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# Phenotypic characterization and ploidy level determination of perennial ryegrass (*Lolium perenne* L.) gene bank accessions and cultivars

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# Preface and acknowledgment

The PPP perennial ryegrass project (WP4) has for me been a long journey with a very steep learning curve. I had my first days as a summer worker in Graminor AS, establishing this huge about 8000 single plant experiment together with my new colleagues. My undergraduate studies were just completed, and I was blissfully unaware of that this experiment should follow me all these years after (it has now been eight!). There have been both pros and cons by knowing the theme of the master thesis already before collecting knowledge and credits. I must thank my employer, Graminor AS, for giving me this opportunity and investment of both time and money on my education. A special thanks to my local supervisor Dr. Petter Marum, without whom this work would not have been possible.

I have learned a lot of all my colleagues in Graminor AS, my main supervisor Prof. Odd Arne Rognli, NMBU, and my co-supervisors Dr. Petter Marum, Graminor and Dr. Mallikarjuna Rao Kovi, NMBU, and my Nordic colleagues in the PPP perennial ryegrass project group. Thank you for all the support and motivation you have shown me in every way. I must also say thank you to all who have done a great job in collecting data at all the four locations. Those in charge at that time were Christer Persson (Läntmannen, Sweden), Anders Søndergaard Larsen (DLF, Denmark), Mika Isolahti (Boreal, Finland) and Petter Marum (Graminor AS, Norway). A big thank you to all the experimental technicians who have worked with this experiment.

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Last, but not least I have to thank my dear family; Ørjan, Hanna Elise, Jørgen and my parents, who have supported me through all these years with studies and work. This would not have happened without your support.

# Summary

Perennial ryegrass (*Lolium perenne* L.) is the most grown perennial grass species all over the world, because of the rapid regrowth and good nutritional composition. Winter survival is challenging when growing perennial ryegrass in the northern and eastern parts of the Nordic/Baltic region. Several Nordic and Baltic universities and breeding companies are collaborating in a pre-breeding project for perennial ryegrass, to develop germplasm that can meet the coming climate changes and increase utilization of perennial ryegrass in this region.

The benefits of pre-breeding are the possibility to increase the genetic variation by intercrossing of diverse genetic material. Phenotypical studies of single plants are common for obtaining knowledge about the variation of the material before making crosses. In this study, we investigated 389 populations of perennial ryegrass from different places in Europe, consisting of both collected material from gene banks, landraces, breeding lines and cultivars. The populations were phenotyped in four single plants experiments in different Nordic locations for the traits winter survival, resistance to crown rust, plant height, heading date and regrowth after 1st cut.

Flow cytometry was used to determine ploidy for all populations. This resulted in 306 diploid, 76 tetraploid and 5 populations which were mixtures of diploids and tetraploids. This information is crucial for utilization of genotypes in further crosses since diploid and tetraploid plants must be crossed separately. The study also deals with comparisons of populations with different ploidy and accession types for these traits.

Passport data for 64 populations were improved by converting collection site to coordinates including altitude for 54 populations. Information about ploidy are important for updating the passport information. Nineteen of the populations had a different ploidy level compared to the origin specified in the passport from the gene banks.

Winter survival is essential for growing perennials. By investigating G x E interactions for different years and locations, winter survival of tetraploid Baltic breeding lines and diploid ecotypes from Eastern Europe were identified as phenotypically stable with god winter survival. Tetraploid populations may appear to have a better de-hardening and re-hardening capacity with fluctuating temperatures during the winter.

# Sammendrag

Flerårig raigras (*Lolium perenne* L.) er velkjent for rask vekst og god fôrkvalitet, og er den mest dyrkede flerårige grasarten i verden. Ved dyrking av flerårig raigras i nordlige strøk er vinterherdighet en utfordring. Nordiske og baltiske universiteter og foredlingsbedrifter har gått sammen om et «pre-breedingprosjekt» i flerårig raigras for å forbedre de egenskapene som trengs for å møte kommende endringer i klimaet og økt dyrking av raigras i denne regionen.

Fordelen ved «pre-breeding» er muligheten til å utvide den genetiske variasjonen ved samkrysning av genetisk materiale med høy diversitet. For å vite noe om variasjonen i materialet før en samkryssning, er det vanlig å studere enkelplanter av ulike populasjoner i forsøk. I denne studien er det sett på 389 populasjoner av flerårig raigras fra ulike steder i Europa bestående av innsamlet materiale, landraser, foredlingslinjer og markedssorter. Populasjonene ble fenotypet i fire enkeltplante-forsøk ved ulike lokasjoner i Norden for egenskapene vinteroverlevelse, rustresistens, høyde, skytetidspunkt og gjenvekst etter første slått.

Flow cytometri ble brukt til å definere ploidinivå hos alle populasjonene. Dette resulterte i 306 diploide, 76 tetraploide og 5 populasjoner med en blanding av begge ploidinivåer. Denne informasjonen er vesentlig for sammensetning av populasjoner til nye krysninger, fordi diploide og tetraploide planter må krysses hver for seg. Det er også gjort sammenlikninger mellom populasjoner av ulike ploidi og aksesjonstype for disse egenskapene.

Bakgrunnsinformasjon til 64 populasjoner ble forbedret ved å konvertere informasjon om innsamlingssted til koordinater, inkludert høyde over havet for 54 populasjoner. Informasjon om ploidi er også viktig for oppdatering av bakgrunnsinformasjon. Nitten populasjoner hadde endring i ploidi i forhold til original informasjon fra genbank.

Vinteroverlevelse er essensielt for flerårige vekster. Ved å se på genotype-miljø samspill over flere år og lokasjoner utpekte tetraploide foredlingslinjer fra de Baltiske landene og diploide økotyper fra Øst-Europa seg med stabile, gode resultater for vinteroverlevelse. Tetraploide populasjoner kan se ut til å ha en bedre evne til å takle av-herding og re-herding ved varierende temperatur gjennom vinteren.

# Contents

# 1.0 Introduction

The expected climatic changes in Northern Europe leads to an extended growing season (1-3 months) for forage production, combined with milder and rainier autumns and winters (Hanssen-Bauer, 2009; Skaugen & Tveito, 2004). The climatic changes lead to changes in the types of abiotic and biotic stresses for plants. Due to this, breeders need new plant genetic resources.  Germplasms collected from different countries have rich genetic diversity, which germplasm stored in gene banks, can be used to develop new cultivars adapted to future climatic conditions.

The aims of this study are determination of ploidy level by flow cytometry and characterization of phenotypic variation for different traits like winter survival, resistance to rust, plant height, heading date and regrowth. These results are further used for comparisons of groups with different ploidy level, and to study stability and adaptation of winter survival over years and locations.

## 1.1 Perennial ryegrass as an important forage grass species

Perennial ryegrass (*Lolium perenne* L.) is an attractive grass species with shiny leaves. The high tillering and quick regrowth make it productive over long growing seasons, with tolerance to both grazing and frequent cuts.

Perennial ryegrass is a member of the Poaea tribe of the Poodae super-tribe in the Pooidae subfamily of the grass family Poaceae (Soreng & Davis, 1998). Genus *Lolium* comprises eight natural diploid (2n = 2x = 14) species which form a part of the *Lolium/Festuca* polyploid complex (Humphreys et al., 2010). The first group consists of inbreeding, annual species acting as weeds. The second group consist of  the most common outbreeding species; the annual/biennial *Lolium multiflorum ssp. italicum* (Italian ryegrass), its annual subspecies *Lolium multiflorum ssp. multiflorum* (Westerwolths ryegrass), and the perennial *Lolium perenne* (Humphreys et al., 2010). The outbreeding (cross-pollinated) nature of this species means, that they don't breed with closely related individuals due to the gametophytic self-incompatibility system (Yamada, 2013). This generates a wide genetic variation within populations, in contrast to the inbred self-pollinators such as wheat and barley.

Several studies have described the relationship between the *Festuca* and *Lolium* genus' where broad-leaved meadow fescue (*Festuca pratensis* Huds*.)* is very closely related to *Lolium* (Charmet et al., 1997; Gaut et al., 2000). Charmet et al. (1997) calculated the divergence of *Lolium* from f*escues* around two million years ago, and the separation of *Lolium* into a separate species about one million years ago. Due to the close relationship, *Festuca* and *Lolium* species can be crossed and interspecific hybrids established. Such *Festuca x Lolium* hybrids are termed *Festulolium*. There are several possible crosses between different *Festuca* and *Lolium* species with different ploidy levels*; L. perenne x F. pratensis*, *L. mulitiflorum x F. pratensis*, and *L. multiflorum x Festuca arundinacea* are some examples (Kopecký et al., 2008). The hybridization combines advantageous traits from both species; productivity and forage quality from the *Lolium* genera and persistence and winter hardiness from the *Festuca* genera (Humphreys et al., 2003).

## 1.2 Agricultural value

Perennial ryegrass is the most grown perennial grass in temperate regions of the world with superior forage quality and palatability, high yield potential, rapid regrowth, high tillering, and tolerance to both grazing and frequent cuts. The main regions for cultivation of perennial ryegrass are the North-Western part of Europe, and the temperate regions of New Zealand, Australia, South-Africa, South America and Japan. The number of perennial ryegrass varieties (>1000) on the Organization for European Economic Co-operation and Development (OECD) list reflects their extensive use (OECD, 2019). This also applies to the widespread use of perennial ryegrass as a catch crop, for sports turfs and amenity grasses, like lawns, road slopes, and other green covered areas. The global seed production in the period from 1998-2007 was 209,674 tons per year, while the EU-27 countries had an average production of 83,660 tons perennial ryegrass seeds between 2000-2010 (Humphreys et al., 2010). In 2016 the European annual production output was 90,000 tons, which accounts for almost 50% of the total grass seed production (forage and turfgrasses) (Bruins, 2016).

In Scandinavia, the largest cultivation range of perennial ryegrass is in Denmark and the southern part of Sweden. In Norway, the diploid varieties are grown as lawn and pasture, while the tetraploid varieties are used for fodder production. Norwegian farmers grow perennial ryegrass along the south-western part of the coastland, because of the milder climate along the coast. Timothy and meadow fescue are more widely used than the perennial ryegrass in the Norwegian inland, due to the insecurity of winter survival.

The meadows with perennial ryegrass are established as pure ryegrass meadows with different ryegrass varieties, or as 10-20% part of a mixture with timothy, meadow fescue and red clover. The area for the production of perennial ryegrass seeds in Norway in 2018 was 110.6 ha, in addition to a yearly import of 4-500 tons seeds, whereas 100-150 tons are sold as seeds for lawn production (Havstad & Aamlid, 2019).

The weaknesses of perennial ryegrass are low persistence under harsh environments such as drought, frost and other winter damages. Winter hardiness is a complex trait, and the plants have to cope with an intricate set of challenges as snow cover, anoxia, plant pathogens, ice encasement, and freezing temperatures (Larsen, 1994). Both winterhardiness and persistence need to be improved to increase the cultivation range for the Nordic regions (Rognli et al., 2018).

Blackmore et al. (2016) compared the genetic diversity of European commercial *Lolium perenne* varieties with European ecotypes (wild/ semi-natural populations) and found a greater genetic variation in the ecotypes. There might be an unexploited source for persistence and other desired traits in the ecotypes. These wild populations have adapted new climates and locations during natural selection since its natural origin around thousands of years ago.

### 1.3 Biogeographic history – the study of the distributions of species and ecosystems in geographic space and time

The Mediterranean basin is considered as the likely origin of ryegrasses. Balfourier et al. (2000) view possible routes for the spread of *Lolium* from the fertile crescent region (which runs along the eastern coast of the Mediterranean into Turkey and to the Persian Gulf), into Europe by primitive agricultural production for about 10,000 years ago. Seeds of ryegrasses were probably spread as weeds by migrating farmers growing cereal crops. The spread of ryegrasses is closely associated with the development of livestock farming.

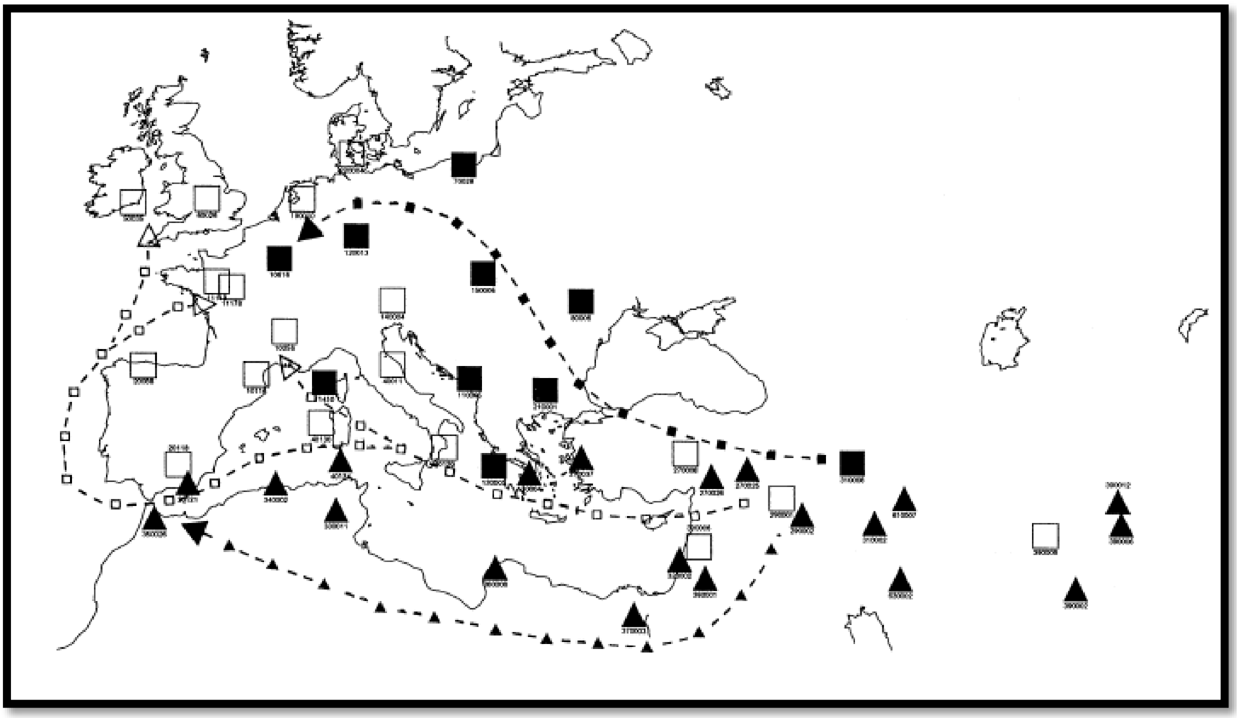


*Figure 1 Map of geographical distribution of the three clusters of populations and possible colonization routes obtained from Balfourier et al. (2000). Danubian movement (white squares), Mediterranean movement (black squares.), North African continental route (black triangles).*

Balfouriers three possible pathways for the spread of ryegrasses are viewed in Figure 1: 1) A northern route named the “Danubian movement” since it follows the river with the same name. This route extends north-east from Iran to Bulgaria, Greece, former Yugoslavia, Romania, Slovakia, Poland, Germany and the eastern part of France; 2) The «Mediterranean movement» has a south-west direction towards Italia, south of France, follows the coastal line of Spain and Portugal, further up to the west of France and Ireland, while 3) the «North Africa continental route” follows the south of the Mediterranean basin west to Marokko.

These routes were figured out by studying the maternally inherited chloroplast DNA (cpDNA) of several natural populations sampled throughout Europe and the Middle east. Another chloroplast study, done by McGrath et al. (2007) supports this movement theory. They found groups of southern, northern and western European perennial ryegrass ecotypes more genetically differentiated from other European and near eastern European ecotypes, and further explained this by the post-glacial separation of the south and north side of the Alps.

## 1.4 Ploidi levels

Perennial ryegrass is naturally a diploid species (2n=2x=14). At the beginning of the twentieth century, there were several attempts to double the chromosome numbers in the plant cell. The discovery of chromosome doubling with colchicine by Blakeslee and Avery (1937) lead to success in this work, and the first chromosome doubling of perennial ryegrass with colchicine was done by Myers (1939). In the 1950s the first tetraploid varieties were released from the Netherlands and Hertzsc from Germany were the first ones to do systematic treatment of breeding materials to induce tetraploids in the late 1950s (Wit, 1958; Wit, 1959 ).

By doubling the chromosome number, plants might have better yield potential (Feuerstein, 1991), higher digestibility, and better resistance to crown rust infection (Humphreys et al., 2010). The tetraploid properties depend on the diploid origin before doubling (Humphreys et al., 2010). Studies on winter survival and freezing tolerance in perennial ryegrass varieties with different ploidy levels by Helgadóttir et al. (2018) showed the tetraploids to be significantly more resistant to snow mold infection than the diploids, while the diploids showed better tolerance to freezing.

Manipulation of ploidy level is an important tool for plant breeding in a number of crops, especially for those who are working with haploids (Bohanec, 2003). It is crucial to know the ploidy level of all the plants in a cross for breeders to control their results. Crosses of e.g. diploid and tetraploid ryegrass can make the further use complicated, and might lead to undesirable admixtures of both ploidy levels, or in some cases infertile triploids, with almost no seed production. Admixtures of ploidy level in grass populations could also be challenging to marker development and gene identification and further influence marker assisted-selection (Wang et al., 2009).

Previously the use of chromosome counting under the microscope was common, but the introduction of flow cytometry by Partec Cell analyzer CA-Ⅱin 1987, has revolutionized this studies (Humphreys et al., 2010).

## 1.5 Flow cytometry (FCM)

The use of FCM is wide, both for basic medical and biological research and medical diagnostics. FCM is an efficient method for determination of the ploidy level, based on a measurement of the DNA content of plant cells (in interphase nuclei). Before running the analysis, the tissue needs to be prepared with an extraction buffer which isolates the nucleus, before staining the cells by a staining solution. Figure 2 shows the further process where particles from the suspension are pumped through a flow cuvette in a very narrow stream flowing inside a larger sheath fluid stream of water or saline, which is used to focus the sample stream into the center. This hydrodynamic focusing makes the cells coming as a single array, one at the time. When the cell passes the laser intercept (interrogation point) and the laser light beam illuminates a single cell, some of the light will strike physical structures within the cell, causing the light to scatter. The scattered light can be measured and correlated with relative cell size and structures inside the cell. A detector collects the light from the fluorescence emission and process the information through the electronic components in the flow cytometer. There are different functions of side or forward scatter functions, which lights the cell from a different angle. The forward scatter function (FSC) is used for measuring the size of the cells, which is used for detection of ploidy (Bohanec, 2003; ThermoFischerScientific).

DeLaat et al. (1987) showed that both individual plants and plant populations can be used to obtain the desired DNA histogram.

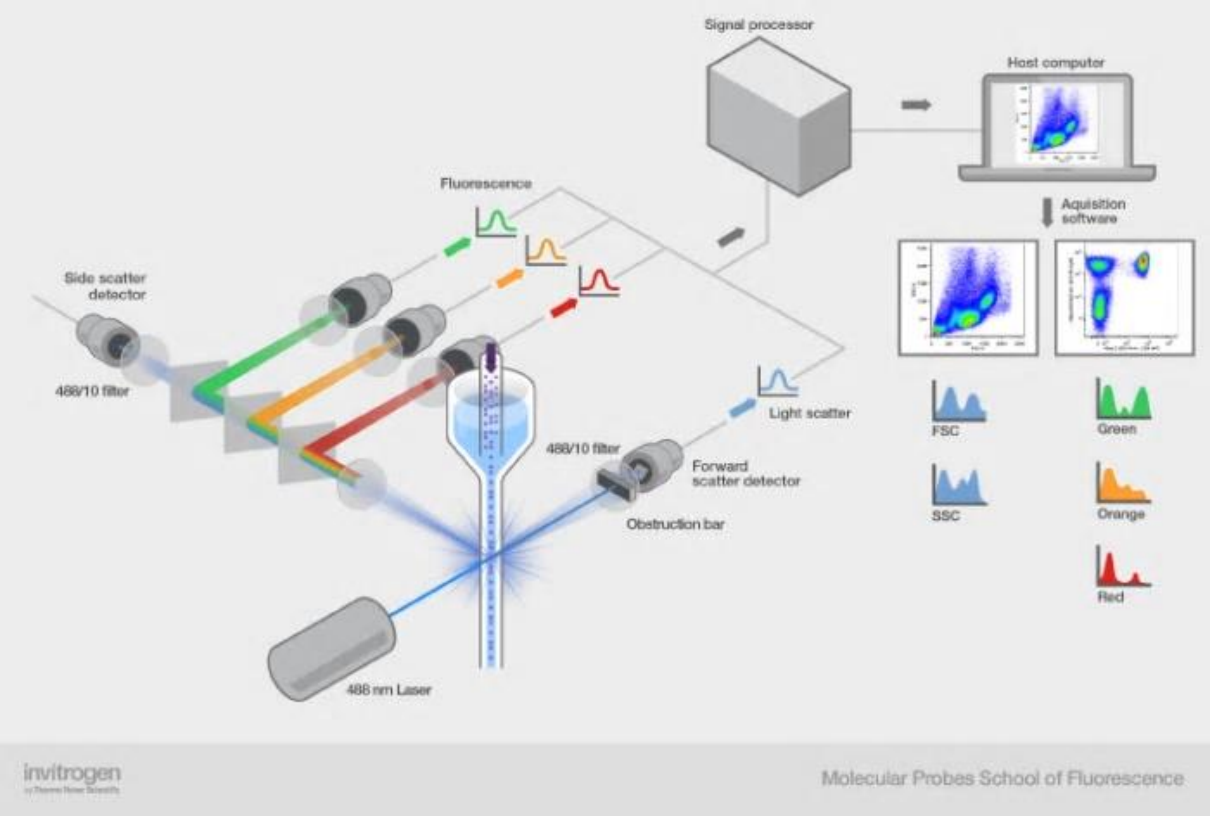


*Figure 2 The working parts of a flow cytometer. (ThermoFischerScientific). For ploidy detection, only the forward scatter detector is used.*

## 1.6 Gene banks

### 1.6.1 Plant Genetic Resources

Since the dawn of time, plants have evolved under prevailing conditions of natural selection, leading to a large amount of genetic variation. Our ancestors began the domestication of wild forms of grasses around 10,000 years ago. Domestication is an evolutionary process by which wild populations are adapting to new environments, as a result of human-controlled selection by collecting seeds and store them until the next growing season. This was the beginning of the selection for agronomical traits, which is the initial step of plant breeding.

Nikolai I. Vavilov (1887-1943), a Russian plant geographer, botanist, and geneticist became known for his numerous collection trips around the world. Based on his understanding of the nature of variation of the earth’s vegetation in the 1920s, he identified several areas characterized by particular diversity (Kurlovich, 2000). He used this theory of centers for collecting, studying and using genetic resources of cultivated plants. His collected material is stored in the N. I. Vavilov All Russian Institute of Plant Genetic Resources (VIR) genebank, named after this significant collector. This VIR genebank is one of the oldest genebanks in the world (Mackay, 2011).

### 1.6.2 Gene banks; a biorepository which preserves genetic material

There are various ways of storing plant genetic resources. *In situ* conservation of plants means conservation of plants in their natural habitat, while *ex situ* conservation is the preservation of seeds or other plant materials (clones, meristems) outside their habitats, often in gene banks. The *ex situ* conservation makes it possible for breeders and researchers to utilize the collected material (Boller & Veteläinen, 2010).

Boller and Veteläinen (2010) describe four different categories of plant genetic resources possibly important for forage breeding. The *wild relatives* are species closely related to the cultivated species. For forage crops with a large amount of genetic variability within the cultivated species, these are of limited importance.

An *ecotype* is a collective term of wild and semi-natural grasses. The lines between cultivated, wild and semi-natural grasses are difficult to draw because permanent grassland exists because of human agricultural activity in areas where forests would be natural vegetation. Use of the term *ecotypes* implies populations that have adapted to local climatic conditions after many years of natural selection, usually involving natural re-seeding but without deliberate human interference such as selection, seed harvest or human-mediated seeding.

Populations adapted to a specific region or location, often a specific farm, are called *landraces*. These are made by repetitive harvesting (selection of locally adapted individuals) and human-mediated re-seeding.

*Cultivars* are very popular as plant genetic resources in forage breeding since they are already known as good yielders in both biomass and seeds. “The breeder’s exemption”, a provision decided by the International Union for the Protection of New Varieties of Plants (UPOV, 1991) makes it possible to use cultivars in breeding for free.

The largest collection of perennial ryegrasses is stored in the European Central Lolium database from “The European cooperative programme for plant genetic resources” (ECPGR). The collection holds 11,920 accessions of perennial ryegrass from 31 different countries (https://eurisco.ipk-gatersleben.de). Other important genebanks are GBIS (Genbank Informations System, Gatersleben), holding 3284 accessions (https://gbis.ipk-gatersleben.de). The GBIS uses the “ægis” database system, with available data of characterization and evaluation including pictures.

The GRIN (National Plant Germplasm System) of the United States department of agriculture (USDA) holds 1213 accessions (https://npgsweb.ars-grin.gov/gringlobal), and the Nordic gene resource center (NordGen) holds 201 accessions (https://sesto.nordgen.org/sesto). It is the latter that runs the global seed vault at Svalbard, a longtime storage of copies of gene bank collections from the entire world.

### 1.6.3 Characterization of gene bank accessions

Characterization of the genebank accessions is crucial to utilize the value of the genetic resources. Vavilov underlined the importance of accurate information to be able to detect the association between plants collected in ecologically specific regions and plant characteristics (Mackay, 2011).

*Passport data* for a given accession gives specific information about the stored material. A passport for an ecotype will contain information about the collection site (coordinates), date of collection, name of the collector, ploidy level, and so on. Breeders can also store their varieties in genebanks, the passport data of a variety should contain the name, the pedigree, and the breeder's designation.

*Characterization data* are descriptors like colors, growth habit or leaves with or without hairs (pubescence) which make it easy to distinguish between genotypes based on morphological characteristics. Breeders do not choose accessions based on this characterization, but it makes it easier to limit the scope of accessions if some of them have an undesirable growth habit or color.

*Evaluation data* describes traits for the plants in a specific area. Other environments often give other expressions of the same traits. Dry matter yield, heading time, reaction to biotic and abiotic stresses and plant height are examples of evaluation data.

New technics makes it possible to collect precise *environmental data* for collection and testing sites and refresh the information of already stored material. Use of geographic information systems (GIS), which provides estimates of environmental parameters at multiple points in time, simplify the selection for breeders and researchers to search for adapted germplasm to their target environment (Boller & Veteläinen, 2010). *Genetic and molecular data* generates huge quantities of information and increase the utilization of plant genetic resources. The possibility of searching for genes and not only phenotypes brings the use of plant genetic resources to a new level.

To obtain utilization of the plant genetic resources in the genebanks, they need to be tested. Genotyping and/or phenotyping of accessions in different locations is quite costly. This is one of the main reasons for collaboration and development of the PPP perennial ryegrass project.

## 1.7 Breeding, Pre-breeding and PPP

Plant breeding is a long-term activity and even longer for perennial crops. From the first cross between single plants, further through several periods of testing and selections until a new cultivar is released on the market, you can count at least 10-20 years.

### 1.7.1 Breeding methods of open-pollinated crops

The first phase of breeding of open-pollinated crops (such as forage grasses) consist of pair- or polycrosses in isolation to prevent contamination by foreign pollen. To get enough seeds for testing, the offspring need to be multiplied by growing in plots isolated by distance, usually among a taller cereal crop like rye. To identify superior families, progeny tests for yield and other important phenotypic characters/traits are evaluated (see below). From the progeny tests, the best parents or families are selected and put together to make new synthetic populations (SYN). The SYN follow the same seed multiplying and testing procedure at several locations before the new promising breeding lines (BL) are selected. This BL can either be selected as a new cultivar or be a part of a recurrent selection program for further improvements. The BL must pass both the DUS test, which proves that they are *Distinct* from other varieties, *Uniform*, and *Stable*, and the official variety test for the value of cultivation and use before they can be approved as a new cultivar.

Forage crops are most often perennial, and they should preferably be long-lasting. *Winter survival* is a very complex trait, affected by the combination of abiotic stresses, like frost, ice encasement, anoxia, waterlogging, desiccation and snow cover, combined with biotic stresses caused by low-temperature fungi (Rognli, 2013). It is a limiting factor for growing perennial ryegrass in the northern regions.

*Heading date (HD)* is determined by a combined effect of photoperiod and temperature. HD is an important trait with high heritability. Quality traits, yield and traits connected to the development of the plant, like height, tiller number, spike length and leaf size are correlated with HD. It is common to separate the breeding material into different earliness groups to ensure stability and uniformity (Fè et al., 2015). HD is a continuous character and the heading groups differ between countries. At northern latitudes, the differences in heading between early and late groups only vary a few days, compared with up to several months at southern latitudes. This is mainly explained by differences in daylength.

*Plant height (PH)* is controlled by the same relationship between photoperiod and temperature as HD, in addition to other genes, soil/nutrition, and effects of external biological factors. PH can be used a proxy for plant biomass. It is important to be aware that biomass yield per land area usually cannot be directly translated from spaced plants to swards (Wilkins & Humphreys, 2003). Defoliation (cutting) of perennial ryegrass trigger plant growth and adaptation to management practice leads to selection. Repeated defoliation (e.g. grazing, lawn mowing) selects for short and prostrate genotypes, while infrequently defoliated meadows with competition for light results in tall and erect genotypes. Late heading is negatively correlated with plant height (Hazard et al., 2006).

To maintain a high total biomass production for herbage production, a rapid *regrowth after the 1st cut* is necessary. There is variation between genotypes as regards how the total biomass is distributed among the harvests/cuts. Northern varieties produce most of yield in the first harvest.

Pathogens like *rusts* (*Puccinia* species) can be particularly damaging to ryegrass swards since they reduce yield, and forage quality like water-soluble carbohydrate and digestibility (Potter, 1987). There is both quantitative and qualitative resistance in ryegrasses, and this natural resistance has been transferred into breeding populations by the use of recurrent phenotypic selection (Humphreys et al., 2010). Reheul and Ghesquiere (1996) found the narrow-sense heritability of crown rust to be 0.46, but the correlation between resistance and yield were negative. Differences in infections between locations are common, and the disease might be spread irregularly over the field.

### 1.7.2 Pre-breeding and PPP

The history of breeding of forage crops is less than 100 years old. Plant breeders always select the best genotypes, often with the greatest emphasis on crop yield. This can lead to a reduction in genetic variability. Pre-breeding is a long-term activity for the extension of the genetic variability *before* the selection of superior genotypes starts.

Breeding of perennial ryegrass is costly and time-consuming, and extension of pre-breeding to introduce new genetic variability is even more costly and time-consuming. A successful breeding program relies very much on proper pre-breeding activities (Rognli, 2016).

In 2011 the Public Private Partnership (PPP) project in pre-breeding of perennial ryegrass was initiated by The Nordic Council of Ministers, with the goal to broaden the genetical base of perennial ryegrass to meet the future demands due to climate change. The principle of PPP projects is a 50/50 cost-sharing between private and public funding (see https://www.nordgen.org/en/plants/ppp-pre-breeding/ongoing-projects/). Through collaboration between breeding companies/institutions and academic institutions in the Nordic and Baltic region, the amount of work and cost is shared, in addition to the exchange of experience and knowledge between the partners.

The different projects in PPP are described in the book “Promoting Nordic Plant Breeding for the Future” (Nilsson et al., 2016). For the perennial ryegrass project, we can read;

*“The basic assumption behind this project is that the available germplasm and active breeding populations of perennial ryegrass are not sufficiently broad to cope with the requirements of the future climate” Rognli (2016)*

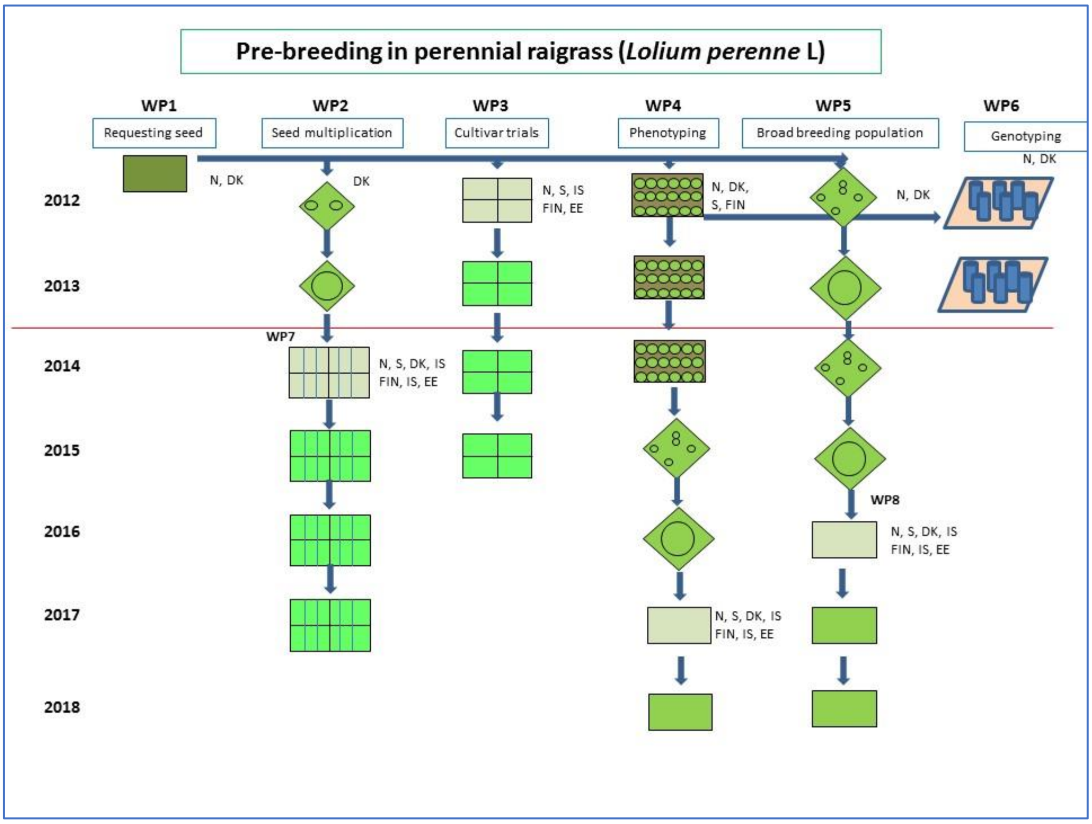


*Figure 3 Flow chart for the first phase of the PPP perennial ryegrass project.*

This project has different work packages (WPs) as viewed in Figure 3 for the first phase of the project (above the red line in the figure). In *WP1* seed samples of populations of material from different genebanks and breeding companies were obtained, and in *WP2* the populations were multiplied for further experiments using 60 randomly selected plants/population. *WP3* was a cultivar yield trial with the most winter hardy cultivars on the Nordic market; 22 cultivars were tested at seven locations from Iceland in west to Estonia in east (Helgadóttir et al., 2018). In *WP4* all populations were phenotyped for different traits at 4 locations in Norway, Sweden, Denmark and Finland, each population represented by 20 randomly selected plants per location. In *WP5* a broad diploid breeding population was established based on two intercrosses of all diploid populations for two generations by single-seed descent; each population was represented by 10 randomly selected plants and intercrossing was performed independently in Denmark by DLF and in Norway by Graminor. Population based genotyping by sequencing (GBS) (Elshire, 2011) was done on all accessions (*WP6*), on a selected number of single plants from the Norwegian WP4 field experiment, and on synthetic populations made with selected plants from this experiment.

In the following two project phases (2014-2017 and 2018-2020) new field trials of swards, single plants experiments (on clones), new crosses, and several new broad populations based on natural selection at different locations have been established, in addition to freezing tests (Helgadóttir et al., 2018), selections for different traits to establish SYN-populations based on the results from the experiments, studies of allele frequency shifts and parental contribution to the SYNs (Schubert, 2019), and estimation of genomic prediction by GEBV (Genomic Estimated Breeding Value) based on the results from yield trials (WP7, 2nd phase) of all populations at locations in seven countries (DK, NO, SE, IS, FI, EE and LT) (Bellucci, 2019).

Project partners are the plant breeding entities Boreal Plant Breeding in Finland, DLF in Denmark, Estonian Crop Research Institute in Estonia, Graminor in Norway, and Lantmännen in Sweden representing the private partners of the PPP consortium. The academic institutions are Aarhus University in Denmark, Agricultural University of Iceland (LBHI) in Iceland and the Norwegian University of Life Sciences (NMBU) in Norway. In addition, the Lithuanian Research Centre for Agriculture and Forestry (LAMMC) in Lithuania (from 2nd phase), and Latvia University of Life Sciences and Technologies (LLU) in Latvia (from 3rd phase) are partners. The research activity of the Baltic partners is financed by own funding.

## 1.8 The aims of the study

As a part of this project, there were collected 393 gene bank accessions (from now on referred to as populations), consisting of both ecotypes, cultivars, breeding lines and landraces of perennial ryegrass, both from the Nordic region and Europe at large. A subsequent phenotypic characterization of all populations was conducted in the years 2012-2014 at four locations in Norway, Sweden, Denmark and Finland.

The main aims of the study are to:

1) Determine the ploidy level of the 393 populations used in the PPP perennial ryegrass project by flow cytometry, as the information about the ploidy level will be crucial for the future breeding work in the PPP project.
2) Improve the passport data for the gene bank accessions by searching in different gene banks and converting collected information into longitude and latitude (expressed in decimal degrees)
3) Characterize and rank the populations for the different traits at each location:
    a. winter survival (2013 and 2014)
    b. heading date
    c. plant height
    d. regrowth after the 1st cut
    e. crown rust resistance
4) Examine phenotypic variation for the traits in relation to ploidy level and population type, i.e. ecotypes vs. cultivars, with emphasis on winter survival.
5) Study the stability and adaptation of winter survival over two years and four locations by the additive main effects and multiplicative interaction (AMMI) analysis

Hypotheses:

- The stated ploidy levels from the gene banks will be the same as after testing with flow cytometry. The collected ecotypes assumed to be diploids, since perennial ryegrass is naturally diploid.
- Ecotypes have larger phenotypic variation than cultivars for all traits. The cultivars are assumed to behave best for agronomic traits.
- Expect tetraploid populations to have best winter survival in winters with much snow, and diploid populations to have best winter survival if the winters are cold with less snow.
- Best resistance to crown rust in tetraploid cultivars
- Populations (cultivars and ecotypes) adapted in the north (longitude > $60^{o}$) are expected to be most winter hardy.

# 2.0 Materials and methods

## 2.1 Description of the gene bank accessions

A total of 393 populations were collected from ten gene banks (mainly European). The passport information for all the populations is available in Appendix 1. The number of accessions from each gene bank and the proportion of ecotypes per gene bank are presented in Figure 4. The populations are classified as cultivars, ecotypes, breeding lines, and landraces. There is also an “unknown” group consisting of 25 populations with insufficient passport information.

The percentage distribution of the accession types is presented in Figure 5. The ecotypes constitute nearly 50% including the categories wild, semi-wild, natural growing and semi-natural. Since the group sizes are very uneven, ecotypes and landraces were merged into a group called ‘ecotypes’, whereas cultivars and breeding lines were merged into a group called ‘cultivars’ to obtain more balanced group for statistical analyses. The unverified population group is only included in analyses when there is no grouping based on accession type. This is specified for the different analyses in chapter 2.5 Statistical analyses.

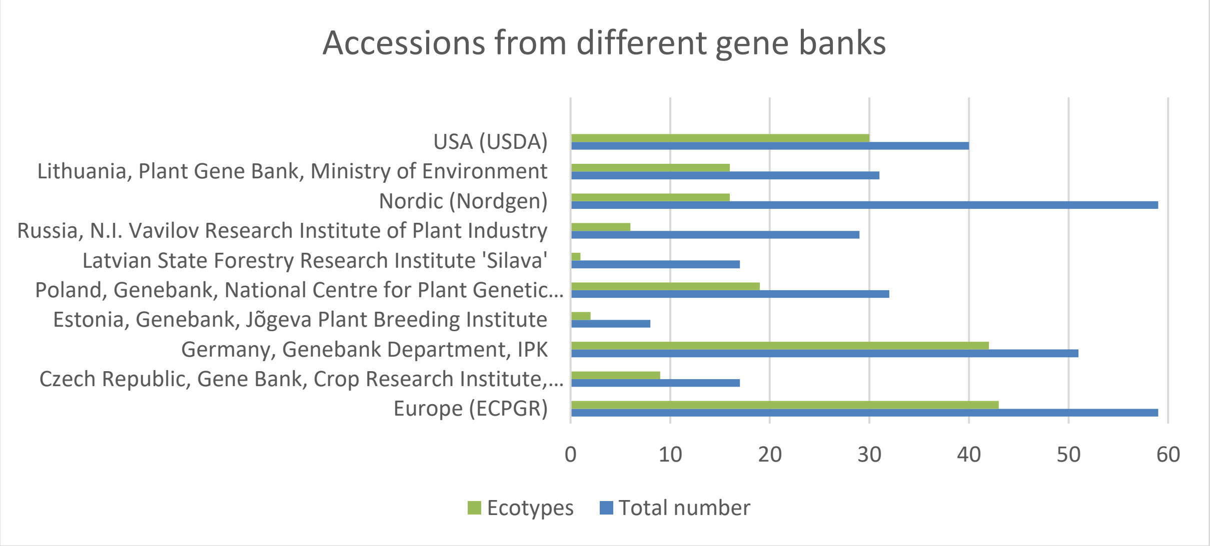


*Figure 4 The number of accessions collected from different gene banks and proportion of ecotypes relative to the total number of accessions.*

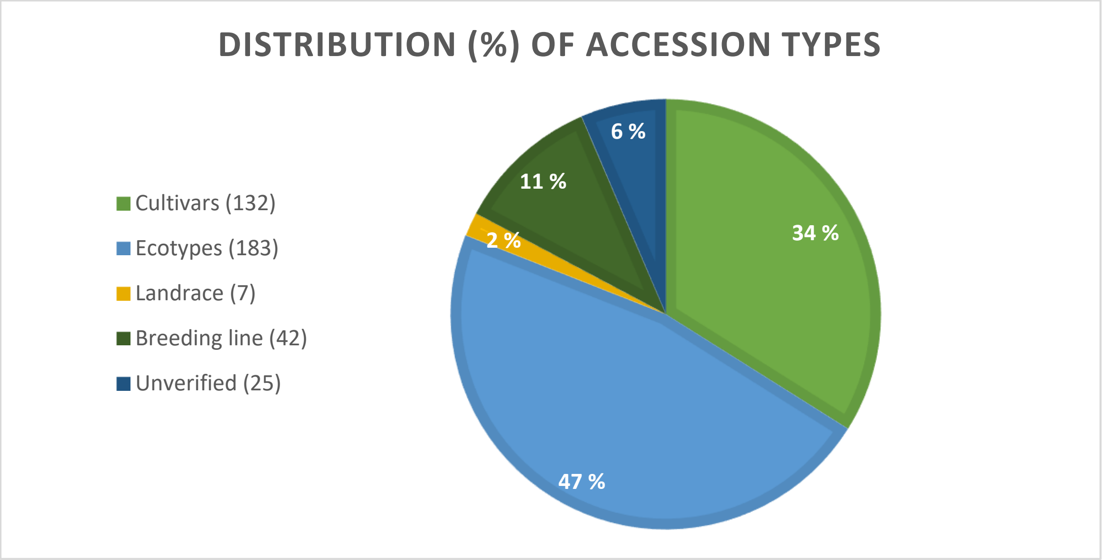


*Figure 5 The percentage distribution of the different accession types. The numbers in parenthesis are the exact number of populations per group. In the following presentation, the cultivar group include the breeding lines (total cultivar n=174), and the ecotypes and landraces are the ecotype group (n=190).*

There are 31 countries of origin, and the distribution of different accession types per country of origin is shown in Table 1. Most of the populations are from Scandinavia and Europe, but there are also populations from Turkey, Japan and Moldova. These might be expected to have a different genetic background compared with the European populations.

The passport data for the gene bank accessions were improved by search for further information on the website for each genebank. Totally 64 populations got coordinates by converting "collection site" with the Google Maps GPS Coordinates (http://www.gps-coordinates.net), 56 of this also got information of elevation at collection site this way. Some of this information might be incorrect. All coordinates were converted to decimal degrees.

*Figure 6 Collection sites for 160 of the total number of 183 collected ecotypes with coordinates (Geographer, 2019).*

Figure 6 shows the geographical distribution of ecotypes collected and stored in gene banks with coordinates in their passport data. The aim of the sampling of populations for the PPP project (WP1) was to obtain as many Nordic populations as possible. The collection was coordinated by NordGen on behalf of the PPP project group.

Only 32% of the populations had initial information about ploidy levels from the providers, almost 2/3 of these were cultivars and 1/3 ecotypes. The initial ploidy information for the collected ecotypes classified 44 ecotypes as diploids, while 48 cultivars were diploids and 34 cultivars were tetraploids. The providers from N.I. Vavilov Research Institute of Plant Industry from Russia, and the United States Department of Agriculture (USDA) had most details about ploidy for their populations.

Table 1 Types of accession per country of origin

| Country of origin | Cultivar | Ecotype | Breeding line | Landrace | Unknown | Total |
|---|---|---|---|---|---|---|
| **Austria** | 2 | | | | | 2 |
| **Belgium** | 1 | | | | | 1 |
| **Canada** | 1 | | | | | 1 |
| **Czech Republic** | 2 | 10 | | | 2 | 14 |
| **Denmark** | 28 | | | | | 28 |
| **Estonia** | 3 | 2 | 4 | | | 9 |
| **Finland** | 3 | | 1 | 1 | | 5 |
| **France** | 4 | 31 | | | | 35 |
| **Germany** | 7 | 31 | | | 1 | 39 |
| **Hungary** | 2 | | | 2 | 12 | 16 |
| **Italy** | | 6 | | | | 6 |
| **Japan** | 2 | | | | 1 | 3 |
| **Kyrgyzstan** | 1[a] | | | | | 1 |
| **Latvia** | 2 | 1 | 14 | | 2 | 19 |
| **Lithuania** | 3 | 16 | 12 | | | 31 |
| **Moldova** | | 1 | | | | 1 |
| **Netherlands** | 8 | | | | | 8 |
| **Norway** | 10 | 10 | 3 | | | 23 |
| **Poland** | 14 | 22 | | | 6 | 42 |
| **Romania** | 1 | 15 | | | | 16 |
| **Russia** | 3 | 2 | | | | 5 |
| **Slovakia** | 1 | 2 | | | | 3 |
| **Slovenia** | 1 | | | | | 1 |
| **Soviet Union** | 3 | | 4 | | | 7 |
| **Sweden** | 14 | 9 | 4 | 3 | | 30 |
| **Switzerland** | 3 | 7 | | 1 | | 11 |
| **Turkey** | | 9 | | | | 9 |
| **United Kingdom** | 6 | 5 | | | | 11 |
| **Ukraine** | 2 | 4 | | | | 6 |
| **Unknown** | 2 | | | | | 2 |
| **USA** | 3 | | | | 1 | 4 |
| **Total** | 132 | 183 | 42 | 7 | 24 | 389 |

**[a] Later confirmed to be *L. multiflorum* based on genotyping (Rognli et al., 2018).**

## 2.2 Description of the field trials design, locations, and climatic conditions

The field experiments were established in June 2012 at four locations. The plants were established from seeds in the greenhouse at DLF, Store Heddinge, Denmark and distributed as small plants to the three other locations for planting. The four experimental sites were Store Heddinge in Denmark, Svalöf in Sweden, Staur Gård in Norway and Jokioinen in Finland (Figure 7 and Table 2).

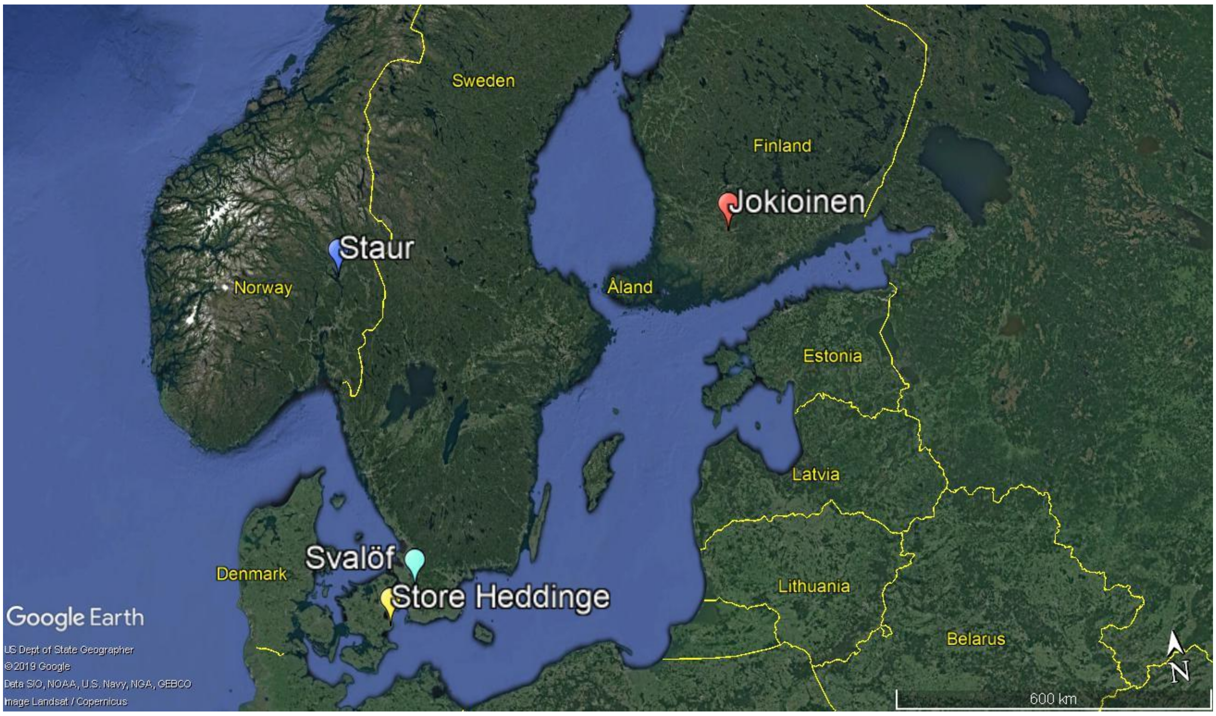


*Figure 7 The experimental sites in Denmark, Sweden, Norway and Finland. The map is made in Google Earth Pro version 7.3.2.5776 (Geographer, 2019)*

The experiments were established following a randomized complete block design with 4 blocks. Each population was represented by 20 randomly selected plants/location, distributed with 5 plants/block planted in rows 50 cm apart. Fertilization and cutting were applied according to common agricultural practices. A total number of 389 populations were tested in WP4. Different initial seed amounts led to an uneven number of populations per location; thus, the experiment in Denmark had 389 populations, Norway 361, Finland 358, and Sweden 354 populations. A core set of 354 populations was tested at all locations.

