32.8	**33.8**	34.8		**34.8**
6	No	High						
7	No	High	31.5	30.7	**31.1**	28.4	31.5	**30.0**
8	No	High						
9	No	High	35.4	31.3	**33.4**	30.7	31.4	**31.1**
10	No	High						
11	No	High	32.4	33.6	**33**	36.7	32.4	**34.6**
12	No	High	37	33.7	**35.4**	32.5	32.6	**32.6**
13	No	High						
14	No	High						
15	Yes	High	41.6	42.7	**42.2**	37.6	31.5	**34.6**
16	Yes	High						
17	Yes	High	49.1	51.5	**50.3**	43.6	36.9	**40.3**
18	Yes	High	44	44.7	**44.4**	40.6	47.2	**43.9**
19	Yes	High						
20	Yes	High	51.1	51.3	**51.2**	43.8	38.5	**41.2**
21	Yes	High	41.5	45.5	**43.5**	37	44.5	**40.8**

22	Yes	High						
23	Yes	High	45.5	45.9	**45.7**	41.1	35.5	**38.3**
24	Yes	High						
25	Yes	High	51.5	51.1	**51.3**	44.9	38.9	**41.9**
26	Yes	High						
27	Yes	High						
28	Yes	High	49.1	50.5	**49.8**	42.7	46.6	**44.7**
29	No	Low						
30	No	Low						
31	No	Low	30.9	33.2	**32.1**	37.5	42.6	**40.1**
32	No	Low	35.5	34.7	**35.1**	37.2	36.6	**36.9**
33	No	Low	29.7	31.6	**30.7**	35.7	36.4	**36.1**
34	No	Low						
35	No	Low	19.7	17.7	**18.7**	30	34.3	**32.2**
36	No	Low	31.2	30.4	**30.8**	32.3	30.5	**31.4**
37	No	Low	22.8	25.3	**24.1**	32.4	33.2	**32.8**
38	No	Low						
39	No	Low	36.2	37.7	**37.0**	32	31.6	**31.8**
40	No	Low						
41	No	Low						
42	No	Low	29.3	30.8	**30.1**	37.2	31.3	**34.3**
43	Yes	Low	49.5	49.9	**49.7**	46.1	33.2	**39.7**
44	Yes	Low						
45	Yes	Low						
46	Yes	Low						
47	Yes	Low	52.3	49.1	**50.7**	42.1	47.9	**45**
48	Yes	Low	49.7	50.9	**50.3**	41.3	47.3	**44.3**
49	Yes	Low	54.5	47.8	**51.2**	43.7	43.2	**43.5**
50	Yes	Low						
51	Yes	Low						
52	Yes	Low	51	49	**50**	45.5	45.7	**45.6**
53	Yes	Low					42.6	
54	Yes	Low	51.1	52.3	**51.7**	44.1	45.1	**44.6**
55	Yes	Low	47.7	47.2	**47.5**	38.3	39.7	**39**
56	Yes	Low	48.4	52.8	**50.6**	46.1	45.6	**45.9**

			3-4-2019					
Samples	**FeHBED**	**Light**	**Old**		**Gem.**	**New**		**Gem.**
1	No	High						
2	No	High	36.3	35.8	**36.1**	35.4	37.5	**36.5**
3	No	High	37.6	36.7	**37.2**	34.4	31.6	**33**
4	No	High	38.7	38.8	**38.8**	36	32.5	**34.3**
5	No	High	33.8	34.2	**34**	30.1	31.6	**30.9**
6	No	High						
7	No	High	31.3	30.6	**31.0**	31.2	30.3	**30.8**
8	No	High						
9	No	High	37.5	28.4	**33.0**	30.5	35	**32.8**
10	No	High						
11	No	High	33.4	32.3	**32.9**	34.7	35.5	**35.1**
12	No	High	36.7	34.3	**35.5**	33.1	31.7	**32.4**
13	No	High						
14	No	High						
15	Yes	High	44.5	41.3	**42.9**	35.9	37.4	**36.7**
16	Yes	High						
17	Yes	High	44.1	47.5	**45.8**	38.1	36.5	**37.3**
18	Yes	High	44	49.1	**46.6**	40.4	37.2	**38.8**
19	Yes	High						
20	Yes	High	46.5	44.2	**45.4**	36.7	37.3	**37**
21	Yes	High	45.5	46.7	**46.1**	34.5	36.2	**35.4**
22	Yes	High						
23	Yes	High	44.5	46.2	**45.4**	40.8	39	**39.9**
24	Yes	High						
25	Yes	High	47.6	45.7	**46.7**	37.2	40.5	**38.9**
26	Yes	High						
27	Yes	High						
28	Yes	High	49.6	51.5	**50.6**	41.6	42.9	**42.3**
29	No	Low						
30	No	Low						
31	No	Low	33.1	35.5	**34.3**	38.6	37.9	**38.3**
32	No	Low	36.9	35.7	**36.3**	37.5	36.2	**36.9**
33	No	Low	30.2	33.1	**31.7**	38.4	36.6	**37.5**
34	No	Low						
35	No	Low	32.9	33.5	**33.2**	35.3	34.4	**34.9**
36	No	Low	31.6	33.1	**32.4**	32.9	33.9	**33.4**
37	No	Low	22.8	27.2	**25**	35.3	35.4	**35.4**
38	No	Low						
39	No	Low	36.5	39.3	**37.9**	31.9	30.3	**31.1**

40	No	Low						
41	No	Low						
42	No	Low	32.4	33.3	**32.9**	35.2	34.8	**35**
43	Yes	Low	46.9	47.1	**47**	38.6	36.4	**37.5**
44	Yes	Low						
45	Yes	Low						
46	Yes	Low						
47	Yes	Low	54.8	53.2	**54**	45	48.3	**46.7**
48	Yes	Low	50.8	50.9	**50.9**	44.2	49.5	**46.9**
49	Yes	Low	56	55.5	**55.8**	45.5	43.1	**44.3**
50	Yes	Low						
51	Yes	Low						
52	Yes	Low	49	52		43.7	46.3	
53	Yes	Low						
54	Yes	Low	54	53.1	**53.6**	45.7	45.2	**45.5**
55	Yes	Low	48.6	47.6	**48.1**	39.1	39.2	**39.2**
56	Yes	Low	48.8	48.4	**48.6**	36.8	38.4	**37.6**

			5-4-2019					
Samples	**FeHBED**	**Light**	**Old**		**Gem.**	**New**		**Gem.**
1	No	High						
2	No	High	36.7	38.3	**37.5**	37.1	38.5	**37.8**
3	No	High	37.9	37.8	**37.9**	35.7	34.2	**35.0**
4	No	High	39.9	40.2	**40.1**	35.8	38	**36.9**
5	No	High	34.9	33.7	**34.3**	30.1	32.2	**31.2**
6	No	High						
7	No	High	31	31.3	**31.2**	31.2	32.8	**32**
8	No	High						
9	No	High	37	31.1	**34.1**	34.4	32.1	**33.3**
10	No	High						
11	No	High	35.5	34.1	**34.8**	34.8	30.2	**32.5**
12	No	High	36.3	34	**35.2**	33.5	33.3	**33.4**
13	No	High						
14	No	High						
15	Yes	High	41.7	40	**40.9**	37.4	35.3	**36.4**
16	Yes	High						
17	Yes	High	50.1	49	**49.6**	38	37.5	**37.8**
18	Yes	High	44.5	44.8	**44.7**	41.2	39.5	**40.4**
19	Yes	High						
20	Yes	High	45.2	45.5	**45.4**	37.3	39.4	**38.4**
21	Yes	High	46.8	47	**46.9**	36.7	37.9	**37.3**

22	Yes	High						
23	Yes	High	47.8	45.8	**46.8**	40.4	39.4	**39.9**
24	Yes	High						
25	Yes	High	48.1	47.8	**48.0**	38.9	41.4	**40.2**
26	Yes	High						
27	Yes	High						
28	Yes	High	50.5	50.3	**50.4**	43.9	44.1	**44**
29	No	Low						
30	No	Low						
31	No	Low	34.9	35.4	**35.2**	40.9	40.1	**40.5**
32	No	Low	38	37.5	**37.8**	41.1	38.6	**39.9**
33	No	Low	36.7	37	**36.9**	37.4	37	**37.2**
34	No	Low						
35	No	Low	34.5	36.1	**35.3**	31.6	35.2	**33.4**
36	No	Low	32.4	32.2	**32.3**	34.9	36.5	**35.7**
37	No	Low	36.8	37.5	**37.2**	31.7	35.7	**33.7**
38	No	Low						
39	No	Low	40.3	36.2	**38.3**	33.9	33.8	**33.9**
40	No	Low						
41	No	Low						
42	No	Low	33.7	34.8	**34.3**	37.5	34.2	**35.9**
43	Yes	Low	49.6	45.2	**47.4**	38.9	39.7	**39.3**
44	Yes	Low						
45	Yes	Low						
46	Yes	Low						
47	Yes	Low	52.5	53	**52.8**	50.6	50	**50.3**
48	Yes	Low	52.3	52.8	**52.6**	47.4	45.7	**46.6**
49	Yes	Low	56	55.2	**55.6**	44.6	47.8	**46.2**
50	Yes	Low						
51	Yes	Low						
52	Yes	Low	44.5	43.6		37.3	41.6	
53	Yes	Low						
54	Yes	Low	51.5	52.5	**52**	47.6	46.9	**47.3**
55	Yes	Low	49.7	46.6	**48.2**	39.6	42.1	**40.9**
56	Yes	Low	48.1	47.9	**48**	40.1	37.8	**39.0**

			8-4-2019					
Samples	**FeHBED**	**Light**	**Old**		**Gem.**	**New**		**Gem.**
1	No	High						
2	No	High	38	39.2	**38.6**	40.3	35.6	**38.0**
3	No	High	38.3	36.9	**37.6**	34.7	38.3	**36.5**
4	No	High	39.7	40.1	**39.9**	37.6	37.8	**37.7**
5	No	High	37.4	33.5	**35.5**	32.2	33.2	**32.7**
6	No	High						
7	No	High	32.2	28.5	**30.4**	31.4	32.3	**31.9**
8	No	High						
9	No	High	36.7	32.2	**34.5**	37.4	36.2	**36.8**
10	No	High						
11	No	High	38	33.3	**35.7**	33.4	36.4	**34.9**
12	No	High	33.9	33.2	**33.6**	33.6	35.8	**34.7**
13	No	High						
14	No	High						
15	Yes	High	34.7	42.9	**38.8**	39.4	37.8	**38.6**
16	Yes	High						
17	Yes	High	48.1	47.5	**47.8**	38.6	40.4	**39.5**
18	Yes	High	46.6	46.1	**46.4**	42.6	39.9	**41.3**
19	Yes	High						
20	Yes	High	47.6	46.9	**47.3**	39.3	41.2	**40.3**
21	Yes	High	47.5	48.1	**47.8**	40.3	38.1	**39.2**
22	Yes	High						
23	Yes	High	46.8	48	**47.4**	41	43.8	**42.4**
24	Yes	High						
25	Yes	High	49.9	47.5	**48.7**	40	43.3	**41.7**
26	Yes	High						
27	Yes	High						
28	Yes	High	50.4	47.7	**49.1**	44.2	44.9	**44.6**
29	No	Low						
30	No	Low						
31	No	Low	34.9	36	**35.5**	42.3	40.7	**41.5**
32	No	Low	38	37	**37.5**	41.2	40.3	**40.8**
33	No	Low	30.5	33.2	**31.9**	38	40.7	**39.4**
34	No	Low						
35	No	Low	36.8	37	**36.9**	35.1	39.5	**37.3**
36	No	Low	32.6	31.1	**31.9**	35.9	36.6	**36.3**
37	No	Low	38.8	38.1	**38.5**	38.1	36.9	**37.5**
38	No	Low						
39	No	Low	35.4	39.1	**37.3**	32.2	33.9	**33.1**

40	No	Low						
41	No	Low						
42	No	Low	33.5	35.4	**34.5**	39.5	39.4	**39.5**
43	Yes	Low	47.9	47.5	**47.7**	40.4	42.1	**41.3**
44	Yes	Low						
45	Yes	Low						
46	Yes	Low						
47	Yes	Low	53.6	53.4	**53.5**	50.5	51.7	**51.1**
48	Yes	Low	55.6	53.9	**54.8**	46.1	49.1	**47.6**
49	Yes	Low	47.5	45.5	**46.5**	41	42.9	**42.0**
50	Yes	Low						
51	Yes	Low						
52	Yes	Low	45.4	48.5		41.4	41.8	
53	Yes	Low						
54	Yes	Low	49.2	49.4	**49.3**	38.2	41.6	**39.9**
55	Yes	Low	41.6	40.4	**41**	35.4	36.2	**35.8**
56	Yes	Low	49	48.1	**48.6**	42.1	39.6	**40.9**

			10-4-2019					
Samples	**FeHBED**	**Light**	**Old**		**Gem.**	**New**		**Gem.**
1	No	High						
2	No	High	40.7	39	**39.9**	36.5	40.4	**38.5**
3	No	High	38.9	37	**38.0**	38	37.7	**37.9**
4	No	High	40.5	40.1	**40.3**	39.2	37.6	**38.4**
5	No	High	36.9	37	**37.0**	32.4	31.3	**31.9**
6	No	High						
7	No	High	30.7	30.3	**30.5**	33.7	36.1	**34.9**
8	No	High						
9	No	High	38.5	33.2	**35.9**	36.3	38.3	**37.3**
10	No	High						
11	No	High	37.9	34.7	**36.3**	31.9	32.8	**32.4**
12	No	High	30.2	34	**32.1**	36.2	35.9	**36.1**
13	No	High						
14	No	High						
15	Yes	High	40.5	42.9	**41.7**	38.8	40.3	**39.6**
16	Yes	High						
17	Yes	High	47.3	50.5	**48.9**	40.6	42.9	**41.8**
18	Yes	High	44.6	44.4	**44.5**	44.7	41.8	**43.3**
19	Yes	High						
20	Yes	High	48.6	46	**47.3**	41.8	41.9	**41.9**
21	Yes	High	48.6	48.8	**48.7**	41.6	39.5	**40.6**

22	Yes	High						
23	Yes	High	49.6	49.7	**49.7**	41.8	43.2	**42.5**
24	Yes	High						
25	Yes	High	49.3	48.3	**48.8**	42.8	45.4	**44.1**
26	Yes	High						
27	Yes	High						
28	Yes	High	46.3	45.5	**45.9**	44.4	43.3	**43.9**
29	No	Low						
30	No	Low						
31	No	Low	35.7	35.2	**35.5**	42.3	43.3	**42.8**
32	No	Low	37.3	38.3	**37.8**	44.4	42.6	**43.5**
33	No	Low	31.4	33.9	**32.7**	41	41.9	**41.5**
34	No	Low						
35	No	Low	37.3	37	**37.2**	35.9	40.2	**38.1**
36	No	Low	32	30.6	**31.3**	36	39.6	**37.8**
37	No	Low	38.6	42.7	**40.7**	40.2	37.6	**38.9**
38	No	Low						
39	No	Low	40.3	38	**39.2**	36.4	37.5	**37.0**
40	No	Low						
41	No	Low						
42	No	Low	35.8	37.9	**36.9**	40.8	40.7	**40.8**
43	Yes	Low	48.8	42.8	**45.8**	43	42.9	**43.0**
44	Yes	Low						
45	Yes	Low						
46	Yes	Low						
47	Yes	Low	54.1	45.5	**49.8**	53.7	50.6	**52.2**
48	Yes	Low	54.7	56.1	**55.4**	47.2	50.3	**48.8**
49	Yes	Low	47.7	51.5	**49.6**	41.8	41.3	**41.6**
50	Yes	Low						
51	Yes	Low						
52	Yes	Low	48	49.7		40.4	44.2	
53	Yes	Low						
54	Yes	Low	50.3	50.4	**50.4**	43.4	40.9	**42.2**
55	Yes	Low	43.9	42.8	**43.4**	36.6	32.1	**34.4**
56	Yes	Low	50.1	50.1	**50.1**	41.9	43.8	**42.9**