Table 2 Information about the experimental sites

| | Denmark:<br>Store Heddinge | Sweden:<br>Svalöf | Norway:<br>Staur Gård | Finland:<br>Jokioinen |
|---|---|---|---|---|
| **Latitude** | 55°18'N | 55°56'N | 60°43'N | 60°48'N |
| **Longitude** | 12°23'E | 13°6'E | 11°06'E | 23°29'E |
| **Altitude, m** | 30 | 65 | 135 | 95 |
| **Soil type** | Fine sand-mixed clay (10-15%) (JB6) | Clay (20-30%) | Clay (25-40%) | Clay |

### 2.2.1 Climatic data for the locations

The climatic data for the different locations is provided by the breeders at each associated location. The weather station in Svalöf is located at Lantmännen. The weather station in Jokioinen is located nearby the experimental trial at Boreal. The Swedish data is provided by LANTMET (LANTMET). For the Danish trial, the weather data are collected for Stevns municipality, and for the Norwegian field trial, the weather data are collected from the weather station Kise (60$^{o}$46’ N, 10$^{o}$48’ E, 130 m a.s.l.) (KlimaServiceSenter). This station is in the same climate zone, approximately 17 km away from Staur Gård.

## 2.3 Phenotypic traits - descriptor traits

The plants were visually scored (except plant height) at each location based on the description in Table 3. Heading (2013), plant height (2013) and regrowth after 1. Cut (2013) were scored at all locations, whereas winter survival was scored in Norway (2013 and 2014), Finland (2013 and 2014), Sweden (2013) and Denmark (2014). Traits scored at only one of the locations are not treated in this thesis. In the Norwegian trial, rust was scored on 1 block (5 plants) only, while plant height was measured on two blocks (10 plants).

**Table 3 Phenotyped traits, scale and description.**

| Trait | Scale | Description |
|---|---|---|
| **Winter survival** | 1-9 | 1= almost dead,<br>9= no signs of damage |
| **Heading** | Days to heading after 1st of January | Date when the first three tillers emerge |
| **Plant height** | cm | The tallest straw of full heading |
| **Regrowth after 1st cut** | 1-9 | 1=weak/slow,<br>9= great/fast |
| **Rust (mainly crown rust, *Puccinia coronata*)*** | 1-9 | 1= completely damaged<br>9= resistant to pathogen |

*** A more specified scale (Schubiger et al., 2016) was used for phenotyping rust: 1: more than 75% of the foliage covered with rust; predominantly leaves with necrosis, 2: 75% of the foliage covered with rust; leaves densely covered with rust and many necrotic leaves, 3: 60% of the foliage covered with rust; leaves densely covered with areas of rust a few necroses, 4: 40 % of the foliage covered with rust; leaves + spotted with many pustules, 5: 25 % of the foliage covered with rust; predominantly leaves with scattered pustules, 6: 10 % of the foliage covered with rust, 7: 5 % of the foliage covered with rust, 8: trace of rust, 9: no rust.**

## 2.4 Determination of ploidy by Flow Cytometry (FCM)

The ploidy determination was done in the laboratory at Graminor AS. The plants were grown from seeds (20-30 seeds per pot and population) in a glasshouse (Figure 8a). for about 4 weeks without special treatment.

Seeds for 383 populations were received from DLF in Denmark (WP1). For 6 populations; ‘Guru (2x)’, ‘Vir51519’, ‘ABY-BA9803.80’, ‘PI598519’, ‘Bronsyn (2x)’, Ba12987’, leaf samples from the WP7 field trials at Graminor (including these populations) were used instead of seedlings, because of too little seed in the seed samples obtained from the gene banks initially (WP1).

*a) The plants were established in greenhouse before testing*

*b) sample material harvested 3-5 cm from basis*

*c) samples stored on ice before preparation*

*d) adding extraction buffer and chopping with a sharp blade*

*e) Filter through a 30 µm filter*

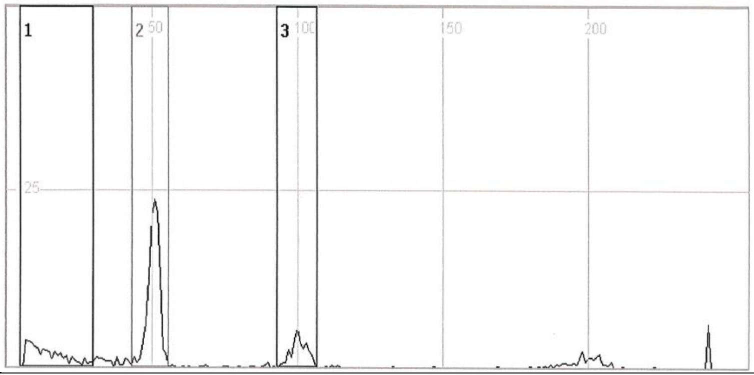
*f) Insert sample into the flow cytometer*

*Figure 8 Pictures from the flow cytometer procedure.*

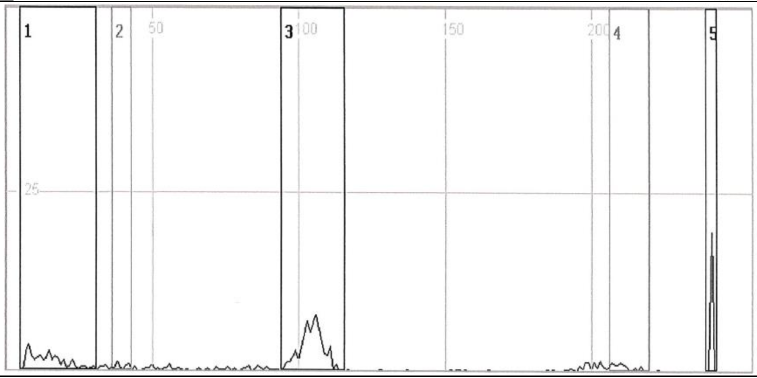
The procedure for ploidy testing is described in pictures in Figure 8. The standard Partec procedure for ploidy analyses (CyStain UV Precise P, 05-5002) of plants was followed. Before sampling, the upper part of the plants was cut away with a scissors. The sampled leaves were harvested 3-5 cm from basis (Figure 8b) from about 4 weeks old plants. Figure 8c shows the size of sampled material (the sample amount in the pictures was enough for several runs if needed). For a sample approximately six leaves at the length of +/-2,5 cm from different plants was used. This was a minor adjustment to the standard protocol (leaf size 0,5 $m^2$), but after different tries and conversations with supervisor Odd Arne Rognli, we decide to do it like this. The populations were tested in bulk, not as single plants, because of time and cost constraints.

The fresh, young leaves were finely chopped with a sharp scalpel blade (Figure 8d) in 400 µl Partec extraction buffer solution (Partec CYStain UV Precise P) for 45 s and incubated for 45 s before the suspension was passed through a 30 µm nylon filter to remove debris (Figure 8e). Partec buffer, 1.6 ml, (DAPI fluorochrome) was added to the filtrate and incubated for 45 s for staining the cells. The suspension was analyzed immediately on a Partec PA Flow Cytometer (Figure 8f).

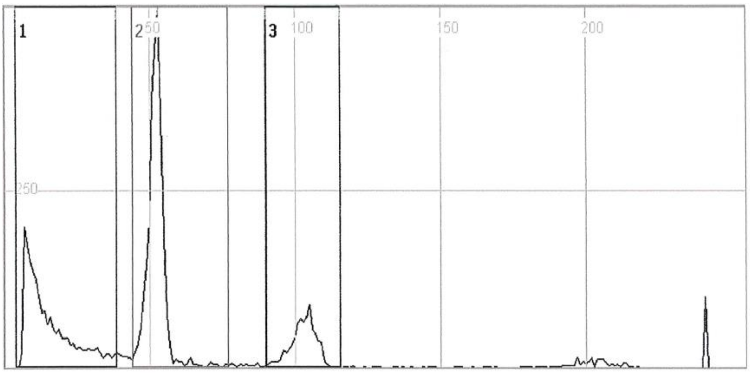
The Partec CyFlow® Ploidy Analyzer «DAPI» was calibrated with Partec Calibration Beads each day before start to control the instrument. The perennial ryegrass varieties ‘Fagerlin (2x)’ and ‘Figgjo (4x)’ were used as standard references, and samples of this were also run as control every day. The diploid level was set to channel (relative fluorescence intensity) 50 (Figure 9a), and tetraploid level to channel 100 (Figure 9b). Figure 9c shows a control with both diploid and tetraploid leaves in one sample. The ploidy level was determined based on the position of the peak for the tested population (Figure 9a-c) compared with the internal standards (‘Figgjo (4x)’ and ‘Fagerlin (2x)’), according to DeLaat et al. (1987). Each population was tested once, but for uncertain results new samples following the same procedure (in bulks) were run from 2 to 6 times, until the results were stable.



*a) Output form a diploid result (peak at channel 50). All diploids had a little peak at channel 100.*



*b) Output form a tetraploid result (peak at channel 100).*



*c) Output form a MIX result (peaks at both channel 50 and 100).*

*Figure 9 Outputs from the flow cytometer showing results from both 2x, 4x and MIX ploidy. Peaks in the right and left part of the histogram views noise in the samples and can be ignored.*

## 2.5 Statistical analyses

All statistical analyses are based on plot means (5 plants/plot). Plot values based on less than 4 plants were changed to missing value.

*Least square means* (LS Means) per population were calculated for each location separately using the PROC GLM (general linear models) for Unbalanced ANOVA (analysis of variance) in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). The GLM procedure uses the method of least squares to fit generalized linear models.

The *Box plot method* was used for comparing the variation between the four locations for the traits heading date, plant height, regrowth after 1st cut, crown rust (only in Denmark and Norway) and winter survival 2013 and 2014.

Diploid cultivars (n=105) and diploid ecotypes (n=176) are compared with tetraploid cultivars (n=65) and tetraploid ecotypes (n=8) for each location separately. The unverified accession type group (n=25) are not a part of these graphs/figures. The total number, N=354, corresponds to the populations included in trials at all locations.

GraphPad Prism8, version 8.3.1 for Windows (GraphPad Software, San Diego, California USA, www.graphpad.com ) was used to make the box plots and test differences between population groups by the Tuckey's multiple comparisons test.

The *Additive Main Effects and Multiplicative Interaction Model* (AMMI) was used to analyze main effects and genotype/population by environment (GE) interactions for winter survival. In the AMMI model, the analysis of variance of the combined data is expressed as follows (Gauch (1988):

$$Y_{ge} = \mu + \alpha_g + \beta_e + \Sigma_n \lambda_n \Upsilon_{\mathrm{gn}} \delta_{en} + \theta_{ge},$$

where $Y_{ge}$ is the mean trait value of genotype (population) $g$ in environment $e$; $\mu$ is the grand mean; $\alpha_g$ is the deviation of populations from the grand mean; $\beta_e$ is the environment mean deviations; $\lambda_n$ is the eigenvalue of principal components analysis (PCA) axis $n$; $Y_{gn}$ and $\delta_{en}$ are the genotype and environment PCA scores for PCA axis $n$; N is the number of PCA axes retained in the model and $\theta_{ge}$ is the residual. Winter survival was scored at four locations in 2013 and two location in 2014, these were considered jointly as six environments in the AMMI analysis.

The AMMI model combines standard analysis of variance (ANOVA) with principal component analysis (PCA) (Zobel et al., 1988). This method extracts genotype and environment main effects and uses principal component analysis (PCA) to explain patterns in the GE interaction from the additive ANOVA model. In this study, the R package Agricolae (http://tarwi.lamolina.edu.pe/~fmendiburu/) was used to conduct AMMI analysis.

The AMMI was performed for the winter survival trait for 323 populations and 6 location/year combinations; SWE_13, NOR_13, FIN_13, DEN_14, NOR_14 and FIN_14. The number 323 refer to the populations with LS means for the WS (more than 4 plants per plot) at all locations. The populations were given an AMMI_ID for more legible figures. The link between population name and AMMI_ID can be found in Appendix 1.

*Variance components* for each trait/location/year combination were estimated by PROC VARCOMP in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) and the following equation used to calculate broad-sense heritability ($H^2_b$):

$$H^2_b=var_b/(var_b + var_w + var_e),$$

where $var_b$ is the variation between population means, $var_w$ is the variation among plants within populations (within-population variation), and $var_e$ the residual variation. Pearson *correlation coefficients* were estimated using PROC CORR in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

# 3.0 Results

## 3.1 Climate variations across the four locations

Climatic variations for the four locations during the experimental period are presented in Figure 10 and Table 4. The locations in Finland and Norway have a similar continental climate with cold winters, while the locations in Denmark and Sweden have a warmer coastal climate. From May to September there is little difference in mean temperature between the four locations, but from September to May the temperatures at the locations in Norway and Finland are noticeably colder than at the locations in Sweden and Denmark. The Swedish location had the highest total precipitation (Table 4), while the Danish location had the lowest precipitation and the highest mean temperature.

Figure 10 shows that the 2012-13 winter was cold from December until March, with snow cover of about 20 cm at the locations in Finland and Norway for more than 140 days. The location in Finland had a higher mean temperature than the Norwegian site from January to March 2013. The temperature at the Norwegian site was more stable than the temperature at the Finnish site. More details about winter temperatures in the Norwegian and Finnis locations are presented in Appendix 2.

The second winter (2013-14) was especially harsh at the Finnish location. December was relatively warm, without snow cover from the middle of December until the second week of January. Within one week, the temperature dropped from +5°C to -18°C, only with a snow cover of about 5 cm in the coldest periods. The snow cover and depth were similar at the Norwegian site, however, the mean temperature in January 2014 was -4.0 °C compared to -8.8 °C at the Finnish site.

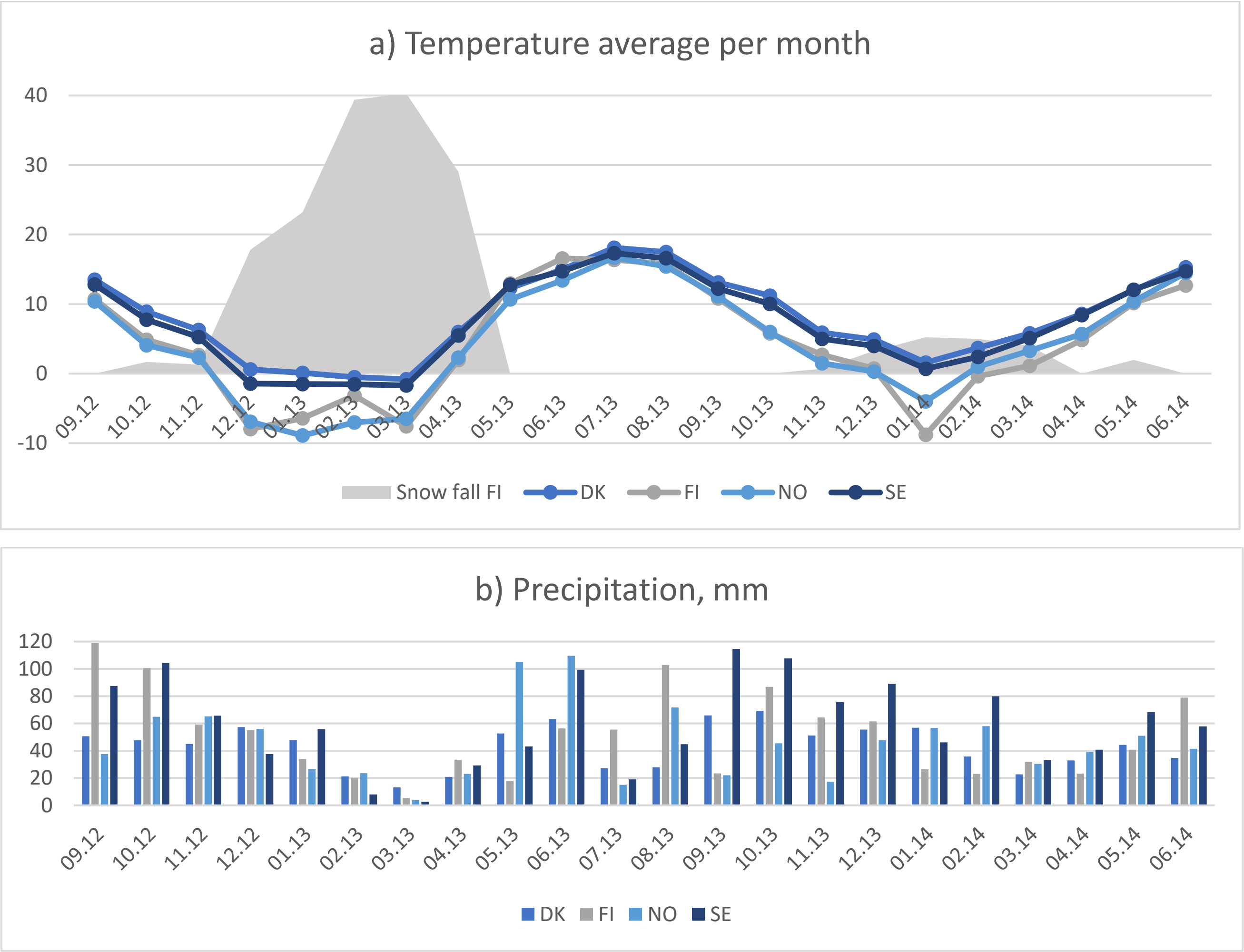


*Figure 10 a) Temperature (mean) and b) precipitation (sum) per month for different locations from September 2012 to June 2014. The grey area in the temperature figure describes the snow depth (mean) at the location in Finland as an illustration of snow amount and duration for the locations in Norway and Finland.*

The variation in precipitation and temperature between the locations might lead to differences in plant growth in summer 2013 considering the large amount of rain at the Norwegian site in May and June (almost double compared to the other locations), in addition to colder temperatures. Only the Swedish location had nearly the same amount of rain in June, while it rained most in July and August at the Finnish location. The Danish location had the lowest rainfall in the period April to August 2013, while the autumn and winter of 2013 was very rainy at the Swedish location.

**Table 4 Mean temperature, precipitation, and duration and amount of snow for the four experimental sites in the period 01.09.2012 – 30.06.2014**

| Location: | Mean temp | Precipitation (sum) | Number of days with snow 2012/13 (mean snow depth, cm) | Number of days with snow 2013/14 (mean snow depth, cm) |
|---|---|---|---|---|
| **Norway** | 4.4 | 1011 | 140 (18.9) | 92 (7.0) |
| **Sweden** | 7.2 | 1310 | na (na) | na (na) |
| **Denmark** | 8.1 | 944 | na (6.8) | na (2.0) |
| **Finland** | 4.4 | 1119 | 145 (28.1) | 65 (4.1) |

## 3.2 Determination of ploidy

The determination of ploidy level by flow cytometer (FCM) identified 306 diploid and 76 tetraploid populations. Passport information with the associated ploidy level for each population can be found in Appendix 1. Five populations were determined as admixtures of diploids and tetraploids, while 6 populations were classified with unknown ploidy, as a result of lack of seed and plant material to test.

Of the 76 tetraploid populations, 8 populations were classified as ecotypes (7 wild and 1 landrace), one ecotype (wild) was determined as a mixture (Table 5). These nine tetraploid (including 1 mix) ecotypes represent 4.9 % of the total number of ecotypes (183).

Table 5 Unexpected ploidy results; tetraploid ecotypes and populations with mixed ploidy

| Acc_no | Acc_name | Accession type | Ploidy from gene bank | Ploidy after test | Country of org. | Provider |
|---|---|---|---|---|---|---|
| **Vir51518** | Vir51518 | Ecotype | 2x | 4x | Russia | [a] VIR, Rus. |
| **PI598442** | ABY-BA9094.72 | Ecotype | 2x | 4x | Switzerland | USDA |
| **LIA1070** | 2751 | Ecotype | na | 4x | Lithuania | [b] PGB, Lith. |
| **LIA1410** | 2904 | Ecotype | na | 4x | Lithuania | [b] PGB, Lith. |
| **LIA1409** | 2906 | Ecotype | na | 4x | Lithuania | [b] PGB, Lith. |
| **LIA1415** | 2909 | Ecotype | na | 4x | Lithuania | [b] PGB, Lith. |
| **LIA1411** | 2911 | Ecotype | na | 4x | Lithuania | [b] PGB, Lith. |
| **LIA1419** | 2905 | Ecotype | na | MIX | Lithuania | [b] PGB, Lith. |
| **Ba12220** | ABY-Ba12220 | Landrace | na | 4x | Switzerland | ECP/GR |
| **NGB1643** | TONGA | Cultivar | 4x | MIX | Denmark | Nordgen |
| **Ivar** | Ivar | Cultivar | 4x | MIX | Norway | Graminor |
| **Pionero** | Pionero | Cultivar | 4x | MIX | Germany | Eurograss |
| **Impresario** | Impresario | Cultivar | 4x | MIX | Denmark | DLF |

[a] N.I. Vavilov Research Institute of Plant Industry, Russia, [b] Plant Gene Bank, Ministry of Environment, Lithuania

After determination by FCM, the ploidy level of 19 populations (15 %) got a change from the original ploidy level stated by the provider (126 populations with origin ploidy). Details about these populations are presented in Table 6. Eleven of the 19 (5.8%) was provided by the N.I. Vavilov Research Institute of Plant Industry, initially classified as diploids but after testing identified as tetraploids.

Thirty-four cultivars were initially classified as tetraploids before being tested. Two of these, ‘Aurora/Chouss’ (France), and ‘Falk’ (Norway) were determined as diploids after testing (Falk was later confirmed to be a MIX). Four tetraploid cultivars, i.e. Tonga (Denmark), Impresario (Denmark), Pionero (Germany) and Ivar (Norway), were determined as MIX (admixture of both diploids and tetraploids).

**Table 6 Populations with changes in ploidy after determination with flow cytometer (FCM)**

| Acc_no | Acc_name | Ploidy from gene bank | Ploidy determ. by FCM | Accession type | Country of org. | Provider |
|---|---|---|---|---|---|---|
| **Vir42504** | M-1 | 2x | 4x | unknown | Japan | a) VIR, Rus. |
| **Vir50879** | Vir50879 | 2x | 4x | unknown | Latvia | a) VIR, Rus. |
| **Vir51253** | Vir51253 | 2x | 4x | unknown | Latvia | a) VIR, Rus. |
| **EST158** | EST158 | 2x | 4x | Breeding l. | Estonia | b) Jõgeva PBI, Est. |
| **Vir42502** | Yatsugane | 2x | 4x | Cultivar | Japan | a) VIR, Rus. |
| **Vir47611** | Svyatoshinskii | 2x | 4x | Cultivar | Ukraine | a) VIR, Rus. |
| **Vir50620** | Malysh | 2x | 4x | Cultivar | Russia | a) VIR, Rus. |
| **Vir50774** | Ruslana | 2x | 4x | Cultivar | Ukraine | a) VIR, Rus. |
| **Vir50929** | Raiti | 2x | 4x | Cultivar | Estonia | a) VIR, Rus. |
| **Vir51515** | BUK-66 | 2x | 4x | Cultivar | . | a) VIR, Rus. |
| **Vir51516** | Duet | 2x | 4x | Cultivar | . | a) VIR, Rus. |
| **Vir51518** | Vir51518 | 2x | 4x | Ecotype | Russia | a) VIR, Rus. |
| **PI598442** | ABY-BA9094.72 | 2x | 4x | Ecotype | Switzerland | USDA |
| **Aurora** | Chouss | 4x | 2x | Cultivar | France | Verneuil |
| **Falk** | Falk | 4x | 2x* | Cultivar | Norway | Graminor |
| **NGB1643** | TONGA | 4x | MIX | Cultivar | Denmark | Nordgen |
| **Ivar** | Ivar | 4x | MIX | Cultivar | Norway | Graminor |
| **Pionero** | Pionero | 4x | MIX | Cultivar | Germany | Eurograss |
| **Impresario** | Impresario | 4x | MIX | Cultivar | Denmark | DLF |

*later confirmed as MIX, a) N.I. Vavilov Research Institute of Plant Industry, Russia, b) Genebank, Jõgeva Plant Breeding Institute, Estonia

## 3.3 Phenotyping results

### 3.3.1 Least square means

Summary of GLM analyses within locations (Appendix 3) view significant differences (p=0.001) for population at each location and for each trait. Block effect is significant for most of the traits and locations, except for heading date in Sweden and Denmark. Significant effect of block means large variation between the different block within a location. This block effect is more common in single plants experiments where the plots consist of different genotypes from the same population, and not clones. Differences in phenotyping and environmental differences (differences in the soil) might also be an explanation.

### 3.3.2 The box plots

Table 7 shows the ANOVA table for all the traits and different box plot comparisons. The difference between the different groups (bars) in the box plots are significant for all traits.

**Table 7 ANOVA tables for the box plots**

| **ANOVA table for trait:** | **SS** | **DF** | **MS** | **F (DFn, DFd)** | **P value** |
|---|---|---|---|---|---|
| **Heading day** | | | | | |
| Treatment (between columns) | 45915 | 15 | 3061 | F (15, 1278) = 230.7 | P<0.0001 |
| Residual (within columns) | 16958 | 1278 | 13.27 | | |
| Total | 62873 | 1293 | | | |
| **Plant height** | | | | | |
| Treatment (between columns) | 317080 | 15 | 21139 | F (15, 1230) = 440.1 | P<0.0001 |
| Residual (within columns) | 59078 | 1230 | 48.03 | | |
| Total | 376158 | 1245 | | | |
| **Regrowth** | | | | | |
| Treatment (between columns) | 537.8 | 15 | 35.86 | F (15, 1285) = 60.11 | P<0.0001 |
| Residual (within columns) | 766.5 | 1285 | 0.5965 | | |
| Total | 1304 | 1300 | | | |
| **Crown rust** | | | | | |
| Treatment (between columns) | 83.74 | 7 | 11.96 | F (7, 569) = 18.34 | P<0.0001 |
| Residual (within columns) | 371.1 | 569 | 0.6522 | | |
| Total | 454.8 | 576 | | | |
| **Winter survival 2013** | | | | | |
| Treatment (between columns) | 3469 | 11 | 315.4 | F (11, 968) = 235.6 | P<0.0001 |
| Residual (within columns) | 1296 | 968 | 1.338 | | |
| Total | 4765 | 979 | | | |
| **Winter survival 2014** | | | | | |
| Treatment (between columns) | 1577 | 11 | 143.4 | F (11, 972) = 351.4 | P<0.0001 |
| Residual (within columns) | 396.5 | 972 | 0.408 | | |
| Total | 1974 | 983 | | | |
| **Winter survival 2013 and 2014** | | | | | |
| Treatment (between columns) | 1892 | 15 | 126.1 | F (15, 1294) = 151.4 | P<0.0001 |
| Residual (within columns) | 1078 | 1294 | 0.833 | | |
| Total | 2970 | 1309 | | | |

All values for significance of comparisons between groups, number behind each group and mean values for each group can be found in Appendix 5 (table 1-7), one per box plot/trait. The box plots can be interpreting this way; one bare represent a group. The bar has a minimum and maximum value; lower and upper line. The distance between these displays the variance of the data/results. The box illustrates 50% of the dataset. The median (middle value of the dataset) is shown by the line inside the box (50th percentile). The bottom and upper line of the box illustrate respectively the 25th and 75th percentiles.

### 3.3.3 Plant height

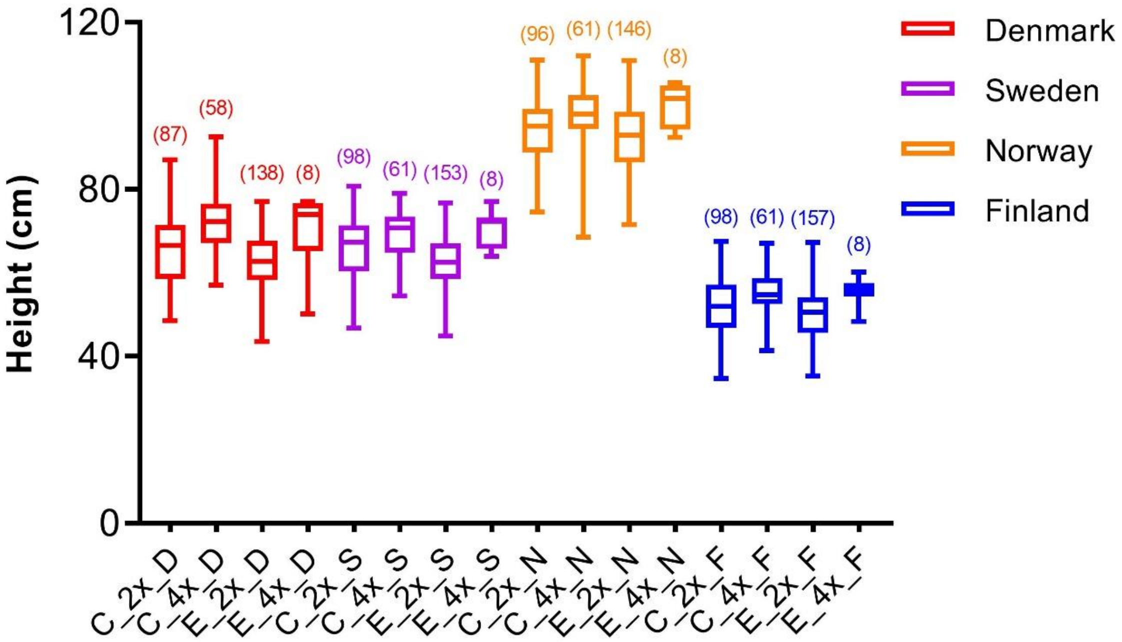


*Figure 11 Variation in plant height between the locations (levels of ploidy (2x= diploid, 4x= tetraploid) and type of accession (C= cultivar, E= ecotype). The scale of measurement is in cm and is measured from the ground to the top of the tallest tiller at full heading. The number behind each class/group is given for each bar.*

The biggest differences in plant height are between the locations (Figure 11), with both ecotypes and cultivars being significantly tallest at the Norwegian site ($p<0.0001$). The Finnish location had significant shorter plants than the other locations (<0.0001), being almost half the height of the Norwegian population groups (differed almost 50 cm). Tetraploid plants tended to be a bit taller than diploids, with the tetraploid cultivars significantly taller than the diploid ecotypes at all locations (<0.0001). The Swedish and

Danish population groups had quite similar height, except for some tall outliers among the cultivar groups in the Danish site.

### 3.3.4 Heading date

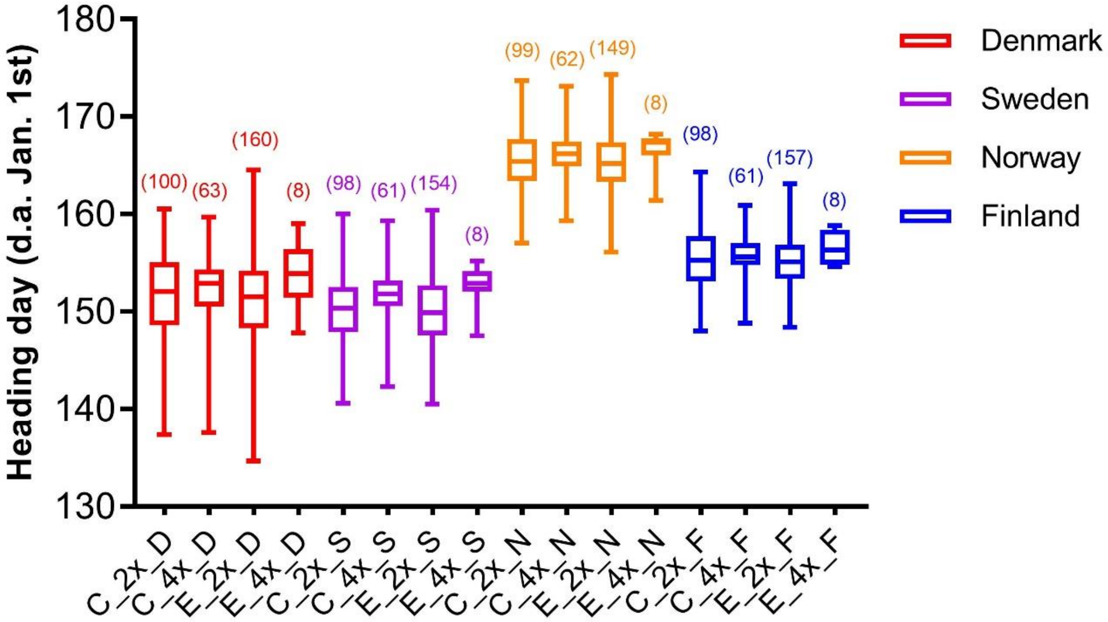


*Figure 12 Variation in heading date (HD), the y-axis shows heading time in days after the 1st of January (130=10th of May, 150=30th of May, 170=19th of June). Levels of ploidy (2x= diploid, 4x= tetraploid) and type of accession (C= cultivar, E= ecotype) for the different locations. The number behind each class/group is given for each bar.*

There is no statistically significant difference for mean heading date between any of the population groups at any locations in Figure 12. Mean heading date at the locations in Norway and Finland were significantly different from each other (p<0.0001), and significantly different from the other two locations (p<0.0001). Denmark and Sweden had the same mean heading date (end of May/beginning of June), it differed by only one day. Finland has a mean heading date 4-5 days later than in Denmark and Sweden, while it is about 15 days later in Norway.

Generally, the diploids have both the earliest and the latest heading genotypes, with no significant difference between the cultivar and ecotype group except in Denmark where the diploid ecotypes had the greatest variability of heading time with the earliest heading at 15th of May and the latest at 15th of June. Norway had the latest heading, with the earliest heading on the 2nd of June and the latest on the 24th of June.

The diploid ecotype ‘PI598441 (2x)’ from Switzerland were the earliest heading population at the locations in both Norway, Denmark and Sweden, and the second earliest in the Finnish location. The diploid German cultivar ‘Ivana (2x)’ was also among the top three earliest at all locations. The Lithuanian diploid ecotype ‘LIA1414, 2903 (2x)’, the Polish diploid ecotype ‘POL15514 (2x)’ and the diploid Danish cultivar ‘TRANI (2x)’ were consistently among the three latest heading populations at all locations.

### 3.3.5 Regrowth after 1st cut

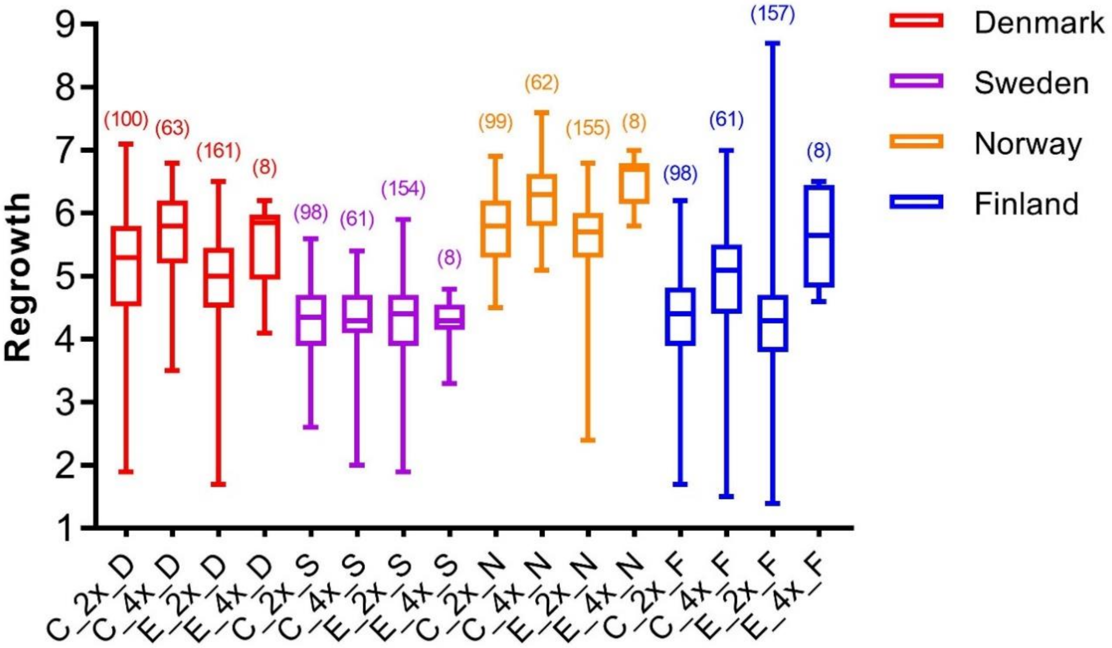


*Figure 13 Regrowth after 1st cut, scale 1-9 where 1 is weak/slow regrowth and 9 is great/fast regrowth. Different colors for each location, C= cultivar, E=ecotype, 2x=diploid, 4x=tetraploid. The number behind each class/group is given for each bar.*

Related to regrowth rate (Figure 13), diploid cultivars and ecotypes had the largest variation in the Danish experiment, while the tetraploid cultivars had a highest mean regrowth (5.7), followed by tetraploid ecotypes (5.4). The difference in regrowth between tetraploid cultivars and diploid ecotypes was significant (p<0.0001). Also, the difference between diploid and tetraploid cultivars was significant (p=0.02), with tetraploid cultivars having significantly better regrowth than diploid cultivars.

In the Swedish location, no significant variation was seen between any of the Swedish population groups, all groups have a mean regrowth around 4.3. The diploid ecotypes had the greatest variation for regrowth in the Swedish trial.

In the Norwegian location, generally faster regrowth was observed, compared with other locations, with the largest variation in the diploid ecotype group. The tetraploid cultivars had significantly better regrowth than both the diploid cultivars (p=0.003) and the diploid ecotypes (p<0.0001). The tetraploid ecotypes had the highest mean regrowth of 6.52. The variation within the diploid and tetraploid cultivars was smaller at the location in Norway compared with locations in the other countries.

In the Finnish site, the tetraploid cultivars had significant better regrowth than diploid cultivars (p<0.0001). The diploid ecotype group demonstrated the overall largest variation in regrowth at the location in Finland. The tetraploid ecotype group showed the highest mean regrowth in the Finnish trial being significantly different from the diploid cultivars (p=0.0002).

To sum up the regrowth variation between locations, the Norwegian site differs from the rest of the locations by having a higher overall regrowth rate compared with the other locations. The tetraploid population groups tend to have the highest regrowth rate, although there were no significant differences between the population groups in the Swedish experiment.

### 3.3.6 Crown rust (Puccinia coronata)

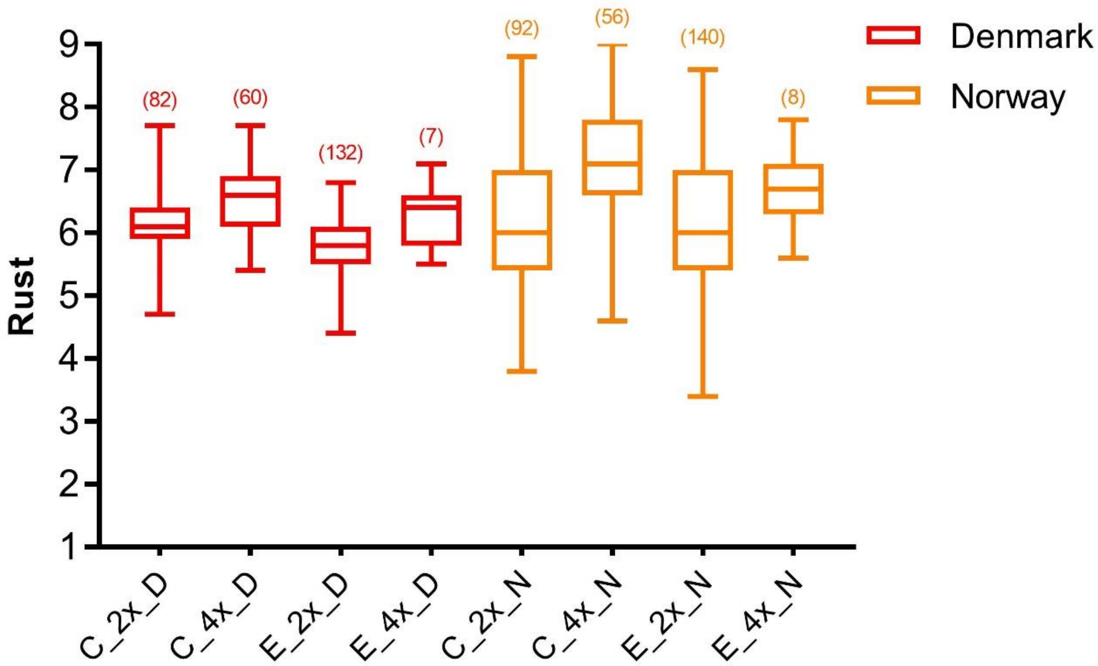


*Figure 14 Variation in susceptibility to crown rust (Puccinia coronta). Scale 1-9, where 1 is more than 75% of the foliage covered with rust, 6 is 10 % covered and 9 has no rust. Different colors for each location, C= cultivar, E=ecotype, 2x=diploid, 4x=tetraploid. The number behind each class/group is given for each bar. Only one block of the Norwegian trial was phenotyped.*

In the Danish trial, the tetraploid cultivars were significantly less susceptible to crown rust (p<0.0001) than the diploid ecotypes (Figure 14), which again were significantly less susceptible (p=0.0281) than the diploid ecotypes. In the Norwegian trial, the tetraploid cultivars were significantly better than both diploid cultivars (p<0.0001) and ecotypes (p<0.0001). Diploid cultivars had the most susceptible populations, but none got a lower score than 3, which means 60% of the leaves covered with rust.

In general, the tetraploid populations were better than the diploids. Within the same ploidy level, cultivars were better than ecotypes, however, the tetraploid ecotypes had better mean value than the diploid cultivar group. The 3 best outliers in the Danish trial were from the diploid cultivar group (Table 8); the Lithuanian breeding line 'LIA368/1159 (2x)', the French cultivar 'Escapade (2x)' and the Russian cultivar 'Maylysh (4x)'. In the Norwegian trial the tetraploid cultivars 'Tetragreen (4x)' from

Denmark and ‘Spidola (4x)’ form Latvia had the best mean scores for rust. The Norwegian diploid cultivar ‘Fure (2x)’ had the third-best scores.

Table 8 Top 3 Crow rust scores after phenotyping in Denmark and Norway (mean values).

| Location | Ploidy | Acc_no | Acc_name | Country_ of_origin | Acc_type | Rust |
|---|---|---|---|---|---|---|
| **Denmark** | 2x | LIA368 | 1159 | Lithuania | Breeding | 7.7 |
| **Denmark** | 2x | Derby_Xtreme | Escapade | France | Cultivar | 7.7 |
| **Denmark** | 4x | Vir50620 | Malysh | Russia | Cultivar | 7.7 |
| **Norway** | 4x | Tetragreen | Tetragreen | Denmark | Cultivar (lawn) | 9.0 |
| **Norway** | 4x | LVA00062 | Spidola | Latvia | Cultivar | 9.0 |
| **Norway** | 2x | NGB2209 | FURE | Norway | Cultivar | 8.8 |

### 3.3.7 Winter survival

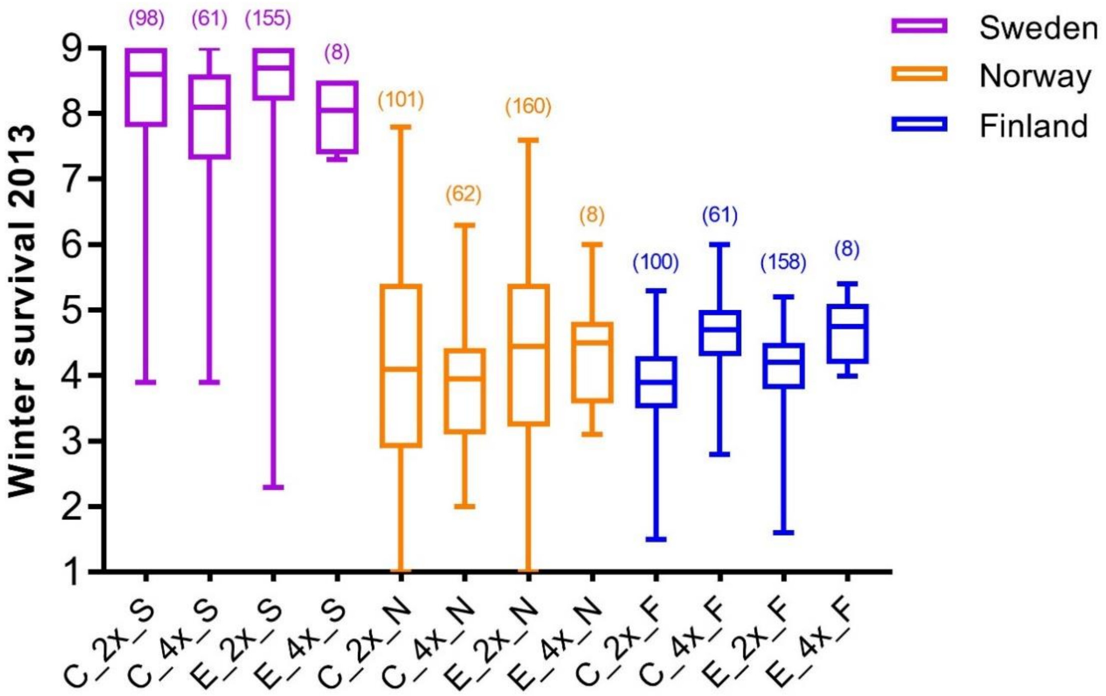


*Figure 15 Variation in winter survival after winter (2012-13), phenotyped in spring 2013. Scale 1-9, where 1 is almost dead and 9 is no signs of damage. Different colors for each location, C= cultivar, E=ecotype, 2x=diploid, 4x=tetraploid. The number behind each class/group is given for each bar.*

Winter survival 2013 (WS13):

Winter survival was very good at the Swedish location (Figure 15) with mean survival around 8 in the spring 2013, while winter survival at the Norwegian and Finnish location was much lower with means around 4. The largest variation in winter survival is within the diploid groups in the Norwegian and Finnish experiments with both big, nice plants and plants which were almost dead. The location in Norway was the only location with almost dead populations (minimum value of 1). There is no significant difference between any of the group means in the Norwegian site, but the populations with the best winter survival is diploids. This is quite the opposite of results at the Finnish site (Figure 15, Table 9). The only significant difference within a location was between diploid and tetraploid cultivars at the Finnish location, tetraploids surviving better than diploids (p=0.0042).

The populations with the best winter survival in the Norwegian trial in 2013 was the Swedish cultivar 'Servo (2x)' and landrace 'Valinge (2x)' (Table 9). The Canadian cultivar 'Norlea (2x)' was also among the top 3 in the Norwegian trial. In the Finnish trial, the Norwegian cultivar 'Trygve (4x)', the Latvian breeding line (b.l.) 'LVA05255, 363/06 (4x)', and the Estonian b.l. 'EST158 (4x)' had the best mean winter survival. The two wild populations 'POL155159 (2x)' and 'DE54092 (2x)' from Poland and Romania, respectively scored best in the Swedish experiment, together with the Lithuanian b.l. 'LIA368, 1159 (2x)'.

**Table 9 Top 3 winter survival 2013 per location (mean values)**

| Location | Ploidy | Acc_no | Acc_name | Country_ of_origin | Acc_type | WS_13 |
|---|---|---|---|---|---|---|
| **Norway13** | 2x | NGB2444 | SERVO | Sweden | Cultivar | 7.8 |
| **Norway13** | 2x | NGB4090 | VALINGE | Sweden | Landrace | 7.6 |
| **Norway13** | 2x | PI278773 | Norlea | Canada | Cultivar | 7.2 |
| **Finland13** | 4x | Trygve | Trygve | Norway | Cultivar | 6.0 |
| **Finland13** | 4x | LVA02522 | 363/06 | Latvia | Breeding_line | 6.0 |
| **Finland13** | 4x | EST158 | EST158 | Estonia | Breeding_line | 5.8 |
| **Sweden13** | 2x | POL155159 | POL155159 | Poland | Ecotype | 9.3 |
| **Sweden13** | 2x | DE54092 | DE54092 | Romania | Ecotype | 9.1 |
| **Sweden13** | 2x | LIA368 | 1159 | Lithuania | Breeding_line | 9.1 |

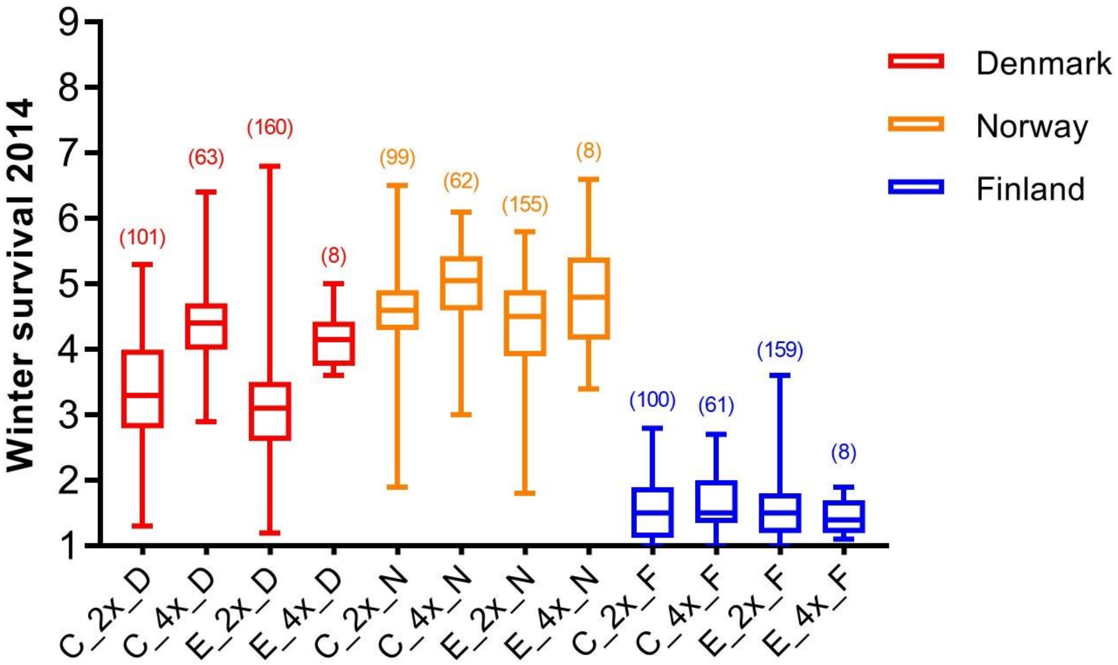


*Figure 16 Variation in winter survival after winter (2013-14), phenotyped in spring 2014. Scale 1-9, where 1 is almost dead and 9 is no signs of damage. Different colors for each location, C= cultivar, E=ecotype, 2x=diploid, 4x=tetraploid. The number behind each class/group is given for each bar.*

Winter survival 2014 (WS14):

The results after the 2014 winter at the Danish location showed clear differences between all groups (Figure 16). Tetraploid cultivars had the best survival (mean value 4.4), which is a whole score better than the diploid cultivar group at 3.4 (p<0.0001), and the diploid ecotype group at 3.1 (p<0.0001). The tetraploid ecotypes differed significantly from the diploid ecotypes (p=0.0004). The diploid ecotypes had the greatest variation among the groups, with the a range from 1.2 to 6.8. The best populations for WS14 in the Danish trial was a diploid ecotype collected in France, ‘Ba12983 (2x)’, provided by the ECP/GR gene bank. A tetraploid breeding line from Latvia (‘LVA02523, 361/06 (4x)’) was the second-best, and the cultivar ‘Impresario’, determined as a ploidy MIX, provided by DLF in Denmark had the third-best results (Table 10).

Table 10 Top 3 best winter survival 2014 per location (mean values).

| Location | Ploidy | Acc_no | Acc_name | Country_ of_org. | Acc_type | WS_14 |
|---|---|---|---|---|---|---|
| **Norway14** | 4x | LIA1410 | 2904 | Lithuania | Ecotype | 6.6 |
| **Norway14** | 2x | Ivana | Ivana | Germany | Cultivar | 6.5 |
| **Norway14** | 4x | LVA02526 | 260/06 | Latvia | Breeding_line | 6.1 |
| **Finland14** | 2x | PI598516 | 363 | Turkey | Ecotype | 3.6 |
| **Finland14** | 2x | NGB1647 | VERNA_PA | Denmark | Cultivar | 2.8 |
| **Finland14** | 2x | NGB4342 | HAGESTAD | Sweden | Ecotype | 2.8 |
| **Denmark14** | 2x | Ba12983 | Ba12983 | France | Ecotype | 6.8 |
| **Denmark14** | 4x | LVA02523 | 361/06 | Latvia | Breeding | 6.4 |
| **Denmark14** | MIX | Impresario | Impresario | Denmark | Cultivar | 5.8 |

Tetraploid cultivars survived best also in the Norwegian location with a mean of 5 for WS14, significantly better than diploid cultivars ($p=0.0023$) and diploid ecotypes ($p<0.0001$). Tetraploid ecotypes did not differ significantly from the others. The population with best mean winter survival in the Norwegian trial in 2014 (Table 10) was a tetraploid wild type (ecotype) collected in Lithuania (‘LIA1410, 2904 (4x)’) and provided by Plant Gene Bank, Ministry of Environment, Lithuania. The diploid cultivar ‘Ivana (2x)’ from Germany, provided by BayP, ranked second and the tetraploid Latvian breeding line ‘260/06 (4x)’ provided by Lithuanian State Forestry Research Institute “Silava” third among the populations with best winter survival during the winter 2014 in the Norwegian site.

Winter injuries were severe at the Finnish location in 2014 with mean values for all groups around 1.5. Less than 20 % of the populations (68/358) had mean scores of 2 or more. There were no significant differences between any of the groups, but the diploid ecotype group had populations with the highest scores, however, they were not higher than 3.6 (Table 10). The population with best mean scores for winter survival in the Finnish site in 2014 was a diploid ecotype collected at 1150 m a.s.l. in Turkey, between Istanbul and Antalya, provided by USDA (U.S. National Plant Germplasm System) as ‘PI598516 (2x)’. The diploid Danish cultivar ‘Verna Pajberg (2x)’ and a diploid Swedish ecotype named ‘Hagestad (2x)’, provided by Nordgen were also among the top three populations in Finnish experiment.

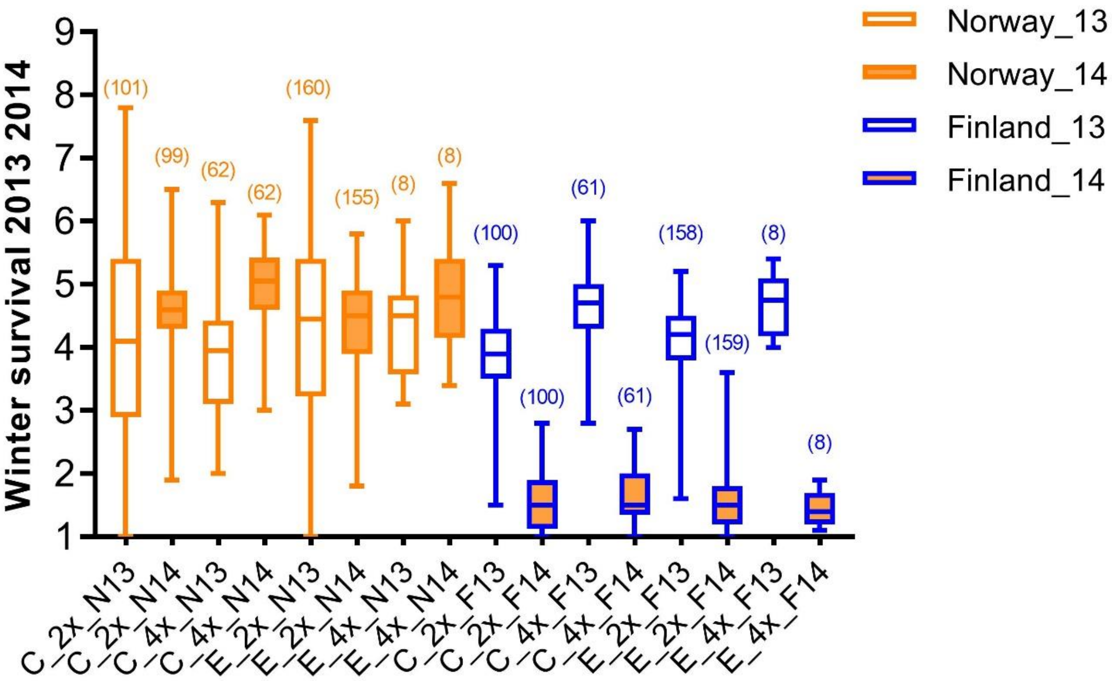


*Figure 17 Variation in winter survival after both winters (2012-13 and 2013-14), phenotyped in spring 2013 and 2014. Scale 1-9, where 1 is almost dead and 9 is no signs of damage. Only breeders in Norway and Finland did phenotyping after both winters. Different colors for each location, C= cultivar, E=ecotype, 2x=diploid, 4x=tetraploid. The number behind each class/group is given for each bar. The different numbers of populations (behind the groups) for the diploid cultivars in Norwegian site in 13 and 14 is due to dead plants after the first winter. For diploid ecotypes in the Finnish site, one population was added in 14, this might be because one population was scored as dead in 2013, probably because of very slow spring growth.*

Population x location x year interactions for winter survival:

The breeders in Norway and Finland did phenotyping for winter survival in two years (Figure 17). At the Finnish location there was a huge difference (3 scores on average, $p<0.0001$) between the two years with severe winter injuries in 2014.

In the Norwegian site, the tetraploid cultivars 14 had the best mean for both years at score 5.0 (not significantly different from diploid cultivars_14, tetraploid ecotypes_13 and 14). The diploid cultivars_13 and diploid ecotypes_13 had the largest variation with both the best outliers at almost 8 and the worst outliers which were almost dead (score 1).

## 3.4 Broad sense heritabilities

**Table 11 Broad sense heritabilities estimated within countries**

| Country | Heading date | Plant height | Regrowth | Crown rust | Winter survival 2013 | Winter survival 2014 |
|---|---|---|---|---|---|---|
| **Denmark** | 0.66 | 0.47 | 0.13 | 0.23 | | 0.26 |
| **Finland** | 0.43 | 0.32 | 0.15 | | 0.19 | 0.16 |
| **Norway** | 0.45 | 0.31 | 0.29 | 0.47 | 0.49 | 0.19 |
| **Sweden** | 0.57 | 0.37 | 0.14 | | 0.37 | |

As expected, broad sense heritabilities of traits that were measured or determined on a time scale (plant height and heading date), were higher than traits that were scored visually using a scale measured. Heritability for heading date was higher at the southern locations Denmark and Sweden than at the more northern locations. It might be caused by daylength and temperature effects on phenological development since many of the ecotype populations originate from locations further south in Europe and overseas. This could contribute to a larger within population variation at the locations in Norway and Finland and lower heritability. The same pattern is evident for plant height which likely could be affected in the same way as heading date. Variation in heritability for the visually scored trait is rather large and will reflect both specific location effects creating different variations within populations and differences in the ability to score the traits consistently, contributing to different error variances.

## 3.5 Genotype environment (GE) analysis by AMMI model for winter survival (WS)

The AMMI model was used to study genotype(population) x environment between different locations/years and 323 of the populations tested in the field trials. The Gollobs test showed that 82.5% of the total sum of squares could be explained by the environment (locations), only 5.3 % by the genotypes (populations) and 12.2% by the G x E effects. The large sum of squares for environments indicate that the environments (locations/year) are very diverse, with large differences between locations and years explaining most of the variation in WS. The first two PC's describe 71.7% of the total variation, with the contribution of PC1 was 58.05% and that of PC2 13.7%. As a result of this, AMMI 1 (PC1 vs mean WS) and AMMI 2 (PC1 vs PC2) biplots were generated to illustrate the genotype x population interaction effects and the effects of environment (Figure 18 and 19).

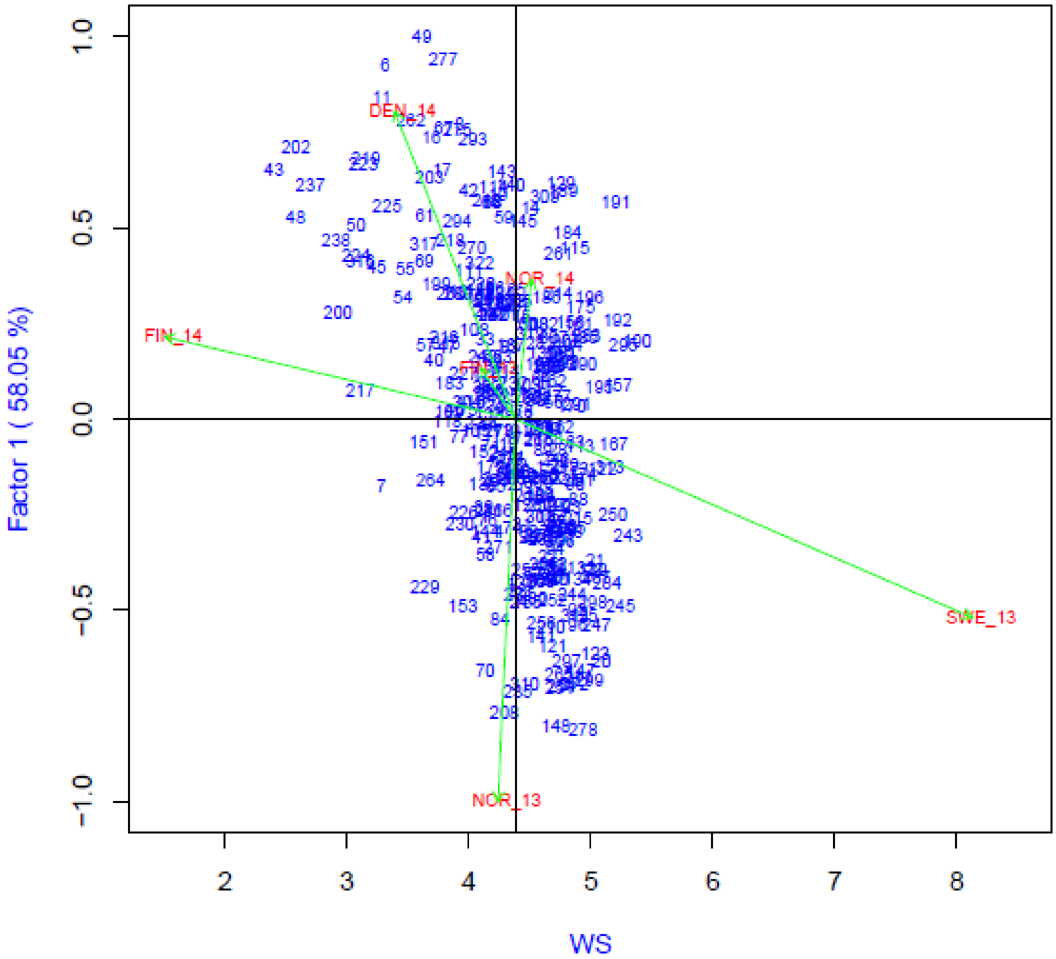


*Figure 18 AMMI 1 biplot model showing relationship between PC1 of the GE interaction and mean winter survival for 323 populations at 6 locations/year combinations.*

The AMMI 1 biplot (Figure 18) shows the six green vectors representing each location for the actual year; Norway (NOR_13/_14), Sweden 13 (SWE_13), Denmark 14 (DEN_14) and Finland (FIN_13/_14). SWE_13 was the location with highest mean scores for WS, there were less than 0.5 score in difference between the NOR_13 and NOR_14, but the longer vectors for the NOR_13 indicates that there variation between the population means were larger than in NOR_14. FIN_14 had the lowest WS mean score (1.5) for all populations. The scatter plot of the populations in this biplot indicates that the populations 190 (‘LVA02522,363/06 (4x)’), 295 (‘Trygve (4x)’) and 243 (POL133324 (2x)) had the best mean WS. The numbers in the scatter plots range from 1 to 323 and refer to the populations which are tested at all locations (see Appendix 1 for details and link between the “AMMI ID/number” and the population names).

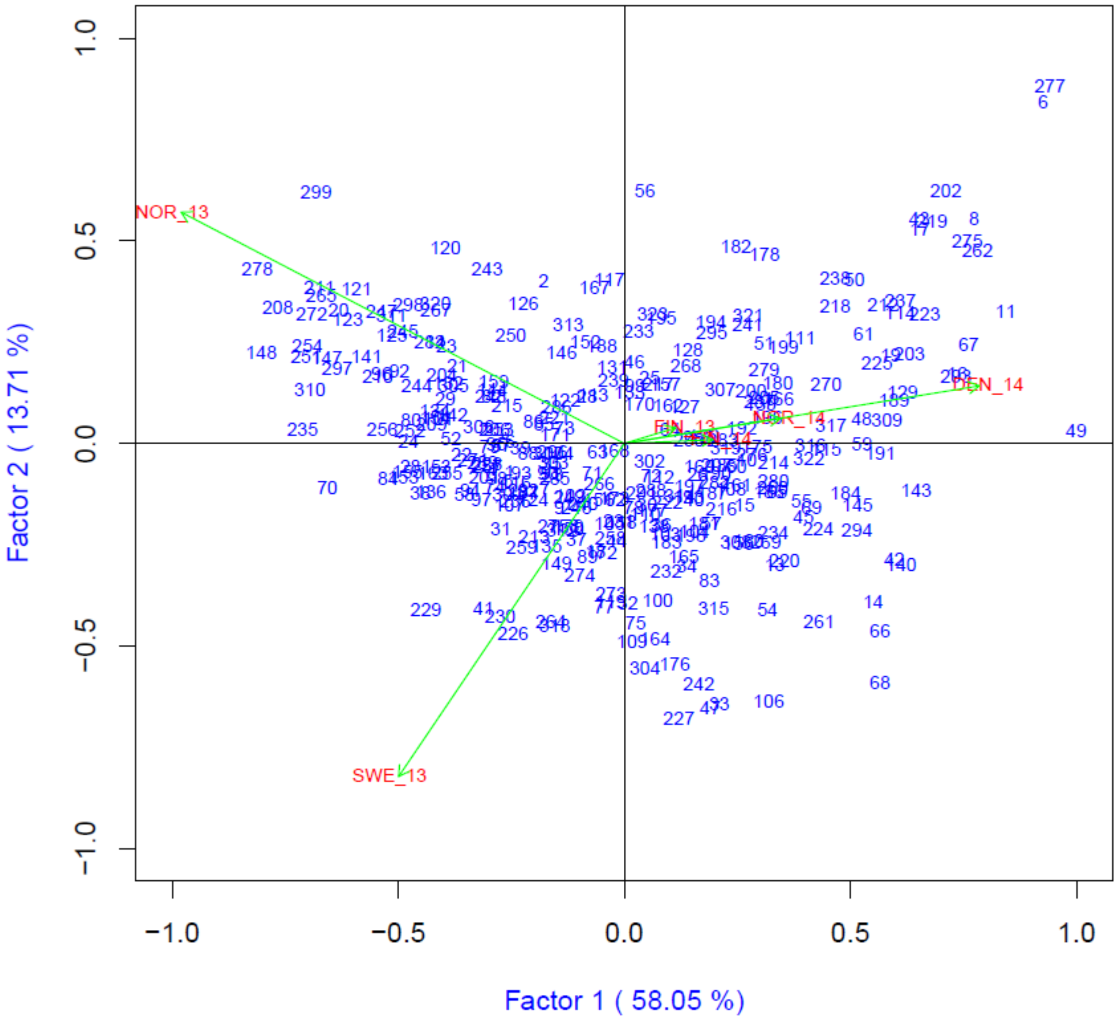


*Figure 19 AMMI 2 biplot showing relationship between 6 locations_year; Denmark_14, Sweden_13, Norway_13/_14 and Finland_13/14 and 323 populations based on winter survival.*

The AMMI 2 biplot (Figure 19) shows that environments NOR_13, SWE_13 and DEN_14 have the largest contributions to the GE interaction effect judged by the separation by PC1, which explains most of the GE interaction. NOR_13 and SWE_13 have opposite effects to all other locations. PC2 separates SWE_13 with the largest contribution from all other locations. FIN_13, FIN_14 and NOR_14 are located nearby each other and close to the origin indicating that these locations have small contributions to the total GE interaction.

The biplot shows that the populations 168 (‘LIA1411/2911 (4x)’), 63 (‘BJÖRKERÖD_PW2702 (2x’) and 302 (‘VERNA_PAJBERG (2x)’) are located close to the origin and are highly stable, but their mean WS values were not among the highest. The populations 6 (‘Aberbite (4x)’) and 277 (‘Salamandra (4x)’) are located far away from the origin, meaning that they are very unstable.

The populations 189 (‘LVA02521,258/06 (4x)’) and 129 (‘Figgjo (4x)’) cluster around the DEN_14 vector. This indicates that they were stable in the Danish environment in 2014, the same for the populations 230 (’ ABY-BA8621.82 (2x)’), 226 (‘ABY-BA8602.00 (2x’) and 41 (‘Ba12958 (2x)’) in Sweden 2013, the populations 211 (Norlea (2x)’), 265 (Prosperowo/BY (2x)’) and 121 (’45-4 (2x)’) in the Norwegian 2013 environment, 64 (‘BUK-66 (4x)’) in Finland 2013, 290 (‘TERRY (4x)’) in Finland 2014, and the populations 196 (‘LVA02528,262/06 (4x)’) and 192 (‘LVA02524,261/06 (4x)’) in the Norwegian location 2014.

## 3.6 Stability

Figure 20 differentiate the populations for mean WS and stability based on the Eberhart and Russell (1966) stability parameter “$b_i$”. This stability parameter was chosen because of the best correlation (0.53) to the mean values. The most stable populations are clustered at $b_i$ =1. In combination with the best mean values, the most winter hardy and stable populations over all are 190, 243, 245, 157, 192,167, 250 (Table 12).

The four populations with admixed ploidy level (‘Ivar’, ‘Falk’, ‘LIA1419’ and ‘Pionero’) were all located within the range 4.20-4.93 in mean values, and 0.86-1.07 in stability. The cultivar with the best survival and at the same time acceptable stability (mean=

5.27, $b_i$ = 0.84) is population 295 (the Norwegian cv. ‘Trygve (4x)’), followed by the Swedish cultivars 284 (‘Svea (2x)’, mean = 5.13, $b_i$ = 1.13) and 313 (‘Viva (2x)’, mean = 5.16, $b_i$ = 0.94).

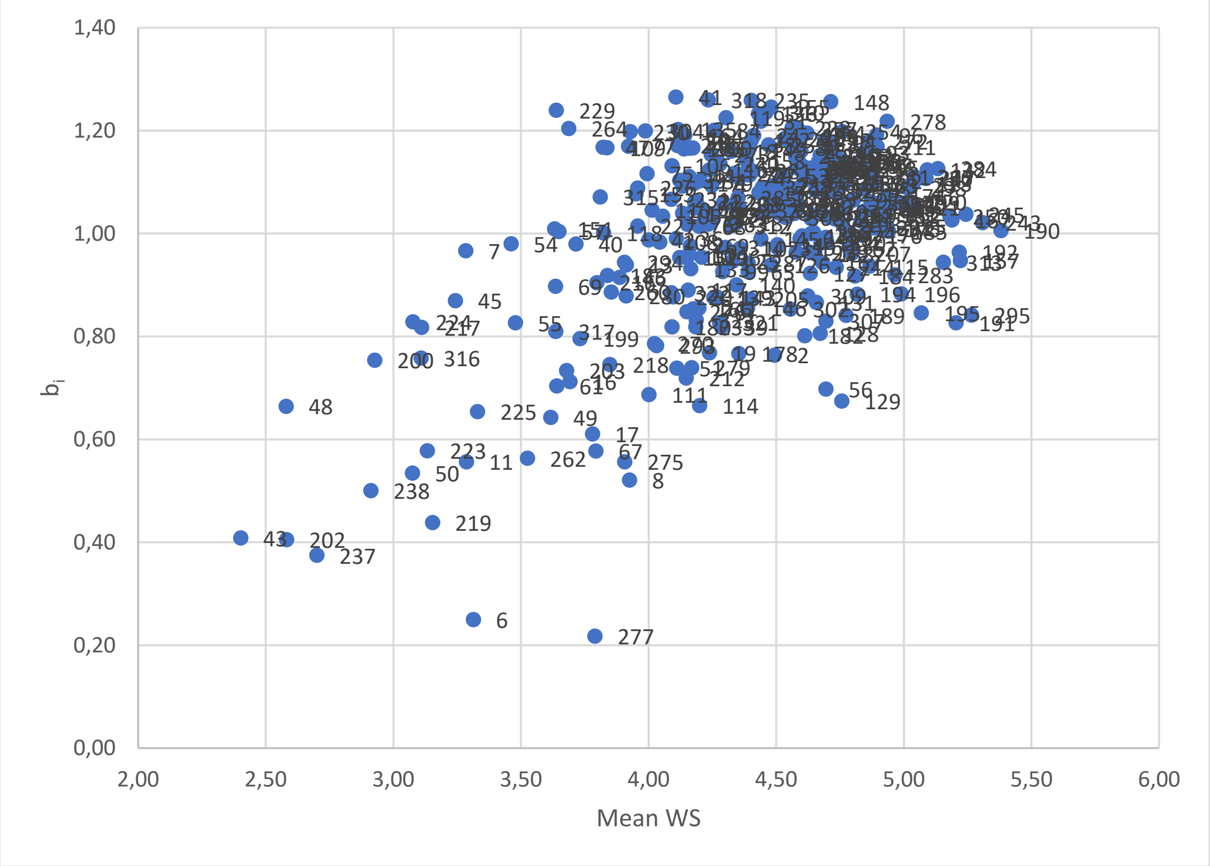


*Figure 20 Stability plot distributed by the stability parameter $b_i$ (Eberhart & Russell, 1966) and mean values. The populations around bi 1 are the most stable and the x-axis describe the total mean value for the populations.*

**Table 12 The most stable populations with the best survival over years and locations**

| Acc_no | Acc_name | Ploidy | AMMY_ID | Country_of_origin | Acc_type | pop.mean WS | $b_i$ |
|---|---|---|---|---|---|---|---|
| **LVA02522** | 363/06 | 4x | 190 | Latvia | Breeding_L. | 5.38 | 1.01 |
| **POL133324** | POL133324 | 2x | 243 | Ukraine | Ecotype | 5.31 | 1.02 |
| **POL133326** | POL133326 | 2x | 245 | Slovakia | Ecotype | 5.24 | 1.04 |
| **LIA1058** | 1894 | 4x | 157 | Lithuania | Breeding_L. | 5.22 | 0.95 |
| **LVA02524** | 261/06 | 4x | 192 | Latvia | Breeding_L. | 5.22 | 0.96 |
| **LIA1410** | 2904 | 4x | 167 | Lithuania | Ecotype | 5.19 | 1.03 |
| **POL133400** | POL133400 | 2x | 250 | Poland | . | 5.18 | 1.03 |

The average of the various common phenotypic stability parameters (Table 13), estimated within the population groups, shows that the tetraploid populations in general are more stable than the diploids, regardless of whether they are cultivars or ecotypes. Stable populations have low values for all parameters (CV%, $b_i$, low $S^2_{di}$ and $W_i$). Also, the range is generally smaller within the tetraploid compared with the diploid group.

**Table 13 Phenotypic stability of winter survival. Average and range of stability parameters for the different population types.**

| | | | Francis[1] | Eberhart & Russell[2] | | Wricke[3] |
|---|---|---|---|---|---|---|
| **Pop. type** | **Ploidy** | **N** | **CV%** | **$b_i$** | **$S^2_{di}$** | **$W_i$** |
| **Cultivar** | 2x | 93 | 53.84<br>(34.35-72.59) | 1.00<br>(0.41-1.26) | 0.79<br>(0.05-2.78) | 3.94<br>(0.43-13.60) |
| | 4x | 60 | 45.47<br>(32.09-53.66) | 0.89<br>(0.22-1.14) | 0.64<br>(0.04-1.74) | 3.66<br>(0.41-20.61) |
| **Ecotype** | 2x | 130 | 54.81<br>(40.01-76.98) | 1.05<br>(0.37-1.27) | 0.61<br>(0,00-5.10) | 3.17<br>(0.24-23.47) |
| | 4x | 8 | 46.80<br>(43.96-52.06) | 0.94<br>(0.82-1.08) | 0.51<br>(0.05-1.52) | 2.36<br>(0.25-6.49) |
| **MIX** | 2x/4x | 3 | 46.19<br>(44.77-47.29) | 0.93<br>(0.86-1.07) | 0.35<br>(0.06-0.53) | 1.85<br>(0.42-2.69) |

**[1] Coefficient of variation CV%=(st.dev/mean)*100 (Francis & Kannenberg, 1978); [2] $b_i$=slope the regression of each population on the environmental (location/year) average, and $S^2_{di}$=deviation from regression (Eberhart & Russell, 1966); $W_i$=ecovalence, the contribution of individual populations to the interaction sum of squares (Wricke, 1962).**

# 4.0 Discussion

## 4.1 Determination of ploidy

Among the 387 populations of the PPP Pre-Breeding Project tested, 306 were found to be diploid, 76 tetraploid, and 5 admixtures of diploids and tetraploids. Forty-four ecotypes and 82 cultivars (32%) had initial information about ploidy levels, and 15 % of these changed ploidies after determination with FCM (12 ecotypes and 7 cultivars). A large proportion (5.8%) of the populations classified with incorrect ploidy level was provided by the N.I. Vavilov gene bank. In fact, 3.8% of the total populations from N.I. Vavilov gene bank were incorrectly classified. This question the quality of the passport data in general, and especially from the N.I. Vavilov gene bank. Ploidy levels stated in passport data from gene banks may be wrong, and determination by FCM is an effective way of examining these.

Perennial ryegrass is naturally diploid, and due to this, the ecotypes were assumed to be diploid. Results from this study, supported by Wang et al. (2009), shows that a small amount (3-4%) of the gene bank accessions classified as ecotypes were identified as tetraploids. It might be discussed whether the classification as ecotype is wrong, or if the collected ecotypes are "escapes" from modern cultivars.

Cultivars classified as admixtures are examples of problems that may arise when plant materials have not been tested for ploidy before being marketed. Further testing of these populations needs to be done, to determine the proportion of ploidy mix, and in which generation the admixture has occurred. The Norwegian cultivar Falk, initially bred as a tetraploid but identified as diploid in this study, were later tested and found to be an admixture. This was discovered due to the surprising results in a freezing test, where 'Falk', as the only tetraploid population, clustered together with the diploids ((Helgadóttir et al., 2018). This led to an extensive testing in 2016 using 28 single plant replicates, which resulted in almost 50/50 diploids and tetraploids. It might be a chance that this is the same for the French cultivar 'Aurora/Chouss' which also originally was classified as tetraploid but was identified as diploid. Although DeLaat et al. (1987) concluded that populations could be used to obtain valid results for ploidy estimation, the present examples underline the benefit of replicates in the testing. An increased number of replicates per population would have given more precise ploidy results but testing as populations instead of single plants should have identified admixtures. Though Flow Cytometry is faster and cheaper than chromosome counting, it is still costly and time-consuming if large numbers of populations are being tested. Populations with ambiguous results were retested six times, compared to one replicate for those who gave clear results in the first run. This was done for the 5 admixtures and the cultivar ‘Falk’ as a complementary test. It should also have been done with the cultivar ‘Aurora/Chouss’, but in total this 7 populations corresponds to less than 2% of the total, and this should be acceptable.

Correct ploidy information is important for further breeding and marker-trait analysis, and for the passport information at gene banks. For the PPP Pre-Breeding Project, the populations have been grouped as diploids and tetraploids for the further work of selections, field trials and further crosses, and genomic studies.

## 4.2 Phenotypic results

### 4.2.1 Plant height, heading day and regrowth after 1st cut

The main findings for heading day and plant height are that the largest differences were between the locations. Mean heading time and plant height at the locations in Sweden and Denmark were almost the same, the Finnish plants were lower and head some days later, and the Norwegian location had the latest heading and the tallest plants, almost 50 cm taller than in the Finnish site. Cold temperatures and high precipitation at the Norwegian location might explain the extensive growth before heading time, since the time for measuring plant height was at full heading.

Notice the large variation in heading for the diploid ecotypes group in the Danish experiment, lasting almost 30 days, compared to the other locations where the variation of the same group was 16 days in the Finnish site, 18 days in the Norwegian site and 20 days in the Swedish site. Barre et al. (2018) also found high variability in heading date in their study of ecotypes in France and Belgium. Humphreys et al. (2010) refer to unpublished material of differences in the spread of heading days between southern and northern locations.

The variation between the location for both heading time and plant height is due to differences in daylength and temperature, in addition to precipitation. Figure 11 shows a clear difference in spring temperature for the Swedish and Danish site compared to locations in Norway and Finland. The temperature at the location in Finland was substantially warmer than at the Norwegian location from last part of May to the end of June. This difference might be due to the abnormal high precipitation in the Norwegian site these months.

The big differences in the number of days to heading for the diploid ecotype group between locations might, in addition to the differences in daylength and temperature, be explained by the uneven number of populations per location. Not all populations were tested at all locations because of limited amounts of seed available, and the ecotypes were the most limited group as regards amounts of seed. The experimental trial in Denmark included all the 389 populations, 35 more than in the Swedish trial where only the core set of populations (354 established at all locations) was tested. The Norwegian experiment had 28 fewer populations compared to the Danish while the Finnish trial had 31 fewer. Though the trials in Finland and Denmark have an equal number of populations, not all the populations are the identical, and this might be the best explanation of the differences.

In contrast to the other traits, it seems like the populations with very early and very late heading are the same across the locations. Though it is differences in heading date between locations, use of these genotypes for breeding will lead to plant material with early heading at several locations. Several studies have shown high (broad sense) heritability of heading date in perennial ryegrass (Ashraf et al., 2016; Barre et al., 2018). The calculations of heritability for this study gave high broad sense heritabilities for all locations, with the range from 0.43 in the Finnish trial to 0.66 in the Danish trial (Table 11).

The tetraploid groups had a higher mean plant height than the diploids. This is not surprising due to the tetraploid benefits like larger leaves and higher yield. It might be discussed whether the measure of tallest straw at full heading is the interesting measure, or if it had been more interesting to measure size of the leaves, as done in other studies (Barre et al., 2018; Gasior et al., 2016).

A similar phenotypic study of ecotypes and cultivars was conducted at Aberystwyth University in 2014 by Gasior et al. (2016), which found CV values of heading date for ecotypes to be 2.7% and 2.8% for cultivars. They did not focus on ploidy levels, but we assume that their material was ecotypes, and compare the results with our diploid cultivars and ecotypes. In our study, the diploid cultivars had a CV of 3.4% (Denmark), 2.5% (Sweden) and 1.9% (Norway and Finland), while the ecotypes CV value were 3.3% (Denmark), 2.5% (Sweden) and 1.8% (Norway and Finland). This underlines the point of little variation in heading days between cultivars and ecotypes, but between the different locations, affected by longitude, temperature and daylength. The ranking of heading time for all populations will then apply to several locations, and by use of standard cultivars with use of known time for heading, the ecotypes can easily be separated in different heading groups. This will make it easier to use the populations in crosses, where all the plants should flower at the same time to get the desired result of a cross with all the plants contributing equally as possible with pollen.

As expected, the tetraploid population groups have the most vigorous growth, demonstrated by having the best regrowth in the fields in Denmark, Norway and Finland. Diploid ecotypes displayed the largest variation in regrowth, thus there are potentially very interesting germplasm among the ecotypes for improving yield. These ecotypes have not been subjected to selection by management practices (repeated harvests, fertilization etc.) for fast regrowth. High temperatures and little precipitation lower the rate of regrowth, while wet and warm weather trigger regrowth. Differences in weather situations might describe some of the variations between the locations.

Scoring of regrowth on a continuous scale between one and nine without further detailed instructions about the scale, contributes to technical errors in phenotyping this trait between the locations. In addition, there were neither any standard description of the time of scoring regrowth after harvest. Thus, heritability of this trait is relatively low, ranging from 0.13 at the Danish site to 0.29 at the Norwegian site (Table 11).

### 4.2.2 Crown rust (Puccinia coronata)

The tetraploid cultivars were generally most tolerant to crown rust. Some diploid cultivars were also quite resistant, e.g. the French cultivar ‘Escapade (2x)’ had good scores at both test sites. The Norwegian population ‘Fure (2x)’ got second-best scores for rust in the Norwegian trial. This is an old breeding line made around 40-50 years ago, with a mix of local collected material and several European cultivars (P. Marum, pers. comm.).

Breeding ryegrasses with durable resistance to rust and other diseases is one of the most important aims for breeders in Europe and explains the good results of cultivars. A genetic effect of tetraploidy is masking of undesirable recessive genes (Wilkins, 1991). This might explain some of the good results for tetraploids, compared to the diploids. It seems that interesting genotypes can be retrieved from the ecotype group too, e.g. the Lithuanian ecotypes ‘LIA1409, 2906 (4x)’ and ‘LIA1418, 2908 (2x)’, and the Italian ecotype ‘PI598433 (2x)’. Selections for resistance depends on suitable conditions for infections and the development of the disease, this may be a reason why Østrem et al. (2018) found Norwegian cultivars to have a low resistance to crown rust when tested at locations in France, Japan and Denmark. In the present study, several of the Norwegian cultivars had good scores for rust resistance at the Norwegian location, however, one can question the level of infection in Norway.

Aavola et al. (2018) studied differences between different ploidy levels and different heading groups for perennial ryegrass. They found tetraploids to be better than the diploids in the first year, but among their main findings was a correlation between late heading and better rust resistance. In the present study there was a weak correlation between rust resistance and heading time (0.06 in the Norwegian trial and 0.04 in the Danish), e.g., the cultivar ‘Barmaxim (4x)’ was late heading (160/9th of June) but with a good of rust resistance (7/ 5% foliage coverage) in the Danish experiment.

Variable results between different locations for evaluation of rust is normal, as documented in results of the EUCARPIA Multi-site Rust Evaluation experiments (Schubiger et al., 2016). They found the rank of the mean scores across the test sites to be stable over several years indicating little GE interactions.

Additional explanations for the low rust infections in the Danish field and variation between the locations may be differences in weather conditions. The Danish location had almost three times more rain than the Norwegian in September 2013. There might also be differences in phenotyping between the locations since the scoring are done by different people. The Danish staff are more used to score for crown rust than the Norwegian, but the description for scoring should prevent excessive variations. There might also be different strains of the *Puccinia coronata* at different locations.

### 4.2.3 Winter survival

Winter stresses like frost, de-hardening, re-hardening, snow cover and snow molds affect tetraploid and diploid perennial ryegrass populations differently. Tetraploid Baltic breeding lines, diploid ecotypes from eastern Europe, in addition to Swedish and Norwegian cultivars demonstrated good and stable winter survival over locations and years.

Though the snow amount and period with snow were almost the same for both the Norwegian and Finnish location the first winter (2013), the diploids survived best in the Norwegian site while the tetraploids had best winter survival in the Finnish site. This might be explained by the differences in temperature. At the location in Norway the mean temperature was relatively stable (Appendix 2, Figure 2a), while the mean temperature at the Finnish site increased in January and February and decreased in March (Appendix 2, Figure 2a). This fluctuation might have started of de-hardening processes in the plants, followed by re-hardening.

The temperatures were only measured in the air and not below the snow. The relative mean temperature was not particularly high. Nevertheless, compared to the normal, the increase has been more than 20 degrees within 12 days from -23 $^{o}$C to 2$^{o}$C at the Finnish site (Appendix 2, Figure 2a). Figure 2b in Appendix 2 view a similar increase in the Norwegian site, but the temperatures drop rapidly compared to the temperature at the Finnish location the first week of February. At the Finnish location, the mean temperature for February is below zero (-2 $^{o}$C).

Controlled studies of de-hardening often start the evaluation at 2°C (Eagles & Williams, 1992) or 3°C (Jørgensen et al., 2010), and the studies of Eagles and Williams (1992) indicated that low-temperature enhancement of hardiness occurs during exposure of fluctuating temperature conditions, either by additional hardening or less de-hardening. According to Kalberer et al. (2006), the history of temperature exposure affects acclimation and de-acclimation in complex ways. The acclimation or de-acclimation depend on the previous conditions to which the plant was exposed and the duration of exposure. This might explain why the plants in the Norwegian trial probably not initiated the de-acclimation process.

Jørgensen et al. (2010) studied de-hardening in cultivars of timothy and perennial ryegrass. The varieties 'Riikka (2x)' from Finland and 'Gunne (2x)' from Sweden were a part of both studies. They did not find significant differences due to de-hardening between the cultivars, but the most rapid de-hardening occurred during the initial days. For timothy, the most frost tolerant cultivars de-hardened more rapidly. This agrees with the study of Kalberer et al. (2007) who found that genotypes of azalea with a high amount of frost resistance de-hardened more readily than genotypes which were more sensitive to frost. This corresponds to our study, where the tetraploids having the best winter survival after fluctuating temperatures in the Finnish site, while the more frost-tolerant diploids (Helgadóttir et al., 2018) had the best scores in the Norwegian site. In our study, the cultivar 'Riikka (2x)' had a mean value of 4.8 and 'Gunne (2x)' 4.6 (of max 6.0) in the Finnish trial in 2013, while in the Norwegian trial for the same year, the mean score was 7.1 for 'Riikka (2x)' (fourth-best) and 4.5 for 'Gunne (2x)' (of max 7.8).

Our study is not designed to study de-hardening and re-hardening, but by keeping this in mind by looking at the results, the top 10 best results for winter survival in the Finnish trial in 2013 were all tetraploids, almost all cultivars or breeding-lines from Norway (coastal climate), Latvia, Lithuania, Estonian, Japan and one ecotype from Russia. It seems like some habitats of origin might be better for developing populations with these properties. Studies on different forage species indicate that populations from northern coastal areas, which have large variations in temperature and snow conditions during the winter, often show a high degree of stability and strong winter resistance (Junttila, 1996; Jørgensen et al., 2010; Svenning et al., 1997). This might also be the same for populations from the Baltic area.

Higher temperatures might also promote an increasing growth of snow molds. Helgadóttir et al. (2018) found the tetraploid group to be more resistant to snow mold compared to the diploids. No observations indicated infections from snow mold to be a problem neither at the location in Norway nor Finland (M. Isolahti, pers. comm, P. Marum, pers.comm.). The high amount of precipitation in September and October 2012 (Figure 10) at Finnish location (almost doubled than in the Norwegian location), might also affect the plants different during their hardening process. The mean temperature was about the same between the two locations, and it seemed to be approximately 2ºC at initial snow cower. This could indicate good conditions for snow mold to establish, but the above comments from the breeders at both locations make this a weak argument.

Another explanation of why the different ploidy groups behave different in the winter 2013 with snow cover, might be differences in temperatures and precipitation during the cold acclimation autumn 2012 between the different locations. Figure 10a does not show differences in temperatures between the locations in Norway and Finland, but we must keep in mind that this is mean temperatures per month. The amount of rain at the Finnish site were high compared to the Norwegian site, but more similar to the Swedish location (Figure 10b). These parameters may have affected the cold acclimation. Dalmannsdottir et al. (2016) have shown that higher pre-acclimation temperatures at higher latitudes reduce the freezing tolerance in red clover, perennial ryegrass and timothy.

Stable mean temperatures at the Swedish location around -2ºC led to a poor differentiation between populations. Most of the populations had very good winter survival, with diploids slightly better than tetraploids. The autumn and winter in the Swedish site were characterized by large amounts of precipitations. Such conditions are expected to increase in the future (Olesen et al., 2011), and though the frost and snow did not lead to strong differentiation between populations, genotypes that survived best genotypes can be important for future breeding.

After the second winter with a warm December in 2013, followed by a sudden cold January 2014 with scarce snow, the very best surviving plants were ecotypes at all locations. In the Finnish experiment, the diploid ecotype, ‘PI598516 (2x)’, collected at 1150 m a.s.l. in Turkey stood out with the best survival. The tetraploid ecotype ‘LIA1410, 2904 (4x)’ from Lithuania did best in the Norwegian trial, and the diploid ‘Ba12983 (2x)’ from France was the best population in the Danish trial after the second winter. Though the ecotypes were the best outliers, the tetraploid cultivars in the locations in Denmark and Norway had significantly best mean values for winter survival. The winter survival in the Finnish site was generally low with no significant difference between the groups.

Helgadóttir et al. (2018) found diploid cultivars to be consistently more freezing-tolerant than tetraploids in artificial freezing tests, this is also a general impression from practical breeding in Norway (P. Marum, pers. comm). Winter survival is a complex trait, and are controlled by more than freezing tolerance (Rognli, 2013). Explanations of the differences between the diploid ecotypes and tetraploid cultivars are first that the cultivars are bred for better winter survival, and the second explanation is that many of the ecotypes originate from countries in southern Europe.

For the diploid and tetraploid cultivar groups, the distribution between the habitat of origin is almost the same, with an emphasis of northern and Baltic countries of origin. Surprisingly, the German cultivar ‘Ivana (2x)’ had the second-best survival in the Norwegian trial in 2014, and this emphasizes that there is not only material bred or collected in areas well known for strong winters as Norway, Finland or Baltic region that is useful for further improvement of winter survival.

### 4.2.4 Stability of winter survival

Winter conditions vary from year to year causing different types of stresses to the plants. During this phenotypic experiment, we got winters both with and without snow. The variation in weather between the locations gives even more diverse weather types. The harsh winter at the Finnish location in 2014 resulted in very low mean winter survival for all populations and little variance. Since this contributes little to the general variance, we tried to remove FIN_14 from the AMMI plot. Since this did not lead to changes in the biplots we decided to keep FIN_14.

By analyzing for stability between the different population types, the tetraploid groups in general were found to be more stable than the diploid groups (Table 13). This might be explained by the higher number of European ecotypes in the diploid groups.

By study multiplicative interaction (AMMI) we searched for populations with high mean value and stability over locations and years. Breeding lines form Latvia and Lithuania, and ecotypes from Ukraine, Slovakia and Poland (Table 12) were the most stable and best surviving populations. The lack of cultivars among this populations is not surprising, since cultivars normally not are bred to be good in such diverse environments, but more specific to a given environment. The possibility to find new genetic resources for breeding of better winter survival for Nordic conditions are promising. Ongoing projects in the PPP pre-breeding collaboration is a continuation of this phenotyping project. Separate plots for selection and adaptation in different environments are established from crosses of the diploid and the tetraploid populations in this study. By repeated selections at each location, the new populations will adapt to the different environments in different ways and hopefully give new robust and stable populations for further breeding of perennial ryegrass for the northern region.

The populations which turned out to be admixtures after ploidy determination looks quite stable. This, and the fact that the tetraploids tend to have good de-hardening and re-hardening capacity, good snow mold resistance (Helgadóttir et al., 2018) and diploids tend to have good tolerance to frost, makes it clear that seed-mixtures of both diploid and tetraploid cultivars will make robust meadows with improved winter hardiness (Helgadóttir et al., 2018; Rognli et al., 2018).

### The limitations of the study

It is important to remember that this is a single plot experiment, consisting of single plants established from populations. The plants are not clones, and in this way reflects the variability within a population in an easier way than with clones (lower number of plants needed). The genetic correlation between single plants and swards vary with traits (Casler & van Santen, 2010). Winter survival itself is only one of many important traits which play an important role in the total yield, which, in combination with forage quality is the most important trait for breeders.

Phenotyping was done by different persons at different locations. But all the experiments had 4 blocks/replications. For time-consuming phenotyping of traits like crown rust and plant height, only one block was phenotyped for crown rust and only two phenotyped for plant height at the Norwegian location.

The AMMI method is originally developed for yield trials with continuous responses (Crossa, 1990; Zobel et al., 1988). The genotypes from the second winter (2014) are not independent form the 2013 genotypes. This only applies to trials in Finland and Norway, and it can be discussed if this is correct or not.

Several studies have been conducted to investigate differences between diploids and tetraploids for different traits as mentioned in this thesis. Further experiments should look deeper into differences in e.g., cold acclimation, de-hardening and re-hardening capacity between different ploidy levels.

## 5.0 Conclusion

Determination of ploidy by flow cytometry found 306 populations to be diploids, 76 tetraploids and 5 to be admixtures. Nineteen of the populations had a different ploidy level compared to that specified in the passport from the gene banks. Eight ecotypes (wild-collected) were determined as tetraploids, and the question is whether these are real ecotypes or escapes from cultivation.

Passport data for 64 populations from different gene banks were improved by converting collections site to coordinates. Fifty-six ecotype populations also got information about altitude for collection site.

Diploid ecotypes had a larger variation than the cultivars for heading date, regrowth and winter survival. Tetraploid cultivars had as expected the best resistance to crown rust. For winter survival in 2014, ecotypes had the best survival at all locations. The tetraploid cultivars had the best winter survival in Finnish trial in 2013 with snow cover, and in the Norwegian and Danish trial in 2014 with less snow. This might be explained by adaptations to coastal climate with high variable climate during the wintertime. Diploid outliers tended to have a better frost tolerance but testing for frost was not a part of this study. Tetraploid groups had in general the most stable populations with less variation and the best means for winter survival.

Populations with high and stable winter survival to all locations were defined, consisting of Baltic breeding lines and ecotypes from Eastern Europe. There were no cultivars among these most stable populations. This is not surprising, since breeding of high yielding cultivars often are adapted to a specific region if they don't are high yielding over numerous regions. The most stable and winter-hardy cultivars were the Norwegian 'Trygve (4x)' and the Swedish 'Viva (2x)' and 'Svea (2x)'.

The most winter-hardy populations were adapted to latitudes below 60°, most of them from the Baltic region (Latvia and Lithuania). Tetraploid populations seem to have better de-hardening and re-hardening capacities than diploids, but this should be studied further.