			12-4-2019					
Samples	**FeHBED**	**Light**	**Old**		**Gem.**	**New**		**Gem.**
1	No	High						
2	No	High	37.1	38.6	**37.9**	37	39.3	**38.2**
3	No	High	38.6	39.1	**38.9**	39.1	37.5	**38.3**
4	No	High	38	38.7	**38.4**	37.1	37.4	**37.3**
5	No	High	35.3	35.8	**35.6**	33.3	34.7	**34**
6	No	High						
7	No	High	32.2	30.8	**31.5**	34.6	34.5	**34.6**
8	No	High						
9	No	High	38.5	32.5	**35.5**	37	39.3	**38.2**
10	No	High						
11	No	High	38.6	45.3	**42.0**	33.3	31.3	**32.3**
12	No	High	32.5	27.6	**30.1**	35.1	34.7	**34.9**
13	No	High						
14	No	High						
15	Yes	High	40.8	41.6	**41.2**	39.5	38.6	**39.1**
16	Yes	High						
17	Yes	High	47.6	48.4	**48**	42.6	38.1	**40.4**
18	Yes	High	46.5	50.2	**48.4**	43.5	42.1	**42.8**
19	Yes	High						
20	Yes	High	48.9	48.5	**48.7**	42.2	40.1	**41.2**
21	Yes	High	46.5	47.4	**47.0**	42.8	45.9	**44.4**
22	Yes	High						
23	Yes	High	48.3	47.5	**47.9**	43.6	43.1	**43.4**
24	Yes	High						
25	Yes	High	46.3	49.9	**48.1**	42.2	46.9	**44.6**
26	Yes	High						
27	Yes	High						
28	Yes	High	47.9	47.4	**47.7**	43.3	42.9	**43.1**
29	No	Low						
30	No	Low						
31	No	Low	43.7	41	**42.4**	35.6	39.5	**37.6**
32	No	Low	42.3	43.7	**43**	34.3	32.9	**33.6**
33	No	Low	42.3	41.4	**41.9**	34.3	35.5	**34.9**
34	No	Low						
35	No	Low	37.2	38.7	**38.0**	38.3	42.2	**40.3**
36	No	Low	29.9	31.9	**30.9**	35.2	38.6	**36.9**
37	No	Low	41.8	40.4	**41.1**	41.8	39.9	**40.9**
38	No	Low						
39	No	Low	36	36.3	**36.2**	28.4	28.4	**28.4**

40	No	Low						
41	No	Low						
42	No	Low	36.9	37.2	**37.1**	40.5	42.6	**41.6**
43	Yes	Low	52.1	50.5	**51.3**	42.9	45.1	**44**
44	Yes	Low						
45	Yes	Low						
46	Yes	Low						
47	Yes	Low	52	51.3	**51.7**	38.7	39.7	**39.2**
48	Yes	Low	48.3	47.5	**47.9**	40.6	41.5	**41.1**
49	Yes	Low	51.1	48.1	**49.6**	41.6	43.8	**42.7**
50	Yes	Low						
51	Yes	Low						
52	Yes	Low	50.1	45.3		41.3	39.4	
53	Yes	Low						
54	Yes	Low	51	50.5	**50.8**	40.6	39.8	**40.2**
55	Yes	Low	44	43.7	**43.9**	37.1	35.2	**36.2**
56	Yes	Low	51	49.8	**50.4**	41.8	44.6	**43.2**

			15-4-2019					
Samples	**FeHBED**	**Light**	**Old**		**Gem.**	**New**		**Gem.**
1	No	High						
2	No	High	41.6	40.4	**41**	38.3	40.3	**39.3**
3	No	High	39.3	38.3	**38.8**	39.6	38.7	**39.2**
4	No	High	38.6	37.6	**38.1**	36.7	41.9	**39.3**
5	No	High	38.8	38.2	**38.5**	34.2	34.6	**34.4**
6	No	High						
7	No	High	30.6	32.8	**31.7**	35.6	36.1	**35.9**
8	No	High						
9	No	High	39.3	32.5	**35.9**	40	39.7	**39.9**
10	No	High						
11	No	High	39.7	36.8	**38.3**	35	34.3	**34.7**
12	No	High	35.4	28.7	**32.1**	35.4	33.1	**34.3**
13	No	High						
14	No	High						
15	Yes	High	44.2	42	**43.1**	40.4	40.6	**40.5**
16	Yes	High						
17	Yes	High	51.7	49.5	**50.6**	43.2	40.8	**42**
18	Yes	High	45.9	49.7	**47.8**	45.7	41	**43.4**
19	Yes	High						
20	Yes	High	48.2	48.6	**48.4**	41.6	44.5	**43.1**
21	Yes	High	48.2	49.2	**48.7**	43.9	42.4	**43.2**

22	Yes	High						
23	Yes	High	47.3	45.6	**46.5**	44.8	44.1	**44.5**
24	Yes	High						
25	Yes	High	50.6	49.7	**50.2**	42.3	44.7	**43.5**
26	Yes	High						
27	Yes	High						
28	Yes	High	47.7	45.2	**46.5**	41.9	44.3	**43.1**
29	No	Low						
30	No	Low						
31	No	Low	43.3	44.6	**44.0**	31.3	32.5	**31.9**
32	No	Low	42.9	42.7	**42.8**	38.7	37.1	**37.9**
33	No	Low	41.9	41.7	**41.8**	36.1	38.2	**37.2**
34	No	Low						
35	No	Low	36.2	39	**37.6**	39	42.8	**40.9**
36	No	Low	30.3	30.8	**30.6**	38	38.4	**38.2**
37	No	Low	40.7	42	**41.4**	44.6	43.1	**43.9**
38	No	Low						
39	No	Low	37.3	39.4	**38.4**	32.7	31	**31.9**
40	No	Low						
41	No	Low						
42	No	Low	33.9	36.6	**35.3**	45.6	44.5	**45.1**
43	Yes	Low	51.6	51.8	**51.7**	45.2	45	**45.1**
44	Yes	Low						
45	Yes	Low						
46	Yes	Low						
47	Yes	Low	51	54.9	**53.0**	39.7	41.7	**40.7**
48	Yes	Low	48.1	48.5	**48.3**	42.6	43.1	**42.9**
49	Yes	Low	50.6	51.1	**50.9**	42.6	44.4	**43.5**
50	Yes	Low						
51	Yes	Low						
52	Yes	Low	46.7	50.2		42.1	42.5	
53	Yes	Low						
54	Yes	Low	49	48.3	**48.7**	38.7	40.6	**39.7**
55	Yes	Low	42.7	44.2	**43.5**	35.5	35.3	**35.4**
56	Yes	Low	51	49.2	**50.1**	43.6	43	**43.3**

			17-4-2019						
Samples	**FeHBED**	**Light**	**Old**		**Gem.**	**New**		**Gem.**	
1	No	High							
2	No	High	39.8	38.5	**39.2**	42.7	42	**42.4**	
3	No	High	40.1	38.2	**39.2**	38.8	40.3	**39.6**	
4	No	High	37.2	39.3	**38.3**	37.6	41.3	**39.5**	
5	No	High	39.7	37.9	**38.8**	36.6	33.9	**35.3**	
6	No	High							
7	No	High	35.1	34.5	**34.8**	32.5	35.4	**34.0**	
8	No	High							
9	No	High	39.7	40.3	**40**	32.7	31	**31.9**	
10	No	High							
11	No	High	41.3	38.7	**40**	34.2	32.4	**33.3**	
12	No	High	33.4	32.8	**33.1**	35.8	35.5	**35.7**	
13	No	High							
14	No	High							
15	Yes	High	42.1	40.5	**41.3**	38.7	40.5	**39.6**	
16	Yes	High							
17	Yes	High	49.9	49.7	**49.8**	40.5	42.8	**41.7**	
18	Yes	High	47.3	48.7	**48**	43.9	42.7	**43.3**	
19	Yes	High							
20	Yes	High	48.1	47.2	**47.7**	43.2	42.5	**42.9**	
21	Yes	High	45.6	50.5	**48.1**	43.4	43.5	**43.5**	
22	Yes	High							
23	Yes	High	49.7	48	**48.9**	43.5	44.2	**43.9**	
24	Yes	High							
25	Yes	High	48.9	48.6	**48.8**	43.9	47.1	**45.5**	
26	Yes	High							
27	Yes	High							
28	Yes	High	44.1	47.2	**45.7**	43.4	43.1	**43.3**	
29	No	Low							
30	No	Low							
31	No	Low	44.5	43.3	**43.9**	38.2	37.2	**37.7**	
32	No	Low	43.5	43.7	**43.6**	38.1	39.6	**38.9**	
33	No	Low	41	40.6	**40.8**	30.3	35.8	**33.1**	
34	No	Low							
35	No	Low	36.5	38.2	**37.4**	42.3	43.5	**42.9**	
36	No	Low	31.5	30.2	**30.9**	36.3	37.5	**36.9**	
37	No	Low	43.8	42.2	**43**	44.9	44.6	**44.8**	
38	No	Low							
39	No	Low	37	37.6	**37.3**	35	32.5	**33.8**	

40	No	Low						
41	No	Low						
42	No	Low	35.9	37.6	**36.8**	42.6	44	**43.3**
43	Yes	Low	48.1	49.3	**48.7**	46.7	44.6	**45.7**
44	Yes	Low						
45	Yes	Low						
46	Yes	Low						
47	Yes	Low	48.8	54.5	**51.7**	42.4	44.3	**43.4**
48	Yes	Low	46.2	50.6	**48.4**	42.7	41.3	**42**
49	Yes	Low	49.3	48.2	**48.8**	45.8	46.5	**46.2**
50	Yes	Low						
51	Yes	Low						
52	Yes	Low	47.1	49.6		43.1	43.6	
53	Yes	Low						
54	Yes	Low	53	53.8	**53.4**	41	40.3	**407**
55	Yes	Low	41.7	42.2	**42.0**	37.4	36.5	**37.0**
56	Yes	Low	50.6	52.3	**51.5**	44.1	43	**43.6**

8.4 SPAD data screening varieties

SPAD data of chlorophyll content in three youngest leaves of a certain measurement day

			27-5-2019				29-5-2019			
Sample	Code	Blank	Young 1	Young 2	Young 3	Average	Young 1	Young 2	Young 3	Average
1	RBL	Yes	32.6	35.9	42.9	37.1	30.2	37.6	39.9	35.9
2	RBL	Yes	40.7	35.4		38.1	39.8	38	43.5	40.4
3	RBL	Yes	32.3	39.2	32.7	34.7	34.9	30.9	38.6	34.8
4	RBL	Yes		36.8		36.8	28.9	28.8	39.8	32.5
5	RBL	No		27.6	31.3	29.5	30.5	33.3	33.3	32.4
6	RBL	No	42.7	33.5	45.7	40.6	36.7	38.5	45.2	40.1
7	RBL	No	38.9	36.1	41.9	39.0	40.7	26	40.7	35.8
8	RBL	No	44.1	31.4		37.8	24.5	39.9	30.7	31.7
9	RBL	No	38.6	31.1		34.9	39.2	31.7	39.2	36.7
10	RBL	No	46.3	38.5	46.6	43.8	30.2	26.5	44.9	33.9
11	RBL	No	36.5	24.9	32.7	31.4	35.1	27.9	35.8	32.9
12	RBL	No	34.9	35.1	37	35.7	35.5	25.7	34.4	31.9
13	RPI	Yes	37.7	32.8	35.4	35.3	39	42.4	33.7	38.4
14	RPI	Yes	40.7	42.8	48.7	44.1	41.8	30.9	31.1	34.6
15	RPI	Yes	33.4	33.8	31.5	32.9	37.2	39.1	39.9	38.7
16	RPI	Yes	40.8	28.1	35.5	34.8	38.6	33.8	39.3	37.2
17	RPI	No					30.5	38.9	37.8	35.7
18	RPI	No	44.6	35.4	44.4	41.5	31.6	36.8	29.6	32.7
19	RPI	No		35.9	42.4	39.2	43.8	26.2	36.5	35.5
20	RPI	No	31.7	28.3	40.9	33.6	32.1	34.9	35.2	34.1

21	RPI	No		41.7		41.7	41.5	32.1	47.2	40.3
22	RPI	No					43.5	41.8	39.9	41.7
23	RPI	No	23.3	41.7		32.5	37.1	32.6	26.1	31.9
24	RPI	No	39.7	27.7	33.3	33.6	38.9	33.7	41.4	38.0
25	RPU	Yes		37.7	50.4	44.1	45.6	43.2	27	38.6
26	RPU	Yes	41.3	30.2	37.1	36.2	30.1	32.4	28.8	30.4
27	RPU	Yes	46.2	46.6	41.8	44.9	34.5	41.5	35.1	37.0
28	RPU	Yes	41.5	27.2	43.2	37.3	42.4	35.4	38.4	38.7
29	RPU	No	40.4	36.5	42.6	39.8	48.3	42.8	45.3	45.5
30	RPU	No	39.4	36.1	44.1	39.9	44	39.1	35.4	39.5
31	RPU	No	50.6	43.6	52.4	48.9	39.7	47.1	38.1	41.6
32	RPU	No		37	54.8	45.9	36.2	45.3	52.1	44.5
33	RPU	No	36.7	45.9	44.3	42.3	44.1	30.9	43.8	39.6
34	RPU	No	44.2	44.7	34	41.0	37	46.4	34.6	39.3
35	RPU	No	40.4	33.6	43.9	39.3	45.4	31.9	43.3	40.2
36	RPU	No		46.6	35.3	41.0	48.5	39.8	52.5	46.9
37	RRE	Yes						28.9		28.9
38	RRE	Yes		30.7		30.7	31.6	26.7	31.7	30.0
39	RRE	Yes			40.2	40.2	38	27	31.4	32.1
40	RRE	Yes		45.1		45.1		31.5	44.9	38.2
41	RRE	No						33.4		33.4
42	RRE	No								
43	RRE	No		34.3		34.3	38	28.7	38.6	35.1
44	RRE	No								
45	RRE	No						28.5		28.5
46	RRE	No		37.5		37.5	32.8	38.8	25.9	32.5
47	RRE	No	34	27.6	39.2	33.6	28.7	32.4	34.3	31.8
48	RRE	Yes						29.9	23.6	26.8
49	RBR	Yes		40.2		40.2	32.8	31.7	40	34.8
50	RBR	Yes		41.6		41.6	26	32	40.9	33.0
51	RBR	Yes		34.8		34.8	39.1	29.6	34.8	34.5
52	RBR	No					29	29.2	40	32.7
53	RBR	No						32.3		32.3
54	RBR	No		34.4		34.4	34.9	28.8	38.7	34.1
55	RBR	No		27.3		27.3	34.2	32.4	38.4	35.0
56	RBR	No	39.9	35.7		37.8	30.5	37.6	36	34.7
57	RBR	No		33.2		33.2	34.3	27.7	34.7	32.2
58	RBR	No								
59	RBR	No	42.6	36.9		39.8	42.8	40.8	30.3	38.0
60	RBR	Yes		44.2		44.2	39.9	34.7	50.9	41.8
61	OGR	Yes	43.1	37.8	48.2	43.0	47.8	38.6	50.4	45.6
62	OGR	Yes	41.5	41.9	52.4	45.3	43.5	44.5	56.7	48.2
63	OGR	Yes					54.5	40.2	41.1	45.3
64	OGR	No	40.4	35.5	50.7	42.2	54.6	39.5	35.8	43.3
65	OGR	No	39.9	36.6	54.9	43.8	41.3	38.6	39.2	39.7

66	OGR	No	48.1	43.2	47.9	46.4	38.6	46.8	49	44.8
67	OGR	No					29.6	38.1	46.1	37.9
68	OGR	No	52.6	50.4	52.7	51.9	36.1	39	46	40.4
69	OGR	No	43.7	39.3	54.5	45.8	34.9	36.6	53.3	41.6
70	OGR	No					34.2	44.7	48.3	42.4
71	OGR	No	39.1	26.3		32.7	46.7	37.5	47.7	44.0
72	OGR	No					42	31.7	48.7	40.8
73	OOR	Yes	40.6	37.4	41.5	39.8	36.6	31.4	49.1	39.0
74	OOR	Yes	41.2	40.9	30.1	37.4	27.2	35.3	45.9	36.1
75	OOR	Yes	34.4	44.9	37.8	39.0	42.8	34.5	27	34.8
76	OOR	Yes		35.7	34.9	35.3	37.1	35.4		36.3
77	OOR	No	42.7	38.8	38.7	40.1	36.2	38.7	45.8	40.2
78	OOR	No	38	32.3	46.3	38.9	41.9	36.4	30.6	36.3
79	OOR	No	36.9	38.3	45.1	40.1	39.1	41.4	42.6	41.0
80	OOR	No	38.8	35.4	45.4	39.9	38.2	40.6	28.6	35.8
81	OOR	No	27.6	29.6	43.2	33.5	30	38.6	44.4	37.7
82	OOR	No	41	30.9	45	39.0	37.8	40.1	43.8	40.6
83	OOR	No	40.3	31.7	44.2	38.7	37.7	52.7	47.5	46.0
84	OOR	Yes					37.3	34.8	44.3	38.8
85	OYE	Yes	48.9	29.7	32.2	36.9	34.3	40.7	50.9	42.0
86	OYE	Yes	36.8	36.6	41.3	38.2	37.3	36.3	39.9	37.8
87	OYE	Yes	41.1	32.2	37	36.8	34.8	32.1	39.9	35.6
88	OYE	No	32.4	37.1	40	36.5	26	19.8	31.4	25.7
89	OYE	No	35.2	30.9	35.5	33.9	33.7	36.2	36.7	35.5
90	OYE	No	39.6	32.4		36.0	30.1	35.5	37.1	34.2
91	OYE	No	37	34.1	33.3	34.8	35	35	39.9	36.6
92	OYE	No	29.8	31.2	36.6	32.5	31	31.7	36.4	33.0
93	OYE	No	32.9	30.5	36.9	33.4	30.5	33.7	35.1	33.1
94	OYE	No					33.2	33.6	39.7	35.5
95	OYE	No	39.4	39.2	35.6	38.1	39.5	32.6	41.1	37.7
96	OYE	No	41.6	31.6		36.6	31.6	34.5	48	38.0
97	OBE	Yes		41.1	45.1	43.1	35.8	48.4	47.6	43.9
98	OBE	Yes	47.1	30	39.7	38.9	37	43.6	45.9	42.2
99	OBE	Yes	33.4	38.7	46.7	39.6	38.2	46.6	47	43.9
100	OBE	Yes	36.1		47.9	42.0	41.7	32.8	48.4	41.0
101	OBE	No					38.5	41.3	38.6	39.5
102	OBE	No	44.4	44.2	40.5	43.0	36.2	42.3	43.2	40.6
103	OBE	No	35.1		40.9	38.0	36.4	42.9	37.7	39.0
104	OBE	No	36.1	42.8		39.5	36.3	33	43.5	37.6
105	OBE	No	34.7		42.1	38.4		31	38.6	34.8
106	OBE	No	44.1	46.1		45.1	49.5	38.6	49.6	45.9
107	OBE	No		48.6		48.6	32.8	37.2	41.7	37.2
108	OBE	Yes	34.8	33	46.8	38.2	31.3	35.3	44.2	36.9
109	OPU	Yes	43.9	42.4	53.6	46.6	41	46	53.2	46.7
110	OPU	Yes	42.8	39.9	53.5	45.4	41	47.4	52.5	47.0

111	OPU	Yes	47.5	38.6	45.6	43.9	47.9	39.6	47.7	45.1
112	OPU	No	43.8	27.4	48.8	40.0	41.8	41.1	48	43.6
113	OPU	No	45.6	47.1	45.4	46.0	46.6	41.7	48	45.4
114	OPU	No	34.2	43.9	45.5	41.2	41.6	46.9	46.1	44.9
115	OPU	No	43.8	46.1	44.5	44.8	40.5	43.6	51.6	45.2
116	OPU	No	37.9	38	49.6	41.8	44.4	40.9	47.9	44.4
117	OPU	No	40.2	45.6		42.9	49.5	54.4	49.1	51.0
118	OPU	No	44.7	42.3	44.1	43.7	44.4	43.4	43.8	43.9
119	OPU	No	38.2	43.3	42.7	41.4	42	45.1	44.3	43.8
120	OPU	No	47.1	44	36.1	42.4	38	47.2	45.2	43.5
224	RBR	No		29.5		29.5	31.7	26.2	38.4	32.1
237	OGR	No	43.9	44.8	53	47.2	33.6	41	51.9	42.2
239	OYE	No					33.5	33.2	37.1	34.6

			3-6-2019				5-6-2019			
Sample	Code	Blank	Young 1	Young 2	Young 3	Average	Young 1	Young 2	Young 3	Average
1	RBL	Yes	50.4	39.1	44.5	44.7	30.5			30.5
2	RBL	Yes	37	44.2	41.5	40.9	27.0	24.8	29.5	27.1
3	RBL	Yes	34	36.7	35.4	35.4	30.3	29.0	24.9	28.1
4	RBL	Yes	37.6	36.6	37	37.1	34.5	33.5	34.5	34.2
5	RBL	No	35.6	24.3	38.9	32.9	24.8	23.1	23.5	23.8
6	RBL	No	32.8	36.9	30.5	33.4	32.2	30.3	31.8	31.4
7	RBL	No	37.5	30.7	34.9	34.4	31.2	31.2	29.2	30.5
8	RBL	No	29.2	28.8	35.6	31.2	32.1	37.5	27.6	32.4
9	RBL	No	25	33.7	30.6	29.8	19.4	23.3	25.4	22.7
10	RBL	No	33.2	29.6	40.1	34.3	30.9	30.7	32.9	31.5
11	RBL	No	36.3	39.5	31.9	35.9	16.3	18.2	16.0	16.8
12	RBL	No	23.9	28.7	25.8	26.1	19.5	25.0	21.2	21.9
13	RPI	Yes	37.7	38.5	39.5	38.6	34.8	35.3	33.2	34.4
14	RPI	Yes	40	46.1	45.2	43.8	43.8	26.2	25.2	31.7
15	RPI	Yes	36.4	28.1	36.4	33.6	32.8	33.1	33.2	33.0
16	RPI	Yes	27.5	32.6	32.5	30.9	30.5	36.3	32.5	33.1
17	RPI	No	36.1	32.3	38.1	35.5	37.2	25.0	32.6	31.6
18	RPI	No	32.2	32.4	33.4	32.7	28.7	30.2	27.4	28.8
19	RPI	No	25.1	27.8	25.7	26.2	34.2	32.1	32.5	32.9
20	RPI	No	33.3	35.8	32.9	34.0	26.1	33.5	27.4	29.0
21	RPI	No	37.3	42.2	37.3	38.9	31.2	31.2	32.7	31.7
22	RPI	No	35.2	37.1	32.8	35.0	27.1	27.2	23.5	25.9
23	RPI	No	25.6	26.2	25.7	25.8	24.1	26.3	26.5	25.6
24	RPI	No	34	40.6	36.2	36.9	28.2	32.1	27.1	29.1

25	RPU	Yes	38.1	41.9	35.5	38.5	30.0	28.1	31.3	29.8
26	RPU	Yes	33.9	33.1	35.3	34.1	31.5	32.4	30.6	31.5
27	RPU	Yes	34.8	40	39.9	38.2	31.1	31.6	34.0	32.2
28	RPU	Yes	48	47.3	43.7	46.3	28.0			28.0
29	RPU	No	38.1	45.5	41.8	41.8	34.5	26.0	22.4	27.6
30	RPU	No	42.4	37	34.3	37.9	30.9	30.8	32.5	31.4
31	RPU	No	52	40.4	41.6	44.7	28.0	20.3	31.0	26.4
32	RPU	No	41.6	42.4	39.5	41.2	35.1	24.4	26.1	28.5
33	RPU	No	26	28	29.2	27.7	32.8	27.2	30.2	30.1
34	RPU	No	35.2	44.7	36.3	38.7	28.7	31.5	32.3	30.8
35	RPU	No	31.3	30.3	32.3	31.3	29.9	34.0	29.3	31.1
36	RPU	No	44.4	39	30.9	38.1	33.4	41.7	36.0	37.0
37	RRE	Yes		32.4	33.7	33.1	35.4	29.6	36.8	33.9
38	RRE	Yes	36.7	31.6	41	36.4	45.1	24.8	30.4	33.4
39	RRE	Yes	39	32.1	38.7	36.6	27.1	28.4	32.7	29.4
40	RRE	Yes	32.2	34.9	40	35.7	34.0	38.5	33.5	35.3
41	RRE	No	25.9	32.3		29.1	34.6	32.6	30.3	32.5
42	RRE	No					31.0	27.0	28.1	28.7
43	RRE	No	41.2	36	31.3	36.2	29.2	27.3	27.6	28.0
44	RRE	No								
45	RRE	No	38.1	40.5	32	36.9	29.6	24.7	34.5	29.6
46	RRE	No	43.9	39.4	45.8	43.0	43.5	34.3	28.2	35.3
47	RRE	No	29.2	35.3	35.4	33.3	30.1	29.6	26.8	28.8
48	RRE	Yes	32.9	42.4	43.2	39.5	29.2	34.8	32.2	32.1
49	RBR	Yes	31.3	34	31	32.1	28.0	32.3	36.5	32.3
50	RBR	Yes	38.5	38.1	44.3	40.3	32.8	31.7	36.0	33.5
51	RBR	Yes	29.1	27.2	29.9	28.7	29.6	26.2	26.0	27.3
52	RBR	No	41.2	33.7	35.6	36.8	34.1	29.2	36.2	33.2
53	RBR	No	33.4	35.8	39.6	36.3	28.1	24.1	31.0	27.7
54	RBR	No	38.1	36.6	29.1	34.6	29.0	25.6	32.5	29.0
55	RBR	No	29.2	28.9	30.8	29.6				
56	RBR	No	35.6	33.7	36.7	35.3	28.6	30.6	30.3	29.8
57	RBR	No	29.2	37.6	36.2	34.3	29.7	32.8	36.4	33.0
58	RBR	No								
59	RBR	No	36.4	30.9	40.2	35.8	32.1	28.2	35.4	31.9
60	RBR	Yes	48.2	38.1	37.2	41.2	34.7	31.0	34.9	33.5
61	OGR	Yes	54.6	55.6	40.4	50.2	37.5	45.9	38.0	40.5
62	OGR	Yes	58.2	48.4	57.6	54.7	41.2	37.0	50.6	42.9
63	OGR	Yes	55.8	52.7	56.3	54.9	39.4	48.0	42.3	43.2
64	OGR	No	65.3	47.3	53.6	55.4	39.7	42.4	46.5	42.9
65	OGR	No	56.1	47.4	52.1	51.9	28.1	33.8	37.8	33.2
66	OGR	No	36.3	48	40.7	41.7	39.6	36.4	39.2	38.4
67	OGR	No	46.1	43.3	54.1	47.8	33.9	36.0	36.5	35.5
68	OGR	No	47.9	46.9	51.2	48.7	31.6	32.1	36.8	33.5
69	OGR	No	52.8	53.8	51.8	52.8	35.4	31.4	41.1	36.0

70	OGR	No	42.3	42.4	45.6	43.4	30.1	30.9	33.1	31.4
71	OGR	No	52.6	46.4	49.3	49.4	28.2	39.6	46.0	37.9
72	OGR	No	51.5	43.1	50.2	48.3	38.5	42.5	48.0	43.0
73	OOR	Yes	43.6	42.6	42.1	42.8	42.7	33.5	38.0	38.1
74	OOR	Yes	40.6	49.5	39.7	43.3	34.3	29.0	28.0	30.4
75	OOR	Yes	39.6	46.9	42.5	43.0	33.2	33.0	37.9	34.7
76	OOR	Yes	35.7	44.2	43.7	41.2	25.5	43.5	36.2	35.1
77	OOR	No	33.2	34.3	42.8	36.8	15.9	30.2	27.3	24.5
78	OOR	No	40.6	25.2	38.8	34.9	26.0	20.2	28.4	24.9
79	OOR	No	55.1	54.6	48	52.6	29.9	25.2	30.4	28.5
80	OOR	No	28.4	38	38.9	35.1	24.2	20.7	25.9	23.6
81	OOR	No	43.4	34.3	42.7	40.1	29.2	31.7	39.3	33.4
82	OOR	No	47.7	38.6	40.2	42.2	19.5	28.5	30.4	26.1
83	OOR	No	43.6	41.2	46.2	43.7	30.6	37.3	33.9	33.9
84	OOR	Yes	45.7	43.4	34.9	41.3	27.1	24.6	24.6	25.4
85	OYE	Yes	39.7	44	43.3	42.3	39.3	32.1	34.1	35.2
86	OYE	Yes	38.1	38.2	34.5	36.9	34.0	38.6	29.7	34.1
87	OYE	Yes	42.6	44.8	42.4	43.3	33.1	36.0	34.4	34.5
88	OYE	No	39.7	39.2	43.1	40.7	35.6	37.0	39.4	37.3
89	OYE	No	48.8	37.9	29.2	38.6	25.4	27.0	21.0	24.5
90	OYE	No	26.1	29.4	30.7	28.7				
91	OYE	No	37.6	33.7	29.4	33.6	28.6	27.0	30.0	28.5
92	OYE	No	32.8	41.2	34.1	36.0	22.4	33.1	30.9	28.8
93	OYE	No	34.8	39.8	37	37.2	27.7	39.7	31.3	32.9
94	OYE	No	28.7	28.6	30.2	29.2	23.6	24.5	30.6	26.2
95	OYE	No	28.7	32	36.5	32.4	27.9	29.6	26.2	27.9
96	OYE	No	39.4	30.5	35.4	35.1	25.8	24.5	26.5	25.6
97	OBE	Yes	36.2	52.1	42.1	43.5	44.2	44.0	44.1	44.1
98	OBE	Yes	28.1	46.3	30.6	35.0	50.3	51.6	44.9	48.9
99	OBE	Yes	40.8	52.6	39.3	44.2	41.4	38.5	46.9	42.3
100	OBE	Yes	34	47.6	43.1	41.6	41.4	39.5	43.4	41.4
101	OBE	No	41.8	41.9	35.6	39.8	35.1	35.3	38.2	36.2
102	OBE	No	28.7	31.2	30.6	30.2	23.0	28.6	34.5	28.7
103	OBE	No	25.6	40.5	41.6	35.9	31.9	29.6	30.0	30.5
104	OBE	No	39	39.4	37.3	38.6	33.6	29.8	26.9	30.1
105	OBE	No	34.3	45	41.1	40.1	37.4	33.8	41.1	37.4
106	OBE	No	42	43.9	36.9	40.9	37.4	29.2	47.7	38.1
107	OBE	No	37.6	41.8	40.2	39.9	30.3	41.7	35.8	35.9
108	OBE	Yes	34.2	47.8	45.9	42.6	31.1	38.5	39.4	36.3
109	OPU	Yes	45	52.4	53.6	50.3	40.1	40.8	49.6	43.5
110	OPU	Yes	46.8	47.9	55.1	49.9	38.2	36.3	40.1	38.2
111	OPU	Yes	47.7	45.5	51.5	48.2	40.7	35.9	45.1	40.6
112	OPU	No	59	58.6	45.9	54.5	28.3	46.9	50.3	41.8
113	OPU	No	36	47.9	46.6	43.5	42.4	33.2	37.7	37.8
114	OPU	No	44.9	43.7	50.2	46.3	32.0	37.8	35.9	35.2

115	OPU	No	52	45.3	42.7	46.7	37.8	38.3	38.8	38.3
116	OPU	No	44.8	42.5	50.4	45.9	34.6	33.7	36.9	35.1
117	OPU	No	45.8	50.6	41.7	46.0	34.0	42.3	45.0	40.4
118	OPU	No	40.2	35.7	43.2	39.7	25.5	38.0	29.4	31.0
119	OPU	No	40.7	48.6	44.9	44.7	39.3	29.3	28.3	32.3
120	OPU	No	40.4	43.5	40.6	41.5	31.6	37.1	27.4	32.0
224	RBR	No	32.4	34.3	42	36.2	27.8	26.9	25.7	26.8
237	OGR	No	52.6	50	43.2	48.6	36.3	29.0	41.9	35.7
239	OYE	No	42.2	35.1	40.7	39.3	21.2	29.7	27.2	26.0