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# Appendix

# Appendix 1

**Accession number, name, origin, type, ploidy level, ammy_id, declatitude, declongitude, elevation and provider for 393 perennial ryegrass populations.**

| Acc_no | Acc_name | Ploidy | AMMY_ID | Country_of_origin | Acc_type | Type | Declat. | Declongit. | Elevation | Provider |
|---|---|---|---|---|---|---|---|---|---|---|
| **14G2000333** | 14G2000333 | Diploid | 1 | Czech_Republic | Ecotype | | 49.21 | 18.26 | 445 | Gene Bank, Crop Research Institute, Prague |
| **14G2000587** | 14G2000587 | Diploid | 2 | Czech_Republic | Ecotype | | 50.59 | 14.1 | 650 | Gene Bank, Crop Research Institute, Prague |
| **14G2000586** | 14G2000586 | Diploid | 3 | Czech_Republic | Ecotype | | 50.52 | 14.01 | 570 | Gene Bank, Crop Research Institute, Prague |
| **14G2000504** | 14G2000504 | Diploid | 4 | Czech_Republic | Ecotype | | 48.94 | 17.78 | 650 | Gene Bank, Crop Research Institute, Prague |
| **14G2000503** | 14G2000503 | Diploid | 5 | Czech_Republic | Ecotype | | 48.94 | 17.78 | 650 | Gene Bank, Crop Research Institute, Prague |
| **Aberbite** | Aberbite | Tetraploid | 6 | UK | Cultivar | Forage | . | . | . | IBERS |
| **Aberimp** | Aberimp | Diploid | 7 | UK | Cultivar | Lawn | . | . | . | IGER |
| **Abermagic** | Abermagic | Diploid | 8 | UK | Cultivar | Forage | . | . | . | IBERS |
| **NGB13338** | ALLEGRO | Diploid | 9 | Denmark | Cultivar | | . | . | . | Nordgen |
| **NGB1632** | AMADO | Diploid | 10 | Denmark | Cultivar | | . | . | . | Nordgen |
| **POL155165** | ANNA | Diploid | 11 | Poland | Cultivar | | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **NGB7508** | APUS | Diploid | 12 | Sweden | Cultivar | | . | . | . | Nordgen |
| **Vir50422** | Aria | Diploid | 13 | Sweden | Cultivar | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **POL155194** | ARKA | Diploid | 14 | Poland | Cultivar | | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **Arsenal** | Arsenal | Diploid | 15 | Germany | Cultivar | Forage | . | . | . | EGB |
| **Arvella** | Arvella | Diploid | 16 | Switzerland | Cultivar | Forage | . | . | . | DSP/ART CH |
| **Arvicola** | Arvicola | Tetraploid | 17 | Germany | Cultivar | Forage | . | . | . | Freudenberger |
| **NGB4265** | ASKELAND_16-60-1 | Diploid | 18 | Norway | Ecotype | | 60.66 | 5.25 | 40 | Nordgen |
| **Aston_princess** | Aston_princess | Tetraploid | 19 | UK | Cultivar | Forage | . | . | . | Eurograss UK |
| **Ba11434** | Ba11434 | Diploid | 20 | Poland | Ecotype | | 50.88 | 20.28 | 200 | ECP/GR |
| **Ba11445** | Ba11445 | Diploid | 21 | Poland | Ecotype | | 49.51 | 20.8 | 700 | ECP/GR |
| **Ba11448** | Ba11448 | Diploid | 22 | Poland | Ecotype | | 49.4 | 20.43 | 500 | ECP/GR |
| **Ba11451** | Ba11451 | Diploid | 23 | Poland | Ecotype | | 49.35 | 20.06 | 1000 | ECP/GR |
| **Ba11461** | Ba11461 | Diploid | 24 | Poland | Ecotype | | 49.35 | 19.85 | 940 | ECP/GR |
| **Ba12220** | ABY-Ba12220 | Tetraploid | 25 | Switzerland | Landrace | | . | . | . | ECP/GR |
| **Ba12275** | Ba12275 | Diploid | 26 | Czech_Republic | Ecotype | | 49.31 | 17.45 | 200 | ECP/GR |
| **Ba12276** | Ba12276 | Diploid | 27 | Czech_Republic | Ecotype | | 49.33 | 18 | 610 | ECP/GR |
| **Ba12277** | Ba12277 | Diploid | 28 | Czech_Republic | . | | . | . | . | ECP/GR |
| **Ba12278** | Ba12278 | . | 29 | Czech_Republic | . | | . | . | . | ECP/GR |
| **Ba12947** | Ba12947 | Diploid | 30 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12948** | Ba12948 | Diploid | 31 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12949** | Ba12949 | Diploid | 32 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12950** | Ba12950 | Diploid | 33 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12951** | Ba12951 | Diploid | 34 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12952** | Ba12952 | Diploid | 35 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12953** | Ba12953 | Diploid | 36 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12954** | Ba12954 | Diploid | 37 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12955** | Ba12955 | Diploid | 38 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12956** | Ba12956 | Diploid | 39 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12957** | Ba12957 | Diploid | 40 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12958** | Ba12958 | Diploid | 41 | Hungary | . | | . | . | . | ECP/GR |
| **Ba12970** | Ba12970 | Diploid | 42 | France | Ecotype | | 47.36 | -0.76 | 30 | ECP/GR |

*Later confirmed as MIX**Not a part of the WP4 experiment

***Later confirmed to be *L. multiflorum* based on genotyping

# Appendix 1

| Acc_no | Acc_name | Ploidy | AMMY_ID | Country_of_origin | Acc_type | Type | Declat. | Declongit. | Elevation | Provider |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ba12971** | Ba12971 | Diploid | 43 | France | Ecotype |  | 47.66 | 3.46 | 10 | ECP/GR |
| **Ba12976** | Ba12976 | Diploid | 44 | France | Ecotype |  | 48.11 | 6.03 | 300 | ECP/GR |
| **Ba12977** | Ba12977 | Diploid | 45 | France | Ecotype |  | 48.6 | 3.21 | 150 | ECP/GR |
| **Ba12978** | Ba12978 | Diploid | 46 | France | Ecotype |  | 48.73 | 7.7 | 150 | ECP/GR |
| **Ba12979** | Ba12979 | Diploid | 47 | France | Ecotype |  | 48.96 | 5.51 | 230 | ECP/GR |
| **Ba12980** | Ba12980 | Diploid | 48 | France | Ecotype |  | 46.43 | -1.45 | 20 | ECP/GR |
| **Ba12983** | Ba12983 | Diploid | 49 | France | Ecotype |  | 48.66 | -3.21 | . | ECP/GR |
| **Ba12988** | Ba12988 | Diploid | 50 | France | Ecotype |  | 46.98 | 1.41 | 170 | ECP/GR |
| **Ba12989** | Ba12989 | Diploid | 51 | France | Ecotype |  | 46.48 | 2.78 | 250 | ECP/GR |
| **Ba13004** | Ba13004 | Diploid | 52 | Germany | Ecotype |  | 51.98 | 10.83 | 245 | ECP/GR |
| **Ba13006** | Ba13006 | Diploid | 53 | Germany | Ecotype |  | 51.88 | 12 | 63 | ECP/GR |
| **Ba9819** | ABY-Ba9819 | Diploid | 54 | UK | Ecotype |  | 52.04 | -4.3 | 220 | ECP/GR |
| **Ba9832** | ABY-Ba9832 | Diploid | 55 | UK | Ecotype |  | 52.07 | -3.12 | 400 | ECP/GR |
| **Vir42146** | Baca | Diploid | 56 | Checkoslovakia | Cultivar |  | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **DE161** | BANAT | Diploid | 57 | Romania | Cultivar |  | . | . | . | Genebank Department, IPK, Germany |
| **Bargold** | Bargold | Diploid | 58 | Holland | Cultivar | Lawn | . | . | . | Barenbrug |
| **Barmaxima** | Barmaxima | Tetraploid | 59 | Holland | Cultivar | Forage | . | . | . | Barenbrug |
| **Barnhem** | Barnhem | Diploid | 60 | Holland | Cultivar | Forage | . | . | . | Barenbrug |
| **NGB1633** | BELIDA | Diploid | 61 | Denmark | Cultivar |  | . | . | . | Nordgen |
| **NGB4339** | BENESTAD_UE1504 | Diploid | 62 | Sweden | Ecotype |  | 55.51 | 13.9 | 40 | Nordgen |
| **NGB4344** | BJÖRKERÖD_PW2702 | Diploid | 63 | Sweden | Ecotype |  | 56.31 | 12.51 | 150 | Nordgen |
| **Vir51515** | BUK-66 | Tetraploid | 64 | . | Cultivar |  | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Burlina1** | Burlina1 | Diploid | 65 | Denmark | Cultivar | Forage | . | . | . | DLF |
| **Calvano1** | Calvano1 | Diploid | 66 | Denmark | Cultivar | Forage | . | . | . | DLF |
| **Cavia** | Cavia | Diploid | 67 | Switzerland | Cultivar | Forage | . | . | . | DSP/ART CH |
| **NGB15401** | CHANTAL | Diploid | 68 | Denmark | Cultivar |  | . | . | . | Nordgen |
| **NGB4117** | DASAS_TRIFOLIUM | Diploid | 69 | Denmark | Cultivar |  | . | . | . | Nordgen |
| **DE27965** | DE27965 | Diploid | 70 | Germany | Ecotype |  | 50.84 | 9.7 | 275 | Genebank Department, IPK, Germany |
| **DE28845** | DE28845 | Diploid | 71 | Germany | Ecotype |  | . | . | . | Genebank Department, IPK, Germany |
| **DE28846** | DE28846 | Diploid | 72 | Germany | Ecotype |  | . | . | . | Genebank Department, IPK, Germany |
| **DE28848** | DE28848 | Diploid | 73 | Germany | Ecotype |  | 50.8 | 9.92 | 345 | Genebank Department, IPK, Germany |
| **DE28849** | DE28849 | Diploid | 74 | Germany | Ecotype |  | 50.64 | 10 | 447 | Genebank Department, IPK, Germany |
| **DE28851** | DE28851 | Diploid | 75 | Germany | Ecotype |  | 50.94 | 9.62 | 310 | Genebank Department, IPK, Germany |
| **DE28856** | DE28856 | Diploid | 76 | Germany | Ecotype |  | 50.96 | 9.91 | 361 | Genebank Department, IPK, Germany |
| **DE33913** | DE33913 | Diploid | 77 | Germany | Ecotype |  | 50.94 | 9.86 | 228 | Genebank Department, IPK, Germany |
| **DE33932** | DE33932 | Diploid | 78 | Germany | Ecotype |  | 50.8 | 9.56 | 267 | Genebank Department, IPK, Germany |
| **DE33943** | DE33943 | Diploid | 79 | Germany | Ecotype |  | 50.1 | 8.39 | 340 | Genebank Department, IPK, Germany |
| **DE50653** | DE50653 | Diploid | 80 | Germany | Ecotype |  | 50.76 | 9.4 | 381 | Genebank Department, IPK, Germany |
| **DE50654** | DE50654 | Diploid | 81 | Germany | Ecotype |  | 50.76 | 9.4 | 381 | Genebank Department, IPK, Germany |
| **DE50667** | DE50667 | Diploid | 82 | Germany | Ecotype |  | 50.75 | 9.34 | 281 | Genebank Department, IPK, Germany |
| **DE50668** | DE50668 | Diploid | 83 | Germany | Ecotype |  | 50.74 | 9.27 | 251 | Genebank Department, IPK, Germany |
| **DE51971** | DE51971 | Diploid | 84 | Germany | Ecotype |  | 51.02 | 9.77 | 230 | Genebank Department, IPK, Germany |
| **DE51987** | DE51987 | Diploid | 85 | Germany | Ecotype |  | 51.03 | 9.7 | 232 | Genebank Department, IPK, Germany |
| **DE51990** | DE51990 | Diploid | 86 | Germany | Ecotype |  | 51.05 | 9.7 | 257 | Genebank Department, IPK, Germany |

*Later confirmed as MIX**Not a part of the WP4 experiment ***Later confirmed to be *L. multiflorum* based on genotyping

# Appendix 1

| Acc_no | Acc_name | Ploidy | AMMY_ID | Country_of_origin | Acc_type | Type | Declat. | Declongit. | Elevation | Provider |
|---|---|---|---|---|---|---|---|---|---|---|
| **DE54063** | DE54063 | Diploid | 87 | Romania | Ecotype | | 46.55 | 24.67 | 388 | Genebank Department, IPK, Germany |
| **DE54064** | DE54064 | Diploid | 88 | Romania | Ecotype | | 46.57 | 24.07 | 374 | Genebank Department, IPK, Germany |
| **DE54065** | DE54065 | Diploid | 89 | Romania | Ecotype | | 46.61 | 24.13 | 317 | Genebank Department, IPK, Germany |
| **DE54066** | DE54066 | Diploid | 90 | Romania | Ecotype | | 46.47 | 24.09 | 272 | Genebank Department, IPK, Germany |
| **DE54084** | DE54084 | Diploid | 91 | Romania | Ecotype | | 47.9 | 26.23 | 289 | Genebank Department, IPK, Germany |
| **DE54085** | DE54085 | Diploid | 92 | Romania | Ecotype | | 47.9 | 26.23 | 289 | Genebank Department, IPK, Germany |
| **DE54088** | DE54088 | Diploid | 93 | Romania | Ecotype | | 46.99 | 24.41 | 323 | Genebank Department, IPK, Germany |
| **DE54089** | DE54089 | Diploid | 94 | Romania | Ecotype | | 46.96 | 24.43 | 320 | Genebank Department, IPK, Germany |
| **DE54090** | DE54090 | Diploid | 95 | Romania | Ecotype | | 46.91 | 24.5 | 346 | Genebank Department, IPK, Germany |
| **DE54091** | DE54091 | Diploid | 96 | Romania | Ecotype | | 46.83 | 24.56 | 454 | Genebank Department, IPK, Germany |
| **DE54092** | DE54092 | Diploid | 97 | Romania | Ecotype | | 46.76 | 24.51 | 378 | Genebank Department, IPK, Germany |
| **DE54093** | DE54093 | Diploid | 98 | Romania | Ecotype | | 46.65 | 24.6 | 331 | Genebank Department, IPK, Germany |
| **DE54456** | DE54456 | Diploid | 99 | Germany | Ecotype | | 50.85 | 9.58 | 278 | Genebank Department, IPK, Germany |
| **DE58136** | DE58136 | Diploid | 100 | Germany | Ecotype | | 50.22 | 8.36 | 361 | Genebank Department, IPK, Germany |
| **DE59277** | DE59277 | Diploid | 101 | Germany | Ecotype | | 50.57 | 9.74 | 298 | Genebank Department, IPK, Germany |
| **DE59284** | DE59284 | Diploid | 102 | Germany | Ecotype | | 50.57 | 9.8 | 325 | Genebank Department, IPK, Germany |
| **DE62300** | DE62300 | Diploid | 103 | France | Ecotype | | 45.7 | 3.34 | 450 | Genebank Department, IPK, Germany |
| **DE62301** | DE62301 | Diploid | 104 | France | Ecotype | | 45.7 | 3.34 | 450 | Genebank Department, IPK, Germany |
| **DE62308** | DE62308 | Diploid | 105 | France | Ecotype | | 45.7 | 3.34 | 450 | Genebank Department, IPK, Germany |
| **DE62309** | DE62309 | Diploid | 106 | France | Ecotype | | 45.7 | 3.34 | 450 | Genebank Department, IPK, Germany |
| **DE62310** | DE62310 | Diploid | 107 | France | Ecotype | | 45.7 | 3.34 | 450 | Genebank Department, IPK, Germany |
| **DE62312** | DE62312 | Diploid | 108 | France | Ecotype | | 45.7 | 3.34 | 450 | Genebank Department, IPK, Germany |
| **DE62313** | DE62313 | Diploid | 109 | France | Ecotype | | 45.7 | 3.34 | 450 | Genebank Department, IPK, Germany |
| **DE62315** | DE62315 | Diploid | 110 | France | Ecotype | | 45.7 | 3.34 | 450 | Genebank Department, IPK, Germany |
| **NGB2731** | DELTA | Diploid | 111 | Sweden | Cultivar | | . | . | . | Nordgen |
| **Double** | Double | Tetraploid | 112 | Denmark | Cultivar | Lawn | . | . | . | DLF |
| **Vir51516** | Duet | Tetraploid | 113 | . | Cultivar | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Dumdrum** | Dumdrum | Tetraploid | 114 | Holland | Cultivar | Forage | . | . | . | Barenbrug |
| **Dunluce** | Dunluce | Tetraploid | 115 | Holland | Cultivar | Forage | . | . | . | Barenbrug |
| **Vir40298** | E_4_Kockoko | Diploid | 116 | Poland | Cultivar | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **NGB2594** | E12 | Diploid | 117 | Sweden | Breeding_L. | | . | . | . | Nordgen |
| **Derby_Xtreme** | Escapade | Diploid | 118 | France | Cultivar | Lawn | . | . | . | Carneau |
| **Esquire** | Esquire | Diploid | 119 | Denmark | Cultivar | Lawn | . | . | . | DLF |
| **144-3** | 144-3 | Diploid | 120 | Estonia | Breeding_L. | | . | . | . | Genebank, Jõgeva Plant Breeding Institute, Estonia |
| **45-4** | 45-4 | Diploid | 121 | Estonia | Breeding_L. | | . | . | . | Genebank, Jõgeva Plant Breeding Institute, Estonia |
| **EST158** | EST158 | Tetraploid | 122 | Estonia | Breeding_L. | | . | . | . | Genebank, Jõgeva Plant Breeding Institute, Estonia |
| **EST279** | EST279 | Diploid | 123 | Estonia | Breeding_L. | | . | . | . | Genebank, Jõgeva Plant Breeding Institute, Estonia |
| **Eurodiamond** | Eurodiamond | Diploid | 124 | Germany | Cultivar | Lawn | . | . | . | EGB |
| **Fagerlin** | Fagerlin | Diploid | 125 | Norway | Cultivar | Forage | . | . | . | Graminor |
| **Falk** | Falk | Diploid* | 126 | Norway | Cultivar | Forage | . | . | . | Graminor |
| **NGB16173** | Fia | Tetraploid | 127 | Norway | Cultivar | Forage | . | . | . | Nordgen |
| **Fia** | Fia | Tetraploid | 128 | Norway | Cultivar | Forage | . | . | . | Graminor |
| **Figgjo** | Figgjo | Tetraploid | 129 | Norway | Cultivar | Forage | . | . | . | Graminor |
| **Fjaler** | Fjaler | Tetraploid | 130 | Norway | Cultivar | Forage | . | . | . | Graminor |

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***Later confirmed to be *L. multiflorum* based on genotyping

# Appendix 1

| Acc_no | Acc_name | Ploidy | AMMY_ID | Country_of_origin | Acc_type | Type | Declat. | Declongit. | Elevation | Provider |
|---|---|---|---|---|---|---|---|---|---|---|
| **NGB4341** | FJÄLKINGE_SB2501 | Diploid | 131 | Sweden | Ecotype | | 56.05 | 14.28 | 90 | Nordgen |
| **NGB2209** | FURE | Diploid | 132 | Norway | Cultivar | | . | . | . | Nordgen |
| **PI632542** | Georgikon | Diploid | 133 | Hungary | Cultivar | | . | . | . | USDA |
| **NGB1533** | GOTHEM_TL0305 | Diploid | 134 | Sweden | Ecotype | | 57.58 | 18.68 | . | Nordgen |
| **Greenway** | Greenway | Diploid | 135 | Denmark | Cultivar | Lawn | . | . | . | DLF |
| **NGB2732** | GUNNE | Diploid | 136 | Sweden | Cultivar | | . | . | . | Nordgen |
| **NGB4342** | HAGESTAD_PW1301 | Diploid | 137 | Sweden | Ecotype | | 55.38 | 14.15 | 15 | Nordgen |
| **Hamlet** | Hamlet | Diploid | 138 | Czech_Republic | Cultivar | Lawn | . | . | . | Zivotice |
| **NGB13322** | HELMER | Tetraploid | 139 | Sweden | Cultivar | | . | . | . | Nordgen |
| **Hurricane** | Hurricane | Tetraploid | 140 | France | Cultivar | Forage | . | . | . | carneau |
| **NGB4345** | HÄLJARÖD_JK3103 | Diploid | 141 | Sweden | Ecotype | | 56.23 | 12.75 | 2 | Nordgen |
| **NGB1523** | HÖRSNE_TL0102 | Diploid | 142 | Sweden | Ecotype | | 57.56 | 18.55 | . | Nordgen |
| **Ideal** | Ideal | Tetraploid | 143 | France | Cultivar | Forage | . | . | . | RAGT |
| **POL155176** | INKA | Diploid | 144 | Poland | Cultivar | | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **Ivana** | Ivana | Diploid | 145 | Germany | Cultivar | Forage | . | . | . | BayP |
| **Ivar** | Ivar | MIX | 146 | Norway | Cultivar | Forage | . | . | . | Graminor |
| **DE7063** | JO_0110 | Diploid | 147 | Finland | Breeding_L. | | . | . | . | Genebank Department, IPK, Germany |
| **Vir38563** | JO_231 | Diploid | 148 | Finland | Cultivar | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **PI298091** | Karcagi | Diploid | 149 | Hungary | Landrace | | . | . | . | USDA |
| **PI632510** | Karcagi | Diploid | 150 | Hungary | Cultivar | | . | . | . | USDA |
| **Keystone2** | Keystone2 | Diploid | 151 | Denmark | Cultivar | Lawn | . | . | . | DLF |
| **EST963** | Kihelkonna_RA02066 | Diploid | 152 | Estonia | Ecotype | | 58.35 | 22.03 | . | Genebank, Jõgeva Plant Breeding Institute, Estonia |
| **DE4573** | LENINGRADSKIJ_809 | Diploid | 153 | Soviet_Union | Breeding_L. | | 59.93 | 30.33 | 17 | Genebank Department, IPK, Germany |
| **Vir20258** | Leningradskii_809 | Diploid | 154 | Russia | Cultivar | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Vir51004** | Leningradskii | Diploid | 155 | Russia | Cultivar | | 54.16 | 37.56 | 195 | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **LIA1056** | 2312 | Tetraploid | 156 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1058** | 1894 | Tetraploid | 157 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1065** | 2745 | Diploid | 158 | Lithuania | Ecotype | | 55.5 | 23.966 | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1066** | 2748 | Diploid | 159 | Lithuania | Ecotype | | 54.75 | 24.25 | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1067** | 2750 | Diploid | 160 | Lithuania | Ecotype | | 54.55 | 24.55 | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1069** | 2299 | Tetraploid | 161 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1070** | 2751 | Tetraploid | 162 | Lithuania | Ecotype | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1071** | 2749 | Diploid | 163 | Lithuania | Ecotype | | 54.58 | 24.55 | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1072** | 2746 | Diploid | 164 | Lithuania | Ecotype | | 55.5 | 23.98 | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1407** | 2198 | Tetraploid | 165 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1409** | 2906 | Tetraploid | 166 | Lithuania | Ecotype | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1410** | 2904 | Tetraploid | 167 | Lithuania | Ecotype | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1411** | 2911 | Tetraploid | 168 | Lithuania | Ecotype | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1414** | 2903 | Diploid | 169 | Lithuania | Ecotype | | 55.58 | 24.96 | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1415** | 2909 | Tetraploid | 170 | Lithuania | Ecotype | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1416** | 2910 | Diploid | 171 | Lithuania | Ecotype | | 55.38 | 23.35 | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1417** | 2907 | Diploid | 172 | Lithuania | Ecotype | | 55.5 | 23.516 | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1418** | 2908 | Diploid | 173 | Lithuania | Ecotype | | 55.5 | 23.48 | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA1419** | 2905 | MIX | 174 | Lithuania | Ecotype | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |

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| Acc_no | Acc_name | Ploidy | AMMY_ID | Country_of_origin | Acc_type | Type | Declat. | Declongit. | Elevation | Provider |
|---|---|---|---|---|---|---|---|---|---|---|
| **LIA362** | 1253 | Tetraploid | 175 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA365** | 1248 | Diploid | 176 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA368** | 1159 | Diploid | 177 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA565** | 1249 | Tetraploid | 178 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA65** | 537 | Diploid | 179 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA66** | 1159 | Diploid | 180 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA849** | 1744 | Tetraploid | 181 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LIA852** | 1399 | Tetraploid | 182 | Lithuania | Breeding_L. | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **Vir49885** | Lorina | Diploid | 183 | France | Cultivar | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **LVA02516** | 184/06 | Tetraploid | 184 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02517** | 356/06 | Tetraploid | 185 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02518** | 355/06 | Tetraploid | 186 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02519** | 353/06 | Tetraploid | 187 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02520** | 177/06 | Diploid | 188 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02521** | 258/06 | Tetraploid | 189 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02522** | 363/06 | Tetraploid | 190 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02523** | 361/06 | Tetraploid | 191 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02524** | 261/06 | Tetraploid | 192 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02525** | 180/06 | Tetraploid | 193 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02526** | 260/06 | Tetraploid | 194 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02527** | 263/06 | Tetraploid | 195 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02528** | 262/06 | Tetraploid | 196 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02529** | 264/06 | Diploid | 197 | Latvia | Ecotype | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LVA02530** | 252/06 | Tetraploid | 198 | Latvia | Breeding_L. | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **Vir42504** | M-1 | Tetraploid | 199 | Japan | . | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **DE4569** | MARKINSKIJ_24 | Diploid | 200 | Soviet_Union | Breeding_L. | | . | . | . | Genebank Department, IPK, Germany |
| **14G2000535** | Marlot | Diploid | 201 | Slovakia | Cultivar | Lawn | . | . | . | Gene Bank, Crop Research Institute, Prague |
| **Vir40889** | Martlett | Diploid | 202 | Austria | Cultivar | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Maurizio** | Maurizio | Tetraploid | 203 | Holland | Cultivar | Forage | . | . | . | Zelder |
| **DE4570** | MOSKOVSKIJ_84 | Diploid | 204 | Soviet_Union | Breeding_L. | | 55.74 | 37.61 | 127 | Genebank Department, IPK, Germany |
| **Navarra** | Navarra | Tetraploid | 205 | Denmark | Cultivar | Forage | . | . | . | DLF-T |
| **POL155192** | NIRA | Diploid | 206 | Poland | Cultivar | | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **NGB4263** | 16-57-2 | Diploid | 207 | Norway | Ecotype | | 61.33 | 5.16 | . | Nordgen |
| **NGB4264** | 16-59-2 | Diploid | 208 | Norway | Ecotype | | 59.75 | 5.75 | 10 | Nordgen |
| **NGB4267** | 16-62-3 | Diploid | 209 | Norway | Ecotype | | 58.75 | 5.75 | 20 | Nordgen |
| **NGB4268** | 16-62-4 | Diploid | 210 | Norway | Ecotype | | 58.75 | 5.75 | 60 | Nordgen |
| **PI278773** | Norlea | Diploid | 211 | Canada | Cultivar | | 51.25 | -85.32 | 172 | USDA |
| **Novello** | Novello | Tetraploid | 212 | Denmark | Cultivar | Forage | . | . | . | DLF |
| **DE4571** | PASAVY | Diploid | 213 | Soviet_Union | Cultivar | | . | . | . | Genebank Department, IPK, Germany |
| **NGB1637** | PATORA | Diploid | 214 | Denmark | Cultivar | | . | . | . | Nordgen |
| **NGB13331** | PAVO | Diploid | 215 | Sweden | Cultivar | | . | . | . | Nordgen |
| **Vir36944** | Perma | Diploid | 216 | Holland | Cultivar | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **PI197270** | PI197270 | Diploid | 217 | Finland | Landrace | | . | . | . | USDA |
| **PI198070** | PI198070 | Diploid | 218 | Sweden | Landrace | | . | . | . | USDA |

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| Acc_no | Acc_name | Ploidy | AMMY_ID | Country_of_origin | Acc_type | Type | Declat. | Declongit. | Elevation | Provider |
|---|---|---|---|---|---|---|---|---|---|---|
| **PI205278** | PI205278 | Diploid | 219 | Turkey | Ecotype | | . | . | . | USDA |
| **PI272120** | PI272120 | Diploid | 220 | Poland | Ecotype | | 54.79 | 18.4 | 13 | USDA |
| **PI272121** | PI272121 | Diploid | 221 | Poland | . | | . | . | . | USDA |
| **PI274637** | PI274637 | Diploid | 222 | Poland | Ecotype | | 51.24 | 22.56 | 192 | USDA |
| **PI595043** | ABY-BA9792.81 | Diploid | 223 | UK | Ecotype | | 52.38 | -3.85 | 300 | USDA |
| **PI595044** | ABY-BA9798.82 | Diploid | 224 | UK | Ecotype | | 51.95 | -3.88 | 100 | USDA |
| **PI595047** | ABY-BA9803.80 | Diploid | 225 | UK | Ecotype | | 51.77 | -3.63 | 350 | USDA |
| **PI598429** | ABY-BA8602.00 | Diploid | 226 | Italy | Ecotype | | 44.08 | 7.8 | 1400 | USDA |
| **PI598430** | ABY-BA8603.00 | Diploid | 227 | Italy | Ecotype | | 44.08 | 7.8 | 1200 | USDA |
| **PI598432** | ABY-BA8614.68 | Diploid | 228 | Italy | Ecotype | | 46.48 | 10.28 | 1410 | USDA |
| **PI598433** | ABY-BA8616.00 | Diploid | 229 | Italy | Ecotype | | 46.48 | 10.28 | 1410 | USDA |
| **PI598434** | ABY-BA8621.82 | Diploid | 230 | Italy | Ecotype | | 46.3 | 11.47 | 950 | USDA |
| **PI598440** | ABY-BA9091.72 | Diploid | 231 | Switzerland | Ecotype | | 46.65 | 6.75 | 840 | USDA |
| **PI598441** | ABY-BA9092.72 | Diploid | 232 | Switzerland | Ecotype | | 46.58 | 6.93 | 860 | USDA |
| **PI598442** | ABY-BA9094.72 | Tetraploid | 233 | Switzerland | Ecotype | | 46.33 | 6.97 | 341 | USDA |
| **PI598443** | ABY-BA9097.84 | Diploid | 234 | Switzerland | Ecotype | | 46.18 | 6.87 | 1600 | USDA |
| **PI598453** | ABY-BA9080.A81 | Diploid | 235 | Romania | Ecotype | | 47.52 | 25.95 | 500 | USDA |
| **PI598454** | ABY-BA9983.81 | Diploid | 236 | Romania | Ecotype | | 47.67 | 22.47 | 25 | USDA |
| **PI598515** | 346 | Diploid | 237 | Turkey | Ecotype | | 38.72 | 30.37 | 1100 | USDA |
| **PI598519** | 513 | Diploid | 238 | Turkey | Ecotype | | 39.55 | 33.12 | 1080 | USDA |
| **PI610802** | ABY-BA10111.82 | Diploid | 239 | Norway | Ecotype | | 59.92 | 5.33 | 10 | USDA |
| **PI619003** | ABY-BA10106.82 | Diploid | 240 | Norway | Ecotype | | 58.88 | 5.6 | 25 | USDA |
| **Pionero** | Pionero | MIX | 241 | Germany | Cultivar | Forage | . | . | . | Eurograss |
| **NGB1638** | PIPPIN_(Lawn) | Diploid | 242 | Denmark | Cultivar | Lawn | . | . | . | Nordgen |
| **POL133324** | POL133324 | Diploid | 243 | Ukraine | Ecotype | | 47.95 | 23.87 | 350 | Genebank, National Centre for Plant Genetic Resources |
| **POL133325** | POL133325 | Diploid | 244 | Ukraine | Ecotype | | 47.95 | 23.87 | 250 | Genebank, National Centre for Plant Genetic Resources |
| **POL133326** | POL133326 | Diploid | 245 | Slovakia | Ecotype | | 49.31 | 21.66 | 360 | Genebank, National Centre for Plant Genetic Resources |
| **POL133327** | POL133327 | Diploid | 246 | Slovakia | Ecotype | | 49.37 | 21.64 | 333 | Genebank, National Centre for Plant Genetic Resources |
| **POL133328** | POL133328 | Diploid | 247 | Ukraine | Ecotype | | 48.98 | 24.7 | 700 | Genebank, National Centre for Plant Genetic Resources |
| **POL133398** | POL133398 | Diploid | 248 | Poland | . | | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **POL133399** | POL133399 | Diploid | 249 | Poland | . | | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **POL133400** | POL133400 | Diploid | 250 | Poland | . | | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **POL133401** | POL133401 | Diploid | 251 | Poland | . | | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155145** | POL155145 | Diploid | 252 | Poland | Ecotype | | 51.15 | 23.81 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155147** | POL155147 | Diploid | 253 | Poland | Ecotype | | 49.61 | 20.71 | 291 | Genebank, National Centre for Plant Genetic Resources |
| **POL155152** | POL155152 | Diploid | 254 | Poland | Ecotype | | 50.63 | 23.38 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155153** | POL155153 | Diploid | 255 | Poland | Ecotype | | 50.45 | 23.48 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155154** | POL155154 | Diploid | 256 | Poland | Ecotype | | 49.4 | 20.56 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155155** | POL155155 | Diploid | 257 | Poland | Ecotype | | 50.76 | 23.25 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155158** | POL155158 | Diploid | 258 | Poland | Ecotype | | 51.15 | 23.81 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155159** | POL155159 | Diploid | 259 | Poland | Ecotype | | 52.76 | 16.96 | 69 | Genebank, National Centre for Plant Genetic Resources |
| **Portstewart** | Portstewart | Diploid | 260 | UK | Cultivar | Forage | . | . | . | Northern Irel |
| **Premium** | Premium | Diploid | 261 | Denmark | Cultivar | Forage | . | . | . | DLF-T |
| **NGB8378** | PRESTO_PAJBJERG | Diploid | 262 | Denmark | Cultivar | | . | . | . | Nordgen |

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| Acc_no | Acc_name | Ploidy | AMMY_ID | Country_of_origin | Acc_type | Type | Declat. | Declongit. | Elevation | Provider |
|---|---|---|---|---|---|---|---|---|---|---|
| **DE4572** | PRIEKULSKIJ_59 | Diploid | 263 | Soviet_Union | Breeding_L. | | . | . | . | Genebank Department, IPK, Germany |
| **Primary** | Primary | Diploid | 264 | USA | Cultivar | Lawn | . | . | . | DLF International Seeds |
| **Vir47191** | Prosperowo/BY | Diploid | 265 | Poland | Cultivar | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **EST968** | Pürksi-Karja_RA02071 | Diploid | 266 | Estonia | Ecotype | | 59.01 | 23.51 | . | Genebank, Jõgeva Plant Breeding Institute, Estonia |
| **EST49** | Raidi | Diploid | 267 | Estonia | Cultivar | | . | . | . | Genebank, Jõgeva Plant Breeding Institute, Estonia |
| **EST50** | Raite | Tetraploid | 268 | Estonia | Cultivar | | . | . | . | Genebank, Jõgeva Plant Breeding Institute, Estonia |
| **Vir50929** | Raiti | Tetraploid | 269 | Estonia | Cultivar | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **NGB15403** | RALLY | Tetraploid | 270 | Denmark | Cultivar | | . | . | . | Nordgen |
| **Regal_5** | Regal_5 | Diploid | 271 | USA | Cultivar | Lawn | . | . | . | DLF International Seeds |
| **NGB8417** | RIIKKA | Diploid | 272 | Finland | Cultivar | | . | . | . | Nordgen |
| **NGB13330** | RONJA | Diploid | 273 | Sweden | Cultivar | | . | . | . | Nordgen |
| **NGB14164** | RONJA | Diploid | 274 | Sweden | Cultivar | | . | . | . | Nordgen |
| **Roy** | Roy | Tetraploid | 275 | Belgium | Cultivar | Forage | . | . | . | RvP |
| **Vir50774** | Ruslana | Tetraploid | 276 | Ukraine | Cultivar | | 50.05 | 30.76 | 175 | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Salamandra** | Salamandra | Tetraploid | 277 | Switzerland | Cultivar | Forage | . | . | . | DSP/ART CH |
| **NGB2444** | SERVO | Diploid | 278 | Sweden | Cultivar | | . | . | . | Nordgen |
| **NGB11675** | SILDIG_DAENO_III | Diploid | 279 | Denmark | Cultivar | | . | . | . | Nordgen |
| **NGB1641** | SILDIG_HUNSBALLE | Diploid | 280 | Denmark | Cultivar | | . | . | . | Nordgen |
| **DE22479** | SIVERSKIJ_809 | Diploid | 281 | Soviet_Union | Cultivar | | . | . | . | Genebank Department, IPK, Germany |
| **LIA58** | Sodre | Tetraploid | 282 | Lithuania | Cultivar | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **LVA00062** | Spidola | Tetraploid | 283 | Latvia | Cultivar | | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **NGB2730** | SVEA | Diploid | 284 | Sweden | Cultivar | | . | . | . | Nordgen |
| **NGB11673** | SVENSK_01408_NO. | Diploid | 285 | Sweden | Breeding_L. | | . | . | . | Nordgen |
| **NGB13887** | SW_E39 | Diploid | 286 | Sweden | Breeding_L. | | . | . | . | Nordgen |
| **NGB13888** | SW_E50 | Diploid | 287 | Sweden | Breeding_L. | | . | . | . | Nordgen |
| **NGB1642** | TACA_TRIFOLIUM | Diploid | 288 | Denmark | Cultivar | | . | . | . | Nordgen |
| **NGB13328** | TAYA | Diploid | 289 | Denmark | Cultivar | | . | . | . | Nordgen |
| **NGB14538** | TERRY | Tetraploid | 290 | Sweden | Cultivar | | . | . | . | Nordgen |
| **Tetragreen** | Tetragreen | Tetraploid | 291 | Denmark | Cultivar | Lawn | . | . | . | DLF |
| **NGB1568** | TOFTA_TL0102 | Diploid | 292 | Sweden | Ecotype | | 57.51 | 18.1 | . | Nordgen |
| **Toronto** | Toronto | Diploid | 293 | Germany | Cultivar | Forage | . | . | . | EGB |
| **NGB4092** | TRANI | Diploid | 294 | Denmark | Cultivar | | . | . | . | Nordgen |
| **Trygve** | Trygve | Tetraploid | 295 | Norway | Cultivar | Forage | . | . | . | Graminor |
| **NGB1646** | URI | Tetraploid | 296 | Denmark | Cultivar | | . | . | . | Nordgen |
| **NGB2602** | VALINGE | Diploid | 297 | Finland | Cultivar | | . | . | . | Nordgen |
| **NGB2590** | VALINGE | Diploid | 298 | Sweden | Landrace | | . | . | . | Nordgen |
| **NGB4090** | VALINGE | Diploid | 299 | Sweden | Landrace | | . | . | . | Nordgen |
| **DE22481** | VEJA | Diploid | 300 | Soviet_Union | Cultivar | | . | . | . | Genebank Department, IPK, Germany |
| **LIA56** | veja | Diploid | 301 | Lithuania | Cultivar | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **NGB1647** | VERNA_PAJBERG | Diploid | 302 | Denmark | Cultivar | | . | . | . | Nordgen |
| **NGB6269** | VIKTORIA | Diploid | 303 | Sweden | Cultivar | | . | . | . | Nordgen |
| **Vir37860** | Vir37860 | Diploid | 304 | Romania | Ecotype | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Vir47200** | Vir47200 | Diploid | 305 | Poland | Ecotype | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Vir49962** | Vir49962 | Diploid | 306 | Moldova | Ecotype | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |

*Later confirmed as MIX**Not a part of the WP4 experiment

***Later confirmed to be *L. multiflorum* based on genotyping

# Appendix 1

| Acc_no | Acc_name | Ploidy | AMMY_ID | Country_of_origin | Acc_type | Type | Declat. | Declongit. | Elevation | Provider |
|---|---|---|---|---|---|---|---|---|---|---|
| **Vir50879** | Vir50879 | Tetraploid | 307 | Latvia | . | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Vir51253** | Vir51253 | Tetraploid | 308 | Latvia | . | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Vir51518** | Vir51518 | Tetraploid | 309 | Russia | Ecotype | | 56.77 | 29.09 | 190 | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Vir51519** | Vir51519 | Diploid | 310 | Russia | Ecotype | | 50.71 | 37.75 | 206 | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Vir51520** | Vir51520 | Diploid | 311 | Ukraine | Ecotype | | 46.48 | 30.72 | 62 | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **NGB2360** | VIRIS | Diploid | 312 | Sweden | Cultivar | | . | . | . | Nordgen |
| **NGB2729** | VIVA | Diploid | 313 | Sweden | Cultivar | | . | . | . | Nordgen |
| **NGB4266** | VOLL_16-62-2 | Diploid | 314 | Norway | Ecotype | | 58.9 | 5.58 | 25 | Nordgen |
| **W6_11256** | 481 | Diploid | 315 | Turkey | Ecotype | | 40.77 | 32.84 | 1410 | USDA |
| **W6_11264** | 512 | Diploid | 316 | Turkey | Ecotype | | 39.55 | 33.12 | 1080 | USDA |
| **W6_9290** | ABY-BA9088.82 | Diploid | 317 | Switzerland | Ecotype | | 46.56 | 6.45 | 707 | USDA |
| **W6_9297** | ABY-BA9101.72 | Diploid | 318 | Switzerland | Ecotype | | 46.19 | 7.4 | 2030 | USDA |
| **POL155218** | WENTO_(SZD291) | Tetraploid | 319 | Poland | Cultivar | | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **NGB4261** | WIR20258 | Diploid | 320 | Norway | Breeding_L. | | . | . | . | Nordgen |
| **NGB4260** | WIR40697 | Tetraploid | 321 | Norway | Breeding_L. | | . | . | . | Nordgen |
| **Vir42502** | Yatsugane | Tetraploid | 322 | Japan | Cultivar | | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **LIA59** | Zvilge | Tetraploid | 323 | Lithuania | Cultivar | | . | . | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **Ba12985** | Ba12985 | . | . | France | Ecotype | | 43.38 | 6.6 | 200 | ECP/GR |
| **Ba13000** | Ba13000 | . | . | Germany | Ecotype | | 54.5 | 13.08 | . | ECP/GR |
| **Ba13001** | Ba13001 | . | . | Germany | Ecotype | | 54.28 | 13.68 | 33 | ECP/GR |
| **Ba13002** | Ba13002 | . | . | Germany | Ecotype | | 53.4 | 12.65 | 33 | ECP/GR |
| **Ba13003** | Ba13003 | . | . | Germany | Ecotype | | 53.45 | 12.73 | 72 | ECP/GR |
| **14G2000588** | Guru | Diploid | . | Austria | Cultivar | Forage | . | . | . | Gene Bank, Crop Research Institute, Prague |
| **14G2000331** | 14G2000331 | Diploid | . | Czech_Republic | Ecotype | | 49.19 | 18.21 | 400 | Gene Bank, Crop Research Institute, Prague |
| **14G2000332** | 14G2000332 | Diploid | . | Czech_Republic | Ecotype | | 49.2 | 18.24 | 420 | Gene Bank, Crop Research Institute, Prague |
| **14G2000523** | 14G2000523 | Diploid | . | Czech_Republic | Ecotype | | 50.53 | 14.09 | 345 | Gene Bank, Crop Research Institute, Prague |
| **Ba12965** | Ba12965 | Diploid | . | France | Ecotype | | 42.83 | 2.01 | 890 | ECP/GR |
| **Ba12967** | Ba12967 | Diploid | . | France | Ecotype | | 43.48 | -1.15 | 120 | ECP/GR |
| **Ba12968** | Ba12968 | Diploid | . | France | Ecotype | | 45.28 | 4.73 | 370 | ECP/GR |
| **Ba12969** | Ba12969 | Diploid | . | France | Ecotype | | 44.56 | 2.85 | 890 | ECP/GR |
| **Ba12972** | Ba12972 | Diploid | . | France | Ecotype | | 47.91 | -2.51 | 30 | ECP/GR |
| **Ba12973** | Ba12973 | Diploid | . | France | Ecotype | | 50.71 | 1.81 | 50 | ECP/GR |
| **Ba12974** | Ba12974 | Diploid | . | France | Ecotype | | 43.73 | 4.73 | 50 | ECP/GR |
| **Ba12975** | Ba12975 | Diploid | . | France | Ecotype | | 47.16 | 5.4 | 180 | ECP/GR |
| **Ba12981** | Ba12981 | Diploid | . | France | Ecotype | | 43.96 | 1.86 | 250 | ECP/GR |
| **Ba12982** | Ba12982 | Diploid | . | France | Ecotype | | 47.28 | 6.35 | 600 | ECP/GR |
| **Ba12986** | Ba12986 | Diploid | . | France | Ecotype | | 44.7 | 6.3 | 1800 | ECP/GR |
| **Ba12987** | Ba12987 | Diploid | . | France | Ecotype | | 49.18 | 1.16 | 90 | ECP/GR |
| **DE54461** | DE54461 | Diploid | . | Germany | Ecotype | | 50.84 | 9.91 | 305 | Genebank Department, IPK, Germany |
| **Ligala** | Ligala | Diploid | . | Germany | Cultivar | Lawn | . | . | . | EGB |
| **Ba13005** | Ba13005 | Diploid | . | Germany | Ecotype | | 50.88 | 13.63 | 535 | ECP/GR |
| **Ba13007** | Ba13007 | Diploid | . | Germany | Ecotype | | 50.98 | 10.91 | 300 | ECP/GR |
| **Ba13008** | Ba13008 | Diploid | . | Germany | Ecotype | | 50.56 | 10.8 | . | ECP/GR |
| **Ba13011** | Ba13011 | Diploid | . | Germany | . | | . | . | . | ECP/GR |

*Later confirmed as MIX**Not a part of the WP4 experiment ***Later confirmed to be *L. multiflorum* based on genotyping

# Appendix 1

| Acc_no | Acc_name | Ploidy | AMMY_ID | Country_of_origin | Acc_type | Type | Declat. | Declongit. | Elevation | Provider |
|---|---|---|---|---|---|---|---|---|---|---|
| **Bronsyn** | Bronsyn | Diploid | . | Holland | Cultivar | Forage | . | . | . | Barenbrug |
| **PI298092** | Babolnai | Diploid | . | Hungary | Landrace |  | . | . | . | USDA |
| **PI598431** | ABY-BA8604.00 | Diploid | . | Italy | Ecotype |  | 44.08 | 7.8 | 1600 | USDA |
| **14G2000627** | Pastbiscnyj*** | Diploid | . | Kyrgyzstan | Cultivar |  | . | . | . | Gene Bank, Crop Research Institute, Prague |
| **LVA00068** | Priekulu_59 | Diploid | . | Latvia | Cultivar |  | . | . | . | Latvian State Forestry Research Institute 'Silava' |
| **LIA1073** | 2747 | Diploid | . | Lithuania | Ecotype |  | 55.38 | 23.98 | . | Plant Gene Bank, Ministry of Environment, Lithuania |
| **PI610803** | ABY-BA10109.82 | Diploid | . | Norway | Ecotype |  | 59.8 | 5.18 | 20 | USDA |
| **NGB4262** | 16-57-1 | Diploid | . | Norway | Ecotype |  | 61.33 | 5.16 | 20 | Nordgen |
| **14G2000008** | Arka | Diploid | . | Poland | Cultivar |  | . | . | . | Gene Bank, Crop Research Institute, Prague |
| **14G2000201** | Niga | Diploid | . | Poland | Cultivar | Lawn | . | . | . | Gene Bank, Crop Research Institute, Prague |
| **Vir47196** | Yomulin/PT | Diploid | . | Poland | Cultivar |  | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **Vir47226** | Vir47226 | Diploid | . | Poland | . |  | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **POL133323** | POL133323 | Diploid | . | Poland | Ecotype |  | 53.11 | 18 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155146** | POL155146 | Diploid | . | Poland | Ecotype |  | 51.3 | 21.33 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155148** | POL155148 | Diploid | . | Poland | Ecotype |  | 51.11 | 22.5 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155150** | POL155150 | Diploid | . | Poland | Ecotype |  | 51.23 | 22.56 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155151** | POL155151 | Diploid | . | Poland | Ecotype |  | 51.23 | 22.56 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155160** | POL155160 | Diploid | . | Poland | Ecotype |  | 51.2 | 23.08 | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155193** | ARGONA | Diploid | . | Poland | Cultivar |  | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155230** | NIGA | Diploid | . | Poland | Cultivar |  | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **PI610825** | ABY-BA9108.79 | Diploid | . | Switzerland | Ecotype |  | 47.18 | 6.92 | 980 | USDA |
| **NGB16597** | Algutsrum_HAJ0203 | Diploid | . | Sweden | Ecotype |  | 56.66 | 16.6 | 29 | Nordgen |
| **PI204710** | PI204710 | Diploid | . | Turkey | Ecotype |  | . | . | . | USDA |
| **PI598414** | 342 | Diploid | . | Turkey | Ecotype |  | . | . | . | USDA |
| **PI598516** | 363 | Diploid | . | Turkey | Ecotype |  | 38.75 | 30.53 | 1150 | USDA |
| **W6_11322** | 693 | Diploid | . | Turkey | Ecotype |  | . | . | . | USDA |
| **Portrush** | Portrush | Diploid | . | UK | Cultivar | Forage | . | . | . | Northern Irel |
| **14G2000204** | NK-200 | Diploid | . | USA | Cultivar |  | . | . | . | Gene Bank, Crop Research Institute, Prague |
| **Vir51517** | Vir51517 | Diploid | . | USA | . |  | . | . | . | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **NGB1643** | TONGA | MIX | . | Denmark | Cultivar |  | . | . | . | Nordgen |
| **Impresario** | Impresario | MIX | . | Denmark | Cultivar | Forage | . | . | . | DLF |
| **14G2000236** | Yatsuboku | Tetraploid | . | Japan | Cultivar |  | . | . | . | Gene Bank, Crop Research Institute, Prague |
| **NGB4259** | FURENESET | Tetraploid | . | Norway | Breeding_L. |  | . | . | . | Nordgen |
| **Einar** | Einar | Tetraploid | . | Norway | Cultivar | Forage | . | . | . | Graminor |
| **POL155219** | SOLEN | Tetraploid | . | Poland | Cultivar |  | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **POL155238** | MAJA | Tetraploid | . | Poland | Cultivar |  | . | . | . | Genebank, National Centre for Plant Genetic Resources |
| **Vir50620** | Malysh | Tetraploid | . | Russia | Cultivar |  | 59 | 61.93 | 88 | N.I. Vavilov Research Institute of Plant Industry, Russia |
| **14G2000538** | Ilirka | Tetraploid | . | Slovenia | Cultivar |  | . | . | . | Gene Bank, Crop Research Institute, Prague |
| **Vir47611** | Svyatoshinskii | Tetraploid | . | Ukraine | Cultivar |  | 50.05 | 30.76 | 175 | N.I. Vavilov Research Institute of Plant Industry, Russia |
| ****14G2000576** | 14G2000576 | Diploid | . | Czech_Republic | Ecotype |  | 50.48 | 13.02 | 745 | Gene Bank, Crop Research Institute, Prague |
| ****Aurora** | Chouss | Diploid | . | France | Cultivar | Forage | . | . | . | Verneuil |
| ****Ba12966** | Ba12966 | Diploid | . | France | Ecotype |  | 45.83 | 5.81 | 220 | ECP/GR |
| ****Ba12984** | Ba12984 | Diploid | . | France | Ecotype |  | 45.5 | 2.83 | 1030 | ECP/GR |

*Later confirmed as MIX**Not a part of the WP4 experiment

***Later confirmed to be *L. multiflorum* based on genotyping

## Appendix 2

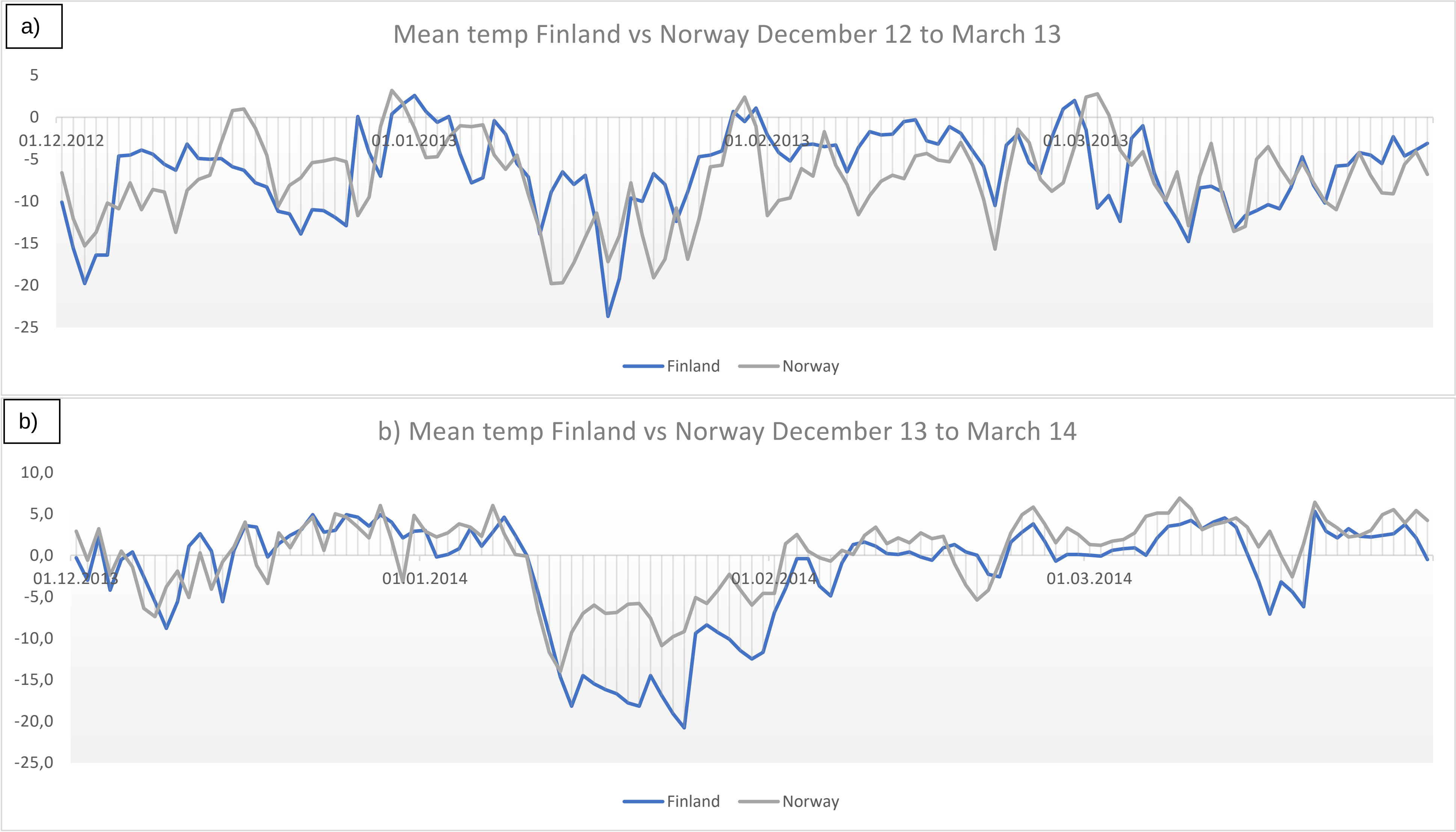

*Figure 1 Differences in temperatures between Finland and Norway for the two different winters 2012/13 (a) and 2013/14 (b). Period 1st of December to 31st of March for both years.*