			7-6-2019				10-6-2019			
Sample	Code	Blank	Young 1	Young 2	Young 3	Average	Young 1	Young 2	Young 3	Average
1	RBL	Yes	36.7	35.2		36.0	24.0			24.0
2	RBL	Yes	30.4	31.5	25.6	29.2	27.3	26.0	31.6	28.3
3	RBL	Yes	25.0	29.6	30.0	28.2	24.1	26.4	26.5	25.7
4	RBL	Yes	29.8	31.3	27.5	29.5	29.4	24.2	28.1	27.2
5	RBL	No	32.3	24.1	23.5	26.6	29.3	29.3	24.3	27.6
6	RBL	No	37.8	30.9	37.1	35.3	31.7	32.6	28.9	31.1
7	RBL	No	28.0	24.0	33.7	28.6	25.3	29.4	29.2	28.0
8	RBL	No	24.4	24.2	22.4	23.7	29.9	27.6	25.5	27.7
9	RBL	No	30.5	28.8	28.3	29.2	24.3	28.1	23.8	25.4
10	RBL	No	30.2	34.8	29.7	31.6	30.0	20.8	24.7	25.2
11	RBL	No	20.4	18.1		19.3	39.8	18.9		29.4
12	RBL	No	21.1	35.1	25.9	27.4	28.3	23.1	25.2	25.5
13	RPI	Yes	27.7	24.9	29.0	27.2	28.7	28.7	26.7	28.0
14	RPI	Yes	23.1	24.9	22.8	23.6	33.8	31.9	28.5	31.4
15	RPI	Yes	26.1	32.8	34.7	31.2	30.4	27.6	25.3	27.8
16	RPI	Yes	27.5	32.4	25.9	28.6	25.2	25.9	29.5	26.9
17	RPI	No	28.3	20.9	26.7	25.3	26.7	33.3	28.5	29.5
18	RPI	No	21.2	26.5	29.5	25.7	22.1	24.4	22.4	23.0
19	RPI	No	32.4	29.4	23.5	28.4	28.3	29.9	27.9	28.7
20	RPI	No	24.6	26.1	26.4	25.7	26.7	22.1	26.5	25.1
21	RPI	No	27.3	28.8	24.4	26.8	28.9	24.1	20.5	24.5
22	RPI	No	34.8	28.4	27.9	30.4	22.9	25.1	22.5	23.5
23	RPI	No	33.9	30.6	21.3	28.6	26.9	28.4	22.8	26.0
24	RPI	No	26.2	30.6	25.9	27.6	26.7	28.9	29.1	28.2

25	RPU	Yes	23.7	29.1	31.6	28.1	26.9	25.8	29.0	27.2
26	RPU	Yes	35.8	23.8	30.8	30.1	25.0	28.4	27.1	26.8
27	RPU	Yes	33.9	33.1	31.9	33.0	26.9	31.2	29.3	29.1
28	RPU	Yes	28.8	27.2		28.0	30.8	25.4	30.5	28.9
29	RPU	No	31.9	28.3	38.6	32.9	30.6	25.7	23.0	26.4
30	RPU	No	33.8	33.4	28.4	31.9	31.3	25.0	27.7	28.0
31	RPU	No	24.8	21.1	28.6	24.8	28.7	20.7	27.6	25.7
32	RPU	No	22.9	18.9	18.5	20.1	21.8	31.2	34.8	29.3
33	RPU	No	34.7	31.3	28.4	31.5	23.7	28.4	27.5	26.5
34	RPU	No	29.1	23.6	30.9	27.9	29.9	26.6	20.0	25.5
35	RPU	No	34.4	27.3	32.0	31.2	31.5	26.4	27.4	28.4
36	RPU	No	39.1	32.3	38.0	36.5	26.5	33.7	34.2	31.5
37	RRE	Yes	25.9	29.7	34.7	30.1	29.6	33.0	26.6	29.7
38	RRE	Yes	26.1	20.6	39.0	28.6	31.7	22.8	31.3	28.6
39	RRE	Yes	21.8	26.1	33.0	27.0	20.5	22.3	29.5	24.1
40	RRE	Yes	35.3	25.4	25.7	28.8	31.2	35.1	25.4	30.6
41	RRE	No	29.2	27.4	27.7	28.1	33.4	22.4	30.5	28.8
42	RRE	No	20.2	19.7	31.6	23.8	23.2	24.4	20.5	22.7
43	RRE	No	24.4	26.3	25.8	25.5	28.8	30.0	27.5	28.8
44	RRE	No								#DIV/0!
45	RRE	No	31.1	23.2	34.7	29.7	31.9	25.0	26.1	27.7
46	RRE	No	30.0	25.1	37.3	30.8	34.7	29.7	24.4	29.6
47	RRE	No	23.7	22.5	22.1	22.8	25.1	20.9	24.6	23.5
48	RRE	Yes	35.8	31.7	39.3	35.6	36.8	27.8	21.3	28.6
49	RBR	Yes	22.1	28.6	22.1	24.3	23.0	23.6	22.5	23.0
50	RBR	Yes	31.4	25.6	23.3	26.8	26.0	30.1	25.9	27.3
51	RBR	Yes	25.8	23.5	22.5	23.9	22.1	25.6	23.8	23.8
52	RBR	No	24.9	24.2	30.7	26.6	26.4	25.4	2.6	18.1
53	RBR	No	21.9	24.1	25.9	24.0	26.6	27.1	22.0	25.2
54	RBR	No	22.4	20.0	19.2	20.5	20.0	20.4	19.5	20.0
55	RBR	No								
56	RBR	No	26.3	25.0	25.4	25.6	25.5	23.3	29.4	26.1
57	RBR	No	28.1	27.4	25.2	26.9	23.9	20.9	22.4	22.4
58	RBR	No								
59	RBR	No	19.7	21.4	26.0	22.4	23.4	23.2	20.3	22.3
60	RBR	Yes	30.2	32.4	27.5	30.0	27.1	25.8	21.9	24.9
61	OGR	Yes	47.9	40.0	52.6	46.8	46.0	37.6	52.6	45.4
62	OGR	Yes	32.2	33.6	45.9	37.2	39.5	34.5	50.6	41.5
63	OGR	Yes	41.6	42.6	47.4	43.9	45.9	35.9	53.6	45.1
64	OGR	No	37.1	29.0	46.7	37.6	42.5	40.2	55.4	46.0
65	OGR	No	35.3	27.1	24.9	29.1	40.1	33.7	40.8	38.2
66	OGR	No	39.5	24.6	40.0	34.7	35.9	35.1	31.2	34.1
67	OGR	No	31.0	33.6	40.7	35.1	41.3	26.3	33.4	33.7
68	OGR	No	38.3	28.1	35.3	33.9	40.2	32.7	45.1	39.3
69	OGR	No	42.3	30.8	40.9	38.0	38.8	35.9	40.8	38.5

70	OGR	No	37.1	33.8	38.8	36.6	34.6	33.5	40.9	36.3
71	OGR	No	33.9	33.5	46.2	37.9	39.7	33.1	44.4	39.1
72	OGR	No	41.2	42.3	49.9	44.5	40.5	48.3	46.3	45.0
73	OOR	Yes	33.7	24.6	47.2	35.2	38.2	36.3	42.5	39.0
74	OOR	Yes	28.7	39.7	29.3	32.6	34.3	39.5	33.7	35.8
75	OOR	Yes	31.9	32.5	42.7	35.7	32.8	35.1	37.4	35.1
76	OOR	Yes	37.7	44.2	42.4	41.4	36.1	52.1	43.0	43.7
77	OOR	No	26.1	34.2	31.8	30.7	41.6	37.8	40.3	39.9
78	OOR	No	31.3	19.8	26.3	25.8	35.3	34.3	28.0	32.5
79	OOR	No	21.2			21.2	18.0			18.0
80	OOR	No	18.0	33.0	25.1	25.4	30.2	31.0	39.7	33.6
81	OOR	No	36.3	21.6	34.1	30.7	33.2	26.3	40.8	33.4
82	OOR	No	32.7	27.3	34.3	31.4	32.5	22.5	31.1	28.7
83	OOR	No	38.3	30.0	38.1	35.5	31.2	45.6	32.3	36.4
84	OOR	Yes	35.6	25.6	37.4	32.9	40.9	29.6	41.0	37.2
85	OYE	Yes	32.9	30.1	33.3	32.1	33.2	36.0	39.6	36.3
86	OYE	Yes	43.8	43.8	30.5	39.4	40.5	32.6	30.8	34.6
87	OYE	Yes	28.7	34.8	36.9	33.5	32.8	29.4	36.4	32.9
88	OYE	No	34.8	30.0	40.2	35.0	34.4	39.4	41.1	38.3
89	OYE	No	33.4	20.8	31.7	28.6	29.3	24.6	26.8	26.9
90	OYE	No								
91	OYE	No	34.7	26.2	26.7	29.2	34.6	28.7	30.5	31.3
92	OYE	No	33.1	28.3	32.3	31.2	32.6	24.5	21.4	26.2
93	OYE	No	23.8	37.7	26.5	29.3	28.4	39.7	31.4	33.2
94	OYE	No	30.3	23.6	30.2	28.0	24.3	28.1	34.1	28.8
95	OYE	No	37.8	28.4	31.0	32.4	28.9	20.8	30.5	26.7
96	OYE	No	21.7	24.5	21.4	22.5	26.4	27.4	23.5	25.8
97	OBE	Yes	39.3	46.6	44.8	43.6	42.5	47.0	48.1	45.9
98	OBE	Yes	21.4	35.6	38.9	32.0	40.4	31.2	53.2	41.6
99	OBE	Yes	45.1	38.5	38.7	40.8	41.2	35.1	30.9	35.7
100	OBE	Yes	39.6	43.5	45.8	43.0	56.7	47.6	40.9	48.4
101	OBE	No	30.8	31.1	40.3	34.1	35.5	32.2	35.0	34.2
102	OBE	No	38.9	33.9	27.7	33.5	32.2	34.6	30.2	32.3
103	OBE	No	29.2	33.1	33.0	31.8	37.0	36.5	28.5	34.0
104	OBE	No	34.0	38.5	32.2	34.9	39.5	37.5	23.6	33.5
105	OBE	No	31.1	33.3	27.5	30.6	34.8	28.5	30.7	31.3
106	OBE	No	25.2	25.9	30.1	27.1	30.0	38.0	40.9	36.3
107	OBE	No	26.2	37.0	33.0	32.1	34.6	37.9	36.1	36.2
108	OBE	Yes	19.2	32.4	28.9	26.8	35.6	30.0	36.8	34.1
109	OPU	Yes	44.9	38.5	47.6	43.7	42.4	37.6	48.0	42.7
110	OPU	Yes	38.0	34.7	41.2	38.0	37.4	36.1	44.6	39.4
111	OPU	Yes	38.8	35.0	49.8	41.2	34.5	41.7	47.2	41.1
112	OPU	No	26.1	20.0		23.1	28.8			28.8
113	OPU	No	39.2	33.7	39.7	37.5	44.0	37.1	37.9	39.7
114	OPU	No	37.7	29.4	31.6	32.9	36.8	33.3	51.1	40.4

115	OPU	No	43.8	37.8	44.1	41.9	40.7	51.4	37.2	43.1
116	OPU	No	41.2	36.6	39.4	39.1	21.3	35.6	36.7	31.2
117	OPU	No	40.9	40.0	41.4	40.8	41.4	37.7	42.6	40.6
118	OPU	No	36.4	26.9	38.7	34.0	12.6	27.3	45.3	28.4
119	OPU	No	17.3	35.3	26.1	26.2	37.1	34.5	37.0	36.2
120	OPU	No	39.0	21.1	33.8	31.3	42.9	34.4	26.0	34.4
224	RBR	No	27.5	21.1	19.8	22.8	24.4	24.0	20.3	22.9
237	OGR	No	30.2	34.2	37.3	33.9	45.4	35.3	31.9	37.5
239	OYE	No	30.5	25.6	31.6	29.2	26.3	26.9	27.4	26.9
121	UBE	Yes	28.4	40.6		34.5	31.5	40.1		35.8
122	UBE	Yes	34.1	28.3	36	32.8	32.5	38.9	44.1	38.5
123	UBE	Yes	18			18.0	25.7			25.7
124	UBE	Yes	36	27.9		32.0	25	18.8	34.8	26.2
125	UBE	No					10.7			10.7
126	UBE	No	9.4			9.4	9.6			9.6
127	UBE	No	10.1	9		9.6	9.2	5.4		7.3
128	UBE	No	11.7			11.7	11.3			11.3
130	UBE	No	10.4			10.4	10.2			10.2
131	UBE	No	14.2	7.3		10.8	13	6		9.5
134	UUR	Yes	38.4			38.4	24.5	20.5		22.5
135	UOR	Yes	30.8	40.5		35.7	20.6	28		24.3
136	UOR	Yes	28.1	23.5		25.8	25.6	23.1		24.4
138	UOR	No					6.5			6.5
142	UOR	No	9	5	7.2	7.1	6.8	8.3		7.6
145	UGR	Yes	33.2			33.2	25.8	35.8		30.8
146	UGR	Yes	34.1	31.8		33.0	31.5	29.7	36.8	32.7
147	UGR	Yes	20.4			20.4				
148	UGR	Yes	17.2	20.9		19.1	28.7	20.3		24.5
149	UGR	No	9.7	6.5		8.1	9.3	8.3		8.8
150	UGR	No	12.1			12.1	15.6			15.6
151	UGR	No								
152	UGR	No	15.2			15.2	13.7	8.1		10.9
154	UGR	No	10.9			10.9	13.4			13.4
156	UGR	Yes	12.7			12.7	19	9.8		14.4
157	UPI	No	32.2			32.2	29	26.5		27.8
161	UPI	No	5			5.0	7.8			7.8
165	UPI	Yes	12.6			12.6	12			12.0
169	UBL	Yes	23.1			23.1	21.4			21.4
170	UBL	Yes	38.5	33.4	42	38.0	38	20.5	28	28.8
172	UBL	No	30.1	39.5	37.3	35.6	39.7	34.7	40.7	38.4
175	UBL	No	7.1			7.1	8.3			8.3
189	URE	Yes	13.5			13.5	13.1			13.1
193	UPU	Yes	32.9	41.9	42	38.9	45.2	42	40.5	42.6
194	UPU	Yes	36.4			36.4	34.5	42.3		38.4

196	UPU	No	43.3	24.8		34.1	36.2	44.8		40.5
199	UPU	No	10.8			10.8	13.2	7.8		10.5
200	UPU	Yes	15.6			15.6	14			14.0
205	UYE	Yes	7.1			7.1	17.5			17.5
206	UYE	Yes	19.7			19.7	18.7			18.7
207	UYE	Yes	16	12.9		14.5	16.5			16.5
208	UYE	No	35.5	26.1	40.8	34.1	38.8	28.7	18.9	28.8
210	UYE	No	13.1	5		9.1	13.2	6.5		9.9
211	UYE	No	12.3			12.3	11.9			11.9
212	UYE	No	10.8			10.8	8.9			8.9
214	UYE	No	14.7			14.7	7.5			7.5
215	UYE	No	13.4			13.4	13.1			13.1
216	UYE	Yes					10.1			10.1
217	UGR	Yes	27	32.8		29.9	21.5	28.5	21.7	23.9
219	UBL	No	39.7	28.2		34.0	42.6	29	25.3	32.3
221	UOR	No	9.4			9.4	10.2	9.2		9.7
222	UPU	No	3.9			3.9	6.8			6.8
223	UOR	No	10.3			10.3	10.7	5.4		8.1
228	UBL	Yes	13			13.0	13.3			13.3
229	UPU	Yes	45.4	23		34.2	39.1	31.3		35.2
230	UGR	Yes	32.7			32.7	22.3			22.3
232	UGR	Yes	32.4	28.1		30.3	26.1	34		30.1

					12-6-2019		14-6-2019			
Sample	Code	Blank	Young 1	Young 2	Young 3	Average	Young 1	Young 2	Young 3	Average
1	RBL	Yes	31.4	28.6	27.1	29.0	34.6	29.8	35.6	33.3
2	RBL	Yes	22.8	23.3	29.5	25.2	25.5	32.4	25.9	27.9
3	RBL	Yes	25.6	30.7	28.2	28.2	27.5	25.8	25.7	26.3
4	RBL	Yes	28.7	34	33.2	32.0	28.7	28.5	33.3	30.2
5	RBL	No	30.1	26.4	24.9	27.1	21.9	23.7	26.8	24.1
6	RBL	No	24.7	29.5	22.9	25.7	34	27.5	25	28.8
7	RBL	No	28.5	28.5	24.6	27.2	20.4	22.8	23.9	22.4
8	RBL	No	33.6	18.4	24.5	25.5	19	24.5	20.6	21.4
9	RBL	No	23.2	28.4	23	24.9	23	21.3	25	23.1
10	RBL	No	26	24	30.7	26.9	32.9	25.7	22.9	27.2
11	RBL	No	30.7	25.6	20.6	25.6	22.2	28.5	30.7	27.1
12	RBL	No	22.5	26.2	25.4	24.7	20.5	25.3	20.4	22.1
13	RPI	Yes	30.6	33.5	30.8	31.6	29.8	32.7	30.5	31.0
14	RPI	Yes	23.9	22.7	25.3	24.0	16.1	24.2	23.5	21.3
15	RPI	Yes	24.6	27.7	31.6	28.0	23.4	24.5	27.8	25.2
16	RPI	Yes	30	28.4	28.5	29.0	29.2	24.2	23.5	25.6
17	RPI	No	18	26.6	24.5	23.0	27.6	26.7	20.5	24.9
18	RPI	No	24.1	23	24.6	23.9	23.3	25.2	19.4	22.6

19	RPI	No	28.5	27.8	29.3	28.5	25.9	25.5	24.2	25.2
20	RPI	No	23.8	22.3	24.8	23.6	21.9	24.3	21.4	22.5
21	RPI	No	27.7	24.8	20.9	24.5	28.2	27.2	28.3	27.9
22	RPI	No	28.5	25.4	24.5	26.1	25.4	19.2	19.7	21.4
23	RPI	No	25.3	25	25.2	25.2	21	22.7	25.2	23.0
24	RPI	No	26.1	27.7	30.9	28.2	23.4	23.3	28.3	25.0
25	RPU	Yes	25.7	29.6	28.5	27.9	22.5	24.6	26.6	24.6
26	RPU	Yes	33.5	31.9	31.7	32.4	31.8	22.1	35.9	29.9
27	RPU	Yes	29.5	31.4	27.6	29.5	24.2	27.2	30.7	27.4
28	RPU	Yes	32.7	23.7	27.6	28.0	26.2	18.9	28.1	24.4
29	RPU	No	26.2	31	26.6	27.9	30.7	23.8	27.7	27.4
30	RPU	No	28.9	23.8	28.3	27.0	29.2	26.2	25	26.8
31	RPU	No	30.7	23.9	30.7	28.4	29.4	22	21.5	24.3
32	RPU	No	33.9	31.6	38.6	34.7	24.6	24.2	28.7	25.8
33	RPU	No	29	24.3	36.7	30.0	23.6	30.6	28.9	27.7
34	RPU	No	25.7	30.6	21.5	25.9	22.6	32	26.1	26.9
35	RPU	No	27	29.5	28.8	28.4	26.4	24.2	26.3	25.6
36	RPU	No	34.3	28.7	33.3	32.1	30.5	25.8	30.8	29.0
37	RRE	Yes	30.1	28.9	25.7	28.2	24.8	35.5	32.1	30.8
38	RRE	Yes	31.4	25.1	35.6	30.7	20.6	32.4	33.5	28.8
39	RRE	Yes	23.2	29.2	25.6	26.0	20.8	28.4	25.1	24.8
40	RRE	Yes	35.9	29.2	29.4	31.5	30.8	27.7	38.5	32.3
41	RRE	No	29	28.2	33.5	30.2	27.9	31.6	31.2	30.2
42	RRE	No	24.2	25.9	27.5	25.9	28.3	32.1	29.7	30.0
43	RRE	No	32.1	28.9	33.5	31.5	21.7	21.6	19.7	21.0
44	RRE	No				0.0				0.0
45	RRE	No	26.7	31.8	32.4	30.3	25.9	30.5	38.5	31.6
46	RRE	No	35	32.1	35.9	34.3	18.7	25.7	35.1	26.5
47	RRE	No	20.3	26.1	26.7	24.4	26.1	28.7	30.5	28.4
48	RRE	Yes	37.3	20.7	35.3	31.1	37.9	40.7	39.6	39.4
49	RBR	Yes	24.7	23.9	23.7	24.1	23.9	25.2	22.8	24.0
50	RBR	Yes	28.6	24.5	30.5	27.9	27.9	28.7	26.3	27.6
51	RBR	Yes	32.3	24.3	25.6	27.4	26.7	26.5	24.2	25.8
52	RBR	No	28.1	25.5	25.6	26.4	20.6	25.5	26.7	24.3
53	RBR	No	22.7	28.1	24.9	25.2	28.7	27.9	27.9	28.2
54	RBR	No	22.5	25.9	23.5	24.0	17.9	28.2	21.5	22.5
55	RBR	No				0.0				0.0
56	RBR	No	28.1	29.9	20.4	26.1	29.2	28.8	23.7	27.2
57	RBR	No	16.7	22	27.8	22.2	21.9	21.5	24.5	22.6
58	RBR	No				0.0				0.0
59	RBR	No	24	26.3	26.7	25.7	27.8	23.3	22.5	24.5
60	RBR	Yes	24.1	23.3	26.4	24.6	24	26.3	22.8	24.4
61	OGR	Yes	27.2	30.3	26.9	28.1	29.5	32.1	24.5	28.7
62	OGR	Yes	51	38.6	55.9	48.5				
63	OGR	Yes	35.6	48	43.6	42.4				

64	OGR	No	39.9	47.1	48.9	45.3				
65	OGR	No	34.9	46.9	41.7	41.2				
66	OGR	No	45.5	32.9	35.9	38.1				
67	OGR	No	26.7	38.9	38	34.5				
68	OGR	No	47.1	38.6	30.8	38.8				
69	OGR	No	40	26.8	24	30.3				
70	OGR	No	37.4	42.1	37.2	38.9				
71	OGR	No	40.3	33.4	34.9	36.2				
72	OGR	No	47.3	47.9	45.6	46.9				
73	OOR	Yes	47	45	40.1	44.0				
74	OOR	Yes	39.1	39.1	48.7	42.3				
75	OOR	Yes	34	39.2	44.4	39.2				
76	OOR	Yes	35.1	33.6	47.7	38.8				
77	OOR	No	37.9	44.1	34.9	39.0				
78	OOR	No	34.9	38.7	29.3	34.3				
79	OOR	No	26.4	35	27.1	29.5				
80	OOR	No	36.1	20.3		18.8				
81	OOR	No	33	32.4	40.2	35.2				
82	OOR	No	40.2	32.4	30.9	34.5				
83	OOR	No	22.3	24.8	35.7	27.6				
84	OOR	Yes	37.7	36.1	36	36.6				
85	OYE	Yes	34.8	31.4	40.5	35.6				
86	OYE	Yes	34.2	40.8	30.6	35.2				
87	OYE	Yes	40.1	35	31.6	35.6				
88	OYE	No	35.4	36	40.9	37.4				
89	OYE	No	37.9	33.6	38.9	36.8				
90	OYE	No	25.5	30.7	31.9	29.4				
91	OYE	No				0.0				
92	OYE	No	30.4	28.1	27.8	28.8				
93	OYE	No	28.4	30.6	31.3	30.1				
94	OYE	No	33.2	37.3	32.8	34.4				
95	OYE	No	29.3	32.6	35.6	32.5				
96	OYE	No	29.2	23.4	35.3	29.3				
97	OBE	Yes	26	28.6	30.6	28.4				
98	OBE	Yes	49.4	43.4	44.5	45.8				
99	OBE	Yes	33.7	42.4	42.8	39.6				
100	OBE	Yes	43.9	35.2	39.4	39.5				
101	OBE	No	28	43	44.4	38.5				
102	OBE	No	30.8	35.4	38.2	34.8				
103	OBE	No	26.5	18.5	37.5	27.5				
104	OBE	No	20.5	33.5	35.3	29.8				
105	OBE	No	35.7	33.5	38.6	35.9				
106	OBE	No	37.9	32.1	28	32.7				
107	OBE	No	36.2	38.1	39.3	37.9				
108	OBE	Yes	35.4	28.9	25.7	30.0				

109	OPU	Yes	22.8	35.4	38	32.1				
110	OPU	Yes	31.9	46.6	37.8	38.8				
111	OPU	Yes	41.2	38.4	36.9	38.8				
112	OPU	No	32.8	42.7	43.3	39.6				
113	OPU	No	34.8			11.6				
114	OPU	No	39	41.7	28.6	36.4				
115	OPU	No	32.6	38.7	38.9	36.7				
116	OPU	No	41.3	38.9	35.1	38.4				
117	OPU	No	44.2	39.4	40.5	41.4				
118	OPU	No	33.3	40.9	43.7	39.3				
119	OPU	No	30.6	35.9	40.1	35.5				
120	OPU	No	36.6	39.4	40.1	38.7				
224	RBR	No	42.1	30.2	33.3	35.2				
237	OGR	No	49.6	39.3	44.2	44.4				
239	OYE	No	26.5	22.7	26	25.1				
121	UBE	Yes	36.5	44			38.7	38.9		
122	UBE	Yes	37.7	20.5	39.8		35.3	32	37.8	
123	UBE	Yes	30.6				31.5	31		
124	UBE	Yes	35.4	28.5	36.2		33.4	34.9	36.9	
125	UBE	No								
126	UBE	No	11.8				11			
127	UBE	No	11.5							
128	UBE	No	12.9							
130	UBE	No	9.7							
131	UBE	No	11.3	8.9			15.1	8.9		
134	UUR	Yes	30.6	30.7	26.4		34.3	33.5	28.5	
135	UOR	Yes	39.5	28.4			30.4	30.5		
136	UOR	Yes	30.6	30.9			28.5	24	31.2	
138	UOR	No	7.1							
142	UOR	No	6	5			8.3	5.3		
145	UGR	Yes	28.6	40.4			33.9	38.7		
146	UGR	Yes	40.1	29.3	35.9		41.2	36.2	37.2	
147	UGR	Yes								
148	UGR	Yes	40.2	24.7	39.6		31.9	28.6	37.7	
149	UGR	No	14.8				8.9			
150	UGR	No	14.3				9			
151	UGR	No								
152	UGR	No	15.8	8.9			15	6.5		
154	UGR	No	13.7				12.7			
156	UGR	Yes	11.3	9.7			16.3	9.1		
157	UPI	No	27.8	38.6			38.1	32.3		
161	UPI	No								
165	UPI	Yes	12.9				11			
169	UBL	Yes	9.5				13.2	23.1		

170	UBL	Yes	41.5	28	29		41.6	26.3	41.9	
172	UBL	No	42.4	25.3	32.6		36.1	33.3	39.5	
175	UBL	No	9.7							
189	URE	Yes	11.7				9.7			
193	UPU	Yes	43.1	42.2	38.2		41.9	42.9	43.8	
194	UPU	Yes	44.8	38.4	28.9		33.3	45.1	30.2	
196	UPU	No	38.1	40.6			37.8	43.5	43.4	
199	UPU	No	14	7.5			13.9			
200	UPU	Yes	13.8				7.4			
205	UYE	Yes	20.2				10.6			
206	UYE	Yes	5.4							
207	UYE	Yes	14.7				17.1			
208	UYE	No	39.4	29.5	28		40.7	33.7	40	
210	UYE	No	13.8	5.4			12.3			
211	UYE	No	11.5				12.1			
212	UYE	No	7.1				9.5			
214	UYE	No	18.1				15.3			
215	UYE	No	13.4				14.1			
216	UYE	Yes	8.9							
217	UGR	Yes	30.2	30.9	26.7		32.5	30.7	27.8	
219	UBL	No	34.3	43.9	37.6		31.6	43.6		
221	UOR	No	5.7	9.8			5.5	9.1		
222	UPU	No	8.4							
223	UOR	No	11.8				10.5			
228	UBL	Yes	12.3				12.5			
229	UPU	Yes	32.6	37.4			46.3	37.5		
230	UGR	Yes	33.1	38.9			25.2	41.1		
232	UGR	Yes	32.5	34.1			34.4	35.6		

					17-6-2019		21-6-2019			
Sample	Code	Blank	Young 1	Young 2	Young 3	Average	Young 1	Young 2	Young 3	Average
1	RBL	Yes	29.2	30	31.7	30.3	28.3	24.8	24.5	25.9
2	RBL	Yes	39.6	28.7	25.9	31.4	23	28.5	27.5	26.3
3	RBL	Yes	30.7	25.1	27.6	27.8	20.2	28.1	27.6	25.3
4	RBL	Yes	33.2	37.5	35.6	35.4	27.4	38.8	30.9	32.4
5	RBL	No	28.8	25.7	25.8	26.8	15.7	18.6	26.3	20.2
6	RBL	No	30.2	28.8	25.4	28.1	29.5	21.7	30.5	27.2
7	RBL	No	33.6	24.5	33.5	30.5	15.5	25.8	17.5	19.6
8	RBL	No	22.4	22.1	21.9	22.1	30.3	20.9	21.4	24.2
9	RBL	No	24.8	23.1	24.5	24.1	23.5	22.7	30.4	25.5
10	RBL	No	24.5	20.4	24.5	23.1	34.3	19.3	26.9	26.8
11	RBL	No	32.2	22.9	27.8	27.6	22.8	30.2	29.3	27.4
12	RBL	No	26.4	20.9	20.4	22.6	19.7	20.7	15.9	18.8

13	RPI	Yes	31.2	28	27.7	29.0	30.3	27.6	32.2	30.0
14	RPI	Yes	21.5	23.4	19.8	21.6	19.6	23.8	19.6	21.0
15	RPI	Yes	21.2	27	23.4	23.9	20.8	30.4	27.1	26.1
16	RPI	Yes	26.6	26.7	28.5	27.3	27.6	27.1	25.9	26.9
17	RPI	No	25.4	26.4	20	23.9	27	19.5	23.8	23.4
18	RPI	No	22.1	18.9	23.6	21.5	23.5	24.9	21	23.1
19	RPI	No	29.8	24.7	22.7	25.7	15	30.3	22.9	22.7
20	RPI	No	21.4	18.9	18.9	19.7	22.6	22.9	20.2	21.9
21	RPI	No	27.7	29.5	27.6	28.3	25.5	20.8	25.1	23.8
22	RPI	No	18.9	25	21.3	21.7	26.4	26.3	23.4	25.4
23	RPI	No	20.7	24.4	21.7	22.3	24.9	23.2	20.3	22.8
24	RPI	No	29.2	24	24.2	25.8	24.9	25.2	28.1	26.1
25	RPU	Yes	27.3	26.9	23.9	26.0	26.1	25.2	22	24.4
26	RPU	Yes	27.7	34	31.9	31.2	25.5	29.9	28.4	27.9
27	RPU	Yes	32	28.8	29.4	30.1	18.4	30	29.9	26.1
28	RPU	Yes	23.8	21.6	28.5	24.6	24.4	25.6	29.8	26.6
29	RPU	No	26.5	19.5	25.3	23.8	19.3	18.3	21.6	19.7
30	RPU	No	29.5	28.3	30.3	29.4	29.3	25	27.1	27.1
31	RPU	No	22.3	25.3	23.6	23.7	27.2	21.2	24.5	24.3
32	RPU	No	32.1	24.1	28.5	28.2	22	25.1	25.8	24.3
33	RPU	No	17.1	24.1	24.1	21.8	19.9	22.8	25.1	22.6
34	RPU	No	21	28.7	22.1	23.9	30.5	22.8	24.4	25.9
35	RPU	No	25	26.1	25.2	25.4	29.2	29	22.5	26.9
36	RPU	No	33.2	32.3	22.7	29.4	24.9	28.4	30.5	27.9
37	RRE	Yes	37.3	24.1	26.2	29.2	23.9	25.7	39.4	29.7
38	RRE	Yes	34	32.8	36.8	34.5	24.9	40.5	28.3	31.2
39	RRE	Yes	29.6	26.6	27.9	28.0	28.5	30.6	30.6	29.9
40	RRE	Yes	24.2	26.2	32	27.5	24	35.2	33.2	30.8
41	RRE	No	24.9	25.5	28.6	26.3	27.3	29.3	24.7	27.1
42	RRE	No	30	25.1	33.3	29.5	35	24.6	27.2	28.9
43	RRE	No	21.8	20.6	19.7	20.7	21.1	22	22.4	21.8
44	RRE	No				0.0				0.0
45	RRE	No	26.1	30.4	25.8	27.4	23.7	25.3	20.2	23.1
46	RRE	No	27.3	18.2	27.5	24.3	20.6	20.3	25	22.0
47	RRE	No	24.5	24.8	25.7	25.0	22.8	30.5	25.1	26.1
48	RRE	Yes	38.5	37.7	38.9	38.4	33.4	38.6	38.4	36.8
49	RBR	Yes	22.5	21.7	20.9	21.7	21.6	22.2	25.6	23.1
50	RBR	Yes	26.1	25	24.8	25.3	28.8	25.1	27.9	27.3
51	RBR	Yes	19.5	20.8	19.5	19.9	22	22.2	23.5	22.6
52	RBR	No	21.6	21.5	26.3	23.1	26	24	24.7	24.9
53	RBR	No	25.3	20.5	19.8	21.9	23.6	24.2	25.3	24.4
54	RBR	No	25.2	20.1	24.1	23.1	20	21.7	21.1	20.9
55	RBR	No				0.0				0.0
56	RBR	No	26.1	27.2	23	25.4	25.3	28.8	24	26.0
57	RBR	No	19.5	30.4	28.5	26.1	27.3	22.9	25.4	25.2