# Appendix 2

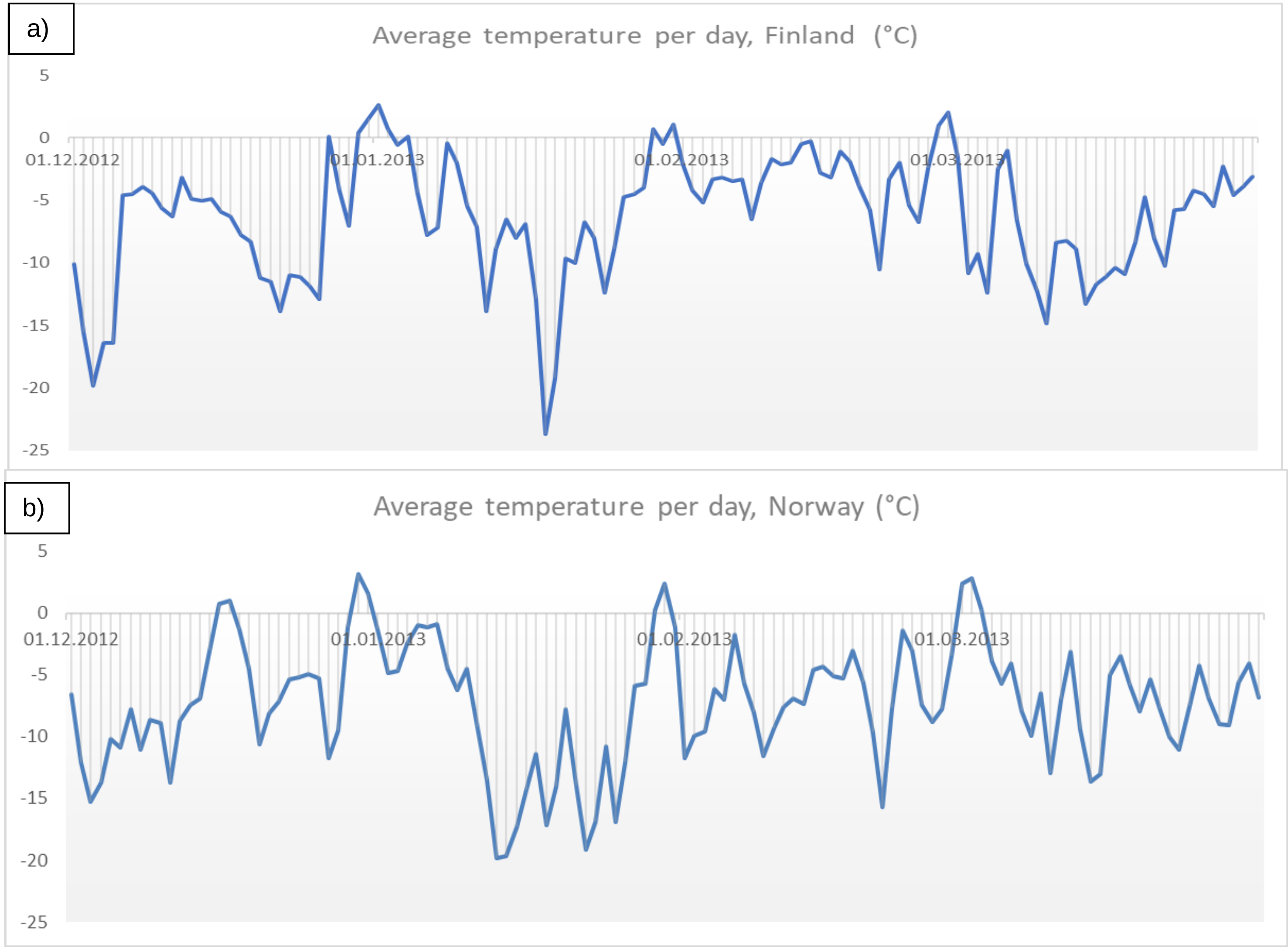

*Figure 2 Average temperature per day, Finland (a) and Norway (b). Period 01.12.2012-31.03.2013.*

# Appendix 3

**Summary of GLM analyses within locations**

| Trait | Location | Source | df | SS | F |
|---|---|---|---:|---:|---:|
| **Heading date** | Sweden | Population | 348 | 16123.59 | 18.71*** |
| | | Block | 3 | 6.05 | 0.81$^{ns}$ |
| | Norway | Population | 344 | 9510.51 | 10.18*** |
| | | Block | 3 | 700.89 | 86.09*** |
| | Denmark | Population | 363 | 21504.96 | 19.20$^{***}$ |
| | | Block | 3 | 4.41 | 0.47$^{ns}$ |
| | Finland | Population | 352 | 7913.64 | 8.99$^{***}$ |
| | | Block | 3 | 148.61 | 19.82$^{***}$ |
| | | | | | |
| **Plant height** | Sweden | Population | 347 | 55791.96 | 5.88$^{***}$ |
| | | Block | 3 | 3030.41 | 36.94$^{***}$ |
| | Norway | Population | 337 | 36034.71 | 2.486$^{***}$ |
| | | Block | 1 | 400.45 | 9.30$^{**}$ |
| | Denmark | Population | 320 | 31497.93 | 4.99$^{***}$ |
| | | Block | 1 | 105.32 | 5.34$^{*}$ |
| | Finland | Population | 352 | 40801.67 | 4.70$^{***}$ |
| | | Block | 3 | 647.12 | 8.76$^{***}$ |
| | | | | | |
| **Regrowth after 1st cut** | Sweden | Population | 348 | 434.80 | 2.32$^{***}$ |
| | | Block | 3 | 25.28 | 15.71$^{***}$ |
| | Norway | Population | 351 | 518.99 | 3.45$^{***}$ |
| | | Block | 3 | 15.76 | 12.26$^{***}$ |
| | Denmark | Population | 364 | 704.53 | 2.09$^{***}$ |
| | | Block | 3 | 143.54 | 51.78$^{***}$ |
| | Finland | Population | 352 | 880.50 | 2.06$^{***}$ |
| | | Block | 3 | 47.78 | 13.15$^{***}$ |
| | | | | | |
| **Winter survival-13** | Sweden | Population | 349 | 1472.99 | 4.90$^{***}$ |
| | | Block | 3 | 62.01 | 24.00$^{***}$ |
| | Norway | Population | 360 | 3007.92 | 10.48$^{***}$ |
| | | Block | 3 | 69.31 | 28.99$^{***}$ |
| | Finland | Population | 356 | 657.72 | 2.48$^{***}$ |
| | | Block | 3 | 126.53 | 56.71$^{***}$ |
| | | | | | |
| **Winter survival-14** | Denmark | Population | 364 | 763.28 | 3.02$^{***}$ |
| | | Block | 3 | 100.59 | 48.45$^{***}$ |
| | Norway | Population | 351 | 555.95 | 3.102$^{***}$ |
| | | Block | 3 | 236.77 | 154.55$^{***}$ |
| | Finland | Population | 357 | 288.23 | 2.46$^{***}$ |
| | | Block | 3 | 18.21 | 18.54$^{***}$ |
| | | | | | |
| **Crown rust** | Denmark | Population | 306 | 194.80 | 2.70$^{***}$ |
| | | Block | 3 | 17.24 | 24.40$^{***}$ |
| | Norway | Population | 321 | 380.34 | . |
| | | Block | 0 | 0.00 | . |

# Appendix 4

**Table 1 Least square means (LS means) for the location in Denmark**

| PPP_id | Acc_no | Acc_name | Loc | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 | MW.S._14 |
|---|---|---|---|---|---|---|---|---|
| 40001 | DE7063 | JO_0110 | DEN | 153.94 | 66.53 | 3.53 | . | 2.16 |
| 40003 | DE161 | BANAT | DEN | 141.01 | 68.00 | 5.00 | 6.31 | 2.50 |
| 40004 | DE22479 | SIVERSKI | DEN | 157.10 | 57.13 | 5.30 | 6.22 | 2.75 |
| 40005 | DE22481 | VEJA | DEN | 149.88 | 67.47 | 5.65 | 6.24 | 3.12 |
| 40006 | DE4571 | PASAVY | DEN | 153.98 | 65.72 | 3.90 | 5.20 | 2.79 |
| 40007 | DE4569 | MARKINSK | DEN | 138.89 | 61.88 | 4.32 | 5.81 | 1.85 |
| 40008 | DE4570 | MOSKOVSK | DEN | 155.60 | . | 4.58 | 6.17 | 3.18 |
| 40009 | DE4572 | PRIEKULS | DEN | 149.33 | . | 4.66 | . | 4.76 |
| 40010 | DE4573 | LENINGRA | DEN | . | . | . | . | 1.44 |
| 40011 | DE28848 | DE28848 | DEN | 149.21 | 66.25 | 5.01 | 5.94 | 3.71 |
| 40012 | DE28856 | DE28856 | DEN | 159.53 | . | 4.46 | 5.92 | 2.76 |
| 40013 | DE58136 | DE58136 | DEN | 143.23 | 75.00 | 5.00 | . | 3.64 |
| 40014 | DE59284 | DE59284 | DEN | 151.91 | 66.97 | 4.88 | 5.59 | 2.99 |
| 40015 | DE50653 | DE50653 | DEN | 151.64 | 61.25 | 4.84 | 5.82 | 3.08 |
| 40016 | DE54461 | DE54461 | DEN | . | . | . | . | . |
| 40017 | DE33943 | DE33943 | DEN | 151.63 | 59.47 | 6.25 | 6.39 | 3.39 |
| 40018 | DE28851 | DE28851 | DEN | 151.71 | 69.38 | 5.33 | 5.65 | 2.77 |
| 40019 | DE50654 | DE50654 | DEN | 153.34 | 65.38 | 4.90 | 4.95 | 2.79 |
| 40020 | DE54456 | DE54456 | DEN | 151.36 | 70.63 | 5.60 | 6.35 | 3.94 |
| 40021 | DE27965 | DE27965 | DEN | 160.71 | 46.25 | 5.06 | 5.78 | 1.86 |
| 40022 | DE51990 | DE51990 | DEN | 146.50 | 61.97 | 5.62 | 5.56 | 3.74 |
| 40023 | DE50667 | DE50667 | DEN | 153.75 | 61.47 | 5.38 | 5.89 | 2.84 |
| 40024 | DE51971 | DE51971 | DEN | 157.10 | 54.47 | 4.53 | 6.12 | 2.48 |
| 40025 | DE59277 | DE59277 | DEN | 155.43 | 59.00 | 4.95 | 5.87 | 3.00 |
| 40026 | DE33932 | DE33932 | DEN | 145.80 | 70.00 | 5.65 | 6.17 | 3.04 |
| 40027 | DE50668 | DE50668 | DEN | 148.29 | 76.88 | 6.06 | 6.21 | 3.38 |
| 40028 | DE51987 | DE51987 | DEN | 157.38 | 53.50 | 5.87 | 6.29 | 3.22 |
| 40029 | DE28846 | DE28846 | DEN | 147.68 | 62.13 | 5.47 | 4.90 | 3.67 |
| 40030 | DE28849 | DE28849 | DEN | 148.25 | 60.00 | 4.31 | 5.90 | 2.63 |
| 40031 | DE28845 | DE28845 | DEN | 154.38 | 58.50 | 5.46 | 5.80 | 3.49 |
| 40032 | DE33913 | DE33913 | DEN | 140.91 | 67.00 | 5.33 | 5.43 | 2.49 |
| 40033 | DE62309 | DE62309 | DEN | 143.48 | 64.25 | 5.28 | 6.73 | 3.45 |
| 40034 | DE62310 | DE62310 | DEN | 149.01 | 57.38 | 4.48 | 5.95 | 2.74 |
| 40035 | DE62308 | DE62308 | DEN | 148.70 | 60.53 | 4.11 | . | 2.23 |
| 40036 | DE62315 | DE62315 | DEN | 148.93 | 63.22 | 4.34 | 5.90 | 2.75 |
| 40037 | DE62300 | DE62300 | DEN | 148.08 | 58.22 | 5.09 | 5.45 | 3.20 |
| 40038 | DE62301 | DE62301 | DEN | 148.86 | 58.47 | 4.27 | . | 2.99 |
| 40039 | DE62313 | DE62313 | DEN | 150.73 | 59.50 | 3.77 | . | 2.27 |
| 40040 | DE54063 | DE54063 | DEN | 150.53 | 70.38 | 5.34 | 5.96 | 3.38 |
| 40041 | DE54064 | DE54064 | DEN | 150.86 | 72.00 | 5.54 | 5.16 | 3.33 |
| 40042 | DE54065 | DE54065 | DEN | 151.98 | 70.00 | 4.83 | 5.81 | 2.90 |
| 40043 | DE54066 | DE54066 | DEN | 150.63 | 66.50 | 4.84 | 6.10 | 3.40 |
| 40044 | DE54084 | DE54084 | DEN | 154.19 | 61.63 | 5.31 | 5.95 | 3.25 |
| 40045 | DE54085 | DE54085 | DEN | 153.81 | 64.47 | 4.25 | 6.70 | 2.99 |
| 40046 | DE54088 | DE54088 | DEN | 149.43 | 69.50 | 5.39 | 5.96 | 2.89 |
| 40047 | DE54089 | DE54089 | DEN | 151.75 | 64.50 | 3.25 | 6.70 | 2.10 |
| 40048 | DE54090 | DE54090 | DEN | 151.56 | 66.50 | 4.91 | 5.37 | 3.01 |
| 40049 | DE54091 | DE54091 | DEN | 148.56 | 68.00 | 4.95 | 6.01 | 2.41 |
| 40050 | DE54092 | DE54092 | DEN | 152.05 | 70.50 | 5.00 | 5.88 | 2.20 |
| 40051 | DE54093 | DE54093 | DEN | 152.10 | 66.00 | 5.00 | 6.23 | 2.59 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Location | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 | MWinter_s_14 |
|---|---|---|---|---|---|---|---|---|
| 40052 | DE62312 | DE62312 | DEN | 152.93 | . | 4.86 | 5.92 | 3.76 |
| 40053 | LIA368 | 1159 | DEN | 155.47 | 61.78 | 6.65 | 7.73 | 4.69 |
| 40054 | LIA852 | 1399 | DEN | 152.99 | 84.53 | 5.50 | 6.28 | 4.36 |
| 40055 | LIA849 | 1744 | DEN | 148.00 | 74.38 | 5.56 | 6.56 | 4.35 |
| 40056 | LIA1407 | 2198 | DEN | 152.16 | 76.47 | 5.17 | 6.16 | 4.20 |
| 40057 | LIA66 | 1159 | DEN | 157.63 | 60.13 | 6.49 | 6.39 | 3.83 |
| 40058 | LIA365 | 1248 | DEN | 155.68 | 62.25 | 5.73 | 5.80 | 3.30 |
| 40059 | LIA565 | 1249 | DEN | 154.20 | 68.00 | 5.95 | 6.57 | 4.25 |
| 40060 | LIA362 | 1253 | DEN | 156.31 | 64.50 | 5.79 | 6.99 | 4.84 |
| 40061 | LIA1058 | 1894 | DEN | 153.01 | 72.00 | 5.93 | 6.13 | 4.49 |
| 40062 | LIA1069 | 2299 | DEN | 154.15 | 66.00 | 6.41 | 6.61 | 4.66 |
| 40063 | LIA1056 | 2312 | DEN | 154.61 | 71.38 | 6.18 | 6.81 | 5.15 |
| 40064 | LIA1065 | 2745 | DEN | 149.54 | 75.00 | 4.70 | 6.03 | 2.64 |
| 40065 | LIA1072 | 2746 | DEN | 155.51 | 57.38 | 6.51 | 6.25 | 3.49 |
| 40066 | LIA1073 | 2747 | DEN | . | . | . | . | . |
| 40067 | LIA1066 | 2748 | DEN | 155.60 | 67.47 | 5.70 | 6.75 | 3.90 |
| 40068 | LIA1071 | 2749 | DEN | 155.21 | 56.97 | 3.98 | 6.20 | 1.92 |
| 40069 | LIA1067 | 2750 | DEN | 154.80 | 58.22 | 5.22 | . | 4.00 |
| 40070 | LIA1070 | 2751 | DEN | 147.76 | 72.50 | 5.83 | 5.77 | 4.21 |
| 40071 | LIA1414 | 2903 | DEN | 164.48 | 48.22 | 6.20 | 6.42 | 4.25 |
| 40072 | LIA1410 | 2904 | DEN | 153.40 | 77.00 | 6.15 | 6.58 | 4.45 |
| 40073 | LIA1419 | 2905 | DEN | 151.45 | 73.13 | 5.45 | 5.77 | 3.75 |
| 40074 | LIA1409 | 2906 | DEN | 155.18 | 73.38 | 5.93 | 7.05 | 4.13 |
| 40075 | LIA1417 | 2907 | DEN | 158.35 | 59.47 | 5.62 | 6.09 | 3.47 |
| 40076 | LIA1418 | 2908 | DEN | 156.88 | 60.47 | 5.92 | 6.77 | 3.72 |
| 40077 | LIA1415 | 2909 | DEN | 154.40 | 74.50 | 5.90 | 6.36 | 4.15 |
| 40078 | LIA1416 | 2910 | DEN | 150.64 | 75.00 | 4.35 | . | 2.60 |
| 40079 | LIA1411 | 2911 | DEN | 153.09 | 76.88 | 5.68 | 6.59 | 3.91 |
| 40080 | LIA65 | 537 | DEN | 156.32 | 64.28 | 5.91 | 5.42 | 2.88 |
| 40081 | LIA58 | Sodre | DEN | 147.80 | 78.22 | 5.78 | 6.07 | 4.59 |
| 40082 | LIA56 | veja | DEN | 149.12 | . | 5.40 | 6.00 | 2.79 |
| 40083 | LIA59 | Zvilge | DEN | 152.98 | 72.88 | 4.33 | 5.90 | 3.17 |
| 40084 | LVA00062 | Spidola | DEN | 153.65 | 70.75 | 5.60 | 6.62 | 4.46 |
| 40085 | LVA00068 | Priekulu | DEN | . | . | . | . | . |
| 40086 | LVA02516 | 184/06 | DEN | 153.70 | 74.00 | 6.81 | 6.66 | 4.98 |
| 40087 | LVA02517 | 356/06 | DEN | 154.28 | 84.47 | 6.32 | 6.87 | 4.52 |
| 40088 | LVA02518 | 355/06 | DEN | 153.99 | 76.38 | 6.28 | 7.36 | 4.46 |
| 40089 | LVA02519 | 353/06 | DEN | 154.90 | 66.00 | 4.95 | 6.75 | 3.70 |
| 40090 | LVA02520 | 177/06 | DEN | 147.59 | 75.00 | 4.77 | 6.12 | 4.30 |
| 40091 | LVA02521 | 258/06 | DEN | 152.83 | 72.47 | 6.65 | 7.07 | 5.57 |
| 40092 | LVA02522 | 363/06 | DEN | 152.08 | 84.47 | 6.19 | 6.78 | 4.58 |
| 40093 | LVA02523 | 361/06 | DEN | 153.85 | 83.53 | 5.36 | 7.03 | 6.40 |
| 40094 | LVA02524 | 261/06 | DEN | 155.86 | 72.88 | 6.46 | 7.24 | 5.15 |
| 40095 | LVA02525 | 180/06 | DEN | 152.95 | 70.00 | 5.68 | 6.09 | 4.38 |
| 40096 | LVA02526 | 260/06 | DEN | 152.50 | 76.88 | 6.44 | 6.44 | 3.94 |
| 40097 | LVA02527 | 263/06 | DEN | 152.91 | 68.22 | 5.90 | 6.78 | 4.61 |
| 40098 | LVA02528 | 262/06 | DEN | 154.80 | 71.00 | 6.64 | 7.05 | 4.79 |
| 40099 | LVA02529 | 264/06 | DEN | 151.31 | 73.50 | 5.45 | 5.91 | 4.05 |
| 40100 | LVA02530 | 252/06 | DEN | 157.86 | 70.53 | 5.66 | 6.09 | 4.41 |
| 40102 | 14G20005 | 14G20005 | DEN | 154.13 | 55.63 | 4.84 | 5.69 | 2.67 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Location | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 | MWinter_s_14 |
|---|---|---|---|---|---|---|---|---|
| 40103 | 14G20005 | 14G20005 | DEN | 155.00 | 54.75 | 5.83 | 5.32 | 3.65 |
| 40104 | 14G20003 | 14G20003 | DEN | 149.83 | . | 4.73 | 5.92 | 3.18 |
| 40105 | 14G20003 | 14G20003 | DEN | 148.38 | 76.97 | 5.97 | 5.30 | 3.42 |
| 40106 | 14G20003 | 14G20003 | DEN | 152.58 | . | 5.46 | 5.52 | 2.16 |
| 40107 | 14G20005 | 14G20005 | DEN | 156.70 | 45.53 | 6.08 | 4.92 | 2.78 |
| 40108 | 14G20005 | 14G20005 | DEN | 156.63 | 61.38 | 6.13 | 5.83 | 3.75 |
| 40109 | 14G20005 | 14G20005 | DEN | 157.54 | 56.25 | 5.40 | 6.15 | 3.35 |
| 40112 | 14G20002 | Yatsubok | DEN | 144.49 | 67.53 | 4.03 | 5.84 | 4.11 |
| 40114 | 14G20005 | Ilirka | DEN | 152.00 | 76.47 | 6.12 | 6.76 | 4.62 |
| 40115 | 14G20000 | Arka | DEN | 158.49 | 54.47 | 4.18 | . | 3.56 |
| 40116 | 14G20006 | Pastbisc | DEN | 149.24 | 86.97 | 1.93 | 6.15 | 2.06 |
| 40119 | 14G20002 | NK-200 | DEN | 156.49 | 54.47 | 4.18 | . | 1.31 |
| 40120 | 14G20002 | Niga | DEN | 153.78 | . | 4.96 | . | 2.88 |
| 40121 | 14G20005 | Marlot | DEN | 150.29 | 68.75 | 6.17 | 5.77 | 3.19 |
| 40122 | 14G20005 | Guru | DEN | 140.21 | 55.50 | 5.59 | 6.46 | 3.05 |
| 40123 | EST49 | Raidi | DEN | 153.06 | 71.38 | 5.77 | 6.03 | 3.64 |
| 40124 | EST50 | Raite | DEN | 152.64 | 74.38 | 6.03 | 6.13 | 4.19 |
| 40125 | EST963 | Kihelkon | DEN | 153.47 | 74.28 | 6.40 | 4.98 | 3.44 |
| 40126 | EST968 | Pürksi-K | DEN | 152.36 | 70.53 | 4.90 | 5.95 | 3.66 |
| 40127 | 45-4 | 45-4 | DEN | 151.04 | 74.28 | 5.45 | 6.20 | 3.19 |
| 40128 | 144-3 | 144-3 | DEN | 152.33 | . | 4.66 | 5.92 | 3.56 |
| 40129 | EST158 | EST158 | DEN | 150.95 | 71.97 | 6.48 | 6.42 | 3.87 |
| 40130 | EST279 | EST279 | DEN | 156.21 | 56.97 | 3.80 | . | 3.06 |
| 40131 | Vir20258 | Leningra | DEN | 146.33 | 80.47 | 4.17 | . | 3.17 |
| 40132 | Vir37860 | Vir37860 | DEN | 151.55 | 61.47 | 4.98 | 5.59 | 2.49 |
| 40133 | Vir38563 | JO_231 | DEN | 155.45 | 63.03 | 4.41 | . | 1.88 |
| 40134 | Vir40298 | E_4_Kock | DEN | 148.45 | 70.00 | 4.20 | 5.70 | 2.98 |
| 40135 | Vir42146 | Baca | DEN | 153.05 | 70.50 | 5.74 | 5.89 | 4.38 |
| 40136 | Vir42502 | Yatsugan | DEN | 150.40 | . | 6.08 | 6.19 | 3.88 |
| 40137 | Vir42504 | M-1 | DEN | 157.22 | 66.78 | 5.59 | 6.58 | 4.08 |
| 40139 | Vir47191 | Prospero | DEN | 153.95 | 65.53 | 4.28 | . | 2.88 |
| 40140 | Vir47196 | Yomulin/ | DEN | 155.09 | 61.78 | 5.48 | 5.59 | 4.06 |
| 40142 | Vir47226 | Vir47226 | DEN | . | . | . | . | . |
| 40143 | Vir47611 | Svyatosh | DEN | 148.27 | 92.53 | 5.17 | 7.08 | 3.46 |
| 40144 | Vir40889 | Martlett | DEN | 144.18 | 72.47 | 4.07 | 6.03 | 2.42 |
| 40145 | Vir49962 | Vir49962 | DEN | 149.08 | 64.47 | 5.12 | 5.92 | 3.51 |
| 40146 | Vir50422 | Aria | DEN | 151.36 | 71.00 | 5.45 | 6.23 | 3.15 |
| 40147 | Vir50620 | Malysh | DEN | 151.54 | . | 5.69 | 7.70 | 3.97 |
| 40148 | Vir50774 | Ruslana | DEN | 151.68 | 84.50 | 4.86 | 6.43 | 4.16 |
| 40149 | Vir50879 | Vir50879 | DEN | 155.49 | 68.13 | 5.23 | 6.38 | 3.85 |
| 40150 | Vir50929 | Raiti | DEN | 153.91 | 76.38 | 5.51 | 6.12 | 4.08 |
| 40151 | Vir51004 | Leningra | DEN | 145.93 | . | 3.43 | . | 1.98 |
| 40152 | Vir51253 | Vir51253 | DEN | 156.24 | 60.72 | 4.43 | . | 3.56 |
| 40153 | Vir36944 | Perma | DEN | 147.74 | 64.47 | 4.80 | . | 2.56 |
| 40154 | Vir49885 | Lorina | DEN | 154.90 | 55.00 | 4.25 | 5.97 | 2.00 |
| 40155 | Vir47200 | Vir47200 | DEN | 158.93 | . | 4.41 | . | 3.31 |
| 40157 | Vir51515 | BUK-66 | DEN | 152.64 | 76.38 | 5.93 | 6.91 | 4.74 |
| 40158 | Vir51516 | Duet | DEN | 152.16 | 84.47 | 4.75 | 6.09 | 4.39 |
| 40159 | Vir51517 | Vir51517 | DEN | 143.68 | . | 5.41 | . | 3.81 |
| 40160 | Vir51518 | Vir51518 | DEN | 150.90 | 75.88 | 5.97 | 5.55 | 5.00 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Location | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 | MWinter_s_14 |
|---|---|---|---|---|---|---|---|---|
| 40161 | Vir51519 | Vir51519 | DEN | 153.74 | 60.72 | 4.68 | . | 2.31 |
| 40162 | Vir51520 | Vir51520 | DEN | 154.48 | 62.63 | 4.41 | 5.69 | 3.21 |
| 40163 | PI197270 | PI197270 | DEN | 149.79 | 66.78 | 4.58 | 5.48 | 2.56 |
| 40164 | PI198070 | PI198070 | DEN | 144.93 | . | 4.86 | 6.42 | 3.96 |
| 40165 | PI204710 | PI204710 | DEN | 149.78 | 56.97 | 3.38 | . | 2.69 |
| 40166 | PI205278 | PI205278 | DEN | 146.98 | 68.13 | 3.83 | 5.65 | 2.60 |
| 40167 | PI272120 | PI272120 | DEN | 141.42 | 70.53 | 4.44 | 5.92 | 3.23 |
| 40168 | PI272121 | PI272121 | DEN | 153.55 | 61.97 | 3.97 | 4.95 | 3.75 |
| 40169 | PI274637 | PI274637 | DEN | 150.18 | 66.97 | 5.47 | 6.30 | 3.87 |
| 40170 | PI278773 | Norlea | DEN | 155.13 | . | 3.26 | . | 2.56 |
| 40171 | PI298091 | Karcagi | DEN | 150.31 | 66.25 | 5.00 | 5.15 | 2.59 |
| 40172 | PI298092 | Babolnai | DEN | 146.97 | 68.03 | 4.15 | 5.73 | 2.94 |
| 40173 | PI595043 | ABY-BA97 | DEN | 144.46 | 64.47 | 4.92 | 5.42 | 3.19 |
| 40174 | PI595044 | ABY-BA97 | DEN | 149.93 | . | 5.16 | . | 3.81 |
| 40175 | PI595047 | ABY-BA98 | DEN | 139.92 | 67.53 | 5.11 | 5.33 | 3.15 |
| 40176 | PI598429 | ABY-BA86 | DEN | 146.98 | 56.88 | 4.54 | . | 1.25 |
| 40177 | PI598430 | ABY-BA86 | DEN | 148.16 | 55.00 | 4.77 | 5.72 | 2.44 |
| 40178 | PI598431 | ABY-BA86 | DEN | . | . | . | . | . |
| 40179 | PI598432 | ABY-BA86 | DEN | 152.26 | 46.78 | 6.11 | 5.12 | 3.46 |
| 40180 | PI598433 | ABY-BA86 | DEN | 152.15 | 43.47 | 4.98 | 5.65 | 1.60 |
| 40181 | PI598434 | ABY-BA86 | DEN | 150.55 | 56.97 | 4.87 | 5.67 | 2.37 |
| 40182 | PI598440 | ABY-BA90 | DEN | 145.68 | 66.00 | 3.97 | 6.40 | 2.62 |
| 40183 | PI598441 | ABY-BA90 | DEN | 134.74 | 64.47 | 6.18 | 4.65 | 3.06 |
| 40184 | PI598442 | ABY-BA90 | DEN | 156.79 | 50.13 | 4.75 | . | 3.58 |
| 40185 | PI598443 | ABY-BA90 | DEN | 144.89 | 72.53 | 5.17 | 5.69 | 3.75 |
| 40186 | PI598453 | ABY-BA90 | DEN | 152.68 | 59.47 | 4.82 | 5.35 | 1.50 |
| 40187 | PI598454 | ABY-BA99 | DEN | 149.69 | 65.63 | 4.56 | 6.19 | 3.00 |
| 40188 | PI598414 | 342 | DEN | 152.79 | 62.50 | 4.00 | 5.65 | 2.56 |
| 40189 | PI598515 | 346 | DEN | 147.84 | 58.03 | 3.44 | . | 2.06 |
| 40190 | PI598516 | 363 | DEN | . | . | . | . | . |
| 40191 | PI598519 | 513 | DEN | 143.53 | 62.47 | 5.05 | 5.15 | 2.21 |
| 40192 | PI610802 | ABY-BA10 | DEN | 141.68 | . | 5.91 | 5.92 | 4.31 |
| 40193 | PI610803 | ABY-BA10 | DEN | . | . | . | . | . |
| 40194 | PI610825 | ABY-BA91 | DEN | 153.49 | 46.97 | 1.68 | . | . |
| 40195 | PI619003 | ABY-BA10 | DEN | 142.39 | 64.47 | 5.05 | 5.31 | 3.40 |
| 40196 | PI632510 | Karcagi | DEN | 148.63 | 68.22 | 5.00 | 5.97 | 3.24 |
| 40197 | PI632542 | Georgiko | DEN | 148.18 | 79.47 | 5.67 | 5.96 | 3.69 |
| 40198 | W6_9290 | ABY-BA90 | DEN | 151.70 | 59.25 | 6.14 | 6.06 | 3.42 |
| 40199 | W6_9297 | ABY-BA91 | DEN | 146.68 | . | 3.66 | . | 1.81 |
| 40200 | W6_11256 | 481 | DEN | 142.11 | 61.13 | 4.63 | 5.83 | 3.52 |
| 40201 | W6_11264 | 512 | DEN | 146.66 | 63.75 | 4.45 | 4.44 | 2.67 |
| 40202 | W6_11322 | 693 | DEN | 150.52 | 59.53 | 4.31 | 5.09 | 2.70 |
| 40203 | NGB1632 | AMADO | DEN | 149.96 | 73.03 | 6.49 | 5.95 | 4.36 |
| 40204 | NGB1633 | BELIDA | DEN | 140.63 | 69.47 | 6.50 | 5.92 | 3.20 |
| 40205 | NGB15401 | CHANTAL | DEN | 152.19 | 73.50 | 4.71 | . | 4.40 |
| 40206 | NGB4117 | DASAS_TR | DEN | 152.08 | 64.47 | 5.20 | 6.42 | 3.94 |
| 40207 | NGB1637 | PATORA | DEN | 158.48 | 61.00 | 6.77 | 6.04 | 5.12 |
| 40208 | NGB1638 | PIPPIN_( | DEN | 159.15 | . | 5.08 | 6.17 | 3.38 |
| 40209 | NGB8378 | PRESTO_P | DEN | 142.28 | 55.47 | 4.50 | 6.95 | 5.01 |
| 40210 | NGB15403 | RALLY | DEN | 155.78 | 67.75 | 4.49 | 6.16 | 3.84 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Location | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 | MWinter_s_14 |
|---|---|---|---|---|---|---|---|---|
| 40211 | NGB1641 | SILDIG_H | DEN | 151.71 | 76.97 | 6.80 | 6.53 | 3.69 |
| 40212 | NGB1642 | TACA_TRI | DEN | 151.61 | 73.22 | 5.02 | 5.40 | 3.80 |
| 40213 | NGB13328 | TAYA | DEN | 154.20 | 57.50 | 4.75 | 6.02 | 3.35 |
| 40214 | NGB1643 | TONGA | DEN | . | . | . | . | . |
| 40215 | NGB4092 | TRANI | DEN | 160.41 | 55.47 | 6.05 | 6.42 | 4.64 |
| 40216 | NGB1646 | URI | DEN | 154.47 | 63.03 | 3.90 | . | 2.94 |
| 40217 | NGB1647 | VERNA_PA | DEN | 144.61 | 76.78 | 5.62 | 5.42 | 2.90 |
| 40218 | NGB11675 | SILDIG_D | DEN | 152.53 | 69.47 | 4.58 | 5.78 | 3.52 |
| 40219 | NGB13338 | ALLEGRO | DEN | 154.05 | 58.53 | 4.88 | 6.42 | 3.30 |
| 40220 | NGB2602 | VALINGE | DEN | 156.05 | 59.28 | 4.26 | 5.48 | 2.26 |
| 40221 | NGB8417 | RIIKKA | DEN | 153.98 | 70.47 | 3.98 | 5.33 | 2.89 |
| 40222 | NGB4259 | FURENESE | DEN | . | . | . | . | . |
| 40223 | NGB4261 | WIR20258 | DEN | 146.48 | 70.63 | 4.95 | 4.69 | 2.81 |
| 40224 | NGB4260 | WIR40697 | DEN | 150.73 | 73.22 | 4.27 | 6.12 | 3.60 |
| 40225 | NGB16173 | Fia | DEN | 148.73 | 77.25 | 5.49 | 5.41 | 4.21 |
| 40226 | NGB2209 | FURE | DEN | 151.18 | . | 4.16 | . | 3.31 |
| 40227 | NGB4262 | 16-57-1 | DEN | . | . | . | . | . |
| 40228 | NGB4263 | 16-57-2 | DEN | 158.40 | . | 5.33 | . | 4.63 |
| 40229 | NGB4264 | 16-59-2 | DEN | 151.18 | . | 4.66 | 5.17 | 1.81 |
| 40230 | NGB4267 | 16-62-3 | DEN | 148.91 | 59.25 | 4.78 | 5.55 | 2.94 |
| 40231 | NGB4268 | 16-62-4 | DEN | 153.76 | 57.00 | 3.47 | 5.90 | 3.15 |
| 40232 | NGB4265 | ASKELAND | DEN | 151.46 | 68.47 | 4.47 | 6.17 | 3.29 |
| 40233 | NGB4266 | VOLL_16- | DEN | 144.27 | 72.00 | 4.68 | 6.20 | 3.73 |
| 40234 | NGB2594 | E12 | DEN | 156.60 | 67.25 | 5.00 | 5.96 | 3.80 |
| 40235 | NGB11673 | SVENSK_0 | DEN | 149.25 | 73.00 | 5.45 | 6.22 | 3.05 |
| 40236 | NGB13887 | SW_E39 | DEN | 152.24 | 77.00 | 5.34 | 6.31 | 3.80 |
| 40237 | NGB13888 | SW_E50 | DEN | 150.90 | 72.75 | 5.16 | 6.15 | 4.48 |
| 40238 | NGB7508 | APUS | DEN | 152.14 | 66.78 | 3.69 | 5.36 | 2.86 |
| 40239 | NGB2731 | DELTA | DEN | 145.25 | 72.50 | 6.30 | 6.35 | 3.70 |
| 40240 | NGB2732 | GUNNE | DEN | 149.47 | 69.28 | 5.65 | 5.98 | 2.19 |
| 40241 | NGB13322 | HELMER | DEN | 148.92 | 81.78 | 6.58 | 6.95 | 4.19 |
| 40242 | NGB13331 | PAVO | DEN | 154.25 | 55.50 | 4.91 | 6.04 | 3.91 |
| 40243 | NGB13330 | RONJA | DEN | 153.96 | 49.25 | 4.18 | 6.15 | 3.34 |
| 40244 | NGB14164 | RONJA | DEN | 152.31 | 59.38 | 4.06 | 6.70 | 3.05 |
| 40245 | NGB2444 | SERVO | DEN | 154.91 | 72.53 | 3.97 | 5.42 | 2.60 |
| 40246 | NGB2730 | SVEA | DEN | 150.08 | 73.00 | 4.98 | 6.21 | 3.30 |
| 40247 | NGB14538 | TERRY | DEN | 151.51 | 75.88 | 6.03 | 6.93 | 4.86 |
| 40248 | NGB6269 | VIKTORIA | DEN | 146.56 | 69.50 | 5.38 | 5.86 | 3.41 |
| 40249 | NGB2360 | VIRIS | DEN | 149.70 | 77.88 | 4.00 | . | 3.28 |
| 40250 | NGB2729 | VIVA | DEN | 153.81 | 73.38 | 5.80 | 6.16 | 4.71 |
| 40251 | NGB2590 | VALINGE | DEN | 155.11 | 66.25 | 4.86 | 5.05 | 2.98 |
| 40252 | NGB4090 | VALINGE | DEN | 155.53 | . | 5.46 | 6.32 | 2.76 |
| 40253 | NGB16597 | Algutsru | DEN | 150.08 | 65.00 | 4.99 | 6.06 | 3.13 |
| 40254 | NGB4339 | BENESTAD | DEN | 147.48 | 70.47 | 6.45 | 6.33 | 4.25 |
| 40255 | NGB4344 | BJÖRKERÖ | DEN | 149.16 | 70.00 | 6.47 | 5.80 | 4.34 |
| 40256 | NGB4341 | FJÄLKING | DEN | 146.53 | 63.75 | 4.57 | 5.98 | 3.77 |
| 40257 | NGB1533 | GOTHEM_T | DEN | 152.29 | 70.53 | 4.09 | 5.89 | 2.50 |
| 40258 | NGB4342 | HAGESTAD | DEN | 151.96 | 72.53 | 4.40 | 5.94 | 3.14 |
| 40259 | NGB4345 | HÄLJARÖD | DEN | 156.68 | 62.47 | 5.12 | 5.52 | 3.45 |
| 40260 | NGB1523 | HÖRSNE_T | DEN | 149.26 | 68.22 | 5.18 | 5.67 | 3.39 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Location | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 | MWinter_s_14 |
|---|---|---|---|---|---|---|---|---|
| 40261 | NGB1568 | TOFTA_TL | DEN | 152.96 | 59.38 | 4.91 | 5.52 | 3.01 |
| 40262 | Falk | Falk | DEN | 149.47 | 76.78 | 5.65 | 5.98 | 3.94 |
| 40263 | Fagerlin | Fagerlin | DEN | 151.56 | 71.25 | 4.94 | 5.52 | 2.75 |
| 40264 | Ivar | Ivar | DEN | 151.68 | . | 4.16 | . | 2.31 |
| 40265 | Figgjo | Figgjo | DEN | 149.69 | 83.50 | 6.09 | 6.62 | 4.75 |
| 40266 | Trygve | Trygve | DEN | 153.23 | 64.38 | 4.89 | 6.15 | 4.75 |
| 40267 | Fia | Fia | DEN | 148.00 | 78.38 | 6.05 | 6.28 | 3.95 |
| 40268 | Einar | Einar | DEN | . | . | . | . | . |
| 40269 | Fjaler | Fjaler | DEN | 148.18 | . | 4.16 | 5.92 | 4.56 |
| 40270 | Ivana | Ivana | DEN | 137.39 | 63.63 | 5.83 | 5.85 | 4.45 |
| 40271 | Arvicola | Arvicola | DEN | 137.55 | 75.50 | 6.05 | 6.24 | 3.75 |
| 40272 | Pionero | Pionero | DEN | 145.03 | 68.00 | 5.99 | 6.08 | 4.05 |
| 40273 | Navarra | Navarra | DEN | 145.93 | 70.50 | 6.01 | 6.57 | 4.15 |
| 40274 | Arvella | Arvella | DEN | 138.53 | . | 6.46 | 5.72 | 4.56 |
| 40275 | Cavia | Cavia | DEN | 144.89 | 66.00 | 5.73 | 6.53 | 4.37 |
| 40276 | Premium | Premium | DEN | 151.71 | 78.50 | 6.70 | 6.10 | 4.93 |
| 40277 | Abermagi | Abermagi | DEN | 150.17 | 68.53 | 5.85 | . | 4.64 |
| 40278 | Dunluce | Dunluce | DEN | 153.05 | 77.00 | 6.70 | 7.28 | 5.81 |
| 40279 | Dumdrum | Dumdrum | DEN | 156.39 | 63.38 | 5.83 | 7.18 | 4.31 |
| 40280 | Aberbite | Aberbite | DEN | 156.62 | . | 3.50 | . | 4.44 |
| 40281 | Aston_pr | Aston_pr | DEN | 159.68 | 65.53 | 5.53 | 6.44 | 4.08 |
| 40282 | Burlina1 | Burlina1 | DEN | 156.34 | 60.50 | 6.00 | 6.91 | 4.06 |
| 40283 | Barmaxim | Barmaxim | DEN | 159.66 | 64.00 | 6.15 | 6.93 | 4.79 |
| 40284 | Calvano1 | Calvano1 | DEN | 151.62 | . | 7.00 | 6.45 | 4.94 |
| 40285 | Arsenal | Arsenal | DEN | 150.00 | 67.50 | 6.34 | 6.26 | 4.18 |
| 40286 | Maurizio | Maurizio | DEN | 150.54 | 70.63 | 5.73 | 5.70 | 5.02 |
| 40287 | Toronto | Toronto | DEN | 149.59 | 70.88 | 7.07 | 6.57 | 5.04 |
| 40288 | Bronsyn | Bronsyn | DEN | . | . | . | . | . |
| 40289 | Impresar | Impresar | DEN | 144.91 | 80.50 | 6.38 | 6.94 | 5.85 |
| 40290 | Salamand | Salamand | DEN | 139.62 | . | 5.95 | . | 4.19 |
| 40291 | Hurrican | Hurrican | DEN | 156.34 | 65.53 | 5.03 | 6.97 | 4.71 |
| 40292 | Novello | Novello | DEN | 157.57 | 65.50 | 6.61 | 6.84 | 4.70 |
| 40294 | Barnhem | Barnhem | DEN | 157.44 | 65.00 | 5.74 | 7.17 | 5.21 |
| 40295 | Ideal | Ideal | DEN | 159.48 | 64.00 | 6.04 | 6.76 | 5.15 |
| 40296 | Portstew | Portstew | DEN | 160.53 | . | 5.72 | 5.33 | 3.61 |
| 40297 | Portrush | Portrush | DEN | . | . | . | . | . |
| 40298 | Roy | Roy | DEN | 152.19 | 70.53 | 5.63 | 6.08 | 4.18 |
| 40300 | Hamlet | Hamlet | DEN | 156.10 | 56.00 | 6.75 | 6.21 | 3.80 |
| 40301 | Keystone | Keystone | DEN | 148.59 | 53.38 | 6.27 | 7.02 | 2.47 |
| 40302 | Greenway | Greenway | DEN | 151.99 | 62.00 | 5.62 | 6.72 | 3.17 |
| 40303 | Eurodiam | Eurodiam | DEN | 156.46 | 53.75 | 5.50 | 6.10 | 3.35 |
| 40304 | Bargold | Bargold | DEN | 154.04 | 56.75 | 6.53 | 6.73 | 3.55 |
| 40305 | Esquire | Esquire | DEN | 148.50 | 62.50 | 5.43 | 5.98 | 2.98 |
| 40306 | Ligala | Ligala | DEN | . | . | . | . | . |
| 40307 | Aberimp | Aberimp | DEN | 159.72 | . | 6.15 | . | 2.19 |
| 40308 | Derby_Xt | Escapade | DEN | 148.51 | 48.53 | 5.56 | 7.72 | 2.33 |
| 40309 | Primary | Primary | DEN | 148.19 | 53.13 | 5.20 | 6.94 | 1.98 |
| 40310 | Regal_5 | Regal_5 | DEN | 146.65 | 57.00 | 4.84 | 7.19 | 2.53 |
| 40311 | Tetragre | Tetragre | DEN | 147.25 | 57.00 | 4.95 | 6.63 | 3.61 |
| 40312 | Double | Double | DEN | 146.04 | 66.00 | 5.58 | 6.84 | 3.98 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Location | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 | MWinter_s_14 |
|---|---|---|---|---|---|---|---|---|
| 40313 | Ba11434 | Ba11434 | DEN | 153.76 | 53.22 | 4.17 | 5.17 | 2.89 |
| 40314 | Ba11445 | Ba11445 | DEN | 153.87 | 58.53 | 5.04 | 5.60 | 3.53 |
| 40315 | Ba11448 | Ba11448 | DEN | 157.73 | . | 3.66 | . | 2.56 |
| 40316 | Ba11461 | Ba11461 | DEN | 152.56 | 70.53 | 4.57 | . | 2.26 |
| 40317 | Ba11451 | Ba11451 | DEN | 151.37 | 63.03 | 5.01 | 5.17 | 3.35 |
| 40318 | Ba12220 | ABY-Ba12 | DEN | 158.98 | 62.75 | 4.07 | 5.93 | 3.72 |
| 40319 | Ba12947 | Ba12947 | DEN | 150.31 | 70.50 | 5.44 | 5.78 | 3.20 |
| 40320 | Ba12948 | Ba12948 | DEN | 147.18 | 71.50 | 4.28 | . | 2.55 |
| 40321 | Ba12949 | Ba12949 | DEN | 150.45 | 68.50 | 4.25 | 6.06 | 2.90 |
| 40322 | Ba12950 | Ba12950 | DEN | 149.25 | 70.00 | 5.36 | 5.94 | 3.13 |
| 40323 | Ba12951 | Ba12951 | DEN | 147.53 | . | 5.86 | 5.42 | 3.56 |
| 40324 | Ba12952 | Ba12952 | DEN | 150.13 | 63.13 | 5.44 | 5.69 | 3.56 |
| 40325 | Ba12953 | Ba12953 | DEN | 149.35 | 64.50 | 4.45 | 5.73 | 3.15 |
| 40326 | Ba12954 | Ba12954 | DEN | 150.26 | 64.28 | 5.64 | 6.19 | 2.98 |
| 40327 | Ba12955 | Ba12955 | DEN | 151.33 | 68.22 | 4.05 | 5.15 | 2.06 |
| 40328 | Ba12956 | Ba12956 | DEN | 146.79 | 73.00 | 4.71 | 5.91 | 2.28 |
| 40329 | Ba12957 | Ba12957 | DEN | 149.62 | 71.50 | 4.60 | 5.36 | 2.01 |
| 40330 | Ba12958 | Ba12958 | DEN | 148.86 | 63.88 | 3.55 | . | 1.64 |
| 40331 | Ba12965 | Ba12965 | DEN | 148.18 | . | 5.91 | 6.17 | 2.31 |
| 40333 | Ba12967 | Ba12967 | DEN | 142.72 | 64.28 | 5.90 | . | 2.44 |
| 40334 | Ba12968 | Ba12968 | DEN | 144.45 | 64.53 | 4.83 | . | 2.05 |
| 40335 | Ba12969 | Ba12969 | DEN | 144.43 | . | 5.41 | . | 2.56 |
| 40336 | Ba12970 | Ba12970 | DEN | 138.59 | 75.47 | 6.28 | 6.65 | 5.21 |
| 40337 | Ba12971 | Ba12971 | DEN | 153.72 | . | 4.80 | 6.70 | 2.59 |
| 40338 | Ba12972 | Ba12972 | DEN | 145.43 | 66.97 | 6.12 | 6.53 | 4.77 |
| 40339 | Ba12973 | Ba12973 | DEN | . | . | . | . | . |
| 40340 | Ba12974 | Ba12974 | DEN | . | . | 1.90 | . | 2.69 |
| 40341 | Ba12975 | Ba12975 | DEN | . | . | . | . | . |
| 40342 | Ba12976 | Ba12976 | DEN | 146.60 | 63.75 | 4.79 | . | 2.87 |
| 40343 | Ba12977 | Ba12977 | DEN | 155.80 | . | 5.72 | 5.95 | 2.12 |
| 40344 | Ba12978 | Ba12978 | DEN | 154.19 | 61.25 | 5.11 | . | 3.25 |
| 40345 | Ba12979 | Ba12979 | DEN | 157.03 | . | 4.33 | 6.17 | 3.15 |
| 40346 | Ba12980 | Ba12980 | DEN | 142.04 | 54.75 | 4.76 | . | 2.56 |
| 40347 | Ba12981 | Ba12981 | DEN | . | . | . | . | . |
| 40348 | Ba12982 | Ba12982 | DEN | . | . | . | . | . |
| 40349 | Ba12983 | Ba12983 | DEN | . | . | . | . | 6.81 |
| 40351 | Ba12985 | Ba12985 | DEN | 140.22 | 53.03 | 3.65 | 5.48 | 2.19 |
| 40352 | Ba12986 | Ba12986 | DEN | . | . | . | . | . |
| 40353 | Ba12987 | Ba12987 | DEN | 137.92 | . | 5.80 | 5.60 | 3.19 |
| 40354 | Ba12988 | Ba12988 | DEN | 149.72 | 61.78 | 6.40 | . | 3.44 |
| 40355 | Ba12989 | Ba12989 | DEN | 151.13 | 63.13 | 5.88 | 5.61 | 3.44 |
| 40356 | Ba9819 | ABY-Ba98 | DEN | 152.93 | . | 5.91 | . | 3.06 |
| 40357 | Ba9832 | ABY-Ba98 | DEN | 150.55 | 67.53 | 5.16 | 5.52 | 3.60 |
| 40358 | Ba12275 | Ba12275 | DEN | 151.90 | 59.13 | 5.32 | 6.16 | 4.72 |
| 40359 | Ba12276 | Ba12276 | DEN | 153.87 | 54.28 | 5.26 | 5.63 | 2.55 |
| 40360 | Ba12277 | Ba12277 | DEN | 150.93 | 61.75 | 5.05 | . | 4.37 |
| 40361 | Ba12278 | Ba12278 | DEN | 156.17 | 54.28 | 6.53 | 5.15 | 3.50 |
| 40362 | Ba13000 | Ba13000 | DEN | 153.50 | 62.50 | 4.20 | 6.20 | 3.60 |
| 40363 | Ba13001 | Ba13001 | DEN | 158.09 | 62.75 | 5.71 | 5.99 | 4.31 |
| 40364 | Ba13002 | Ba13002 | DEN | 150.92 | 63.03 | 5.40 | . | 3.79 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Location | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 | MWinter_s_14 |
|---|---|---|---|---|---|---|---|---|
| 40365 | Ba13003 | Ba13003 | DEN | 156.37 | 48.53 | 6.05 | 5.73 | 2.84 |
| 40366 | Ba13004 | Ba13004 | DEN | 156.83 | 55.00 | 5.13 | 5.53 | 3.07 |
| 40367 | Ba13005 | Ba13005 | DEN | 154.24 | 58.22 | 4.68 | 5.65 | 4.31 |
| 40368 | Ba13006 | Ba13006 | DEN | 160.02 | 51.88 | 3.58 | 5.40 | 2.18 |
| 40369 | Ba13007 | Ba13007 | DEN | 157.43 | . | 4.41 | . | . |
| 40370 | Ba13008 | Ba13008 | DEN | 155.52 | 62.53 | 4.31 | 5.44 | 3.23 |
| 40373 | Ba13011 | Ba13011 | DEN | 136.10 | 60.00 | 4.54 | 6.48 | 4.15 |
| 40374 | POL13332 | POL13332 | DEN | . | . | . | . | . |
| 40375 | POL13332 | POL13332 | DEN | 154.87 | 61.88 | 6.45 | 5.94 | 4.70 |
| 40376 | POL13332 | POL13332 | DEN | 152.70 | . | 5.28 | 6.20 | 3.08 |
| 40377 | POL13332 | POL13332 | DEN | 151.34 | 63.50 | 5.85 | 5.73 | 3.00 |
| 40378 | POL13332 | POL13332 | DEN | 150.98 | 69.50 | 5.10 | 5.53 | 3.28 |
| 40379 | POL13332 | POL13332 | DEN | 151.05 | 63.75 | 4.39 | 6.19 | 3.43 |
| 40380 | POL13339 | POL13339 | DEN | 150.54 | 67.50 | 5.65 | 6.33 | 4.01 |
| 40381 | POL13339 | POL13339 | DEN | 151.67 | 64.00 | 4.83 | 6.53 | 3.65 |
| 40382 | POL13340 | POL13340 | DEN | 152.78 | 64.50 | 5.07 | 5.64 | 4.82 |
| 40383 | POL13340 | POL13340 | DEN | 160.51 | 53.38 | 4.71 | 5.73 | 2.35 |
| 40384 | POL15514 | POL15514 | DEN | 158.19 | 57.75 | 4.65 | 5.05 | 2.76 |
| 40385 | POL15514 | POL15514 | DEN | 155.59 | 61.25 | 4.56 | 5.23 | 2.83 |
| 40386 | POL15514 | POL15514 | DEN | 158.60 | 53.22 | 4.28 | 6.19 | 3.69 |
| 40387 | POL15514 | POL15514 | DEN | . | . | . | . | . |
| 40388 | POL15515 | POL15515 | DEN | 160.27 | 58.03 | 2.63 | . | 2.43 |
| 40389 | POL15515 | POL15515 | DEN | 149.69 | 68.13 | 3.94 | . | 2.75 |
| 40390 | POL15515 | POL15515 | DEN | 157.69 | 57.63 | 4.66 | 5.56 | 2.46 |
| 40391 | POL15515 | POL15515 | DEN | 158.78 | 47.47 | 5.12 | 5.64 | 2.65 |
| 40392 | POL15515 | POL15515 | DEN | 160.06 | 51.47 | 3.85 | 4.65 | 2.49 |
| 40393 | POL15515 | POL15515 | DEN | 161.46 | 44.47 | 3.67 | 5.53 | 3.19 |
| 40394 | POL15515 | POL15515 | DEN | 151.91 | 69.38 | 5.14 | 5.81 | 3.58 |
| 40395 | POL15515 | POL15515 | DEN | 146.85 | 71.00 | 4.75 | 5.91 | 3.45 |
| 40396 | POL15516 | POL15516 | DEN | . | . | . | . | . |
| 40397 | POL15516 | ANNA | DEN | 137.99 | 60.72 | 2.92 | . | 3.81 |
| 40398 | POL15517 | INKA | DEN | 152.53 | 56.63 | 4.88 | 6.33 | 2.69 |
| 40399 | POL15519 | NIRA | DEN | 153.90 | 55.38 | 5.44 | 6.43 | 3.16 |
| 40400 | POL15519 | ARGONA | DEN | 156.54 | 66.50 | 6.18 | 6.47 | 4.21 |
| 40401 | POL15519 | ARKA | DEN | 158.63 | 51.97 | 5.42 | 6.23 | 5.29 |
| 40402 | POL15521 | WENTO_(S | DEN | 152.86 | 72.50 | 4.90 | 7.20 | 4.06 |
| 40403 | POL15521 | SOLEN | DEN | 153.75 | 59.88 | 5.30 | 5.52 | 3.55 |
| 40404 | POL15523 | NIGA | DEN | 152.61 | 70.50 | 5.91 | 6.83 | 4.26 |
| 40405 | POL15523 | MAJA | DEN | 153.14 | 69.53 | 6.24 | 6.38 | 3.93 |