58	RBR	No				0.0				0.0
59	RBR	No	26.9	21.5	22.9	23.8	21.3	30.5	26.4	26.1
60	RBR	Yes	25	21	19.8	21.9	26.8	24.5	30.8	27.4
61	OGR	Yes	18.2	21.3	30.6	23.4				
62	OGR	Yes								
63	OGR	Yes								
64	OGR	No								
65	OGR	No								
66	OGR	No								
67	OGR	No								
68	OGR	No								
69	OGR	No								
70	OGR	No								
71	OGR	No								
72	OGR	No								
73	OOR	Yes								
74	OOR	Yes								
75	OOR	Yes								
76	OOR	Yes								
77	OOR	No								
78	OOR	No								
79	OOR	No								
80	OOR	No								
81	OOR	No								
82	OOR	No								
83	OOR	No								
84	OOR	Yes								
85	OYE	Yes								
86	OYE	Yes								
87	OYE	Yes								
88	OYE	No								
89	OYE	No								
90	OYE	No								
91	OYE	No								
92	OYE	No								
93	OYE	No								
94	OYE	No								
95	OYE	No								
96	OYE	No								
97	OBE	Yes								
98	OBE	Yes								
99	OBE	Yes								
100	OBE	Yes								
101	OBE	No								
102	OBE	No								

103	OBE	No								
104	OBE	No								
105	OBE	No								
106	OBE	No								
107	OBE	No								
108	OBE	Yes								
109	OPU	Yes								
110	OPU	Yes								
111	OPU	Yes								
112	OPU	No								
113	OPU	No								
114	OPU	No								
115	OPU	No								
116	OPU	No								
117	OPU	No								
118	OPU	No								
119	OPU	No								
120	OPU	No								
224	RBR	No					22	21.2	21.8	21.7
237	OGR	No								
239	OYE	No								
121	UBE	Yes	40.2	31.5	34.5					
122	UBE	Yes	31	28.7	37					
123	UBE	Yes	30.1	38.6						
124	UBE	Yes	35.4	36.2	33.1					
125	UBE	No								
126	UBE	No								
127	UBE	No	8.9							
128	UBE	No								
130	UBE	No								
131	UBE	No	13.1	5.9						
134	UUR	Yes	34.5	36.4	28.9					
135	UOR	Yes	27.4	35.1	36.1					
136	UOR	Yes	30.7	32.1	32					
138	UOR	No								
142	UOR	No	5.4							
145	UGR	Yes	26.6	27.3	41.1					
146	UGR	Yes	36.7	35.3	41.8					
147	UGR	Yes								
148	UGR	Yes	31.7	38.4	35					
149	UGR	No	9.4							
150	UGR	No								
151	UGR	No	9.7							
152	UGR	No	14.5							

154	UGR	No	10.2							
156	UGR	Yes	18	5.4						
157	UPI	No	35.8	37.5	28.9					
161	UPI	No								
165	UPI	Yes	8.9							
169	UBL	Yes	30.6							
170	UBL	Yes	26.4	25.4	25.2					
172	UBL	No								
175	UBL	No								
189	URE	Yes	5.8							
193	UPU	Yes	44.7	30.8	42.7					
194	UPU	Yes	40	35.4						
196	UPU	No	30.6	38.8	44.8					
199	UPU	No	13.1							
200	UPU	Yes	6.5							
205	UYE	Yes								
206	UYE	Yes								
207	UYE	Yes	12.2							
208	UYE	No	39.6	37.4	37.5					
210	UYE	No	10.9							
211	UYE	No	8.5							
212	UYE	No	5.5							
214	UYE	No	12.3							
215	UYE	No	8.9							
216	UYE	Yes								
217	UGR	Yes	36.6	36	25.7					
219	UBL	No	34.5	33.1	35.7					
221	UOR	No	5.4	8.8						
222	UPU	No								
223	UOR	No	10.5							
228	UBL	Yes	9.6							
229	UPU	Yes	35.4	31.5						
230	UGR	Yes	30.1	35.4						
232	UGR	Yes	36	36.4						

8.5 T-tests two-tailed equal variance: ratio above to belowground biomass of soybean

Below is a table around the significance of the ratio of above to belowground biomass in between control and experimental soybean groups and in between light regimes.

Ratio aboveground to belowground biomass soybean	**Two-tailed equal variance t-test (p=0.05)**
Between control/ experimental of first destruction	0.89
Between control/ experimental of second destruction	0.25
Between experimental of High and Low light first destruction	0.99
Between control of High and Low light first destruction	0.16
Between experimental of High and Low light second destruction	**0.01**
Between control of High and Low light second destruction	0.13

8.6 Dry weight Soybean, both destructions

Dry weight Soy bean						
Plant Sample	**FeHBED**	**Light condition**	**Harvest**	**Aboveground biomass (gram)**	**Belowground biomass (gram)**	**Ratio Aboveground to Belowground**
1	No	High	1	0,5703	0,203	2,809359606
6	No	High	1	0,4692	0,283	1,65795053
8	No	High	1	0,3715	0,1701	2,184009406
10	No	High	1	0,6473	0,2067	3,131591679
13	No	High	1	0,3925	0,1351	2,905255366
14	No	High	1	0,6352	0,2414	2,631317316
29	No	Low	1	0,3119	0,1176	2,652210884
30	No	Low	1	0,3673	0,2003	1,833749376
34	No	Low	1	0,4709	0,1702	2,766745006
38	No	Low	1	0,3655	0,1177	3,105352591
40	No	Low	1	0,5086	0,237	2,145991561
41	No	Low	1	0,5176	0,1858	2,785791173
16	Yes	High	1	0,6743	0,3089	2,18290709
19	Yes	High	1	0,7615	0,2885	2,639514731
22	Yes	High	1	0,6738	0,237	2,843037975
24	Yes	High	1	0,6437	0,3153	2,041547732
26	Yes	High	1	0,587	0,2517	2,332141438
27	Yes	High	1	0,5645	0,216	2,613425926
44	Yes	Low	1	0,6622	0,2382	2,780016793
45	Yes	Low	1	0,5365	0,1831	2,930092845
46	Yes	Low	1	0,6647	0,27	2,461851852
50	Yes	Low	1	0,5568	0,2051	2,714773281
51	Yes	Low	1	0,8613	0,2791	3,085990684
53	Yes	Low	1	0,5023	0,2216	2,266696751
2	No	High	2	1,3474	0,4146	3,249879402
3	No	High	2	0,9817	0,3232	3,037438119
4	No	High	2	1,151	0,362	3,179558011
5	No	High	2	1,5549	0,3682	4,222976643
7	No	High	2	0,6369	0,2017	3,157659891
9	No	High	2	0,4987	0,1396	3,57234957
11	No	High	2	1,184	0,3497	3,385759222
12	No	High	2	0,9539	0,3722	2,562869425
31	No	Low	2	0,89	0,222	4,009009009
32	No	Low	2	1,0992	0,2898	3,792960663
33	No	Low	2	1,0427	0,228	4,573245614
35	No	Low	2	0,9169	0,2301	3,984789222
36	No	Low	2	0,8179	0,2676	3,056427504
37	No	Low	2	0,7712	0,2072	3,722007722
39	No	Low	2	1,097	0,2639	4,156877605
42	No	Low	2	1,0615	0,2318	4,579378775
15	Yes	High	2	0,9436	0,3217	2,933167547
17	Yes	High	2	1,4178	0,5967	2,376068376
18	Yes	High	2	1,6339	0,4558	3,584686266
20	Yes	High	2	1,3435	0,4048	3,318922925
21	Yes	High	2	1,3193	0,3899	3,383688125
23	Yes	High	2	1,5017	0,4455	3,370819304
25	Yes	High	2	1,6566	0,5263	3,147634429
28	Yes	High	2	1,3359	0,4351	3,07032866
43	Yes	Low	2	1,2702	0,5138	2,472168159
47	Yes	Low	2	0,8996	0,246	3,656910569
48	Yes	Low	2	1,0091	0,2424	4,162953795
49	Yes	Low	2	1,0882	0,2376	4,57996633
52	Yes	Low	2	1,073	0,2745	3,908925319
54	Yes	Low	2	1,0243	0,4042	2,534141514
55	Yes	Low	2	0,9104	0,2548	3,57299843
56	Yes	Low	2	0,9006	0,2178	4,134986226

8.7 Dry weight Screening Grass seed varieties

Dry weight above and belowground biomass screening varieties

Sample	Fe added	Aboveground weight (g)	Belowground weight (g)	Ratio above to belowground biomass
1 RBL	Yes	0.601	1.018	0.590
2 RBL	Yes	1.391	0.603	2.306
3 RBL	Yes	1.689	1.247	1.354
4 RBL	Yes	1.707	1.176	1.451
5 RBL	No	1.833	0.764	2.399
6 RBL	No	1.854	1.340	1.383
7 RBL	No	1.903	0.844	2.254
8 RBL	No	1.945	1.427	1.363
9 RBL	No	1.931	1.038	1.860
10 RBL	No	2.022	1.233	1.640
11 RBL	No	0.582	0.703	0.829
12 RBL	No	1.395	1.581	0.882
13 RPI	Yes	1.247	3.093	0.403
14 RPI	Yes	0.654	1.184	0.553
15 RPI	Yes	1.404	3.008	0.467
16 RPI	Yes	1.647	2.142	0.769
17 RPI	No	1.207	2.795	0.432
18 RPI	No	1.456	2.016	0.722
19 RPI	No	0.990	1.934	0.512
20 RPI	No	1.475	2.465	0.598
21 RPI	No	1.611	2.378	0.678
22 RPI	No	1.328	1.929	0.688
23 RPI	No	1.457	2.139	0.681
24 RPI	No	1.469	1.583	0.928
25 RPU	Yes	1.574	2.152	0.731
26 RPU	Yes	1.563	3.137	0.498
27 RPU	Yes	2.162	2.762	0.783
28 RPU	Yes	0.698	0.931	0.751
29 RPU	No	1.099	2.686	0.409
30 RPU	No	1.675	4.105	0.408
31 RPU	No	1.007	2.388	0.422
32 RPU	No	0.777	0.909	0.855
33 RPU	No	1.227	2.106	0.583
34 RPU	No	1.460	3.150	0.463
35 RPU	No	1.280	2.515	0.509
36 RPU	No	1.521	1.586	0.959
37 RRE	Yes	0.912	0.442	2.062

38 RRE	Yes	1.394	1.227	1.136
39 RRE	Yes	1.630	1.365	1.194
40 RRE	Yes	1.735	1.757	0.987
41 RRE	No	1.335	1.159	1.152
42 RRE	No	1.021	0.725	1.409
43 RRE	No	1.540	1.054	1.461
45 RRE	No	1.238	1.083	1.143
46 RRE	No	1.471	1.099	1.339
47 RRE	No	1.829	1.870	0.978
48 RRE	No	1.122	0.987	1.137
49 RBR	Yes	1.221	2.353	0.519
50 RBR	Yes	1.272	3.046	0.418
51 RBR	Yes	1.490	4.664	0.320
52 RBR	Yes	1.129	2.334	0.484
53 RBR	No	1.293	3.573	0.362
54 RBR	No	1.193	3.598	0.332
55 RBR	No	0.254	0.643	0.395
56 RBR	No	1.410	4.468	0.316
57 RBR	No	0.949	2.036	0.466
59 RBR	No	0.887	2.882	0.308
60 RBR	No	1.324	6.317	0.210
224 RBR	No	1.011	3.863	0.262
61 OGR	Yes	0.760	1.428	0.533
62 OGR	Yes	0.737	2.166	0.340
63 OGR	Yes	0.757	2.435	0.311
64 OGR	Yes	0.726	2.423	0.300
65 OGR	No	0.620	2.290	0.271
66 OGR	No	0.802	2.409	0.333
67 OGR	No	0.648	2.175	0.298
68 OGR	No	0.574	2.208	0.260
69 OGR	No	0.446	2.190	0.204
70 OGR	No	0.854	2.602	0.328
71 OGR	No	0.705	1.812	0.389
72 OGR	No	0.606	2.026	0.299
237 OGR	No	0.910	2.864	0.318
73 OOR	Yes	0.490	1.278	0.383
74 OOR	Yes	1.050	2.047	0.513
75 OOR	Yes	0.980	2.691	0.364
76 OOR	Yes	0.499	1.562	0.319
77 OOR	No	0.700	1.680	0.417
78 OOR	No	0.695	1.313	0.529
80 OOR	No	0.959	1.187	0.808
81 OOR	No	0.564	1.251	0.451

82 OOR	No	0.484	1.201	0.403
83 OOR	No	1.103	2.749	0.401
84 OOR	No	0.614	1.708	0.359
85 OYE	Yes	0.954	1.907	0.500
86 OYE	Yes	0.761	1.883	0.404
87 OYE	Yes	0.751	1.739	0.432
88 OYE	Yes	0.812	1.767	0.460
89 OYE	No	0.879	1.317	0.668
90 OYE	No	0.183	0.204	0.898
91 OYE	No	0.526	0.830	0.633
92 OYE	No	0.754	1.579	0.478
93 OYE	No	0.987	2.742	0.360
94 OYE	No	0.655	1.017	0.644
95 OYE	No	0.785	0.982	0.800
96 OYE	No	0.900	1.844	0.488
239 OYE	No	1.053	2.266	0.465
97 OBE	Yes	0.663	3.057	0.217
98 OBE	Yes	0.615	2.273	0.271
99 OBE	Yes	0.667	2.337	0.285
100 OBE	Yes	0.373	2.711	0.138
101 OBE	No	0.643	1.623	0.396
102 OBE	No	0.215	0.914	0.235
103 OBE	No	0.552	1.765	0.313
104 OBE	No	0.610	1.494	0.408
105 OBE	No	0.563	1.508	0.373
106 OBE	No	0.283	0.896	0.315
107 OBE	No	0.691	1.880	0.367
109 OPU	Yes	1.061	2.472	0.429
110 OPU	Yes	0.934	1.646	0.567
111 OPU	Yes	0.781	3.126	0.250
112 OPU	Yes	0.149	0.753	0.198
113 OPU	No	1.016	2.421	0.420
114 OPU	No	1.005	2.478	0.406