# Appendix 4

**Table 2 Least square means (LS means) for the location in Finland**

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MW.S._14 | MHeading_13 | MHeight_13 | MRegrowth_13 |
|---|---|---|---|---|---|---|---|---|
| 40001 | DE7063 | JO_0110 | FIN | 4.50 | 2.50 | 156.15 | 59.25 | 5.40 |
| 40003 | DE161 | BANAT | FIN | 3.60 | 1.00 | 151.44 | 53.25 | 3.00 |
| 40004 | DE22479 | SIVERSKIJ_809 | FIN | 3.90 | 1.80 | 159.85 | 44.70 | 4.80 |
| 40005 | DE22481 | VEJA | FIN | 3.90 | 1.90 | 152.61 | 55.51 | 4.05 |
| 40006 | DE4571 | PASAVY | FIN | 4.00 | 2.10 | 155.90 | 50.55 | 3.60 |
| 40007 | DE4569 | MARKINSKIJ_24 | FIN | 2.70 | 1.10 | 150.70 | 48.92 | 3.13 |
| 40008 | DE4570 | MOSKOVSKIJ_84 | FIN | 4.44 | 2.30 | 156.94 | 46.05 | 4.40 |
| 40009 | DE4572 | PRIEKULSKIJ_59 | FIN | 3.10 | 1.00 | 154.36 | 47.05 | 3.50 |
| 40010 | DE4573 | LENINGRADSKIJ_809 | FIN | 3.80 | 1.80 | 153.14 | 52.38 | 5.11 |
| 40011 | DE28848 | DE28848 | FIN | 4.20 | 2.10 | 155.15 | 51.90 | 4.40 |
| 40012 | DE28856 | DE28856 | FIN | 4.40 | 1.60 | 159.54 | 42.12 | 4.66 |
| 40013 | DE58136 | DE58136 | FIN | 3.10 | 1.20 | 149.99 | 52.40 | 2.60 |
| 40014 | DE59284 | DE59284 | FIN | 3.40 | 2.50 | 155.62 | 43.59 | 3.88 |
| 40015 | DE50653 | DE50653 | FIN | 4.20 | 1.30 | 155.50 | 49.95 | 5.20 |
| 40016 | DE54461 | DE54461 | FIN | 4.40 | 1.60 | 156.25 | 47.25 | 4.60 |
| 40017 | DE33943 | DE33943 | FIN | 4.10 | 1.50 | 154.10 | 49.18 | 4.40 |
| 40018 | DE28851 | DE28851 | FIN | 3.30 | 1.60 | 154.71 | 51.29 | 4.10 |
| 40019 | DE50654 | DE50654 | FIN | 4.60 | 1.90 | 155.10 | 55.45 | 4.00 |
| 40020 | DE54456 | DE54456 | FIN | 4.20 | 1.50 | 155.58 | 53.05 | 4.25 |
| 40021 | DE27965 | DE27965 | FIN | 4.20 | 1.50 | 156.10 | 48.05 | 4.20 |
| 40022 | DE51990 | DE51990 | FIN | 4.00 | 1.20 | 153.41 | 55.75 | 3.75 |
| 40023 | DE50667 | DE50667 | FIN | 4.40 | 1.60 | 156.00 | 48.39 | 4.55 |
| 40024 | DE51971 | DE51971 | FIN | 4.10 | 1.20 | 160.15 | 43.15 | 4.40 |
| 40025 | DE59277 | DE59277 | FIN | 4.40 | 1.50 | 156.90 | 52.25 | 3.80 |
| 40026 | DE33932 | DE33932 | FIN | 5.10 | 1.60 | 151.30 | 56.05 | 4.20 |
| 40027 | DE50668 | DE50668 | FIN | 4.10 | 1.70 | 152.98 | 58.21 | 3.60 |
| 40028 | DE51987 | DE51987 | FIN | 4.30 | 1.30 | 158.25 | 40.25 | 4.80 |
| 40029 | DE28846 | DE28846 | FIN | 3.64 | 1.40 | 154.54 | 53.25 | 4.93 |
| 40030 | DE28849 | DE28849 | FIN | 3.80 | 1.70 | 154.95 | 49.40 | 4.40 |
| 40031 | DE28845 | DE28845 | FIN | 3.10 | 1.40 | 157.85 | 50.31 | 4.30 |
| 40032 | DE33913 | DE33913 | FIN | 3.20 | 1.20 | 155.69 | 46.03 | 2.82 |
| 40033 | DE62309 | DE62309 | FIN | 4.90 | 1.20 | 151.65 | 48.35 | 4.20 |
| 40034 | DE62310 | DE62310 | FIN | 4.50 | 2.50 | 154.75 | 43.35 | 4.40 |
| 40035 | DE62308 | DE62308 | FIN | 3.80 | 1.70 | 155.02 | 49.25 | 4.95 |
| 40036 | DE62315 | DE62315 | FIN | 4.30 | 1.20 | 154.15 | 50.30 | 4.20 |
| 40037 | DE62300 | DE62300 | FIN | 4.50 | 1.60 | 153.27 | 52.95 | 5.13 |
| 40038 | DE62301 | DE62301 | FIN | 4.30 | 1.90 | 154.66 | 44.99 | 4.70 |
| 40039 | DE62313 | DE62313 | FIN | 3.90 | 1.10 | 155.93 | 47.26 | 5.40 |
| 40040 | DE54063 | DE54063 | FIN | 3.80 | 1.80 | 152.88 | 55.81 | 3.65 |
| 40041 | DE54064 | DE54064 | FIN | 4.50 | 2.30 | 154.20 | 57.55 | 3.60 |
| 40042 | DE54065 | DE54065 | FIN | 4.50 | 2.00 | 154.40 | 58.05 | 4.20 |
| 40043 | DE54066 | DE54066 | FIN | 4.98 | 2.10 | 154.49 | 54.98 | 4.55 |
| 40044 | DE54084 | DE54084 | FIN | 5.20 | 2.20 | 155.95 | 52.40 | 4.40 |
| 40045 | DE54085 | DE54085 | FIN | 4.40 | 1.90 | 155.74 | 51.32 | 3.86 |
| 40046 | DE54088 | DE54088 | FIN | 5.20 | 1.50 | 152.25 | 54.15 | 4.60 |
| 40047 | DE54089 | DE54089 | FIN | 5.10 | 1.60 | 153.60 | 54.05 | 4.40 |
| 40048 | DE54090 | DE54090 | FIN | 4.90 | 1.70 | 152.53 | 54.86 | 5.00 |
| 40049 | DE54091 | DE54091 | FIN | 4.60 | 1.40 | 153.28 | 57.65 | 3.45 |
| 40050 | DE54092 | DE54092 | FIN | 4.70 | 2.60 | 153.90 | 58.96 | 4.35 |
| 40051 | DE54093 | DE54093 | FIN | 4.20 | 1.50 | 154.39 | 53.65 | 3.20 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MWinter_s_13 | MWinter_s_14 | MHeading_13 | MHeight_13 | MRegrowth_13 |
|---|---|---|---|---|---|---|---|---|
| 40052 | DE62312 | DE62312 | FIN | 3.70 | 1.20 | 155.45 | 41.45 | 4.60 |
| 40053 | LIA368 | 1159 | FIN | 4.46 | 1.10 | 159.14 | 43.24 | 4.36 |
| 40054 | LIA852 | 1399 | FIN | 5.71 | 1.20 | 156.25 | 53.54 | 5.60 |
| 40055 | LIA849 | 1744 | FIN | 4.68 | 1.40 | 153.60 | 61.65 | 5.20 |
| 40056 | LIA1407 | 2198 | FIN | 4.28 | 1.40 | 156.52 | 56.22 | 5.35 |
| 40057 | LIA66 | 1159 | FIN | 4.10 | 1.50 | 157.75 | 47.50 | 4.20 |
| 40058 | LIA365 | 1248 | FIN | 3.77 | 1.40 | 158.64 | 52.60 | 4.00 |
| 40059 | LIA565 | 1249 | FIN | 4.55 | 1.30 | 155.94 | 57.85 | 4.40 |
| 40060 | LIA362 | 1253 | FIN | 5.06 | 1.40 | 156.36 | 56.25 | 5.72 |
| 40061 | LIA1058 | 1894 | FIN | 5.23 | 2.20 | 156.05 | 60.78 | 6.50 |
| 40062 | LIA1069 | 2299 | FIN | 4.71 | 1.60 | 157.00 | 53.59 | 4.93 |
| 40063 | LIA1056 | 2312 | FIN | 4.20 | 2.00 | 157.45 | 51.40 | 5.20 |
| 40064 | LIA1065 | 2745 | FIN | 4.31 | 1.40 | 152.56 | 63.75 | 5.32 |
| 40065 | LIA1072 | 2746 | FIN | 3.80 | 1.10 | 161.17 | 40.86 | 8.68 |
| 40066 | LIA1073 | 2747 | FIN | 4.26 | 2.10 | 159.73 | 54.15 | 4.52 |
| 40067 | LIA1066 | 2748 | FIN | 4.26 | 1.10 | 158.56 | 46.95 | 4.92 |
| 40068 | LIA1071 | 2749 | FIN | 3.70 | 1.80 | 156.28 | 51.64 | 4.05 |
| 40069 | LIA1067 | 2750 | FIN | 3.26 | 1.30 | 161.23 | 45.58 | 3.62 |
| 40070 | LIA1070 | 2751 | FIN | 4.10 | 1.90 | 154.70 | 56.45 | 4.60 |
| 40071 | LIA1414 | 2903 | FIN | 4.04 | 1.60 | 163.05 | 43.65 | 7.06 |
| 40072 | LIA1410 | 2904 | FIN | 4.04 | 1.50 | 156.54 | 57.19 | 6.53 |
| 40073 | LIA1419 | 2905 | FIN | 4.90 | 1.90 | 154.95 | 57.25 | 4.80 |
| 40074 | LIA1409 | 2906 | FIN | 5.11 | 1.20 | 155.14 | 55.32 | 6.53 |
| 40075 | LIA1417 | 2907 | FIN | 4.55 | 1.00 | 157.73 | 45.30 | 4.85 |
| 40076 | LIA1418 | 2908 | FIN | 4.26 | 1.50 | 159.43 | 45.63 | 5.82 |
| 40077 | LIA1415 | 2909 | FIN | 4.80 | 1.70 | 156.06 | 57.73 | 5.65 |
| 40078 | LIA1416 | 2910 | FIN | 4.78 | 1.60 | 152.91 | 60.68 | 5.15 |
| 40079 | LIA1411 | 2911 | FIN | 5.11 | 1.10 | 158.14 | 60.12 | 6.26 |
| 40080 | LIA65 | 537 | FIN | 3.77 | 1.50 | 157.77 | 53.52 | 4.60 |
| 40081 | LIA58 | Sodre | FIN | 4.31 | 1.20 | 154.30 | 55.25 | 3.53 |
| 40082 | LIA56 | veja | FIN | 3.64 | 1.90 | 152.84 | 59.80 | 4.33 |
| 40083 | LIA59 | Zvilge | FIN | 4.30 | 1.60 | 157.49 | 53.20 | 3.60 |
| 40084 | LVA00062 | Spidola | FIN | 5.66 | 2.10 | 156.80 | 48.79 | 4.40 |
| 40085 | LVA00068 | Priekulu_59 | FIN | 5.26 | 1.30 | 155.26 | 55.95 | 4.52 |
| 40086 | LVA02516 | 184/06 | FIN | 4.40 | 2.00 | 154.40 | 54.20 | 4.60 |
| 40087 | LVA02517 | 356/06 | FIN | 4.84 | 1.80 | 157.27 | 54.57 | 5.53 |
| 40088 | LVA02518 | 355/06 | FIN | 4.97 | 1.40 | 155.94 | 53.92 | 5.46 |
| 40089 | LVA02519 | 353/06 | FIN | 3.93 | 1.40 | 155.40 | 53.80 | 4.55 |
| 40090 | LVA02520 | 177/06 | FIN | 4.04 | 1.60 | 154.60 | 58.30 | 2.80 |
| 40091 | LVA02521 | 258/06 | FIN | 5.60 | 1.40 | 152.99 | 67.03 | 5.65 |
| 40092 | LVA02522 | 363/06 | FIN | 6.00 | 2.20 | 155.15 | 60.50 | 7.00 |
| 40093 | LVA02523 | 361/06 | FIN | 4.00 | 2.70 | 156.46 | 54.11 | 6.65 |
| 40094 | LVA02524 | 261/06 | FIN | 5.15 | 2.00 | 156.56 | 58.26 | 5.80 |
| 40095 | LVA02525 | 180/06 | FIN | 3.91 | 2.00 | 155.92 | 52.52 | 4.40 |
| 40096 | LVA02526 | 260/06 | FIN | 4.90 | 1.70 | 156.50 | 59.94 | 5.40 |
| 40097 | LVA02527 | 263/06 | FIN | 4.70 | 2.40 | 157.00 | 50.05 | 4.80 |
| 40098 | LVA02528 | 262/06 | FIN | 4.97 | 2.20 | 154.97 | 56.39 | 3.46 |
| 40099 | LVA02529 | 264/06 | FIN | 4.44 | 2.00 | 156.17 | 55.39 | 6.00 |
| 40100 | LVA02530 | 252/06 | FIN | 4.96 | 1.20 | 157.26 | 58.15 | 5.32 |
| 40102 | 14G2000587 | 14G2000587 | FIN | 4.95 | 2.60 | 156.20 | 45.81 | 4.95 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MWinter_s_13 | MWinter_s_14 | MHeading_13 | MHeight_13 | MRegrowth_13 |
|---|---|---|---|---|---|---|---|---|
| 40103 | 14G2000586 | 14G2000586 | FIN | 4.80 | 1.70 | 158.98 | 43.36 | 4.25 |
| 40104 | 14G2000331 | 14G2000331 | FIN | 4.04 | 1.40 | 153.20 | 54.75 | 4.06 |
| 40105 | 14G2000332 | 14G2000332 | FIN | 4.57 | 1.30 | 153.34 | 53.84 | 4.86 |
| 40106 | 14G2000333 | 14G2000333 | FIN | 3.50 | 1.50 | 157.53 | 49.56 | 4.02 |
| 40107 | 14G2000504 | 14G2000504 | FIN | 4.44 | 1.40 | 157.34 | 54.52 | 4.66 |
| 40109 | 14G2000503 | 14G2000503 | FIN | 5.11 | 1.60 | 158.40 | 50.99 | 6.80 |
| 40115 | 14G2000008 | Arka | FIN | . | 1.50 | . | . | . |
| 40116 | 14G2000627 | Pastbiscnyj | FIN | 1.73 | 1.00 | 161.40 | 49.24 | 6.01 |
| 40121 | 14G2000535 | Marlot | FIN | 3.85 | 1.60 | 156.89 | 49.47 | 4.33 |
| 40122 | 14G2000588 | Guru | FIN | 4.66 | 1.50 | 149.16 | 47.55 | 4.52 |
| 40123 | EST49 | Raidi | FIN | 5.11 | 2.20 | 154.54 | 60.99 | 4.93 |
| 40124 | EST50 | Raite | FIN | 4.69 | 1.30 | 156.35 | 52.45 | 4.41 |
| 40125 | EST963 | Kihelkonna_RA02066 | FIN | 2.60 | 1.00 | 157.57 | 51.06 | 4.68 |
| 40126 | EST968 | Pürksi-Karja_RA02071 | FIN | 4.04 | 1.30 | 155.63 | 59.53 | 4.94 |
| 40127 | 45-4 | 45-4 | FIN | 3.26 | 1.00 | 157.96 | 51.80 | 4.02 |
| 40128 | 144-3 | 144-3 | FIN | 5.07 | 1.40 | 154.04 | 60.12 | 4.93 |
| 40129 | EST158 | EST158 | FIN | 5.77 | 1.90 | 154.64 | 59.04 | 5.73 |
| 40130 | EST279 | EST279 | FIN | 5.26 | 1.50 | 155.76 | 51.65 | 4.52 |
| 40131 | Vir20258 | Leningradskii_809 | FIN | 4.06 | 1.20 | 154.56 | 57.35 | 4.52 |
| 40132 | Vir37860 | Vir37860 | FIN | 4.17 | 1.20 | 153.34 | 54.70 | 3.60 |
| 40133 | Vir38563 | JO_231 | FIN | 4.88 | 1.80 | 156.13 | 54.64 | 6.20 |
| 40134 | Vir40298 | E_4_Kockoko | FIN | 3.75 | 1.10 | 152.65 | 58.67 | 4.00 |
| 40135 | Vir42146 | Baca | FIN | 4.86 | 1.10 | 154.66 | 53.95 | 2.92 |
| 40136 | Vir42502 | Yatsugane | FIN | 5.40 | 1.00 | 154.83 | 59.45 | 5.20 |
| 40137 | Vir42504 | M-1 | FIN | 3.61 | 1.30 | 158.13 | 53.45 | 4.42 |
| 40139 | Vir47191 | Prosperowo/BY | FIN | 3.75 | 2.20 | 155.35 | 52.70 | 4.73 |
| 40142 | Vir47226 | Vir47226 | FIN | 4.50 | 1.10 | 154.98 | 52.03 | 5.20 |
| 40144 | Vir40889 | Martlett | FIN | 2.04 | 1.00 | 156.22 | 42.10 | 2.93 |
| 40145 | Vir49962 | Vir49962 | FIN | 4.57 | 1.60 | 154.87 | 50.52 | 3.60 |
| 40146 | Vir50422 | Aria | FIN | 3.90 | 1.60 | 154.58 | 59.63 | 4.95 |
| 40148 | Vir50774 | Ruslana | FIN | 4.43 | 1.20 | 153.59 | 60.16 | 5.25 |
| 40149 | Vir50879 | Vir50879 | FIN | 5.40 | 1.40 | 158.15 | 55.39 | 6.50 |
| 40150 | Vir50929 | Raiti | FIN | 4.57 | 1.70 | 155.50 | 58.89 | 5.20 |
| 40151 | Vir51004 | Leningradskii | FIN | 4.30 | 1.80 | 153.33 | 62.85 | 4.45 |
| 40152 | Vir51253 | Vir51253 | FIN | 4.50 | 2.20 | 156.20 | 56.75 | 4.85 |
| 40153 | Vir36944 | Perma | FIN | 3.91 | 1.40 | 153.10 | 51.60 | 3.60 |
| 40154 | Vir49885 | Lorina | FIN | 3.64 | 1.10 | 155.34 | 47.59 | 4.66 |
| 40155 | Vir47200 | Vir47200 | FIN | 4.85 | 1.70 | 156.78 | 52.04 | 4.35 |
| 40157 | Vir51515 | BUK-66 | FIN | 3.77 | 1.70 | 155.32 | 58.65 | 4.26 |
| 40158 | Vir51516 | Duet | FIN | 5.38 | 2.20 | 155.28 | 57.00 | 5.40 |
| 40159 | Vir51517 | Vir51517 | FIN | 3.11 | 1.10 | 151.27 | 46.39 | 4.40 |
| 40160 | Vir51518 | Vir51518 | FIN | 5.41 | 1.60 | 154.61 | 55.00 | 5.48 |
| 40161 | Vir51519 | Vir51519 | FIN | 4.00 | 1.50 | 156.85 | 49.35 | 3.20 |
| 40162 | Vir51520 | Vir51520 | FIN | 4.28 | 2.50 | 155.84 | 50.76 | 3.75 |
| 40163 | PI197270 | PI197270 | FIN | 2.66 | 1.20 | 154.67 | 50.11 | 5.68 |
| 40164 | PI198070 | PI198070 | FIN | 3.10 | 1.00 | 152.47 | 62.72 | 3.78 |
| 40166 | PI205278 | PI205278 | FIN | 4.17 | 1.50 | 153.90 | 51.30 | 2.33 |
| 40167 | PI272120 | PI272120 | FIN | 3.51 | 1.10 | 151.05 | 57.85 | 4.00 |
| 40168 | PI272121 | PI272121 | FIN | 4.04 | 1.20 | 156.00 | 52.25 | 4.66 |
| 40169 | PI274637 | PI274637 | FIN | 4.31 | 1.50 | 155.50 | 54.12 | 5.00 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MWinter_s_13 | MWinter_s_14 | MHeading_13 | MHeight_13 | MRegrowth_13 |
|---|---|---|---|---|---|---|---|---|
| 40170 | PI278773 | Norlea | FIN | 4.67 | 2.40 | 156.39 | 61.39 | 4.13 |
| 40171 | PI298091 | Karcagi | FIN | 4.84 | 1.80 | 154.14 | 51.79 | 3.33 |
| 40172 | PI298092 | Babolnai | FIN | 2.74 | 1.00 | 153.24 | 56.70 | 4.26 |
| 40173 | PI595043 | ABY-BA9792.81 | FIN | 2.84 | 1.20 | 153.10 | 44.24 | 2.73 |
| 40174 | PI595044 | ABY-BA9798.82 | FIN | 2.40 | 1.40 | 156.75 | 36.57 | 4.20 |
| 40175 | PI595047 | ABY-BA9803.80 | FIN | 3.40 | 1.20 | 151.35 | 53.25 | 5.10 |
| 40176 | PI598429 | ABY-BA8602.00 | FIN | 4.03 | 1.30 | 153.28 | 45.95 | 4.10 |
| 40177 | PI598430 | ABY-BA8603.00 | FIN | 4.01 | 1.20 | 153.74 | 40.62 | 5.00 |
| 40178 | PI598431 | ABY-BA8604.00 | FIN | 3.28 | 1.40 | 153.54 | 40.45 | 3.33 |
| 40179 | PI598432 | ABY-BA8614.68 | FIN | 4.10 | 2.30 | 158.34 | 39.79 | 3.33 |
| 40180 | PI598433 | ABY-BA8616.00 | FIN | 2.71 | 2.60 | 156.60 | 35.25 | 3.72 |
| 40181 | PI598434 | ABY-BA8621.82 | FIN | 3.91 | 1.40 | 154.27 | 49.32 | 4.13 |
| 40182 | PI598440 | ABY-BA9091.72 | FIN | 4.31 | 1.00 | 152.57 | 50.85 | 4.66 |
| 40183 | PI598441 | ABY-BA9092.72 | FIN | 4.31 | 1.20 | 148.36 | 43.95 | 4.33 |
| 40184 | PI598442 | ABY-BA9094.72 | FIN | 4.70 | 1.30 | 158.45 | 48.40 | 4.60 |
| 40185 | PI598443 | ABY-BA9097.84 | FIN | 4.31 | 1.30 | 151.54 | 61.65 | 4.40 |
| 40186 | PI598453 | ABY-BA9080.A81 | FIN | 4.20 | 1.90 | 155.11 | 49.90 | 3.65 |
| 40187 | PI598454 | ABY-BA9983.81 | FIN | 3.78 | 1.70 | 154.14 | 49.01 | 2.85 |
| 40188 | PI598414 | 342 | FIN | 2.80 | 1.10 | 155.30 | 38.40 | 1.44 |
| 40189 | PI598515 | 346 | FIN | 2.40 | 1.10 | 157.17 | 36.86 | . |
| 40190 | PI598516 | 363 | FIN | 2.04 | 1.00 | . | . | 1.68 |
| 40191 | PI598519 | 513 | FIN | 3.67 | 1.00 | 152.64 | 43.75 | 3.04 |
| 40192 | PI610802 | ABY-BA10111.82 | FIN | 4.18 | 2.40 | 151.67 | 51.65 | 5.46 |
| 40193 | PI610803 | ABY-BA10109.82 | FIN | 4.30 | 3.60 | 150.95 | 50.25 | 2.60 |
| 40194 | PI610825 | ABY-BA9108.79 | FIN | 3.50 | 1.60 | 159.20 | 38.63 | 3.95 |
| 40195 | PI619003 | ABY-BA10106.82 | FIN | 3.80 | 1.70 | 152.10 | 54.30 | 3.80 |
| 40196 | PI632510 | Karcagi | FIN | 4.50 | 1.50 | 153.10 | 58.70 | 3.20 |
| 40197 | PI632542 | Georgikon | FIN | 4.15 | 1.00 | 152.87 | 58.65 | 4.13 |
| 40198 | W6_9290 | ABY-BA9088.82 | FIN | 4.00 | 1.10 | 154.54 | 50.86 | 4.80 |
| 40199 | W6_9297 | ABY-BA9101.72 | FIN | 4.44 | 1.80 | 151.64 | 52.32 | 3.60 |
| 40200 | W6_11256 | 481 | FIN | 3.77 | 1.40 | 151.60 | 52.79 | 4.40 |
| 40201 | W6_11264 | 512 | FIN | 3.78 | 1.10 | 152.16 | 51.45 | 2.52 |
| 40202 | W6_11322 | 693 | FIN | 3.37 | 1.10 | 155.84 | 48.87 | 2.33 |
| 40203 | NGB1632 | AMADO | FIN | 3.80 | 1.10 | 154.54 | 52.45 | 4.84 |
| 40204 | NGB1633 | BELIDA | FIN | 3.48 | 1.10 | 150.80 | 52.99 | 4.93 |
| 40205 | NGB15401 | CHANTAL | FIN | 4.13 | 1.50 | 157.20 | 51.10 | 4.75 |
| 40206 | NGB4117 | DASAS_TRIFOLIUM | FIN | 3.51 | 1.20 | 156.27 | 58.45 | 4.40 |
| 40207 | NGB1637 | PATORA | FIN | 4.06 | 1.30 | 159.69 | 45.45 | 4.66 |
| 40208 | NGB1638 | PIPPIN_(Lawn) | FIN | 4.00 | 1.70 | 162.36 | 42.24 | 4.80 |
| 40209 | NGB8378 | PRESTO_PAJBJERG | FIN | 2.84 | 1.10 | 152.82 | 50.75 | 3.46 |
| 40210 | NGB15403 | RALLY | FIN | 4.44 | 1.90 | 158.47 | 46.05 | 4.40 |
| 40211 | NGB1641 | SILDIG_HUNSBALLE | FIN | 4.04 | 1.30 | 153.80 | 60.79 | 4.13 |
| 40212 | NGB1642 | TACA_TRIFOLIUM | FIN | 4.70 | 1.10 | 154.45 | 62.05 | 5.20 |
| 40213 | NGB13328 | TAYA | FIN | 3.75 | 1.40 | 157.68 | 42.74 | 3.45 |
| 40214 | NGB1643 | TONGA | FIN | 2.71 | 1.50 | 152.91 | 51.13 | 3.42 |
| 40215 | NGB4092 | TRANI | FIN | 3.13 | 1.10 | 164.26 | 40.78 | 4.57 |
| 40216 | NGB1646 | URI | FIN | 4.84 | 1.70 | 154.80 | 56.65 | 4.66 |
| 40217 | NGB1647 | VERNA_PAJBERG | FIN | 4.84 | 1.50 | 152.14 | 57.12 | 4.13 |
| 40218 | NGB11675 | SILDIG_DAENO_III | FIN | 4.44 | 1.10 | 155.74 | 58.79 | 4.93 |
| 40219 | NGB13338 | ALLEGRO | FIN | 3.37 | 1.90 | 159.10 | 41.87 | 3.46 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MWinter_s_13 | MWinter_s_14 | MHeading_13 | MHeight_13 | MRegrowth_13 |
|---|---|---|---|---|---|---|---|---|
| 40220 | NGB2602 | VALINGE | FIN | 4.30 | 2.80 | 154.90 | 52.50 | 4.60 |
| 40221 | NGB8417 | RIIKKA | FIN | 4.84 | 2.10 | 155.20 | 55.05 | 3.86 |
| 40222 | NGB4259 | FURENESET | FIN | 2.97 | 2.30 | 156.05 | 50.57 | 5.20 |
| 40223 | NGB4261 | WIR20258 | FIN | 4.20 | 1.90 | 152.54 | 62.51 | 5.37 |
| 40224 | NGB4260 | WIR40697 | FIN | 4.57 | 1.20 | 154.94 | 59.95 | 5.13 |
| 40225 | NGB16173 | Fia | FIN | 4.70 | 2.00 | 153.40 | 55.78 | 5.25 |
| 40226 | NGB2209 | FURE | FIN | 3.64 | 2.00 | 154.26 | 54.75 | 4.12 |
| 40227 | NGB4262 | 16-57-1 | FIN | 4.60 | 1.30 | 155.49 | 54.89 | 4.55 |
| 40228 | NGB4263 | 16-57-2 | FIN | 4.45 | 1.80 | 158.86 | 48.96 | 5.00 |
| 40229 | NGB4264 | 16-59-2 | FIN | 3.91 | 2.40 | 155.94 | 54.12 | 5.20 |
| 40230 | NGB4267 | 16-62-3 | FIN | 3.51 | 2.30 | 153.05 | 49.87 | 4.26 |
| 40231 | NGB4268 | 16-62-4 | FIN | 4.18 | 2.00 | 156.11 | 56.13 | 5.30 |
| 40232 | NGB4265 | ASKELAND_16-60-1 | FIN | 4.04 | 1.70 | 156.54 | 56.12 | 4.40 |
| 40233 | NGB4266 | VOLL_16-62-2 | FIN | 3.91 | 1.30 | 152.27 | 55.79 | 3.86 |
| 40234 | NGB2594 | E12 | FIN | 3.37 | 1.40 | 159.04 | 51.99 | 4.60 |
| 40235 | NGB11673 | SVENSK_01408_NO. | FIN | 4.00 | 1.20 | 153.40 | 57.70 | 4.80 |
| 40236 | NGB13887 | SW_E39 | FIN | 4.17 | 1.80 | 154.57 | 62.19 | 4.66 |
| 40237 | NGB13888 | SW_E50 | FIN | 4.20 | 1.20 | 155.17 | 57.46 | 4.68 |
| 40238 | NGB7508 | APUS | FIN | 3.46 | 1.60 | 156.03 | 49.48 | 3.72 |
| 40239 | NGB2731 | DELTA | FIN | 3.46 | 1.00 | 152.06 | 54.25 | 3.72 |
| 40240 | NGB2732 | GUNNE | FIN | 4.46 | 1.10 | 154.76 | 57.05 | 4.92 |
| 40241 | NGB13322 | HELMER | FIN | 3.46 | 1.50 | 155.58 | 53.63 | 6.12 |
| 40242 | NGB13331 | PAVO | FIN | 3.91 | 2.10 | 160.09 | 42.75 | 4.40 |
| 40243 | NGB13330 | RONJA | FIN | 3.33 | 1.10 | 159.53 | 40.85 | 2.50 |
| 40244 | NGB14164 | RONJA | FIN | 3.37 | 1.60 | 159.11 | 41.08 | 1.72 |
| 40245 | NGB2444 | SERVO | FIN | 3.77 | 2.10 | 156.66 | 61.70 | 4.33 |
| 40246 | NGB2730 | SVEA | FIN | 5.00 | 1.50 | 153.57 | 51.26 | 4.68 |
| 40247 | NGB14538 | TERRY | FIN | 5.10 | 1.90 | 154.91 | 60.63 | 5.85 |
| 40248 | NGB6269 | VIKTORIA | FIN | 3.70 | 1.20 | 151.89 | 67.45 | 4.15 |
| 40249 | NGB2360 | VIRIS | FIN | 3.64 | 1.60 | 154.82 | 55.30 | 4.33 |
| 40250 | NGB2729 | VIVA | FIN | 4.17 | 1.30 | 154.80 | 53.99 | 4.93 |
| 40251 | NGB2590 | VALINGE | FIN | 4.97 | 2.20 | 156.94 | 58.79 | 5.20 |
| 40252 | NGB4090 | VALINGE | FIN | 4.61 | 2.30 | 156.06 | 57.95 | 4.60 |
| 40254 | NGB4339 | BENESTAD_UE1504 | FIN | 4.17 | 2.30 | 153.67 | 48.19 | 3.60 |
| 40255 | NGB4344 | BJÖRKERÖD_PW2702 | FIN | 4.24 | 1.60 | 153.07 | 54.34 | 5.20 |
| 40256 | NGB4341 | FJÄLKINGE_SB2501 | FIN | 3.77 | 1.50 | 153.80 | 47.39 | 4.40 |
| 40257 | NGB1533 | GOTHEM_TL0305 | FIN | 4.46 | 2.60 | 155.36 | 51.35 | 4.52 |
| 40258 | NGB4342 | HAGESTAD_PW1301 | FIN | 4.04 | 1.60 | 154.40 | 49.82 | 4.00 |
| 40259 | NGB4345 | HÄLJARÖD_JK3103 | FIN | 3.60 | 2.50 | 159.18 | 48.53 | 4.66 |
| 40260 | NGB1523 | HÖRSNE_TL0102 | FIN | 3.73 | 2.40 | 153.87 | 54.45 | 4.93 |
| 40261 | NGB1568 | TOFTA_TL0102 | FIN | 4.23 | 2.80 | 156.08 | 43.66 | 4.60 |
| 40262 | Falk | Falk | FIN | 2.60 | 1.00 | . | . | . |
| 40263 | Fagerlin | Fagerlin | FIN | 4.06 | 1.70 | 154.31 | 62.10 | 4.82 |
| 40264 | Ivar | Ivar | FIN | 4.71 | 2.50 | 155.14 | 55.77 | 5.53 |
| 40265 | Figgjo | Figgjo | FIN | 5.50 | 1.90 | 154.20 | 65.00 | 6.40 |
| 40266 | Trygve | Trygve | FIN | 6.04 | 2.50 | 155.07 | 55.19 | 4.66 |
| 40267 | Fia | Fia | FIN | 4.90 | 2.30 | 153.01 | 59.26 | 5.20 |
| 40268 | Einar | Einar | FIN | 4.26 | 2.60 | 155.21 | 52.85 | 4.02 |
| 40269 | Fjaler | Fjaler | FIN | 4.31 | 2.30 | 154.07 | 54.92 | 3.86 |
| 40270 | Ivana | Ivana | FIN | 3.48 | 2.30 | 148.02 | 54.75 | 5.06 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MWinter_s_13 | MWinter_s_14 | MHeading_13 | MHeight_13 | MRegrowth_13 |
|---|---|---|---|---|---|---|---|---|
| 40271 | Arvicola | Arvicola | FIN | 4.00 | 1.70 | 148.80 | 59.84 | 4.40 |
| 40272 | Pionero | Pionero | FIN | 3.60 | 1.40 | 154.88 | 48.44 | 3.60 |
| 40273 | Navarra | Navarra | FIN | 4.70 | 1.30 | 153.60 | 51.60 | 4.20 |
| 40274 | Arvella | Arvella | FIN | 3.70 | 1.10 | 150.25 | 49.35 | 5.00 |
| 40275 | Cavia | Cavia | FIN | 3.64 | 1.20 | 151.77 | 52.94 | 5.26 |
| 40276 | Premium | Premium | FIN | 4.31 | 1.50 | 155.67 | 56.52 | 5.20 |
| 40277 | Abermagic | Abermagic | FIN | 4.70 | 1.00 | 154.85 | 58.10 | 5.00 |
| 40278 | Dunluce | Dunluce | FIN | 5.00 | 1.90 | 155.48 | 56.38 | 5.11 |
| 40279 | Dumdrum | Dumdrum | FIN | 4.93 | 1.70 | 157.55 | 53.40 | 5.00 |
| 40280 | Aberbite | Aberbite | FIN | 3.50 | 1.40 | 157.08 | 49.46 | 4.50 |
| 40281 | Aston_princess | Aston_princess | FIN | 4.31 | 1.50 | 160.94 | 41.39 | 5.20 |
| 40282 | Burlina1 | Burlina1 | FIN | 4.13 | 1.60 | 158.50 | 48.53 | 4.70 |
| 40283 | Barmaxima | Barmaxima | FIN | 5.11 | 1.80 | 160.55 | 50.82 | 5.73 |
| 40284 | Calvano1 | Calvano1 | FIN | 3.80 | 1.40 | 158.73 | 54.06 | 3.91 |
| 40285 | Arsenal | Arsenal | FIN | 3.90 | 1.80 | 156.14 | 51.48 | 4.10 |
| 40286 | Maurizio | Maurizio | FIN | 2.84 | 1.50 | 157.40 | 48.75 | 4.26 |
| 40287 | Toronto | Toronto | FIN | 3.33 | 1.10 | 155.14 | 52.09 | 3.91 |
| 40288 | Bronsyn | Bronsyn | FIN | 1.50 | 1.00 | . | . | . |
| 40289 | Impresario | Impresario | FIN | 3.28 | 1.00 | 152.99 | 56.24 | 4.06 |
| 40290 | Salamandra | Salamandra | FIN | 4.30 | 1.00 | 150.04 | 54.80 | 4.40 |
| 40291 | Hurricane | Hurricane | FIN | 4.30 | 1.40 | 157.18 | 53.09 | 4.95 |
| 40292 | Novello | Novello | FIN | 4.50 | 1.30 | 158.50 | 52.56 | 4.85 |
| 40294 | Barnhem | Barnhem | FIN | 3.70 | 2.40 | 158.00 | 51.85 | 5.40 |
| 40295 | Ideal | Ideal | FIN | 4.25 | 1.80 | 158.94 | 44.34 | 5.60 |
| 40296 | Portstewart | Portstewart | FIN | 3.20 | 1.20 | 159.90 | 46.64 | 4.60 |
| 40297 | Portrush | Portrush | FIN | 4.00 | 1.00 | 158.28 | 46.20 | 5.37 |
| 40298 | Roy | Roy | FIN | 4.97 | 1.30 | 155.94 | 53.65 | 5.20 |
| 40300 | Hamlet | Hamlet | FIN | 3.80 | 1.60 | 156.20 | 47.68 | 5.00 |
| 40301 | Keystone2 | Keystone2 | FIN | 3.15 | 1.00 | 152.54 | 42.60 | 3.55 |
| 40302 | Greenway | Greenway | FIN | 3.00 | 1.30 | 155.87 | 43.25 | 2.93 |
| 40303 | Eurodiamond | Eurodiamond | FIN | 4.57 | 1.90 | 162.40 | 41.85 | 4.13 |
| 40304 | Bargold | Bargold | FIN | 3.06 | 1.30 | 156.46 | 44.65 | 4.12 |
| 40305 | Esquire | Esquire | FIN | 4.13 | 1.00 | 153.11 | 46.98 | 4.35 |
| 40306 | Ligala | Ligala | FIN | 4.31 | 1.50 | 160.20 | 34.59 | 4.40 |
| 40307 | Aberimp | Aberimp | FIN | 3.51 | 1.10 | 160.07 | 39.39 | 3.60 |
| 40308 | Derby_Xtreme | Escapade | FIN | 3.11 | 1.00 | 152.14 | 40.99 | 2.00 |
| 40309 | Primary | Primary | FIN | 2.66 | 1.30 | 152.86 | 50.58 | 3.12 |
| 40310 | Regal_5 | Regal_5 | FIN | 2.84 | 1.20 | 150.87 | 41.09 | 1.82 |
| 40311 | Tetragreen | Tetragreen | FIN | 4.20 | 1.70 | 155.04 | 45.89 | 4.05 |
| 40312 | Double | Double | FIN | 4.04 | 1.10 | 153.53 | 48.96 | 2.42 |
| 40313 | Ba11434 | Ba11434 | FIN | 5.23 | 2.20 | 156.60 | 53.61 | 4.20 |
| 40314 | Ba11445 | Ba11445 | FIN | 4.20 | 2.40 | 156.60 | 53.12 | 4.05 |
| 40315 | Ba11448 | Ba11448 | FIN | 5.10 | 1.40 | 158.93 | 43.76 | 4.40 |
| 40316 | Ba11461 | Ba11461 | FIN | 4.57 | 1.80 | 154.89 | 50.80 | 4.33 |
| 40317 | Ba11451 | Ba11451 | FIN | 4.70 | 2.20 | 157.30 | 50.80 | 5.00 |
| 40318 | Ba12220 | ABY-Ba12220 | FIN | 4.40 | 1.70 | 158.80 | 54.05 | 5.60 |
| 40319 | Ba12947 | Ba12947 | FIN | 4.80 | 1.10 | 153.15 | 57.00 | 3.80 |
| 40320 | Ba12948 | Ba12948 | FIN | 4.70 | 1.70 | 153.20 | 59.15 | 4.20 |
| 40321 | Ba12949 | Ba12949 | FIN | 3.70 | 1.30 | 153.50 | 54.35 | 3.60 |
| 40322 | Ba12950 | Ba12950 | FIN | 3.90 | 1.60 | 152.75 | 48.80 | 3.40 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MWinter_s_13 | MWinter_s_14 | MHeading_13 | MHeight_13 | MRegrowth_13 |
|---|---|---|---|---|---|---|---|---|
| 40323 | Ba12951 | Ba12951 | FIN | 4.84 | 1.10 | 151.54 | 57.32 | 3.33 |
| 40324 | Ba12952 | Ba12952 | FIN | 4.50 | 2.20 | 153.40 | 52.00 | 3.40 |
| 40325 | Ba12953 | Ba12953 | FIN | 3.70 | 1.40 | 153.13 | 52.15 | 3.35 |
| 40326 | Ba12954 | Ba12954 | FIN | 4.10 | 1.00 | 153.64 | 51.10 | 3.85 |
| 40327 | Ba12955 | Ba12955 | FIN | 3.70 | 1.90 | 155.44 | 49.19 | 2.90 |
| 40328 | Ba12956 | Ba12956 | FIN | 4.40 | 1.80 | 151.80 | 53.00 | 3.95 |
| 40329 | Ba12957 | Ba12957 | FIN | 4.70 | 1.60 | 151.88 | 56.26 | 4.15 |
| 40330 | Ba12958 | Ba12958 | FIN | 4.70 | 1.70 | 152.95 | 50.50 | 3.20 |
| 40333 | Ba12967 | Ba12967 | FIN | 1.64 | 1.00 | 152.98 | 45.50 | 2.42 |
| 40336 | Ba12970 | Ba12970 | FIN | 2.66 | 1.00 | 150.36 | 52.25 | 1.92 |
| 40337 | Ba12971 | Ba12971 | FIN | 2.44 | 1.00 | 156.22 | 38.99 | 2.46 |
| 40339 | Ba12973 | Ba12973 | FIN | 4.57 | 1.10 | 153.77 | 50.00 | 4.93 |
| 40340 | Ba12974 | Ba12974 | FIN | 2.31 | 1.00 | 152.69 | 54.05 | 7.35 |
| 40342 | Ba12976 | Ba12976 | FIN | 4.20 | 1.10 | 153.03 | 52.40 | 4.20 |
| 40343 | Ba12977 | Ba12977 | FIN | 3.98 | 1.00 | 157.84 | 45.30 | 4.10 |
| 40344 | Ba12978 | Ba12978 | FIN | 4.10 | 1.70 | 155.09 | 49.32 | 4.68 |
| 40345 | Ba12979 | Ba12979 | FIN | 4.30 | 1.20 | 159.43 | 42.69 | 4.15 |
| 40346 | Ba12980 | Ba12980 | FIN | 2.44 | 1.00 | 154.22 | 39.60 | 3.86 |
| 40347 | Ba12981 | Ba12981 | FIN | 2.70 | 1.00 | 152.00 | 45.71 | 3.70 |
| 40349 | Ba12983 | Ba12983 | FIN | 2.84 | 1.00 | 162.34 | 35.24 | 4.36 |
| 40351 | Ba12985 | Ba12985 | FIN | 1.37 | 1.00 | . | . | . |
| 40354 | Ba12988 | Ba12988 | FIN | 2.97 | 1.60 | 155.29 | 47.20 | 3.93 |
| 40355 | Ba12989 | Ba12989 | FIN | 4.30 | 1.20 | 154.65 | 53.90 | 4.80 |
| 40356 | Ba9819 | ABY-Ba9819 | FIN | 4.00 | 1.20 | 154.80 | 48.45 | 4.40 |
| 40357 | Ba9832 | ABY-Ba9832 | FIN | 2.26 | 1.50 | 155.52 | 45.27 | 3.73 |
| 40358 | Ba12275 | Ba12275 | FIN | 4.40 | 1.90 | 156.10 | 48.51 | 4.40 |
| 40359 | Ba12276 | Ba12276 | FIN | 4.65 | 1.10 | 155.08 | 53.41 | 4.60 |
| 40360 | Ba12277 | Ba12277 | FIN | 3.50 | 1.70 | 154.99 | 44.53 | 4.60 |
| 40361 | Ba12278 | Ba12278 | FIN | 4.04 | 1.50 | 156.57 | 53.07 | 4.66 |
| 40366 | Ba13004 | Ba13004 | FIN | 4.44 | 1.60 | 162.45 | 36.64 | 3.13 |
| 40368 | Ba13006 | Ba13006 | FIN | 4.40 | 1.70 | 162.55 | 42.80 | 4.60 |
| 40374 | POL133323 | POL133323 | FIN | 4.97 | 1.40 | 156.40 | 55.92 | 4.40 |
| 40375 | POL133324 | POL133324 | FIN | 4.65 | 2.00 | 157.46 | 49.31 | 4.80 |
| 40376 | POL133325 | POL133325 | FIN | 3.80 | 1.90 | 155.08 | 53.85 | 3.77 |
| 40377 | POL133326 | POL133326 | FIN | 5.20 | 1.60 | 154.25 | 55.30 | 4.20 |
| 40378 | POL133327 | POL133327 | FIN | 4.44 | 1.80 | 153.67 | 56.05 | 4.40 |
| 40379 | POL133328 | POL133328 | FIN | 4.40 | 2.40 | 153.60 | 56.00 | 4.20 |
| 40380 | POL133398 | POL133398 | FIN | 4.10 | 2.40 | 155.34 | 56.31 | 3.95 |
| 40381 | POL133399 | POL133399 | FIN | 4.71 | 1.50 | 154.27 | 56.95 | 4.13 |
| 40382 | POL133400 | POL133400 | FIN | 4.90 | 1.70 | 155.15 | 57.95 | 4.40 |
| 40383 | POL133401 | POL133401 | FIN | 4.26 | 1.40 | 160.30 | 53.32 | 5.28 |
| 40384 | POL155145 | POL155145 | FIN | 5.18 | 2.50 | 159.94 | 47.23 | 3.25 |
| 40386 | POL155147 | POL155147 | FIN | 4.30 | 1.80 | 161.75 | 42.20 | 4.75 |
| 40387 | POL155148 | POL155148 | FIN | 3.90 | 2.10 | 163.00 | 39.80 | 4.15 |
| 40390 | POL155152 | POL155152 | FIN | 4.84 | 1.60 | 157.34 | 49.92 | 4.13 |
| 40391 | POL155153 | POL155153 | FIN | 3.77 | 1.70 | 161.12 | 45.95 | 4.66 |
| 40392 | POL155154 | POL155154 | FIN | 4.78 | 2.50 | 159.84 | 45.28 | 3.85 |
| 40393 | POL155155 | POL155155 | FIN | 4.57 | 1.20 | 161.81 | 42.89 | 4.13 |
| 40394 | POL155158 | POL155158 | FIN | 4.18 | 1.50 | 153.75 | 58.11 | 4.30 |
| 40395 | POL155159 | POL155159 | FIN | 4.44 | 1.50 | 152.97 | 67.25 | 4.06 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MWinter_s_13 | MWinter_s_14 | MHeading_13 | MHeight_13 | MRegrowth_13 |
|---|---|---|---|---|---|---|---|---|
| 40397 | POL155165 | ANNA | FIN | 2.71 | 1.00 | 151.54 | 51.24 | 5.16 |
| 40398 | POL155176 | INKA | FIN | 3.24 | 1.40 | 157.47 | 43.12 | 3.86 |
| 40399 | POL155192 | NIRA | FIN | 5.20 | 1.70 | 155.44 | 44.85 | 5.02 |
| 40401 | POL155194 | ARKA | FIN | 3.51 | 1.30 | 158.12 | 47.95 | 4.40 |
| 40402 | POL155218 | WENTO_(SZD291) | FIN | 4.71 | 1.40 | 154.67 | 62.32 | 5.73 |
| 40403 | POL155219 | SOLEN | FIN | 3.00 | 1.30 | 157.17 | 54.06 | 1.48 |
| 40404 | POL155230 | NIGA | FIN | 4.57 | 1.90 | 157.20 | 48.85 | 4.93 |
| 40405 | POL155238 | MAJA | FIN | 3.64 | 1.40 | 155.25 | 55.40 | 4.40 |