115 OPU	No	0.691	2.492	0.277
116 OPU	No	1.031	1.775	0.581
117 OPU	No	0.793	1.631	0.487
118 OPU	No	0.703	1.898	0.371
119 OPU	No	0.871	2.326	0.375
120 OPU	No	1.023	1.535	0.666
121 UBE	Yes	0.089	0.251	0.354
122 UBE	Yes	0.160	0.518	0.309
123 UBE	Yes	0.094	0.091	1.031
124 UBE	Yes	0.089	0.184	0.487
127 UBE	No	0.017	0.013	1.248
131 UBE	No	0.015	0.019	0.781
134 UOR	Yes	0.070	0.129	0.544
135 UOR	Yes	0.083	0.168	0.491
136 UOR	Yes	0.063	0.122	0.514
139 UOR	No	0.010	0.008	1.276
142 UOR	No	0.022	0.015	1.469
221 UOR	No	0.014	0.017	0.804
223 UOR	No	0.014	0.016	0.877
145 UGR	Yes	0.076	0.351	0.217
146 UGR	Yes	0.094	0.255	0.370
148 UGR	Yes	0.071	0.305	0.232
217 UGR	Yes	0.076	0.196	0.388
230 UGR	Yes	0.042	0.146	0.286
232 UGR	Yes	0.057	0.103	0.554

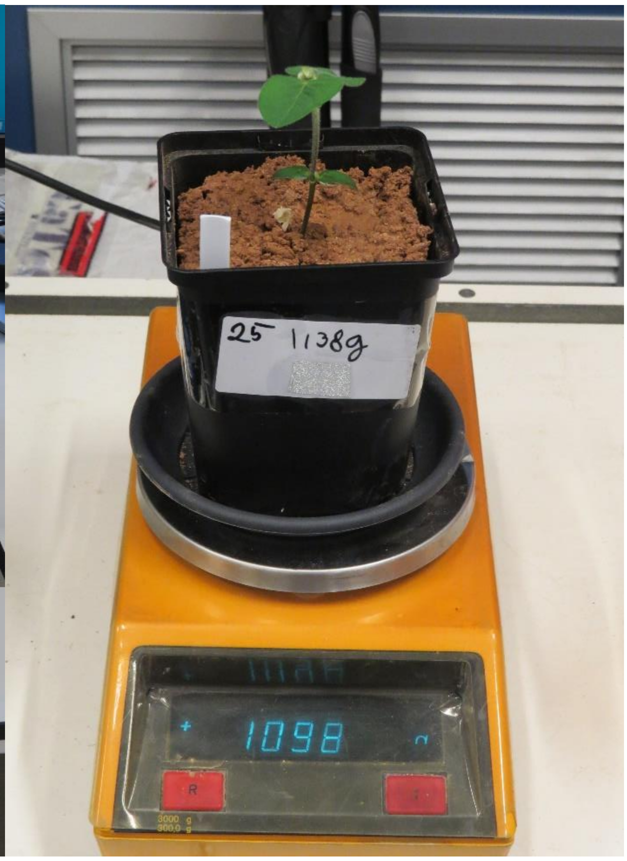
149 UGR	No	0.013	0.015	0.860
151 UGR	No	0.011	0.015	0.693
152 UGR	No	0.015	0.027	0.542
154 UGR	No	0.011	0.014	0.754
156 UGR	No	0.014	0.023	0.631
157 UPI	Yes	0.062	0.103	0.608
165 UPI	No	0.012	0.012	1.017
169 UBL	Yes	0.027	0.061	0.452
170 UBL	Yes	0.104	0.224	0.464
172 UBL	Yes	0.151	0.385	0.391
219 UBL	Yes	0.091	0.138	0.660
228 UBL	No	0.013	0.017	0.796
185 URE	No	0.007	0.012	0.617
189 URE	No	0.014	0.021	0.668
193 UPU	Yes	0.112	0.385	0.291
194 UPU	Yes	0.045	0.127	0.353
196 UPU	Yes	0.103	0.202	0.511
229 UPU	Yes	0.056	0.307	0.182
198 UPU	No	0.007	0.018	0.394
199 UPU	No	0.013	0.018	0.747
200 UPU	No	0.012	0.015	0.760
204 UPU	No	0.009	0.013	0.679
222 UPU	No	0.009	0.021	0.434
205 UYE	Yes	0.023	0.015	1.468
207 UYE	Yes	0.021	0.012	1.669
208 UYE	Yes	0.127	0.579	0.219

210 UYE	No	0.012	0.018	0.659
211 UYE	No	0.008	0.014	0.584
212 UYE	No	0.009	0.014	0.625
214 UYE	No	0.005	0.013	0.411
215 UYE	No	0.015	0.017	0.895

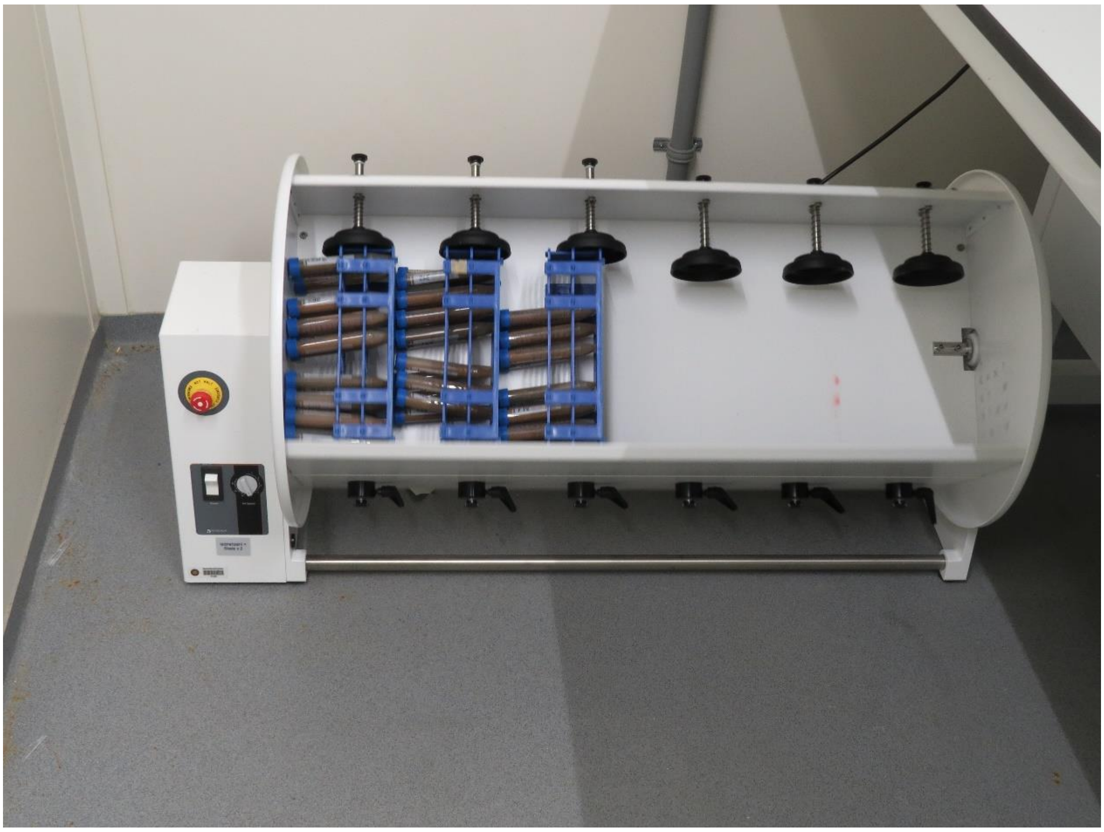
8.8 Equipment used in the lab

The pictures beneath show the different types of equipment that was used for the experiments and analyses.

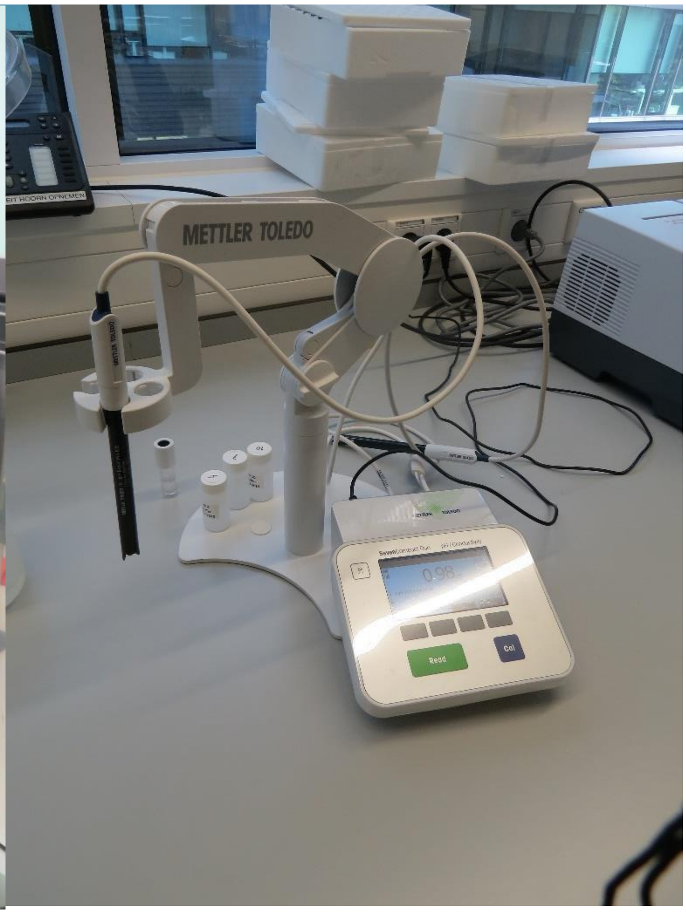
A: Mettler Toledo scale 1/10000 gram precision



B: Water measurement scale 1/1 gram precision

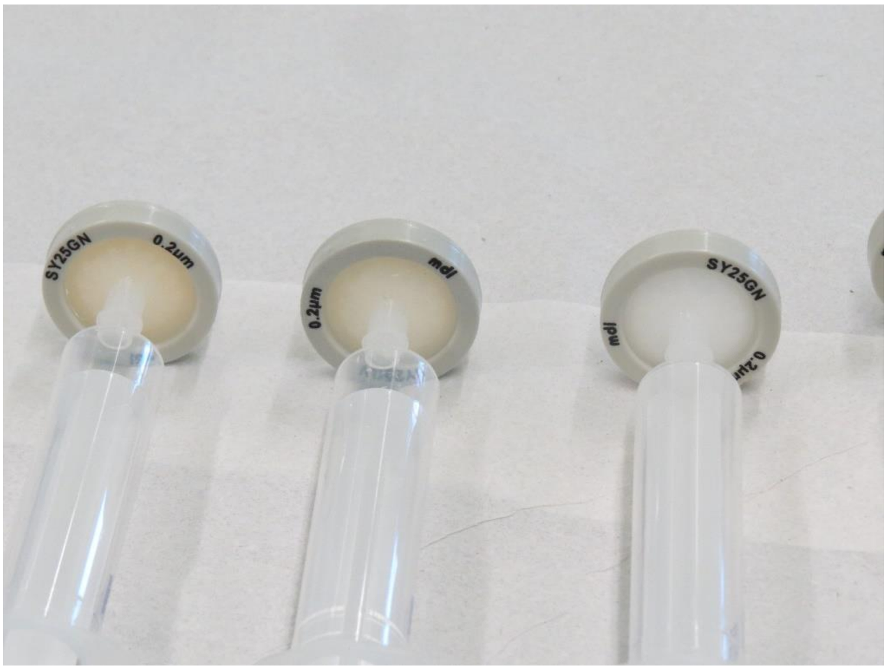


C: End over end shaker used in testing Revised Fe Binding Assay



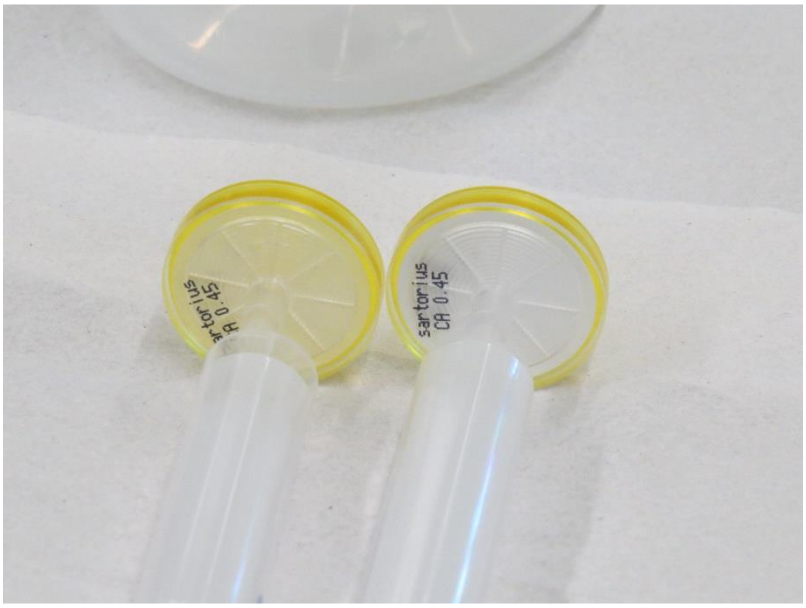
D: Oven used at 70 degrees for drying and Fe binding assay

E: pH-meter used in all experiments



F: Gray SY25GN 0,2um filter used as a standard for the Revised Fe Binding Assay tests

G: Blue SY25NN 0,2um Nylon-66 Modi filter used as a variant to standard filter

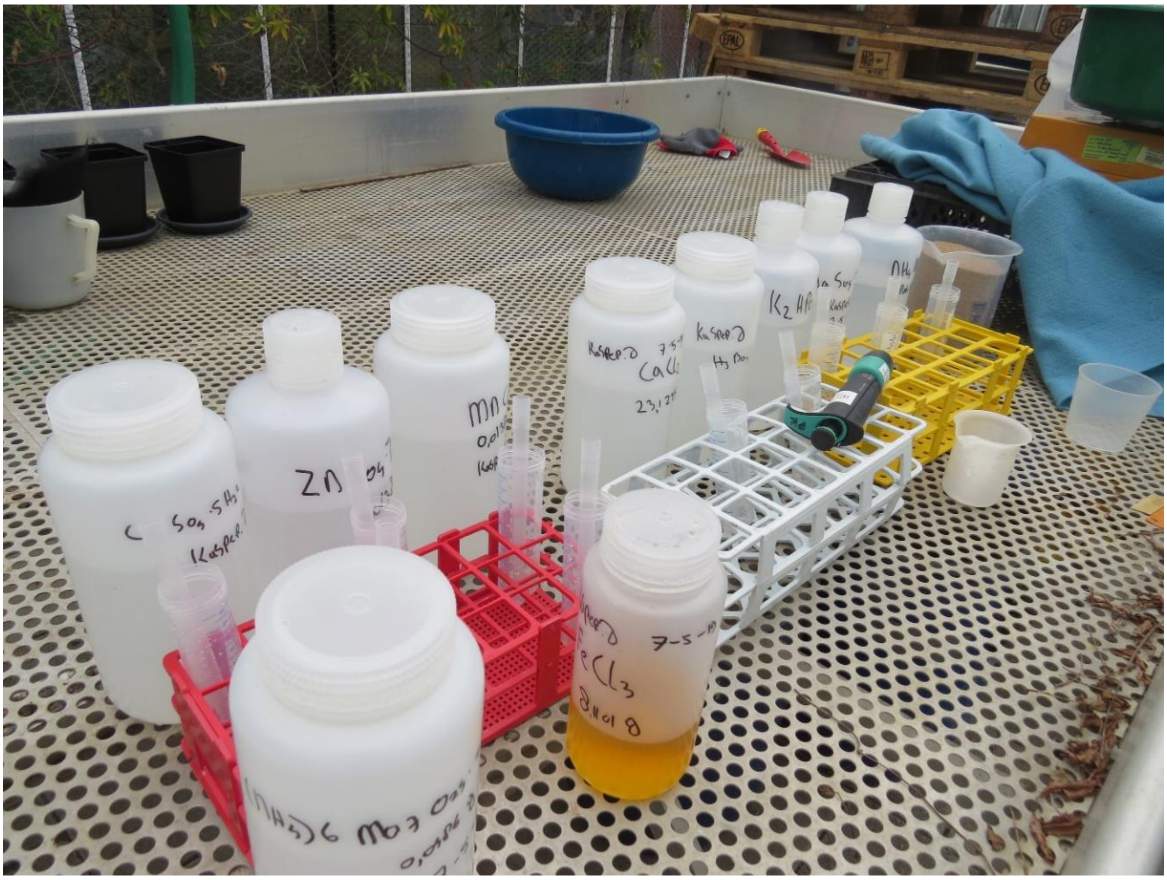


H: Yellow Sartorius Ca 0,45 um filter used as a variant to standard filter

8.9 Soil preparation

The following pictures were taken during the preparation of the soil and pots for the screening experiment.