# Appendix 4

**Table 3 Least square means (LS means) for the location in Norway**

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MW.S._14 | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 |
|---|---|---|---|---|---|---|---|---|---|
| 40001 | DE7063 | JO_0110 | NOR | 6.75 | 4.60 | 165.55 | 95.30 | 6.45 | 4.80 |
| 40003 | DE161 | BANAT | NOR | 2.65 | 4.64 | 160.74 | 88.50 | 5.10 | 6.00 |
| 40004 | DE22479 | SIVERSKIJ_809 | NOR | 5.50 | 3.50 | 168.30 | 100.50 | 5.90 | 6.20 |
| 40005 | DE22481 | VEJA | NOR | 4.90 | 4.95 | 164.00 | 101.50 | 5.85 | 6.00 |
| 40006 | DE4571 | PASAVY | NOR | 4.54 | 4.55 | 165.64 | 86.33 | 5.60 | 6.75 |
| 40007 | DE4569 | MARKINSKIJ_24 | NOR | 2.13 | 3.92 | 162.17 | 87.76 | 5.03 | . |
| 40008 | DE4570 | MOSKOVSKIJ_84 | NOR | 5.91 | 3.57 | 168.24 | 94.91 | 5.68 | . |
| 40009 | DE4572 | PRIEKULSKIJ_59 | NOR | 4.10 | 4.30 | 164.75 | 88.50 | 5.65 | 7.40 |
| 40010 | DE4573 | LENINGRADSKIJ_809 | NOR | 4.86 | 3.40 | 163.89 | 100.90 | 4.90 | 6.80 |
| 40011 | DE28848 | DE28848 | NOR | 5.28 | 5.29 | 163.66 | 93.60 | 6.15 | 6.80 |
| 40012 | DE28856 | DE28856 | NOR | 4.71 | 3.19 | 168.23 | 80.60 | 5.66 | 5.40 |
| 40013 | DE58136 | DE58136 | NOR | 3.50 | 4.70 | 160.30 | 83.60 | 5.25 | 5.80 |
| 40014 | DE59284 | DE59284 | NOR | 4.40 | 4.30 | 164.05 | 90.40 | 5.50 | 3.40 |
| 40015 | DE50653 | DE50653 | NOR | 5.90 | 3.90 | 166.15 | 91.40 | 5.65 | 5.40 |
| 40016 | DE54461 | DE54461 | NOR | 4.40 | 3.65 | 163.80 | 91.60 | 5.35 | 5.20 |
| 40017 | DE33943 | DE33943 | NOR | 5.45 | 4.55 | 166.70 | 93.10 | 6.20 | 5.60 |
| 40018 | DE28851 | DE28851 | NOR | 3.18 | 4.41 | 165.52 | 95.84 | 5.72 | 6.20 |
| 40019 | DE50654 | DE50654 | NOR | 4.70 | 4.35 | 166.05 | 94.90 | 5.65 | 5.20 |
| 40020 | DE54456 | DE54456 | NOR | 4.45 | 3.80 | 165.24 | 90.80 | 5.20 | 7.00 |
| 40021 | DE27965 | DE27965 | NOR | 5.55 | 2.70 | 169.80 | 102.00 | 5.55 | 5.40 |
| 40022 | DE51990 | DE51990 | NOR | 5.30 | 4.70 | 162.80 | 93.30 | 6.20 | 5.80 |
| 40023 | DE50667 | DE50667 | NOR | 5.30 | 4.40 | 165.26 | 79.50 | 5.80 | 7.40 |
| 40024 | DE51971 | DE51971 | NOR | 5.45 | 3.31 | 170.15 | 85.70 | 5.28 | 7.75 |
| 40025 | DE59277 | DE59277 | NOR | 5.85 | 4.65 | 168.20 | 94.20 | 5.40 | 5.80 |
| 40026 | DE33932 | DE33932 | NOR | 3.90 | 4.65 | 160.45 | 92.90 | 5.80 | 8.00 |
| 40027 | DE50668 | DE50668 | NOR | 3.20 | 5.05 | 162.49 | 98.38 | 5.35 | 8.40 |
| 40028 | DE51987 | DE51987 | NOR | 4.70 | 3.60 | 169.35 | 84.20 | 5.35 | 6.00 |
| 40029 | DE28846 | DE28846 | NOR | 4.00 | 4.55 | 163.30 | 93.30 | 5.90 | 6.20 |
| 40030 | DE28849 | DE28849 | NOR | 4.85 | 4.40 | 162.85 | 94.40 | 5.55 | 6.80 |
| 40031 | DE28845 | DE28845 | NOR | 4.35 | 4.34 | 166.99 | 94.10 | 5.50 | 7.40 |
| 40032 | DE33913 | DE33913 | NOR | 3.35 | 4.64 | 159.70 | 85.40 | 5.70 | 6.80 |
| 40033 | DE62309 | DE62309 | NOR | 2.10 | 4.15 | 164.14 | 85.56 | 4.95 | 5.20 |
| 40034 | DE62310 | DE62310 | NOR | 4.90 | 4.40 | 163.20 | 83.10 | 5.60 | 7.40 |
| 40035 | DE62308 | DE62308 | NOR | 3.60 | 4.85 | 165.17 | 89.80 | 5.50 | 7.60 |
| 40036 | DE62315 | DE62315 | NOR | 3.43 | 4.37 | 165.94 | 88.16 | 5.34 | . |
| 40037 | DE62300 | DE62300 | NOR | 3.72 | 5.28 | 162.35 | 84.38 | 5.21 | 5.40 |
| 40038 | DE62301 | DE62301 | NOR | 3.20 | 4.50 | 164.59 | 88.10 | 5.35 | 6.40 |
| 40039 | DE62313 | DE62313 | NOR | 2.85 | 4.35 | 165.60 | 78.20 | 5.40 | 6.00 |
| 40040 | DE54063 | DE54063 | NOR | 5.45 | 4.90 | 163.75 | 102.00 | 5.60 | 7.40 |
| 40041 | DE54064 | DE54064 | NOR | 5.30 | 4.95 | 163.30 | 103.30 | 6.25 | 6.60 |
| 40042 | DE54065 | DE54065 | NOR | 4.20 | 5.05 | 164.50 | 107.40 | 5.45 | 5.80 |
| 40043 | DE54066 | DE54066 | NOR | 5.05 | 4.70 | 163.80 | 105.10 | 5.30 | 5.00 |
| 40044 | DE54084 | DE54084 | NOR | 5.05 | 5.00 | 165.40 | 100.30 | 5.75 | 5.80 |
| 40045 | DE54085 | DE54085 | NOR | 6.40 | 4.65 | 163.30 | 104.50 | 5.95 | 4.20 |
| 40046 | DE54088 | DE54088 | NOR | 5.10 | 5.35 | 162.90 | 109.80 | 6.50 | 5.80 |
| 40047 | DE54089 | DE54089 | NOR | 5.10 | 5.35 | 163.50 | 101.60 | 5.35 | 7.00 |
| 40048 | DE54090 | DE54090 | NOR | 5.45 | 5.20 | 163.45 | 94.60 | 6.10 | 5.80 |
| 40049 | DE54091 | DE54091 | NOR | 6.40 | 5.55 | 161.05 | 99.80 | 6.25 | 5.20 |
| 40050 | DE54092 | DE54092 | NOR | 5.10 | 5.15 | 163.65 | 94.60 | 6.15 | 6.80 |
| 40051 | DE54093 | DE54093 | NOR | 5.15 | 5.70 | 163.55 | 99.50 | 5.85 | 6.80 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MW.S._14 | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 |
|---|---|---|---|---|---|---|---|---|---|
| 40052 | DE62312 | DE62312 | NOR | 3.25 | 4.50 | 165.50 | 83.20 | 5.55 | 5.60 |
| 40053 | LIA368 | 1159 | NOR | 4.45 | 4.59 | 168.94 | 93.00 | 6.13 | 6.00 |
| 40054 | LIA852 | 1399 | NOR | 4.52 | 4.88 | 167.21 | 99.30 | 6.01 | 7.40 |
| 40055 | LIA849 | 1744 | NOR | 4.00 | 5.30 | 163.38 | 100.80 | 6.48 | 6.20 |
| 40056 | LIA1407 | 2198 | NOR | 3.90 | 5.03 | 165.31 | 97.68 | 6.48 | 8.00 |
| 40057 | LIA66 | 1159 | NOR | 3.32 | 4.71 | 167.73 | 99.64 | 5.97 | 5.60 |
| 40058 | LIA365 | 1248 | NOR | 2.98 | 4.38 | 167.33 | 98.44 | 5.87 | 7.40 |
| 40059 | LIA565 | 1249 | NOR | 4.16 | 5.11 | 167.10 | 98.30 | 6.85 | 7.40 |
| 40060 | LIA362 | 1253 | NOR | 4.12 | 5.61 | 166.48 | 102.38 | 6.61 | 7.20 |
| 40061 | LIA1058 | 1894 | NOR | 5.11 | 5.70 | 167.03 | 102.60 | 7.11 | 7.00 |
| 40062 | LIA1069 | 2299 | NOR | 4.10 | 5.63 | 167.73 | 94.20 | 6.49 | 8.00 |
| 40063 | LIA1056 | 2312 | NOR | 3.94 | 4.64 | 167.76 | 99.50 | 5.89 | 6.60 |
| 40064 | LIA1065 | 2745 | NOR | 4.25 | 4.98 | 162.68 | 100.63 | 6.34 | 5.00 |
| 40065 | LIA1072 | 2746 | NOR | 3.25 | 4.21 | 169.08 | 86.40 | 6.01 | 6.40 |
| 40066 | LIA1073 | 2747 | NOR | 3.80 | 5.19 | 168.06 | 93.73 | 5.95 | 7.00 |
| 40067 | LIA1066 | 2748 | NOR | 5.85 | 4.61 | 169.28 | 98.50 | 6.21 | 6.20 |
| 40068 | LIA1071 | 2749 | NOR | 5.40 | 5.70 | 166.01 | 100.38 | 6.65 | 8.20 |
| 40069 | LIA1067 | 2750 | NOR | 3.20 | 5.19 | 169.48 | 92.35 | 5.13 | 7.75 |
| 40070 | LIA1070 | 2751 | NOR | 4.58 | 5.05 | 161.41 | 93.95 | 6.84 | 6.20 |
| 40071 | LIA1414 | 2903 | NOR | 4.25 | 5.75 | 174.30 | 91.60 | 6.00 | 5.60 |
| 40072 | LIA1410 | 2904 | NOR | 6.05 | 6.63 | 165.66 | 102.50 | 7.03 | 7.80 |
| 40073 | LIA1419 | 2905 | NOR | 5.20 | 4.85 | 163.40 | 90.70 | 6.25 | 6.60 |
| 40074 | LIA1409 | 2906 | NOR | 3.30 | 4.06 | 166.92 | 105.64 | 6.81 | 6.80 |
| 40075 | LIA1417 | 2907 | NOR | 4.08 | 4.40 | 167.68 | 93.68 | 5.65 | 5.20 |
| 40076 | LIA1418 | 2908 | NOR | 4.38 | 4.66 | 168.04 | 98.70 | 6.78 | 6.80 |
| 40077 | LIA1415 | 2909 | NOR | 4.85 | 5.10 | 167.05 | 101.00 | 6.10 | 6.80 |
| 40078 | LIA1416 | 2910 | NOR | 4.70 | 5.16 | 163.20 | 96.20 | 5.50 | 7.75 |
| 40079 | LIA1411 | 2911 | NOR | 4.55 | 4.30 | 167.80 | 105.10 | 6.80 | 6.60 |
| 40080 | LIA65 | 537 | NOR | 4.12 | 4.21 | 168.01 | 93.80 | 5.81 | 5.40 |
| 40081 | LIA58 | Sodre | NOR | 4.00 | 4.90 | 164.60 | 108.80 | 6.65 | 7.00 |
| 40082 | LIA56 | veja | NOR | 5.00 | 5.18 | 163.43 | 103.50 | 6.15 | 6.60 |
| 40083 | LIA59 | Zvilge | NOR | 4.32 | 4.61 | 164.68 | 101.20 | 6.98 | 4.60 |
| 40084 | LVA00062 | Spidola | NOR | 4.24 | 4.93 | 169.98 | 103.40 | 5.66 | 9.00 |
| 40085 | LVA00068 | Priekulu_59 | NOR | 3.55 | 4.15 | 165.45 | 95.00 | 6.10 | 4.80 |
| 40086 | LVA02516 | 184/06 | NOR | 3.34 | 5.83 | 167.40 | 96.30 | 6.85 | 7.20 |
| 40087 | LVA02517 | 356/06 | NOR | 4.25 | 5.60 | 166.00 | 99.50 | 6.95 | 7.60 |
| 40088 | LVA02518 | 355/06 | NOR | 3.55 | 5.13 | 167.74 | 110.84 | 6.53 | 7.60 |
| 40089 | LVA02519 | 353/06 | NOR | 3.60 | 5.24 | 166.73 | 106.35 | 6.15 | 6.60 |
| 40090 | LVA02520 | 177/06 | NOR | 5.24 | 4.54 | 164.94 | 97.40 | 6.05 | 6.00 |
| 40091 | LVA02521 | 258/06 | NOR | 3.33 | 5.10 | 165.14 | 97.84 | 7.15 | 7.20 |
| 40092 | LVA02522 | 363/06 | NOR | 4.55 | 5.95 | 164.78 | 102.13 | 7.25 | 6.80 |
| 40093 | LVA02523 | 361/06 | NOR | 3.92 | 5.61 | 167.35 | 106.60 | 7.61 | 6.60 |
| 40094 | LVA02524 | 261/06 | NOR | 4.60 | 5.70 | 167.50 | 111.85 | 7.01 | 6.50 |
| 40095 | LVA02525 | 180/06 | NOR | 4.25 | 5.23 | 167.86 | 96.30 | 6.51 | 6.60 |
| 40096 | LVA02526 | 260/06 | NOR | 4.60 | 6.11 | 165.44 | 98.10 | 6.54 | 8.00 |
| 40097 | LVA02527 | 263/06 | NOR | 5.30 | 5.25 | 166.45 | 106.60 | 6.90 | 7.80 |
| 40098 | LVA02528 | 262/06 | NOR | 4.19 | 5.54 | 165.83 | 104.60 | 6.43 | 6.40 |
| 40099 | LVA02529 | 264/06 | NOR | 3.98 | 4.56 | 164.73 | 98.20 | 6.15 | 6.80 |
| 40100 | LVA02530 | 252/06 | NOR | 4.05 | 5.08 | 166.41 | 95.10 | 5.41 | 7.80 |
| 40102 | 14G2000587 | 14G2000587 | NOR | 5.23 | 4.11 | 167.40 | 93.85 | 5.50 | 4.75 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MW.S._14 | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 |
|---|---|---|---|---|---|---|---|---|---|
| 40103 | 14G2000586 | 14G2000586 | NOR | 4.90 | 4.25 | 167.50 | 82.10 | 5.80 | 5.80 |
| 40104 | 14G2000331 | 14G2000331 | NOR | 3.98 | 4.96 | 165.70 | 99.95 | 5.96 | 7.00 |
| 40105 | 14G2000332 | 14G2000332 | NOR | 4.21 | 4.61 | 162.89 | 94.00 | 5.69 | 6.00 |
| 40106 | 14G2000333 | 14G2000333 | NOR | 4.55 | 4.74 | 166.75 | 89.20 | 6.38 | 6.50 |
| 40107 | 14G2000504 | 14G2000504 | NOR | 4.80 | 3.50 | 168.03 | 91.80 | 6.36 | 4.80 |
| 40108 | 14G2000523 | 14G2000523 | NOR | 4.78 | 4.01 | 167.35 | 95.40 | 5.68 | 5.40 |
| 40109 | 14G2000503 | 14G2000503 | NOR | 5.12 | 4.08 | 168.81 | 90.40 | 5.94 | 6.00 |
| 40114 | 14G2000538 | Ilirka | NOR | 3.00 | 4.60 | 166.74 | 96.66 | 6.61 | . |
| 40115 | 14G2000008 | Arka | NOR | 2.30 | 4.83 | 171.14 | 88.56 | 5.87 | . |
| 40116 | 14G2000627 | Pastbiscnyj | NOR | 0.05 | . | . | . | . | . |
| 40121 | 14G2000535 | Marlot | NOR | 5.25 | 4.55 | 165.00 | 97.40 | 6.55 | 5.20 |
| 40122 | 14G2000588 | Guru | NOR | 3.06 | 4.58 | 157.18 | 77.36 | 5.28 | 6.75 |
| 40123 | EST49 | Raidi | NOR | 6.60 | 4.80 | 162.80 | 103.80 | 6.55 | 6.60 |
| 40124 | EST50 | Raite | NOR | 4.55 | 5.50 | 164.90 | 103.40 | 6.60 | 7.80 |
| 40125 | EST963 | Kihelkonna_RA02066 | NOR | 4.85 | 4.75 | 164.55 | 109.50 | 6.40 | 6.00 |
| 40126 | EST968 | Pürksi-Karja_RA02071 | NOR | 4.55 | 4.56 | 164.05 | 98.35 | 5.85 | 7.00 |
| 40127 | 45-4 | 45-4 | NOR | 6.96 | 4.51 | 165.35 | 110.90 | 6.93 | 5.60 |
| 40128 | 144-3 | 144-3 | NOR | 6.73 | 5.14 | 164.54 | 105.40 | 6.55 | 5.20 |
| 40129 | EST158 | EST158 | NOR | 5.46 | 5.40 | 165.38 | 97.41 | 6.19 | . |
| 40130 | EST279 | EST279 | NOR | 6.99 | 4.11 | 167.01 | 93.80 | 5.64 | 8.40 |
| 40131 | Vir20258 | Leningradskii_809 | NOR | 5.85 | 4.54 | 162.28 | 99.90 | 6.01 | 5.40 |
| 40132 | Vir37860 | Vir37860 | NOR | 2.83 | 4.52 | 163.49 | 95.16 | 5.01 | . |
| 40133 | Vir38563 | JO_231 | NOR | 6.98 | 4.48 | 166.50 | 97.20 | 6.15 | 6.75 |
| 40134 | Vir40298 | E_4_Kockoko | NOR | 4.71 | 4.04 | 161.61 | 94.44 | 6.31 | 3.80 |
| 40135 | Vir42146 | Baca | NOR | 5.44 | 4.18 | 164.77 | 108.80 | 6.23 | 4.80 |
| 40136 | Vir42502 | Yatsugane | NOR | 2.73 | 4.11 | 167.42 | 94.25 | 5.85 | 7.50 |
| 40137 | Vir42504 | M-1 | NOR | 3.19 | 3.85 | 168.15 | 91.40 | 5.89 | 6.00 |
| 40139 | Vir47191 | Prosperowo/BY | NOR | 7.10 | 4.31 | 165.58 | 97.80 | 6.48 | 5.40 |
| 40142 | Vir47226 | Vir47226 | NOR | 5.75 | 4.60 | 167.25 | 100.50 | 6.20 | 5.00 |
| 40144 | Vir40889 | Martlett | NOR | 1.41 | 4.57 | 162.76 | . | 4.77 | . |
| 40145 | Vir49962 | Vir49962 | NOR | 5.65 | 4.35 | 163.05 | 89.10 | 6.15 | 4.40 |
| 40146 | Vir50422 | Aria | NOR | 2.40 | 4.54 | 164.52 | 93.24 | 5.68 | 5.40 |
| 40148 | Vir50774 | Ruslana | NOR | 3.30 | 3.56 | 166.17 | 94.09 | 6.26 | 7.25 |
| 40149 | Vir50879 | Vir50879 | NOR | 4.08 | 4.88 | 167.83 | 97.08 | 6.54 | 6.00 |
| 40150 | Vir50929 | Raiti | NOR | 2.90 | 3.93 | 166.22 | 95.84 | 5.23 | 6.80 |
| 40151 | Vir51004 | Leningradskii | NOR | 5.45 | 5.05 | 161.75 | 98.70 | 5.80 | 5.80 |
| 40152 | Vir51253 | Vir51253 | NOR | 3.35 | 5.65 | 165.68 | 99.40 | 5.95 | 7.60 |
| 40153 | Vir36944 | Perma | NOR | 2.72 | 4.44 | 163.98 | 84.10 | 5.81 | 5.00 |
| 40154 | Vir49885 | Lorina | NOR | 2.90 | 4.54 | 167.87 | 96.64 | 5.58 | 4.80 |
| 40155 | Vir47200 | Vir47200 | NOR | 5.78 | 3.94 | 167.35 | 95.80 | 5.94 | 4.80 |
| 40157 | Vir51515 | BUK-66 | NOR | 4.55 | 4.45 | 165.15 | 103.20 | 6.05 | 7.80 |
| 40158 | Vir51516 | Duet | NOR | 5.25 | 4.30 | 165.10 | 104.90 | 6.75 | 6.60 |
| 40159 | Vir51517 | Vir51517 | NOR | 0.86 | . | . | . | . | . |
| 40160 | Vir51518 | Vir51518 | NOR | 3.08 | 5.50 | 167.69 | 92.40 | 5.80 | 6.60 |
| 40161 | Vir51519 | Vir51519 | NOR | 6.46 | 3.98 | 166.01 | 98.44 | 4.95 | 5.60 |
| 40162 | Vir51520 | Vir51520 | NOR | 6.71 | 4.74 | 165.76 | 99.90 | 6.04 | 4.80 |
| 40163 | PI197270 | PI197270 | NOR | 3.08 | 2.76 | 165.62 | 84.59 | 5.33 | . |
| 40164 | PI198070 | PI198070 | NOR | 3.13 | 5.34 | 163.01 | 93.91 | 6.12 | . |
| 40165 | PI204710 | PI204710 | NOR | 1.65 | 3.55 | 163.99 | . | 3.87 | 5.80 |
| 40166 | PI205278 | PI205278 | NOR | 1.73 | 4.47 | . | . | 3.18 | . |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MW.S._14 | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 |
|---|---|---|---|---|---|---|---|---|---|
| 40167 | PI272120 | PI272120 | NOR | 2.55 | 4.99 | 159.85 | . | 5.97 | . |
| 40168 | PI272121 | PI272121 | NOR | 5.30 | 5.01 | 166.50 | 104.00 | 6.26 | 6.80 |
| 40169 | PI274637 | PI274637 | NOR | 3.72 | 3.93 | 163.98 | 86.40 | 5.23 | 7.60 |
| 40170 | PI278773 | Norlea | NOR | 7.15 | 4.99 | 164.76 | 101.23 | 5.81 | 7.00 |
| 40171 | PI298091 | Karcagi | NOR | 4.10 | 4.50 | 163.14 | 90.16 | 5.74 | . |
| 40172 | PI298092 | Babolnai | NOR | 2.11 | . | . | . | . | . |
| 40173 | PI595043 | ABY-BA9792.81 | NOR | 1.70 | 4.55 | 162.09 | 85.91 | 5.18 | . |
| 40174 | PI595044 | ABY-BA9798.82 | NOR | 1.75 | 2.38 | 166.46 | . | 4.44 | . |
| 40175 | PI595047 | ABY-BA9803.80 | NOR | 1.95 | 4.28 | 159.99 | 82.34 | 3.81 | 6.75 |
| 40176 | PI598429 | ABY-BA8602.00 | NOR | 3.50 | 3.91 | 164.81 | 83.24 | 5.31 | 4.40 |
| 40177 | PI598430 | ABY-BA8603.00 | NOR | 2.33 | 3.56 | 167.87 | 89.44 | 4.88 | 6.60 |
| 40178 | PI598431 | ABY-BA8604.00 | NOR | 3.58 | 2.83 | 163.08 | 76.25 | 5.10 | 6.60 |
| 40179 | PI598432 | ABY-BA8614.68 | NOR | 5.35 | 4.40 | 164.65 | 75.40 | 5.65 | 7.40 |
| 40180 | PI598433 | ABY-BA8616.00 | NOR | 4.12 | 3.28 | 163.93 | 71.64 | 4.46 | 8.60 |
| 40181 | PI598434 | ABY-BA8621.82 | NOR | 3.90 | 3.09 | 164.80 | 86.30 | 4.61 | 6.80 |
| 40182 | PI598440 | ABY-BA9091.72 | NOR | 3.62 | 4.48 | 163.01 | 83.68 | 5.40 | 5.75 |
| 40183 | PI598441 | ABY-BA9092.72 | NOR | 3.45 | 4.85 | 156.14 | 83.18 | 5.55 | 6.40 |
| 40184 | PI598442 | ABY-BA9094.72 | NOR | 4.38 | 3.45 | 168.21 | 104.30 | 6.28 | 5.60 |
| 40185 | PI598443 | ABY-BA9097.84 | NOR | 2.95 | 5.31 | 160.54 | 98.64 | 5.57 | 7.40 |
| 40186 | PI598453 | ABY-BA9080.A81 | NOR | 6.13 | 4.48 | 163.94 | 105.10 | 5.61 | 6.20 |
| 40187 | PI598454 | ABY-BA9983.81 | NOR | 4.59 | 3.89 | 164.40 | 97.35 | 4.94 | 6.00 |
| 40188 | PI598414 | 342 | NOR | 0.49 | . | . | . | . | . |
| 40189 | PI598515 | 346 | NOR | 1.26 | 3.55 | . | . | 3.32 | 6.00 |
| 40190 | PI598516 | 363 | NOR | 0.75 | 1.82 | . | . | 3.72 | . |
| 40191 | PI598519 | 513 | NOR | 1.90 | 3.24 | 165.63 | 78.84 | 3.61 | 5.25 |
| 40192 | PI610802 | ABY-BA10111.82 | NOR | 5.00 | 4.30 | 158.23 | 84.30 | 5.60 | 5.40 |
| 40193 | PI610803 | ABY-BA10109.82 | NOR | 5.72 | 3.41 | 158.91 | 84.25 | 5.71 | 5.25 |
| 40194 | PI610825 | ABY-BA9108.79 | NOR | 4.23 | 3.75 | 167.51 | 83.05 | 5.86 | 6.40 |
| 40195 | PI619003 | ABY-BA10106.82 | NOR | 4.32 | 4.41 | 158.76 | 91.40 | 5.41 | 5.60 |
| 40196 | PI632510 | Karcagi | NOR | 4.56 | 4.85 | 161.90 | 101.85 | 5.80 | 7.00 |
| 40197 | PI632542 | Georgikon | NOR | 4.30 | 3.70 | 162.35 | 97.00 | 5.85 | 7.20 |
| 40198 | W6_9290 | ABY-BA9088.82 | NOR | 2.33 | 4.33 | 165.76 | 86.38 | 5.08 | 5.40 |
| 40199 | W6_9297 | ABY-BA9101.72 | NOR | 3.65 | 5.40 | 159.90 | 79.55 | 5.25 | 4.20 |
| 40200 | W6_11256 | 481 | NOR | 2.66 | 3.51 | 161.74 | 87.91 | 4.64 | 6.00 |
| 40201 | W6_11264 | 512 | NOR | 1.76 | 3.16 | 161.49 | 75.91 | 4.22 | . |
| 40202 | W6_11322 | 693 | NOR | 1.18 | . | . | . | . | . |
| 40203 | NGB1632 | AMADO | NOR | 3.45 | 4.21 | 163.75 | 97.48 | 4.88 | 5.60 |
| 40204 | NGB1633 | BELIDA | NOR | 2.45 | 5.41 | 160.26 | . | 4.73 | 6.40 |
| 40205 | NGB15401 | CHANTAL | NOR | 1.78 | 4.63 | 170.61 | 90.24 | 5.71 | 7.20 |
| 40206 | NGB4117 | DASAS_TRIFOLIUM | NOR | 2.32 | 3.63 | 168.56 | 98.88 | 5.29 | 5.50 |
| 40207 | NGB1637 | PATORA | NOR | 3.92 | 5.01 | 170.40 | 99.15 | 5.48 | 7.60 |
| 40208 | NGB1638 | PIPPIN_(Lawn) | NOR | 2.72 | 4.28 | 173.75 | 91.90 | 6.48 | 5.00 |
| 40209 | NGB8378 | PRESTO_PAJBJERG | NOR | 2.32 | 4.44 | 160.68 | 93.75 | 4.84 | 7.25 |
| 40210 | NGB15403 | RALLY | NOR | 2.90 | 4.73 | 168.33 | 98.09 | 5.87 | 6.75 |
| 40211 | NGB1641 | SILDIG_HUNSBALLE | NOR | 2.80 | 3.99 | 167.55 | 93.43 | 5.55 | 6.80 |
| 40212 | NGB1642 | TACA_TRIFOLIUM | NOR | 4.10 | 4.70 | 164.40 | 90.93 | 5.95 | 6.20 |
| 40213 | NGB13328 | TAYA | NOR | 5.40 | 4.35 | 165.86 | 92.48 | 5.40 | 5.80 |
| 40214 | NGB1643 | TONGA | NOR | 3.60 | 4.93 | 161.03 | 92.15 | 5.89 | 6.00 |
| 40215 | NGB4092 | TRANI | NOR | 2.38 | 4.48 | 172.18 | 97.40 | 6.81 | 5.40 |
| 40216 | NGB1646 | URI | NOR | 4.39 | 3.03 | 166.34 | 102.09 | 5.11 | 7.75 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MW.S._14 | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 |
|---|---|---|---|---|---|---|---|---|---|
| 40217 | NGB1647 | VERNA_PAJBERG | NOR | 4.00 | 4.70 | 162.05 | 91.40 | 5.35 | 7.20 |
| 40218 | NGB11675 | SILDIG_DAENO_III | NOR | 3.40 | 4.55 | 166.85 | 96.30 | 5.75 | 5.80 |
| 40219 | NGB13338 | ALLEGRO | NOR | 4.65 | 4.54 | 166.63 | 89.50 | 5.14 | 5.50 |
| 40220 | NGB2602 | VALINGE | NOR | 6.60 | 4.75 | 165.70 | 104.60 | 6.40 | 5.00 |
| 40221 | NGB8417 | RIIKKA | NOR | 7.12 | 4.14 | 167.81 | 108.30 | 6.68 | 4.80 |
| 40222 | NGB4259 | FURENESET | NOR | 3.46 | 3.95 | 163.03 | 91.84 | 6.18 | 6.75 |
| 40223 | NGB4261 | WIR20258 | NOR | 6.20 | 4.70 | 161.60 | 97.50 | 6.35 | 5.20 |
| 40224 | NGB4260 | WIR40697 | NOR | 3.85 | 5.41 | 164.88 | 102.50 | 7.14 | 6.80 |
| 40225 | NGB16173 | Fia | NOR | 4.36 | 4.63 | 164.28 | 94.76 | 6.41 | . |
| 40226 | NGB2209 | FURE | NOR | 6.19 | 4.99 | 164.36 | 104.03 | 6.33 | 8.75 |
| 40227 | NGB4262 | 16-57-1 | NOR | 4.70 | 3.76 | 165.95 | 94.20 | 5.74 | 6.40 |
| 40228 | NGB4263 | 16-57-2 | NOR | 4.20 | 4.95 | 169.25 | 88.20 | 6.80 | 5.40 |
| 40229 | NGB4264 | 16-59-2 | NOR | 6.68 | 3.30 | 165.95 | 102.40 | 6.39 | 4.40 |
| 40230 | NGB4267 | 16-62-3 | NOR | 5.83 | 4.96 | 162.30 | 92.10 | 6.36 | 8.00 |
| 40231 | NGB4268 | 16-62-4 | NOR | 6.39 | 3.91 | 166.26 | 96.40 | 5.95 | 6.75 |
| 40232 | NGB4265 | ASKELAND_16-60-1 | NOR | 4.06 | 4.50 | 165.60 | 94.50 | 5.71 | 7.50 |
| 40233 | NGB4266 | VOLL_16-62-2 | NOR | 3.75 | 4.36 | 161.55 | 100.20 | 5.56 | 5.40 |
| 40234 | NGB2594 | E12 | NOR | 4.94 | 4.31 | 167.38 | 93.90 | 6.16 | 5.20 |
| 40235 | NGB11673 | SVENSK_01408_NO. | NOR | 4.55 | 4.35 | 164.70 | 90.10 | 6.60 | 5.20 |
| 40236 | NGB13887 | SW_E39 | NOR | 5.20 | 4.90 | 165.15 | 96.50 | 5.90 | 6.00 |
| 40237 | NGB13888 | SW_E50 | NOR | 3.80 | 5.05 | 165.10 | 97.70 | 5.90 | 7.00 |
| 40238 | NGB7508 | APUS | NOR | 6.07 | 5.09 | 164.81 | 109.60 | 5.74 | 6.20 |
| 40239 | NGB2731 | DELTA | NOR | 3.26 | 4.84 | 161.99 | 93.00 | 5.83 | 7.40 |
| 40240 | NGB2732 | GUNNE | NOR | 5.20 | 4.63 | 164.14 | 96.10 | 6.55 | 6.20 |
| 40241 | NGB13322 | HELMER | NOR | 3.65 | 5.08 | 165.88 | 102.40 | 6.88 | 8.40 |
| 40242 | NGB13331 | PAVO | NOR | 5.80 | 4.65 | 166.35 | 93.70 | 5.65 | 7.40 |
| 40243 | NGB13330 | RONJA | NOR | 3.80 | 4.50 | 167.90 | 85.50 | 5.10 | 4.60 |
| 40244 | NGB14164 | RONJA | NOR | 4.08 | 4.61 | 165.28 | 97.00 | 5.28 | 5.40 |
| 40245 | NGB2444 | SERVO | NOR | 7.77 | 5.21 | 165.43 | 100.28 | 6.16 | 7.25 |
| 40246 | NGB2730 | SVEA | NOR | 6.55 | 5.35 | 164.65 | 100.40 | 6.20 | 6.40 |
| 40247 | NGB14538 | TERRY | NOR | 4.61 | 5.03 | 165.68 | 104.30 | 6.69 | 7.60 |
| 40248 | NGB6269 | VIKTORIA | NOR | 4.96 | 4.75 | 162.13 | 93.40 | 6.58 | 5.80 |
| 40249 | NGB2360 | VIRIS | NOR | 4.34 | 3.59 | 164.91 | 101.60 | 6.46 | 6.60 |
| 40250 | NGB2729 | VIVA | NOR | 6.05 | 5.00 | 166.35 | 106.20 | 6.05 | 5.80 |
| 40251 | NGB2590 | VALINGE | NOR | 6.65 | 5.19 | 166.49 | 95.03 | 6.24 | 8.20 |
| 40252 | NGB4090 | VALINGE | NOR | 7.63 | 5.03 | 165.24 | 105.00 | 6.10 | 6.20 |
| 40254 | NGB4339 | BENESTAD_UE1504 | NOR | 4.66 | 4.04 | 162.41 | 94.60 | 6.06 | 5.60 |
| 40255 | NGB4344 | BJÖRKERÖD_PW2702 | NOR | 5.09 | 4.98 | 162.93 | 98.10 | 6.33 | 7.40 |
| 40256 | NGB4341 | FJÄLKINGE_SB2501 | NOR | 4.98 | 4.81 | 162.15 | 91.30 | 5.54 | 6.00 |
| 40257 | NGB1533 | GOTHEM_TL0305 | NOR | 5.90 | 5.15 | 165.25 | 95.10 | 5.85 | 7.40 |
| 40258 | NGB4342 | HAGESTAD_PW1301 | NOR | 4.99 | 4.20 | 164.81 | 92.20 | 5.50 | 8.20 |
| 40259 | NGB4345 | HÄLJARÖD_JK3103 | NOR | 6.60 | 3.90 | 167.60 | 89.50 | 5.65 | 8.00 |
| 40260 | NGB1523 | HÖRSNE_TL0102 | NOR | 5.86 | 4.43 | 163.35 | 93.60 | 5.90 | 6.20 |
| 40261 | NGB1568 | TOFTA_TL0102 | NOR | 5.00 | 4.64 | 166.70 | 88.60 | 5.44 | 7.60 |
| 40262 | Falk | Falk | NOR | 5.81 | 4.51 | 166.44 | 106.60 | 6.01 | 6.00 |
| 40263 | Fagerlin | Fagerlin | NOR | 6.58 | 4.91 | 163.88 | 99.18 | 6.48 | 8.00 |
| 40264 | Ivar | Ivar | NOR | 4.73 | 4.68 | 165.46 | 98.00 | 7.01 | 7.60 |
| 40265 | Figgjo | Figgjo | NOR | 3.08 | 5.33 | 164.71 | 109.05 | 6.56 | 6.80 |
| 40266 | Trygve | Trygve | NOR | 4.99 | 5.36 | 164.95 | 102.75 | 6.30 | 6.80 |
| 40267 | Fia | Fia | NOR | 4.48 | 4.70 | 163.27 | 96.44 | 6.38 | 8.20 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MW.S._14 | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 |
|---|---|---|---|---|---|---|---|---|---|
| 40268 | Einar | Einar | NOR | 6.30 | 4.20 | 164.78 | 99.96 | 6.24 | . |
| 40269 | Fjaler | Fjaler | NOR | 4.23 | 4.81 | 164.33 | 91.60 | 6.28 | 7.60 |
| 40270 | Ivana | Ivana | NOR | 2.90 | 6.51 | 157.00 | 78.58 | 5.46 | 4.75 |
| 40271 | Arvicola | Arvicola | NOR | 2.65 | 5.75 | 159.30 | 88.40 | 6.05 | 7.20 |
| 40272 | Pionero | Pionero | NOR | 3.94 | 5.29 | 163.36 | 92.53 | 6.08 | 6.40 |
| 40273 | Navarra | Navarra | NOR | 3.65 | 4.86 | 164.06 | 95.30 | 5.66 | 6.60 |
| 40274 | Arvella | Arvella | NOR | 2.00 | 4.69 | 159.38 | 83.38 | 5.19 | 7.25 |
| 40275 | Cavia | Cavia | NOR | 2.05 | 4.82 | 161.04 | 77.41 | 4.82 | . |
| 40276 | Premium | Premium | NOR | 3.00 | 5.41 | 165.56 | 102.20 | 6.14 | 5.25 |
| 40277 | Abermagic | Abermagic | NOR | 2.55 | 4.86 | 168.89 | 100.45 | 5.24 | 8.00 |
| 40278 | Dunluce | Dunluce | NOR | 3.80 | 4.74 | 166.23 | 100.40 | 5.98 | 6.60 |
| 40279 | Dumdrum | Dumdrum | NOR | 2.87 | 5.13 | 168.01 | 95.50 | 5.21 | 6.20 |
| 40280 | Aberbite | Aberbite | NOR | 1.99 | 4.21 | 170.09 | . | 6.36 | . |
| 40281 | Aston_princess | Aston_princess | NOR | 2.85 | 6.09 | 172.88 | 92.43 | 5.61 | 8.50 |
| 40282 | Burlina1 | Burlina1 | NOR | 3.25 | 5.10 | 168.54 | 98.30 | 5.60 | 6.80 |
| 40283 | Barmaxima | Barmaxima | NOR | 2.81 | 4.10 | 171.62 | 91.16 | 6.07 | . |
| 40284 | Calvano1 | Calvano1 | NOR | 2.12 | 4.68 | 169.35 | 99.30 | 5.01 | 7.60 |
| 40285 | Arsenal | Arsenal | NOR | 3.55 | 5.61 | 167.88 | 96.20 | 5.89 | 6.20 |
| 40286 | Maurizio | Maurizio | NOR | 2.55 | 4.23 | 168.05 | 100.15 | 5.41 | 7.80 |
| 40287 | Toronto | Toronto | NOR | 2.46 | 5.68 | 166.00 | 93.50 | 5.58 | 6.20 |
| 40288 | Bronsyn | Bronsyn | NOR | 0.29 | . | . | . | . | . |
| 40289 | Impresario | Impresario | NOR | 0.90 | 4.91 | . | . | 4.96 | . |
| 40290 | Salamandra | Salamandra | NOR | 2.30 | 5.44 | 164.27 | 91.04 | 5.45 | 6.80 |
| 40291 | Hurricane | Hurricane | NOR | 2.24 | 5.01 | 171.23 | 94.45 | 5.49 | 6.80 |
| 40292 | Novello | Novello | NOR | 3.10 | 4.90 | 169.35 | 92.80 | 5.85 | 5.80 |
| 40294 | Barnhem | Barnhem | NOR | 4.01 | 4.54 | 170.06 | 97.70 | 6.24 | 6.20 |
| 40295 | Ideal | Ideal | NOR | 2.45 | 4.86 | 173.13 | 87.63 | 5.60 | 7.00 |
| 40296 | Portstewart | Portstewart | NOR | 2.80 | 4.43 | 169.89 | 97.34 | 5.00 | 7.40 |
| 40297 | Portrush | Portrush | NOR | 2.46 | 4.88 | 170.60 | 92.90 | 5.78 | 6.00 |
| 40298 | Roy | Roy | NOR | 2.38 | 5.18 | 166.31 | 102.50 | 5.81 | 5.75 |
| 40300 | Hamlet | Hamlet | NOR | 4.05 | 4.85 | 166.56 | 76.60 | 5.10 | 5.00 |
| 40301 | Keystone2 | Keystone2 | NOR | 3.49 | 3.59 | 162.98 | 76.00 | 4.55 | 5.00 |
| 40302 | Greenway | Greenway | NOR | 4.30 | 4.33 | 164.08 | 88.16 | 5.14 | . |
| 40303 | Eurodiamond | Eurodiamond | NOR | 4.85 | 4.28 | 168.58 | 87.00 | 5.14 | 8.00 |
| 40304 | Bargold | Bargold | NOR | 5.10 | 3.00 | 167.13 | 94.20 | 5.63 | 7.20 |
| 40305 | Esquire | Esquire | NOR | 3.70 | 5.01 | 163.64 | 78.90 | 4.95 | 5.40 |
| 40306 | Ligala | Ligala | NOR | 4.80 | 4.80 | 169.55 | 86.30 | 5.85 | 7.60 |
| 40307 | Aberimp | Aberimp | NOR | 3.45 | 1.85 | 170.45 | 88.20 | 5.30 | 5.60 |
| 40308 | Derby_Xtreme | Escapade | NOR | 3.40 | 4.45 | 162.37 | 74.59 | 4.45 | 8.50 |
| 40309 | Primary | Primary | NOR | 3.39 | 4.34 | 160.28 | 87.10 | 4.91 | 6.00 |
| 40310 | Regal_5 | Regal_5 | NOR | 5.04 | 4.24 | 161.72 | 82.24 | 5.17 | 6.00 |
| 40311 | Tetragreen | Tetragreen | NOR | 4.49 | 5.75 | 162.96 | 68.59 | 5.20 | 9.00 |
| 40312 | Double | Double | NOR | 4.35 | 5.50 | 162.44 | 85.13 | 5.50 | 7.20 |
| 40313 | Ba11434 | Ba11434 | NOR | 7.10 | 4.50 | 166.60 | 100.80 | 6.40 | 5.40 |
| 40314 | Ba11445 | Ba11445 | NOR | 6.29 | 5.00 | 167.30 | 100.40 | 6.61 | 4.80 |
| 40315 | Ba11448 | Ba11448 | NOR | 5.31 | 4.35 | 169.00 | 90.70 | 5.21 | 4.80 |
| 40316 | Ba11461 | Ba11461 | NOR | 5.51 | 4.24 | 165.36 | 89.90 | 5.94 | 5.20 |
| 40317 | Ba11451 | Ba11451 | NOR | 6.36 | 5.16 | 164.88 | 101.70 | 6.18 | 5.40 |
| 40318 | Ba12220 | ABY-Ba12220 | NOR | 4.36 | 4.45 | 167.64 | 95.30 | 6.61 | 7.20 |
| 40319 | Ba12947 | Ba12947 | NOR | 3.98 | 5.21 | 163.88 | 99.70 | 5.68 | 5.40 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MW.S._14 | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 |
|---|---|---|---|---|---|---|---|---|---|
| 40320 | Ba12948 | Ba12948 | NOR | 4.66 | 4.63 | 162.60 | 96.40 | 6.50 | 4.80 |
| 40321 | Ba12949 | Ba12949 | NOR | 3.69 | 5.18 | 163.43 | 93.20 | 5.14 | 4.00 |
| 40322 | Ba12950 | Ba12950 | NOR | 2.49 | 4.87 | 163.69 | 95.16 | 5.25 | . |
| 40323 | Ba12951 | Ba12951 | NOR | 3.26 | 4.08 | 162.33 | 99.04 | 5.07 | 5.40 |
| 40324 | Ba12952 | Ba12952 | NOR | 5.13 | 4.98 | 162.40 | 100.80 | 5.53 | 5.60 |
| 40325 | Ba12953 | Ba12953 | NOR | 3.49 | 4.31 | 162.70 | 88.45 | 5.16 | 4.40 |
| 40326 | Ba12954 | Ba12954 | NOR | 4.18 | 4.54 | 165.77 | 91.84 | 5.28 | 6.00 |
| 40327 | Ba12955 | Ba12955 | NOR | 5.26 | 4.66 | 164.25 | 104.80 | 5.85 | 6.80 |
| 40328 | Ba12956 | Ba12956 | NOR | 4.50 | 4.40 | 162.10 | 89.50 | 5.65 | 7.20 |
| 40329 | Ba12957 | Ba12957 | NOR | 2.70 | 4.58 | 164.70 | 102.00 | 5.25 | 5.40 |
| 40330 | Ba12958 | Ba12958 | NOR | 4.00 | 4.30 | 163.15 | 85.30 | 5.75 | 4.60 |
| 40333 | Ba12967 | Ba12967 | NOR | 0.45 | 3.07 | . | . | 2.38 | . |
| 40336 | Ba12970 | Ba12970 | NOR | 2.29 | 4.86 | 159.50 | 91.40 | 4.29 | 8.00 |
| 40337 | Ba12971 | Ba12971 | NOR | 1.30 | 3.04 | 166.69 | . | 3.56 | 7.50 |
| 40339 | Ba12973 | Ba12973 | NOR | 2.71 | 4.50 | 167.45 | 85.13 | 5.44 | 5.40 |
| 40340 | Ba12974 | Ba12974 | NOR | 0.25 | . | . | . | . | . |
| 40342 | Ba12976 | Ba12976 | NOR | 3.70 | 4.53 | 163.43 | 84.40 | 5.58 | 5.60 |
| 40343 | Ba12977 | Ba12977 | NOR | 1.56 | 4.19 | 172.97 | 84.80 | 4.85 | 7.60 |
| 40344 | Ba12978 | Ba12978 | NOR | 4.05 | 3.68 | 167.68 | 87.60 | 5.28 | 5.00 |
| 40345 | Ba12979 | Ba12979 | NOR | 2.22 | 3.51 | 171.11 | 73.56 | 4.82 | . |
| 40346 | Ba12980 | Ba12980 | NOR | 1.14 | 2.91 | . | . | 2.96 | . |
| 40347 | Ba12981 | Ba12981 | NOR | 0.76 | . | . | . | . | . |
| 40349 | Ba12983 | Ba12983 | NOR | 1.46 | 2.89 | . | 81.84 | 5.08 | 7.75 |
| 40351 | Ba12985 | Ba12985 | NOR | 0.00 | . | . | . | . | . |
| 40354 | Ba12988 | Ba12988 | NOR | 2.25 | 3.03 | 168.58 | 87.58 | 4.46 | . |
| 40355 | Ba12989 | Ba12989 | NOR | 3.45 | 4.76 | 166.34 | 93.28 | 5.75 | 7.00 |
| 40356 | Ba9819 | ABY-Ba9819 | NOR | 1.85 | 3.11 | 166.07 | 89.09 | 4.81 | 5.60 |
| 40357 | Ba9832 | ABY-Ba9832 | NOR | 2.30 | 3.86 | 166.83 | 86.16 | 4.95 | 6.20 |
| 40358 | Ba12275 | Ba12275 | NOR | 4.25 | 4.71 | 166.07 | 97.04 | 5.77 | 5.00 |
| 40359 | Ba12276 | Ba12276 | NOR | 4.30 | 4.55 | 165.59 | 101.23 | 6.09 | 5.40 |
| 40360 | Ba12277 | Ba12277 | NOR | 5.30 | 4.85 | 163.60 | 89.20 | 5.95 | 7.60 |
| 40361 | Ba12278 | Ba12278 | NOR | 6.00 | 4.40 | 166.83 | 95.20 | 6.39 | 5.00 |
| 40366 | Ba13004 | Ba13004 | NOR | 5.65 | 4.08 | 168.61 | 100.10 | 5.54 | 6.20 |
| 40368 | Ba13006 | Ba13006 | NOR | 5.28 | 4.55 | 170.14 | 92.30 | 5.56 | 7.80 |
| 40374 | POL133323 | POL133323 | NOR | 5.55 | 3.81 | 168.48 | 103.30 | 5.90 | 6.40 |
| 40375 | POL133324 | POL133324 | NOR | 6.90 | 4.95 | 167.90 | 101.40 | 6.50 | 5.60 |
| 40376 | POL133325 | POL133325 | NOR | 6.25 | 4.55 | 165.05 | 98.90 | 6.35 | 5.40 |
| 40377 | POL133326 | POL133326 | NOR | 6.75 | 5.11 | 164.74 | 107.40 | 6.26 | 4.60 |
| 40378 | POL133327 | POL133327 | NOR | 4.65 | 5.38 | 164.26 | 88.85 | 6.11 | 7.20 |
| 40379 | POL133328 | POL133328 | NOR | 6.98 | 4.78 | 164.71 | 91.10 | 6.10 | 5.60 |
| 40380 | POL133398 | POL133398 | NOR | 5.90 | 4.50 | 165.20 | 94.90 | 6.40 | 5.60 |
| 40381 | POL133399 | POL133399 | NOR | 4.80 | 4.05 | 163.60 | 95.50 | 6.30 | 6.40 |
| 40382 | POL133400 | POL133400 | NOR | 6.38 | 4.18 | 166.58 | 115.90 | 6.25 | 4.40 |
| 40383 | POL133401 | POL133401 | NOR | 6.80 | 3.95 | 168.10 | 91.50 | 6.15 | 6.20 |
| 40384 | POL155145 | POL155145 | NOR | 5.80 | 3.75 | 168.04 | 105.59 | 6.08 | 5.25 |
| 40386 | POL155147 | POL155147 | NOR | 5.58 | 4.34 | 169.08 | 92.90 | 6.01 | 6.40 |
| 40387 | POL155148 | POL155148 | NOR | 6.05 | 4.40 | 172.55 | 91.10 | 5.75 | 7.40 |
| 40390 | POL155152 | POL155152 | NOR | 6.85 | 4.21 | 168.08 | 110.80 | 6.34 | 4.00 |
| 40391 | POL155153 | POL155153 | NOR | 5.34 | 4.56 | 168.95 | 88.90 | 6.30 | 6.60 |
| 40392 | POL155154 | POL155154 | NOR | 5.90 | 3.90 | 169.45 | 99.10 | 6.35 | 5.00 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MW.S._14 | MHeading_13 | MHeight_13 | MRegrowth_13 | MRust_13 |
|---|---|---|---|---|---|---|---|---|---|
| 40393 | POL155155 | POL155155 | NOR | 5.26 | 4.49 | 168.38 | 91.90 | 5.51 | 8.20 |
| 40394 | POL155158 | POL155158 | NOR | 4.28 | 5.01 | 164.56 | 102.63 | 5.91 | 4.75 |
| 40395 | POL155159 | POL155159 | NOR | 4.78 | 3.88 | 163.01 | 103.20 | 5.34 | 3.60 |
| 40397 | POL155165 | ANNA | NOR | 1.46 | 5.25 | 160.16 | . | 4.54 | . |
| 40398 | POL155176 | INKA | NOR | 5.09 | 4.28 | 165.90 | 85.10 | 5.30 | 5.20 |
| 40399 | POL155192 | NIRA | NOR | 5.42 | 4.64 | 166.55 | 82.25 | 4.98 | 7.75 |
| 40401 | POL155194 | ARKA | NOR | 2.64 | 5.04 | 170.51 | 88.50 | 5.54 | 6.40 |
| 40402 | POL155218 | WENTO_(SZD291) | NOR | 3.81 | 4.99 | 165.34 | 97.43 | 6.10 | 7.00 |
| 40403 | POL155219 | SOLEN | NOR | 3.78 | 4.28 | 166.15 | 92.40 | 6.01 | 6.00 |
| 40404 | POL155230 | NIGA | NOR | 4.60 | 4.99 | 166.68 | 93.55 | 5.48 | 5.75 |
| 40405 | POL155238 | MAJA | NOR | 4.05 | 5.00 | 167.20 | 90.40 | 5.30 | 8.00 |