A: Eco-style AZ-kalk which used for buffering of soil



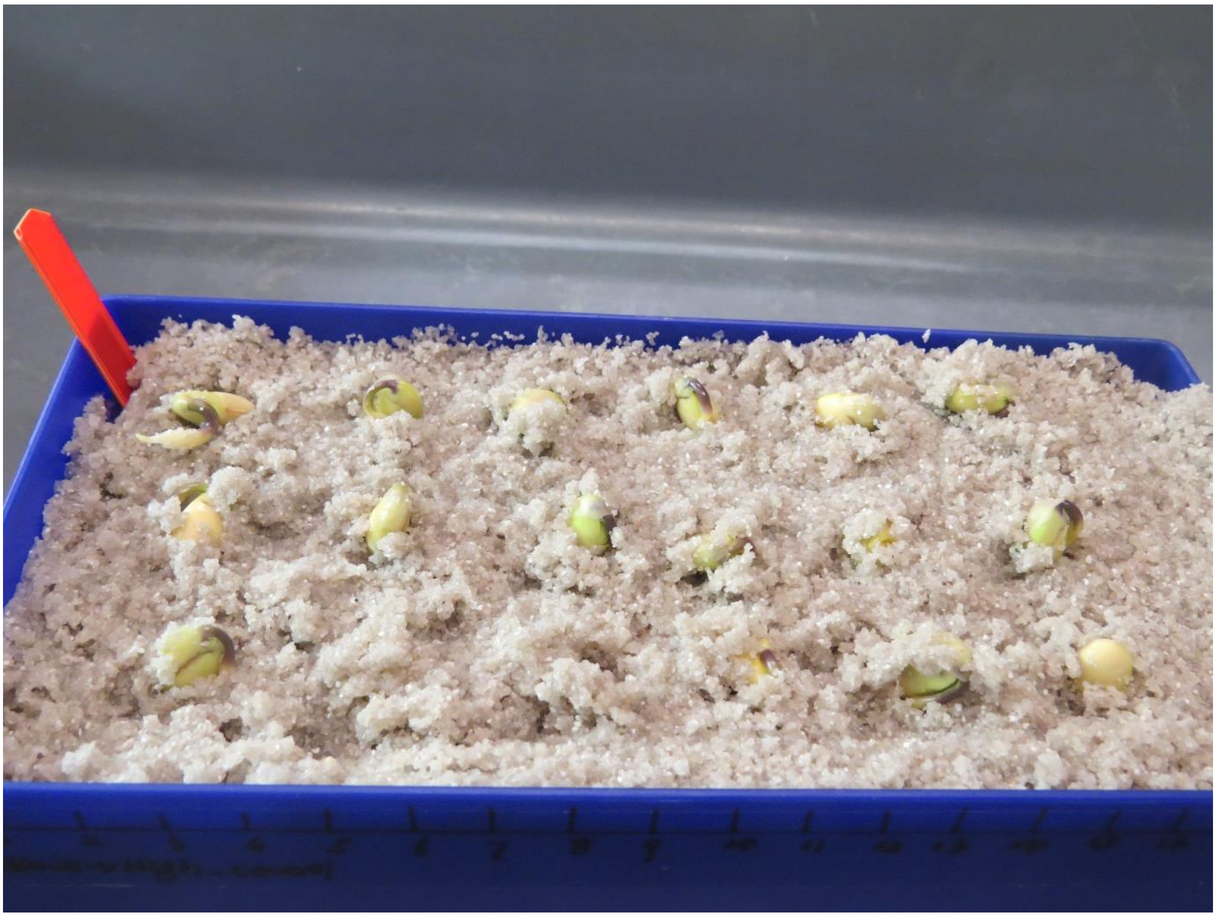
B: Set-up of nutrients added to the soil of each pot.

C: Quartz sand from Germany used as main soil component and weighing set-up

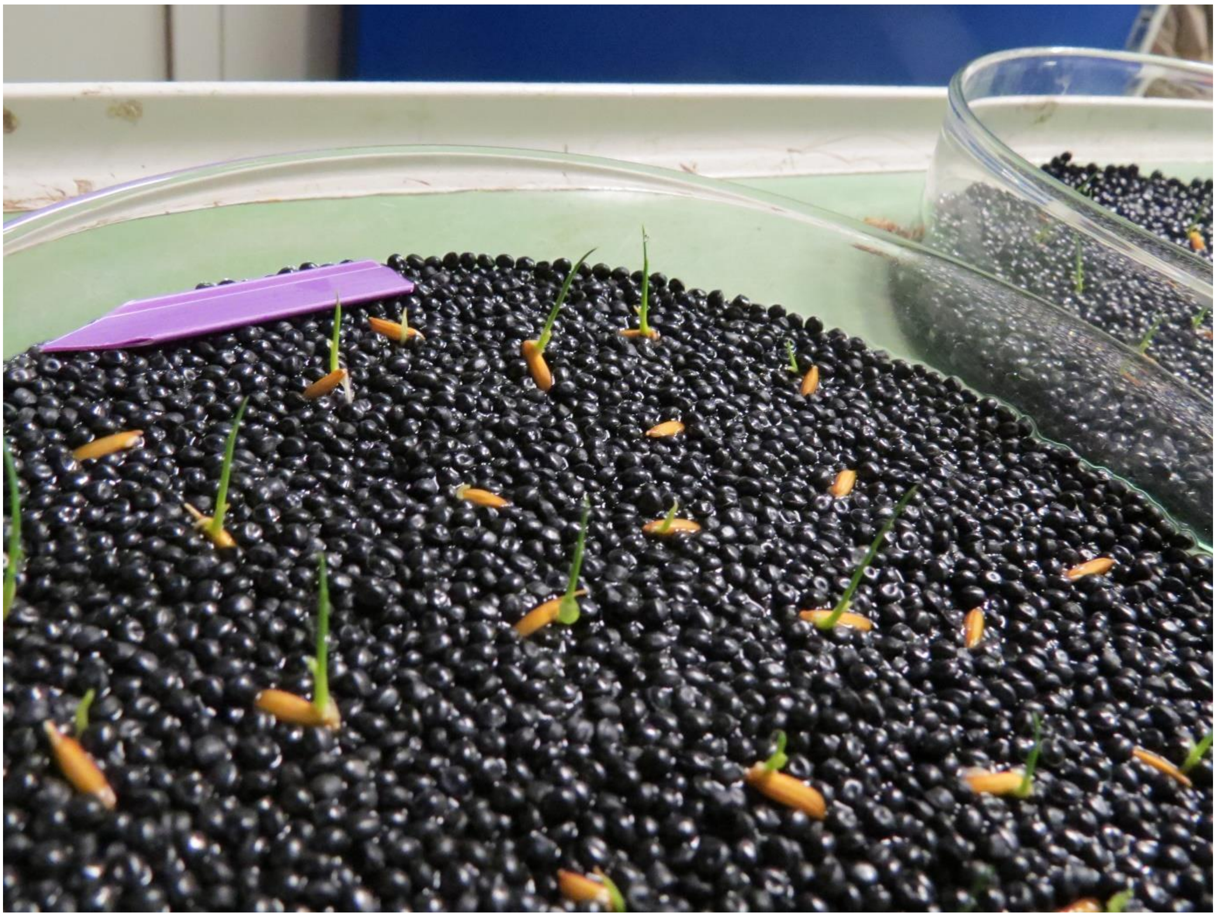
D: Finished pot with its unique code and starting weight

8.10 Seed germination and transfer phase

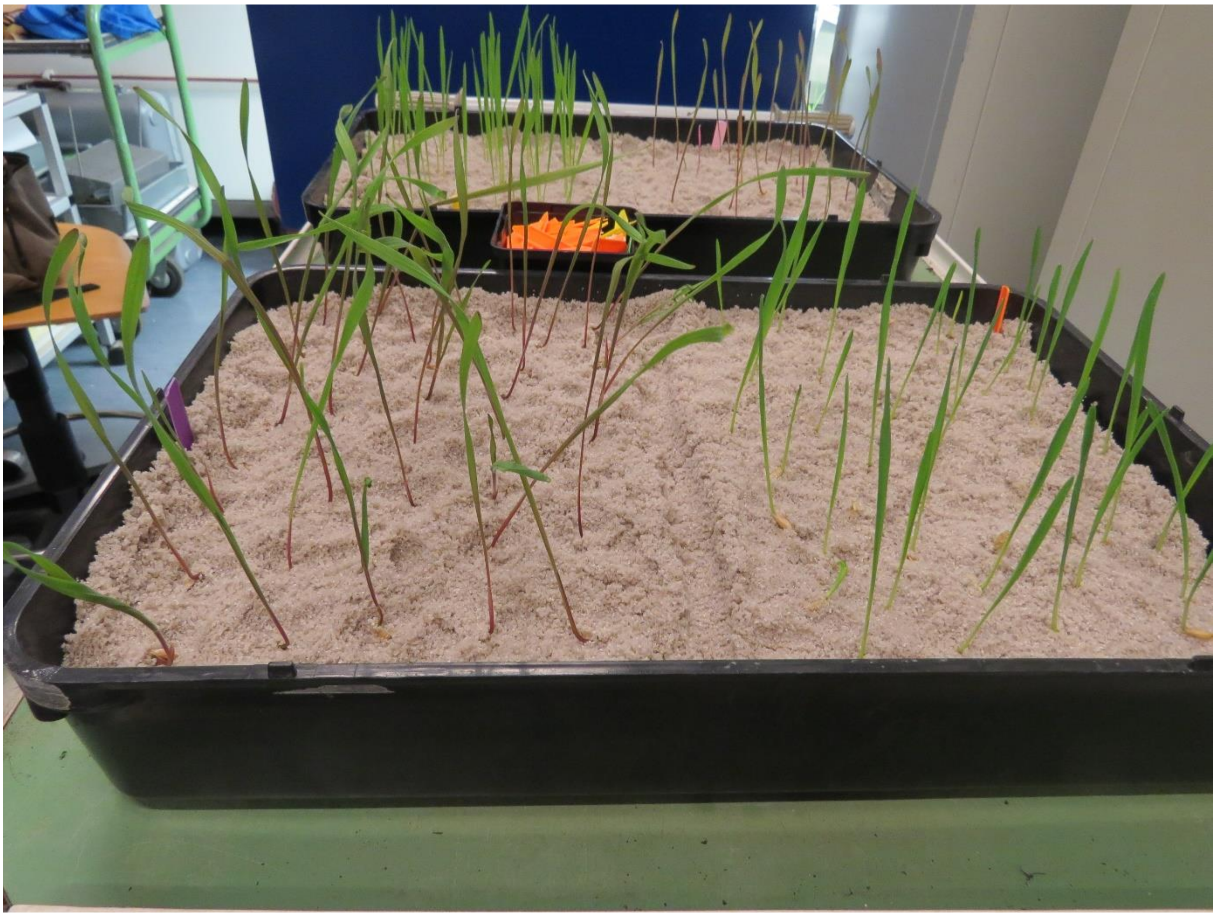
The following pictures are all taken during the germination and transfer phase showing the methods used and length of plants before transfer



A: Germination of soybean on quartz sand. Plastic humidity cap removed



B: Germination of rice seeds on floating plastic beads. Glass humidity cap removed



C: Germination of rye (left) and oat (right) species on quartz sand. Plastic humidity cap removed

D: Sample of a germinated rye seed before transfer

8.11 Harvesting and destruction phase

The following pictures show the plants during the harvesting phase for the root exudates and the preparation of the above and belowground biomass for drying.

A: Root system of a Walliser Binnega rye plan. Close to complete coverage of the available volume

B: Result of root washing to remove sand from an oat species before harvesting of root exudate

C: Syringe and filter used during root exudate harvest

D: Harvesting of root exudate for a 3-hour period

E: Destruction: Separation of aboveground form belowground biomass of rye plants

F: Cleaning of belowground biomass of Soybean plant

8.12 List of substances used for the tests the Fe binding assay

The following tables show the calculations around and specifications of the chemical substances used for the Fe binding assay tests. Due to space constraints, the table was divided into two parts that can be placed next to each other. The preparation of the right amount of HEDTA is placed in the third table.

	Required chemicals for Revised Fe binding Assay				
Chemical Formula	**Name**	**Specifications (M or g/L)**	**Moleculair weight (g/mol)**	**ml needed for each pot**	**Flask volume used (ml)**
FeCl3*6H2O	Iron(III)chloride hexahydrate	0,0006M	270,295	0,5	250
CH3COONa	Sodium acetate	1M	82,034	1	250
HCl	Hydrogen Chloride	6M	36,46	0,25	100
HONH2*HCl	Hydroxylammonium chloride	80g/L	69,49	0,5	250
FZ	Ferrozine	2,5g/L	492,46	0,25	100
CH3COONa	Sodium acetate	2M	82,034	1	250
	Micropur	10mg/L		1	250

ml needed for 250 titrations	**Gram needed for 250 titrations**	**Gram needed for 1 revised Fe binding assay**	**Gram needed Test (30 titrations possible)**	**Amount of ml to dissolve grams in for 30 titrations**
125	**0,020272125**	8,10885E-05	**0,002432655**	**15**
250	**20,5085**	0,082034	**2,46102**	**30**
62,5	**13,6725**	0,05469	**1,6407**	**7,5**
125	**10**	0,04	**1,2**	**15**
62,5	**0,15625**	0,000625	**0,01875**	**7,5**
250	**41,017**	0,164068	**4,92204**	**30**
250	**0,0025**	0,00001	**0,0003**	**30**

Substance	Concentration (Mol)	Moleculair weight (g/mol)	add water up to (L)	Gram Needed for 5,0mmol HEDTA	Notes
HEDTA	0,005	344,2	0,05	0,08605	Take 1ml of the 5,0mmol and add until 100ml of 50umol

8.13 One way ANOVAs of the ratios of above to belowground dry weight biomass in the screening varieties

One-way ANOVA between 5 rye (Val Peccia, Walliser Binnega, Ried Loetschentall, Beka and CADI) varieties. The sum, average and variance of the ratios of above to belowground dry weight biomass of the rye varieties is given, as well as the values to determine significance (F, F-critical and p) (p=0,05).

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
Valer Peccia	8	12,610	1,576	0,335
Wallisser Binnega	8	5,239	0,655	0,022
Ried Loetschentall	8	4,608	0,576	0,046
Beka	7	8,619	1,231	0,031
CADI	8	2,649	0,331	0,006

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	8,29	4	2,072	23,124	2,7E-09	2,650
Within Groups	3,05	34	0,090			
Total	11,33	38				

One-way ANOVA between 5 oat (Ebene, Adliker, Hative des Alpes, Brune de Mont-calme and Expander) varieties. The sum, average and variance of the ratios of above to belowground dry weight biomass of the rye varieties is given, as well as the values to determine significance (F, F-critical and p) (p=0,05).

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
Ebene	9	2,699	0,300	0,003
Adliker	7	3,368	0,481	0,024
Hative des Alpes	9	5,433	0,604	0,030
Brune de Mont-calme	7	2,408	0,344	0,004
Expander	8	3,582	0,448	0,016

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0,494	4	0,124	8,087	0,0001	2,641
Within Groups	0,535	35	0,015			
Total	1,029	39				

One-way ANOVA between 5 upland rice (NERICA 18, NERICA 4, NERICA 15, NERICA 3, NERICA 16) varieties. The sum, average and variance of the ratios of above to belowground dry weight biomass of the rye varieties is given, as well as the values to determine significance (F, F-critical and p) (p=0,05).

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
NERICA 18	2	2,029	1,015	0,109
NERICA 4	4	4,426	1,106	0,102
NERICA 15	5	3,480	0,696	0,015
CNAX	2	1,286	0,643	0,001
NERICA 3	5	3,015	0,603	0,031
NERICA 16	5	3,174	0,635	0,030

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0,859	5	0,172	4,068	0,013	2,810
Within Groups	0,718	17	0,042			
Total	1,577	22				