# Appendix 4

**Table 4 Least square means (LS means) for the location in Sweden**

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MHeight_13 | MRegrowth_13 | MHeading_13 |
|---|---|---|---|---|---|---|---|
| 40001 | DE7063 | JO_0110 | SWE | 9.00 | 67.11 | 4.05 | 152.30 |
| 40003 | DE161 | BANAT | SWE | 7.50 | 60.04 | 3.70 | 141.18 |
| 40004 | DE22479 | SIVERSKIJ_809 | SWE | 9.00 | 63.73 | 4.95 | 154.81 |
| 40005 | DE22481 | VEJA | SWE | 8.65 | 66.43 | 3.91 | 147.94 |
| 40006 | DE4571 | PASAVY | SWE | 9.00 | 68.03 | 4.15 | 150.61 |
| 40007 | DE4569 | MARKINSKIJ_24 | SWE | 5.86 | 56.69 | 3.39 | 143.21 |
| 40008 | DE4570 | MOSKOVSKIJ_84 | SWE | 8.65 | 63.78 | 4.55 | 150.61 |
| 40009 | DE4572 | PRIEKULSKIJ_59 | SWE | 8.15 | 64.95 | 4.45 | 148.10 |
| 40010 | DE4573 | LENINGRADSKIJ_809 | SWE | 8.40 | 64.04 | 3.95 | 148.09 |
| 40011 | DE28848 | DE28848 | SWE | 8.85 | 63.14 | 4.70 | 147.89 |
| 40012 | DE28856 | DE28856 | SWE | 8.25 | 57.20 | 4.08 | 154.70 |
| 40013 | DE58136 | DE58136 | SWE | 8.90 | 68.65 | 5.51 | 142.80 |
| 40014 | DE59284 | DE59284 | SWE | 8.56 | 58.80 | 3.95 | 149.26 |
| 40015 | DE50653 | DE50653 | SWE | 9.00 | 59.90 | 3.86 | 150.50 |
| 40016 | DE54461 | DE54461 | SWE | 8.11 | 56.95 | 4.04 | 148.59 |
| 40017 | DE33943 | DE33943 | SWE | 9.00 | 61.25 | 4.55 | 151.45 |
| 40018 | DE28851 | DE28851 | SWE | 8.70 | 64.50 | 4.01 | 147.60 |
| 40019 | DE50654 | DE50654 | SWE | 8.75 | 60.29 | 4.16 | 150.64 |
| 40020 | DE54456 | DE54456 | SWE | 7.85 | 62.05 | 4.60 | 150.65 |
| 40021 | DE27965 | DE27965 | SWE | 9.00 | 59.33 | 4.48 | 155.96 |
| 40022 | DE51990 | DE51990 | SWE | 8.75 | 68.30 | 4.50 | 146.05 |
| 40023 | DE50667 | DE50667 | SWE | 8.40 | 61.26 | 3.95 | 150.75 |
| 40024 | DE51971 | DE51971 | SWE | 9.00 | 59.08 | 4.56 | 155.90 |
| 40025 | DE59277 | DE59277 | SWE | 9.00 | 67.00 | 4.70 | 152.60 |
| 40026 | DE33932 | DE33932 | SWE | 8.41 | 65.90 | 4.66 | 146.15 |
| 40027 | DE50668 | DE50668 | SWE | 8.56 | 72.95 | 4.46 | 147.31 |
| 40028 | DE51987 | DE51987 | SWE | 8.20 | 54.00 | 4.48 | 153.35 |
| 40029 | DE28846 | DE28846 | SWE | 8.25 | 62.10 | 4.64 | 145.85 |
| 40030 | DE28849 | DE28849 | SWE | 8.75 | 55.20 | 4.11 | 147.40 |
| 40031 | DE28845 | DE28845 | SWE | 8.40 | 71.91 | 4.65 | 153.30 |
| 40032 | DE33913 | DE33913 | SWE | 8.65 | 52.80 | 3.35 | 141.45 |
| 40033 | DE62309 | DE62309 | SWE | 8.75 | 57.46 | 4.95 | 143.76 |
| 40034 | DE62310 | DE62310 | SWE | 9.00 | 52.50 | 4.35 | 148.05 |
| 40035 | DE62308 | DE62308 | SWE | 8.15 | 57.60 | 3.70 | 146.50 |
| 40036 | DE62315 | DE62315 | SWE | 8.03 | 64.08 | 3.97 | 146.98 |
| 40037 | DE62300 | DE62300 | SWE | 8.55 | 52.51 | 4.02 | 148.35 |
| 40038 | DE62301 | DE62301 | SWE | 8.06 | 61.66 | 4.88 | 146.44 |
| 40039 | DE62313 | DE62313 | SWE | 8.55 | 61.45 | 4.80 | 149.30 |
| 40040 | DE54063 | DE54063 | SWE | 9.00 | 68.65 | 4.60 | 148.75 |
| 40041 | DE54064 | DE54064 | SWE | 9.00 | 73.45 | 4.85 | 150.30 |
| 40042 | DE54065 | DE54065 | SWE | 9.00 | 75.93 | 4.76 | 149.08 |
| 40043 | DE54066 | DE54066 | SWE | 9.00 | 71.80 | 4.80 | 149.55 |
| 40044 | DE54084 | DE54084 | SWE | 9.00 | 69.50 | 4.69 | 153.26 |
| 40045 | DE54085 | DE54085 | SWE | 9.00 | 63.01 | 4.59 | 151.26 |
| 40046 | DE54088 | DE54088 | SWE | 9.00 | 72.60 | 4.65 | 149.26 |
| 40047 | DE54089 | DE54089 | SWE | 9.00 | 72.80 | 4.50 | 149.75 |
| 40048 | DE54090 | DE54090 | SWE | 9.00 | 66.66 | 4.45 | 149.35 |
| 40049 | DE54091 | DE54091 | SWE | 9.00 | 69.40 | 4.64 | 146.35 |
| 40050 | DE54092 | DE54092 | SWE | 9.06 | 66.87 | 4.77 | 149.10 |
| 40051 | DE54093 | DE54093 | SWE | 9.00 | 76.75 | 5.20 | 149.90 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MHeight_13 | MRegrowth_13 | MHeading_13 |
|---|---|---|---|---|---|---|---|
| 40052 | DE62312 | DE62312 | SWE | 7.85 | 59.68 | 4.70 | 149.85 |
| 40053 | LIA368 | 1159 | SWE | 9.06 | 64.93 | 3.66 | 153.68 |
| 40054 | LIA852 | 1399 | SWE | 7.00 | 69.39 | 4.20 | 155.14 |
| 40055 | LIA849 | 1744 | SWE | 8.86 | 71.67 | 4.78 | 147.68 |
| 40056 | LIA1407 | 2198 | SWE | 9.00 | 68.68 | 4.46 | 151.74 |
| 40057 | LIA66 | 1159 | SWE | 7.09 | 63.54 | 4.25 | 150.61 |
| 40058 | LIA365 | 1248 | SWE | 9.00 | 73.21 | 4.92 | 152.54 |
| 40059 | LIA565 | 1249 | SWE | 6.75 | 76.36 | 4.29 | 153.31 |
| 40060 | LIA362 | 1253 | SWE | 8.45 | 71.56 | 4.28 | 153.23 |
| 40061 | LIA1058 | 1894 | SWE | 8.60 | 72.01 | 4.09 | 151.10 |
| 40062 | LIA1069 | 2299 | SWE | 8.70 | 76.15 | 4.90 | 152.20 |
| 40063 | LIA1056 | 2312 | SWE | 9.06 | 73.87 | 4.73 | 151.02 |
| 40064 | LIA1065 | 2745 | SWE | 8.72 | 71.10 | 4.10 | 148.92 |
| 40065 | LIA1072 | 2746 | SWE | 9.00 | 63.10 | 5.45 | 153.80 |
| 40066 | LIA1073 | 2747 | SWE | 9.00 | 67.08 | 4.65 | 152.99 |
| 40067 | LIA1066 | 2748 | SWE | 8.85 | 64.79 | 5.15 | 153.85 |
| 40068 | LIA1071 | 2749 | SWE | 9.00 | 73.55 | 4.89 | 151.24 |
| 40069 | LIA1067 | 2750 | SWE | 8.31 | 67.85 | 3.96 | 154.18 |
| 40070 | LIA1070 | 2751 | SWE | 8.25 | 73.33 | 3.34 | 147.45 |
| 40071 | LIA1414 | 2903 | SWE | 8.56 | 58.51 | 4.98 | 158.55 |
| 40072 | LIA1410 | 2904 | SWE | 8.46 | 77.13 | 4.45 | 152.15 |
| 40073 | LIA1419 | 2905 | SWE | 9.00 | 74.61 | 5.05 | 148.11 |
| 40074 | LIA1409 | 2906 | SWE | 7.25 | 70.09 | 4.33 | 153.55 |
| 40075 | LIA1417 | 2907 | SWE | 8.92 | 62.07 | 2.94 | 156.30 |
| 40076 | LIA1418 | 2908 | SWE | 8.75 | 64.53 | 5.15 | 157.68 |
| 40077 | LIA1415 | 2909 | SWE | 8.45 | 71.53 | 4.29 | 152.26 |
| 40078 | LIA1416 | 2910 | SWE | 8.32 | 71.80 | 4.78 | 147.35 |
| 40079 | LIA1411 | 2911 | SWE | 8.52 | 73.20 | 4.63 | 153.48 |
| 40080 | LIA65 | 537 | SWE | 8.59 | 71.47 | 4.18 | 154.02 |
| 40081 | LIA58 | Sodre | SWE | 8.52 | 70.13 | 4.02 | 148.02 |
| 40082 | LIA56 | veja | SWE | 9.00 | 71.90 | 4.19 | 148.35 |
| 40083 | LIA59 | Zvilge | SWE | 7.12 | 65.40 | 3.55 | 152.35 |
| 40084 | LVA00062 | Spidola | SWE | 8.40 | 62.51 | 4.28 | 154.35 |
| 40085 | LVA00068 | Priekulu_59 | SWE | 8.90 | 67.48 | 4.30 | 149.28 |
| 40086 | LVA02516 | 184/06 | SWE | 8.30 | 71.80 | 4.05 | 153.15 |
| 40087 | LVA02517 | 356/06 | SWE | 8.63 | 72.80 | 4.90 | 153.15 |
| 40088 | LVA02518 | 355/06 | SWE | 8.31 | 71.35 | 4.22 | 152.08 |
| 40089 | LVA02519 | 353/06 | SWE | 8.19 | 67.02 | 4.28 | 152.33 |
| 40090 | LVA02520 | 177/06 | SWE | 8.19 | 74.80 | 4.25 | 148.62 |
| 40091 | LVA02521 | 258/06 | SWE | 7.64 | 72.82 | 4.66 | 151.13 |
| 40092 | LVA02522 | 363/06 | SWE | 9.00 | 77.94 | 4.53 | 150.91 |
| 40093 | LVA02523 | 361/06 | SWE | 8.60 | 76.35 | 4.40 | 153.20 |
| 40094 | LVA02524 | 261/06 | SWE | 8.70 | 75.79 | 4.05 | 152.80 |
| 40095 | LVA02525 | 180/06 | SWE | 8.79 | 71.52 | 4.43 | 151.47 |
| 40096 | LVA02526 | 260/06 | SWE | 7.65 | 75.89 | 4.73 | 152.11 |
| 40097 | LVA02527 | 263/06 | SWE | 8.15 | 73.15 | 4.85 | 152.10 |
| 40098 | LVA02528 | 262/06 | SWE | 8.25 | 73.60 | 4.85 | 152.88 |
| 40099 | LVA02529 | 264/06 | SWE | 8.44 | 65.66 | 4.66 | 150.15 |
| 40100 | LVA02530 | 252/06 | SWE | 9.00 | 73.43 | 4.40 | 153.19 |
| 40102 | 14G2000587 | 14G2000587 | SWE | 7.40 | 53.51 | 4.11 | 151.68 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MHeight_13 | MRegrowth_13 | MHeading_13 |
|---|---|---|---|---|---|---|---|
| 40103 | 14G2000586 | 14G2000586 | SWE | 8.90 | 63.10 | 4.60 | 151.95 |
| 40106 | 14G2000333 | 14G2000333 | SWE | 8.35 | 68.79 | 4.90 | 153.05 |
| 40107 | 14G2000504 | 14G2000504 | SWE | 8.56 | 59.33 | 4.36 | 153.06 |
| 40109 | 14G2000503 | 14G2000503 | SWE | 9.06 | 60.05 | 4.15 | 154.60 |
| 40115 | 14G2000008 | Arka | SWE | 8.65 | 68.40 | 5.02 | 154.23 |
| 40116 | 14G2000627 | Pastbiscnyj | SWE | . | . | . | . |
| 40121 | 14G2000535 | Marlot | SWE | 9.06 | 68.67 | 4.45 | 150.42 |
| 40123 | EST49 | Raidi | SWE | 8.80 | 69.39 | 4.58 | 149.45 |
| 40124 | EST50 | Raite | SWE | 7.95 | 79.06 | 4.09 | 151.08 |
| 40125 | EST963 | Kihelkonna_RA02066 | SWE | 7.69 | 72.78 | 3.82 | 151.03 |
| 40126 | EST968 | Pürksi-Karja_RA02071 | SWE | 8.72 | 70.47 | 4.18 | 150.08 |
| 40127 | 45-4 | 45-4 | SWE | 8.69 | 74.29 | 4.00 | 150.23 |
| 40128 | 144-3 | 144-3 | SWE | 8.39 | 76.33 | 3.92 | 150.43 |
| 40129 | EST158 | EST158 | SWE | 8.85 | 69.21 | 3.85 | 151.48 |
| 40130 | EST279 | EST279 | SWE | 9.00 | 69.40 | 4.41 | 152.95 |
| 40131 | Vir20258 | Leningradskii_809 | SWE | 9.00 | 68.08 | 3.53 | 147.60 |
| 40132 | Vir37860 | Vir37860 | SWE | 8.81 | 66.88 | 4.46 | 148.92 |
| 40133 | Vir38563 | JO_231 | SWE | 9.06 | 65.00 | 3.72 | 153.30 |
| 40134 | Vir40298 | E_4_Kockoko | SWE | 8.65 | 66.55 | 3.55 | 148.72 |
| 40135 | Vir42146 | Baca | SWE | 7.11 | 72.07 | 4.08 | 151.02 |
| 40136 | Vir42502 | Yatsugane | SWE | 7.31 | 71.18 | 3.82 | 151.52 |
| 40137 | Vir42504 | M-1 | SWE | 6.66 | 66.27 | 3.43 | 153.77 |
| 40139 | Vir47191 | Prosperowo/BY | SWE | 8.80 | 68.05 | 3.35 | 154.15 |
| 40142 | Vir47226 | Vir47226 | SWE | 8.60 | 67.24 | 4.53 | 151.31 |
| 40144 | Vir40889 | Martlett | SWE | 3.85 | 54.85 | 3.90 | 146.46 |
| 40145 | Vir49962 | Vir49962 | SWE | 9.00 | 67.53 | 3.80 | 149.20 |
| 40146 | Vir50422 | Aria | SWE | 7.79 | 76.77 | 5.05 | 150.97 |
| 40148 | Vir50774 | Ruslana | SWE | 7.65 | 72.70 | 3.48 | 150.70 |
| 40149 | Vir50879 | Vir50879 | SWE | 7.76 | 73.69 | 4.36 | 153.68 |
| 40150 | Vir50929 | Raiti | SWE | 8.10 | 74.94 | 4.64 | 151.40 |
| 40151 | Vir51004 | Leningradskii | SWE | 9.00 | 70.14 | 3.21 | 144.38 |
| 40152 | Vir51253 | Vir51253 | SWE | 8.45 | 73.71 | 4.54 | 151.75 |
| 40153 | Vir36944 | Perma | SWE | 7.45 | 57.00 | 3.65 | 148.10 |
| 40154 | Vir49885 | Lorina | SWE | 7.75 | 62.08 | 3.76 | 151.74 |
| 40155 | Vir47200 | Vir47200 | SWE | 8.70 | 67.38 | 4.09 | 153.66 |
| 40157 | Vir51515 | BUK-66 | SWE | 8.45 | 72.96 | 4.80 | 151.45 |
| 40158 | Vir51516 | Duet | SWE | 8.65 | 75.06 | 4.20 | 151.30 |
| 40159 | Vir51517 | Vir51517 | SWE | 3.53 | 61.87 | 3.11 | 143.96 |
| 40160 | Vir51518 | Vir51518 | SWE | 7.55 | 73.18 | 4.83 | 152.03 |
| 40161 | Vir51519 | Vir51519 | SWE | 9.00 | 65.46 | 3.59 | 153.10 |
| 40162 | Vir51520 | Vir51520 | SWE | 8.80 | 74.35 | 5.25 | 152.91 |
| 40163 | PI197270 | PI197270 | SWE | 6.50 | 65.54 | 2.77 | 149.85 |
| 40164 | PI198070 | PI198070 | SWE | 6.36 | 60.80 | 4.15 | 145.07 |
| 40166 | PI205278 | PI205278 | SWE | 4.45 | 57.12 | 3.36 | 147.46 |
| 40167 | PI272120 | PI272120 | SWE | 7.90 | 65.87 | 4.26 | 141.71 |
| 40168 | PI272121 | PI272121 | SWE | 8.75 | 68.95 | 4.55 | 152.70 |
| 40169 | PI274637 | PI274637 | SWE | 8.29 | 64.48 | 4.31 | 148.88 |
| 40170 | PI278773 | Norlea | SWE | 8.80 | 75.80 | 3.80 | 150.07 |
| 40171 | PI298091 | Karcagi | SWE | 8.90 | 67.00 | 4.15 | 150.00 |
| 40172 | PI298092 | Babolnai | SWE | 7.99 | 62.55 | 5.78 | 147.32 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MHeight_13 | MRegrowth_13 | MHeading_13 |
|---|---|---|---|---|---|---|---|
| 40173 | PI595043 | ABY-BA9792.81 | SWE | 5.22 | 64.59 | 4.69 | 144.23 |
| 40174 | PI595044 | ABY-BA9798.82 | SWE | 6.92 | 52.92 | 3.74 | 149.13 |
| 40175 | PI595047 | ABY-BA9803.80 | SWE | 5.80 | 56.86 | 5.06 | 142.94 |
| 40176 | PI598429 | ABY-BA8602.00 | SWE | 8.75 | 58.14 | 2.66 | 148.74 |
| 40177 | PI598430 | ABY-BA8603.00 | SWE | 8.80 | 46.93 | 3.75 | 149.34 |
| 40178 | PI598431 | ABY-BA8604.00 | SWE | 7.95 | 52.25 | 3.58 | 147.53 |
| 40179 | PI598432 | ABY-BA8614.68 | SWE | 9.06 | 51.67 | 4.98 | 149.75 |
| 40180 | PI598433 | ABY-BA8616.00 | SWE | 8.92 | 44.88 | 3.00 | 148.94 |
| 40181 | PI598434 | ABY-BA8621.82 | SWE | 9.00 | 50.35 | 3.89 | 150.23 |
| 40182 | PI598440 | ABY-BA9091.72 | SWE | 8.20 | 53.89 | 4.39 | 147.61 |
| 40183 | PI598441 | ABY-BA9092.72 | SWE | 8.60 | 54.95 | 4.59 | 140.54 |
| 40184 | PI598442 | ABY-BA9094.72 | SWE | 7.30 | 64.28 | 4.28 | 154.26 |
| 40185 | PI598443 | ABY-BA9097.84 | SWE | 8.09 | 64.61 | 4.34 | 145.90 |
| 40186 | PI598453 | ABY-BA9080.A81 | SWE | 9.00 | 68.33 | 5.00 | 150.64 |
| 40187 | PI598454 | ABY-BA9983.81 | SWE | 8.70 | 62.23 | 4.32 | 149.44 |
| 40188 | PI598414 | 342 | SWE | 4.72 | 51.00 | 3.44 | 147.98 |
| 40189 | PI598515 | 346 | SWE | 4.53 | 48.12 | . | 148.71 |
| 40190 | PI598516 | 363 | SWE | 6.63 | 48.50 | 1.93 | 147.54 |
| 40191 | PI598519 | 513 | SWE | 4.85 | 52.80 | 2.54 | 145.28 |
| 40192 | PI610802 | ABY-BA10111.82 | SWE | 8.30 | 58.00 | 2.75 | 142.31 |
| 40193 | PI610803 | ABY-BA10109.82 | SWE | 9.00 | 58.86 | 2.74 | 141.99 |
| 40194 | PI610825 | ABY-BA9108.79 | SWE | 8.45 | 55.36 | 3.15 | 152.50 |
| 40195 | PI619003 | ABY-BA10106.82 | SWE | 8.65 | 62.70 | 4.05 | 143.45 |
| 40196 | PI632510 | Karcagi | SWE | 9.06 | 75.53 | 3.78 | 148.22 |
| 40197 | PI632542 | Georgikon | SWE | 7.75 | 69.56 | 3.90 | 148.61 |
| 40198 | W6_9290 | ABY-BA9088.82 | SWE | 6.64 | 57.18 | 4.70 | 149.43 |
| 40199 | W6_9297 | ABY-BA9101.72 | SWE | 9.00 | 57.48 | 3.55 | 144.00 |
| 40200 | W6_11256 | 481 | SWE | 8.30 | 55.73 | 3.45 | 142.60 |
| 40201 | W6_11264 | 512 | SWE | 6.18 | 49.90 | 3.17 | 145.64 |
| 40202 | W6_11322 | 693 | SWE | 5.52 | 55.17 | 3.86 | 151.16 |
| 40203 | NGB1632 | AMADO | SWE | 7.84 | 67.63 | 4.33 | 148.60 |
| 40204 | NGB1633 | BELIDA | SWE | 6.00 | 62.05 | 3.80 | 144.24 |
| 40205 | NGB15401 | CHANTAL | SWE | 8.55 | 72.75 | 4.65 | 151.15 |
| 40206 | NGB4117 | DASAS_TRIFOLIUM | SWE | 7.31 | 72.62 | 4.38 | 150.23 |
| 40207 | NGB1637 | PATORA | SWE | 8.40 | 73.05 | 4.55 | 154.90 |
| 40208 | NGB1638 | PIPPIN_(Lawn) | SWE | 9.00 | 68.16 | 5.01 | 157.16 |
| 40209 | NGB8378 | PRESTO_PAJBJERG | SWE | 5.44 | 58.76 | 4.32 | 143.05 |
| 40210 | NGB15403 | RALLY | SWE | 6.83 | 69.15 | 4.57 | 155.27 |
| 40211 | NGB1641 | SILDIG_HUNSBALLE | SWE | 7.45 | 73.55 | 4.78 | 149.99 |
| 40212 | NGB1642 | TACA_TRIFOLIUM | SWE | 8.52 | 75.13 | 5.32 | 148.75 |
| 40213 | NGB13328 | TAYA | SWE | 9.06 | 56.90 | 4.61 | 152.65 |
| 40214 | NGB1643 | TONGA | SWE | 7.45 | 60.01 | 3.87 | 146.63 |
| 40215 | NGB4092 | TRANI | SWE | 7.70 | 60.40 | 4.90 | 160.04 |
| 40216 | NGB1646 | URI | SWE | 8.15 | 68.51 | 4.27 | 151.79 |
| 40217 | NGB1647 | VERNA_PAJBERG | SWE | 8.09 | 65.48 | 4.31 | 144.43 |
| 40218 | NGB11675 | SILDIG_DAENO_III | SWE | 7.00 | 72.55 | 4.49 | 151.40 |
| 40219 | NGB13338 | ALLEGRO | SWE | 8.90 | 63.85 | 4.60 | 153.00 |
| 40220 | NGB2602 | VALINGE | SWE | 9.00 | 71.30 | 3.61 | 151.81 |
| 40221 | NGB8417 | RIIKKA | SWE | 9.00 | 72.20 | 3.68 | 151.82 |
| 40222 | NGB4259 | FURENESET | SWE | 7.94 | 54.41 | 2.05 | 150.37 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MHeight_13 | MRegrowth_13 | MHeading_13 |
|---|---|---|---|---|---|---|---|
| 40223 | NGB4261 | WIR20258 | SWE | 8.28 | 67.18 | 2.97 | 145.93 |
| 40224 | NGB4260 | WIR40697 | SWE | 6.94 | 67.65 | 4.80 | 151.76 |
| 40225 | NGB16173 | Fia | SWE | 8.10 | 72.48 | 3.35 | 145.21 |
| 40226 | NGB2209 | FURE | SWE | 9.00 | 69.68 | 4.78 | 147.90 |
| 40227 | NGB4262 | 16-57-1 | SWE | 8.40 | 67.30 | 4.30 | 152.22 |
| 40228 | NGB4263 | 16-57-2 | SWE | 8.55 | 52.57 | 4.76 | 155.87 |
| 40229 | NGB4264 | 16-59-2 | SWE | 8.35 | 62.89 | 3.05 | 149.41 |
| 40230 | NGB4267 | 16-62-3 | SWE | 9.00 | 62.25 | 3.56 | 148.39 |
| 40231 | NGB4268 | 16-62-4 | SWE | 9.00 | 66.31 | 3.19 | 151.36 |
| 40232 | NGB4265 | ASKELAND_16-60-1 | SWE | 8.85 | 75.05 | 4.50 | 150.30 |
| 40233 | NGB4266 | VOLL_16-62-2 | SWE | 8.25 | 67.09 | 4.10 | 145.89 |
| 40234 | NGB2594 | E12 | SWE | 7.31 | 70.88 | 4.17 | 154.66 |
| 40235 | NGB11673 | SVENSK_01408_NO. | SWE | 8.55 | 68.11 | 4.89 | 149.39 |
| 40236 | NGB13887 | SW_E39 | SWE | 8.60 | 68.10 | 4.20 | 150.45 |
| 40237 | NGB13888 | SW_E50 | SWE | 7.71 | 80.81 | 4.53 | 149.22 |
| 40238 | NGB7508 | APUS | SWE | 8.50 | 61.50 | 4.50 | 152.61 |
| 40239 | NGB2731 | DELTA | SWE | 6.65 | 63.84 | 4.35 | 144.43 |
| 40240 | NGB2732 | GUNNE | SWE | 9.00 | 67.60 | 5.59 | 146.33 |
| 40241 | NGB13322 | HELMER | SWE | 7.55 | 70.68 | 4.28 | 150.29 |
| 40242 | NGB13331 | PAVO | SWE | 9.00 | 56.75 | 4.75 | 152.35 |
| 40243 | NGB13330 | RONJA | SWE | 9.00 | 57.40 | 4.66 | 152.58 |
| 40244 | NGB14164 | RONJA | SWE | 9.00 | 63.76 | 4.38 | 152.48 |
| 40245 | NGB2444 | SERVO | SWE | 9.06 | 71.67 | 3.77 | 152.00 |
| 40246 | NGB2730 | SVEA | SWE | 9.00 | 70.20 | 4.45 | 146.90 |
| 40247 | NGB14538 | TERRY | SWE | 8.70 | 75.10 | 4.75 | 149.95 |
| 40248 | NGB6269 | VIKTORIA | SWE | 8.80 | 65.94 | 3.73 | 146.08 |
| 40249 | NGB2360 | VIRIS | SWE | 8.80 | 70.76 | 4.48 | 149.01 |
| 40250 | NGB2729 | VIVA | SWE | 8.70 | 75.20 | 4.91 | 151.24 |
| 40251 | NGB2590 | VALINGE | SWE | 8.70 | 66.38 | 3.30 | 153.18 |
| 40252 | NGB4090 | VALINGE | SWE | 8.40 | 68.35 | 3.62 | 153.41 |
| 40254 | NGB4339 | BENESTAD_UE1504 | SWE | 9.00 | 61.70 | 4.20 | 146.45 |
| 40255 | NGB4344 | BJÖRKERÖD_PW2702 | SWE | 9.00 | 65.69 | 4.96 | 146.64 |
| 40256 | NGB4341 | FJÄLKINGE_SB2501 | SWE | 8.11 | 61.35 | 4.13 | 145.86 |
| 40257 | NGB1533 | GOTHEM_TL0305 | SWE | 8.94 | 66.10 | 3.04 | 150.50 |
| 40258 | NGB4342 | HAGESTAD_PW1301 | SWE | 9.00 | 66.70 | 4.90 | 150.33 |
| 40259 | NGB4345 | HÄLJARÖD_JK3103 | SWE | 9.00 | 58.90 | 4.14 | 153.40 |
| 40260 | NGB1523 | HÖRSNE_TL0102 | SWE | 9.00 | 60.64 | 4.66 | 148.06 |
| 40261 | NGB1568 | TOFTA_TL0102 | SWE | 9.00 | 60.60 | 4.10 | 150.65 |
| 40262 | Falk | Falk | SWE | 8.12 | 76.97 | 4.07 | 152.55 |
| 40263 | Fagerlin | Fagerlin | SWE | 8.81 | 71.46 | 2.63 | 149.85 |
| 40264 | Ivar | Ivar | SWE | 7.60 | 64.98 | 3.45 | 151.75 |
| 40265 | Figgjo | Figgjo | SWE | 7.28 | 75.86 | 4.26 | 149.09 |
| 40266 | Trygve | Trygve | SWE | 8.15 | 65.35 | 3.60 | 152.00 |
| 40267 | Fia | Fia | SWE | 7.70 | 64.21 | 3.26 | 147.86 |
| 40268 | Einar | Einar | SWE | 7.15 | 74.93 | 2.43 | 149.04 |
| 40269 | Fjaler | Fjaler | SWE | 8.30 | 64.30 | 3.89 | 148.15 |
| 40270 | Ivana | Ivana | SWE | 8.00 | 53.64 | 3.91 | 141.14 |
| 40271 | Arvicola | Arvicola | SWE | 5.43 | 61.19 | 4.66 | 142.26 |
| 40272 | Pionero | Pionero | SWE | 7.10 | 60.81 | 3.71 | 149.05 |
| 40273 | Navarra | Navarra | SWE | 7.53 | 62.70 | 4.11 | 148.13 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MHeight_13 | MRegrowth_13 | MHeading_13 |
|---|---|---|---|---|---|---|---|
| 40274 | Arvella | Arvella | SWE | 6.20 | 57.86 | 4.65 | 140.63 |
| 40275 | Cavia | Cavia | SWE | 5.98 | 63.35 | 4.70 | 145.72 |
| 40276 | Premium | Premium | SWE | 9.06 | 69.47 | 4.58 | 146.88 |
| 40277 | Abermagic | Abermagic | SWE | 5.40 | 70.51 | 4.55 | 152.28 |
| 40278 | Dunluce | Dunluce | SWE | 8.35 | 68.98 | 4.63 | 152.24 |
| 40279 | Dumdrum | Dumdrum | SWE | 6.36 | 71.50 | 4.38 | 156.13 |
| 40280 | Aberbite | Aberbite | SWE | 3.94 | 56.93 | 3.53 | 158.06 |
| 40281 | Aston_princess | Aston_princess | SWE | 6.70 | 62.66 | 4.30 | 156.98 |
| 40282 | Burlina1 | Burlina1 | SWE | 8.00 | 69.84 | 4.65 | 152.49 |
| 40283 | Barmaxima | Barmaxima | SWE | 7.40 | 59.88 | 5.35 | 159.28 |
| 40284 | Calvano1 | Calvano1 | SWE | 8.44 | 72.76 | 5.26 | 151.61 |
| 40285 | Arsenal | Arsenal | SWE | 8.35 | 72.35 | 5.21 | 149.16 |
| 40286 | Maurizio | Maurizio | SWE | 6.43 | 62.48 | 4.14 | 152.21 |
| 40287 | Toronto | Toronto | SWE | 6.68 | 70.85 | 5.36 | 149.21 |
| 40288 | Bronsyn | Bronsyn | SWE | . | . | . | . |
| 40289 | Impresario | Impresario | SWE | . | . | . | . |
| 40290 | Salamandra | Salamandra | SWE | 4.11 | 60.07 | 4.20 | 146.12 |
| 40291 | Hurricane | Hurricane | SWE | 8.00 | 65.80 | 4.51 | 155.24 |
| 40292 | Novello | Novello | SWE | 6.48 | 61.14 | 4.51 | 156.05 |
| 40294 | Barnhem | Barnhem | SWE | 8.45 | 58.70 | 5.14 | 155.53 |
| 40295 | Ideal | Ideal | SWE | 7.60 | 69.03 | 4.81 | 156.17 |
| 40296 | Portstewart | Portstewart | SWE | 7.48 | 59.58 | 4.15 | 155.31 |
| 40297 | Portrush | Portrush | SWE | 8.70 | 62.88 | 4.45 | 155.06 |
| 40298 | Roy | Roy | SWE | 5.43 | 61.93 | 4.63 | 151.36 |
| 40300 | Hamlet | Hamlet | SWE | 8.75 | 61.79 | 5.01 | 150.26 |
| 40301 | Keystone2 | Keystone2 | SWE | 7.79 | 51.77 | 3.83 | 147.07 |
| 40302 | Greenway | Greenway | SWE | 8.89 | 55.90 | 5.45 | 149.70 |
| 40303 | Eurodiamond | Eurodiamond | SWE | 9.00 | 62.30 | 5.06 | 154.45 |
| 40304 | Bargold | Bargold | SWE | 9.00 | 55.04 | 4.20 | 151.63 |
| 40305 | Esquire | Esquire | SWE | 9.00 | 60.11 | 4.00 | 147.50 |
| 40306 | Ligala | Ligala | SWE | 9.00 | 54.20 | 4.71 | 154.68 |
| 40307 | Aberimp | Aberimp | SWE | 7.50 | 53.95 | 3.98 | 156.55 |
| 40308 | Derby_Xtreme | Escapade | SWE | 7.95 | 46.81 | 3.85 | 146.70 |
| 40309 | Primary | Primary | SWE | 8.65 | 50.61 | 4.56 | 145.66 |
| 40310 | Regal_5 | Regal_5 | SWE | 8.60 | 46.91 | 4.90 | 144.29 |
| 40311 | Tetragreen | Tetragreen | SWE | 8.85 | 58.20 | 4.88 | 147.60 |
| 40312 | Double | Double | SWE | 8.65 | 59.65 | 4.70 | 147.40 |
| 40313 | Ba11434 | Ba11434 | SWE | 9.00 | 65.65 | 4.45 | 152.46 |
| 40314 | Ba11445 | Ba11445 | SWE | 9.00 | 66.00 | 3.90 | 152.45 |
| 40315 | Ba11448 | Ba11448 | SWE | 8.85 | 62.39 | 3.20 | 153.04 |
| 40316 | Ba11461 | Ba11461 | SWE | 8.79 | 58.78 | 4.18 | 150.77 |
| 40317 | Ba11451 | Ba11451 | SWE | 8.88 | 60.86 | 4.08 | 149.49 |
| 40318 | Ba12220 | ABY-Ba12220 | SWE | 7.75 | 63.85 | 4.05 | 155.15 |
| 40319 | Ba12947 | Ba12947 | SWE | 8.50 | 65.45 | 4.26 | 150.95 |
| 40320 | Ba12948 | Ba12948 | SWE | 9.00 | 72.34 | 4.26 | 146.60 |
| 40321 | Ba12949 | Ba12949 | SWE | 9.00 | 70.06 | 5.04 | 149.54 |
| 40322 | Ba12950 | Ba12950 | SWE | 9.00 | 68.05 | 4.61 | 148.55 |
| 40323 | Ba12951 | Ba12951 | SWE | 8.47 | 64.83 | 4.38 | 147.12 |
| 40324 | Ba12952 | Ba12952 | SWE | 9.00 | 67.93 | 5.01 | 148.71 |
| 40325 | Ba12953 | Ba12953 | SWE | 8.20 | 65.70 | 4.20 | 147.20 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MHeight_13 | MRegrowth_13 | MHeading_13 |
|---|---|---|---|---|---|---|---|
| 40326 | Ba12954 | Ba12954 | SWE | 8.80 | 67.90 | 4.50 | 148.80 |
| 40327 | Ba12955 | Ba12955 | SWE | 9.00 | 70.46 | 4.65 | 150.34 |
| 40328 | Ba12956 | Ba12956 | SWE | 8.15 | 66.64 | 5.04 | 146.98 |
| 40329 | Ba12957 | Ba12957 | SWE | 7.30 | 70.85 | 4.60 | 148.95 |
| 40330 | Ba12958 | Ba12958 | SWE | 9.00 | 70.05 | 3.70 | 148.10 |
| 40336 | Ba12970 | Ba12970 | SWE | 7.98 | 59.73 | 4.18 | 141.98 |
| 40337 | Ba12971 | Ba12971 | SWE | 3.94 | 53.41 | 5.08 | 150.14 |
| 40339 | Ba12973 | Ba12973 | SWE | 6.68 | 58.85 | 4.77 | 149.64 |
| 40340 | Ba12974 | Ba12974 | SWE | 2.31 | 55.01 | 4.70 | 146.37 |
| 40342 | Ba12976 | Ba12976 | SWE | 8.45 | 60.15 | 4.60 | 146.40 |
| 40343 | Ba12977 | Ba12977 | SWE | 6.61 | 60.19 | 4.68 | 154.34 |
| 40344 | Ba12978 | Ba12978 | SWE | 7.24 | 60.92 | 4.54 | 152.65 |
| 40345 | Ba12979 | Ba12979 | SWE | 8.75 | 60.66 | 4.50 | 154.83 |
| 40346 | Ba12980 | Ba12980 | SWE | 5.43 | . | 3.72 | 146.33 |
| 40347 | Ba12981 | Ba12981 | SWE | 2.90 | 51.48 | 2.25 | 148.18 |
| 40349 | Ba12983 | Ba12983 | SWE | 6.50 | 69.00 | 4.62 | 158.33 |
| 40351 | Ba12985 | Ba12985 | SWE | . | . | . | . |
| 40354 | Ba12988 | Ba12988 | SWE | 5.26 | 56.62 | 3.60 | 150.27 |
| 40355 | Ba12989 | Ba12989 | SWE | 6.81 | 63.41 | 4.99 | 149.74 |
| 40356 | Ba9819 | ABY-Ba9819 | SWE | 7.65 | 58.50 | 4.30 | 149.65 |
| 40357 | Ba9832 | ABY-Ba9832 | SWE | 7.15 | 60.08 | 4.73 | 149.95 |
| 40358 | Ba12275 | Ba12275 | SWE | 8.65 | 67.10 | 5.85 | 151.15 |
| 40359 | Ba12276 | Ba12276 | SWE | 8.72 | 64.30 | 3.38 | 150.23 |
| 40360 | Ba12277 | Ba12277 | SWE | 8.65 | 56.88 | 3.55 | 149.61 |
| 40361 | Ba12278 | Ba12278 | SWE | 9.00 | 62.85 | 4.39 | 154.29 |
| 40366 | Ba13004 | Ba13004 | SWE | 9.00 | 60.99 | 4.60 | 155.29 |
| 40368 | Ba13006 | Ba13006 | SWE | 8.85 | 59.53 | 5.05 | 158.04 |
| 40374 | POL133323 | POL133323 | SWE | 8.15 | 69.03 | 5.21 | 153.93 |
| 40375 | POL133324 | POL133324 | SWE | 8.85 | 67.86 | 4.45 | 154.58 |
| 40376 | POL133325 | POL133325 | SWE | 9.00 | 71.60 | 4.85 | 150.30 |
| 40377 | POL133326 | POL133326 | SWE | 9.00 | 68.06 | 5.00 | 151.15 |
| 40378 | POL133327 | POL133327 | SWE | 9.00 | 67.24 | 4.65 | 151.31 |
| 40379 | POL133328 | POL133328 | SWE | 9.00 | 69.39 | 4.88 | 149.85 |
| 40380 | POL133398 | POL133398 | SWE | 9.00 | 65.30 | 4.85 | 148.20 |
| 40381 | POL133399 | POL133399 | SWE | 9.00 | 66.33 | 4.84 | 149.61 |
| 40382 | POL133400 | POL133400 | SWE | 9.00 | 66.25 | 4.63 | 151.38 |
| 40383 | POL133401 | POL133401 | SWE | 9.00 | 62.17 | 3.80 | 154.70 |
| 40384 | POL155145 | POL155145 | SWE | 9.00 | 65.40 | 3.88 | 155.60 |
| 40386 | POL155147 | POL155147 | SWE | 9.00 | 65.78 | 4.33 | 156.81 |
| 40387 | POL155148 | POL155148 | SWE | 9.00 | 67.81 | 4.82 | 160.41 |
| 40390 | POL155152 | POL155152 | SWE | 9.00 | 66.00 | 4.24 | 153.23 |
| 40391 | POL155153 | POL155153 | SWE | 9.00 | 62.51 | 4.80 | 155.40 |
| 40392 | POL155154 | POL155154 | SWE | 9.00 | 61.11 | 4.19 | 155.98 |
| 40393 | POL155155 | POL155155 | SWE | 9.00 | 67.62 | 4.88 | 157.76 |
| 40394 | POL155158 | POL155158 | SWE | 9.00 | 75.45 | 4.38 | 149.02 |
| 40395 | POL155159 | POL155159 | SWE | 9.33 | . | 3.00 | . |
| 40397 | POL155165 | ANNA | SWE | 5.19 | 58.17 | 4.27 | 143.48 |
| 40398 | POL155176 | INKA | SWE | 8.10 | 56.15 | 4.33 | 151.58 |
| 40399 | POL155192 | NIRA | SWE | 8.85 | 57.60 | 4.39 | 151.59 |
| 40401 | POL155194 | ARKA | SWE | 8.65 | 70.56 | 5.23 | 156.68 |

# Appendix 4

| PPP_id | Acc_no | Acc_name | Loc | MW.S._13 | MHeight_13 | MRegrowth_13 | MHeading_13 |
|---|---|---|---|---|---|---|---|
| 40402 | POL155218 | WENTO_(SZD291) | SWE | 8.05 | 73.46 | 4.33 | 151.53 |
| 40403 | POL155219 | SOLEN | SWE | 7.41 | 67.05 | 4.49 | 152.80 |
| 40404 | POL155230 | NIGA | SWE | 9.00 | 63.05 | 3.56 | 152.40 |
| 40405 | POL155238 | MAJA | SWE | 7.26 | 66.12 | 4.68 | 152.23 |

# Appendix 5

## Heading day 2013

**Tabel 1: Tukey's multiple comparison test for Heading day 2013**

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| **C_2x_D vs. C_4x_D** | -0.88 | -2.895 to 1.128 | No | ns | 0.9817 | A-B |
| **C_2x_D vs. E_2x_D** | 0.18 | -1.416 to 1.772 | No | ns | >0.9999 | A-C |
| **C_2x_D vs. E_4x_D** | -2.48 | -7.078 to 2.112 | No | ns | 0.8953 | A-D |
| **C_2x_D vs. C_2x_S** | 1.31 | -0.4722 to 3.083 | No | ns | 0.4566 | A-E |
| **C_2x_D vs. C_4x_S** | -0.34 | -2.370 to 1.693 | No | ns | >0.9999 | A-F |
| **C_2x_D vs. E_2x_S** | 1.33 | -0.2737 to 2.938 | No | ns | 0.2435 | A-G |
| **C_2x_D vs. E_4x_S** | -1.23 | -5.828 to 3.362 | No | ns | >0.9999 | A-H |
| **C_2x_D vs. C_2x_N** | -14.05 | -15.83 to -12.28 | Yes | **** | <0.0001 | A-I |
| **C_2x_D vs. C_4x_N** | -14.98 | -17.00 to -12.96 | Yes | **** | <0.0001 | A-J |
| **C_2x_D vs. E_2x_N** | -13.87 | -15.48 to -12.25 | Yes | **** | <0.0001 | A-K |
| **C_2x_D vs. E_4x_N** | -15.21 | -19.80 to -10.61 | Yes | **** | <0.0001 | A-L |
| **C_2x_D vs. C_2x_F** | -4.18 | -5.954 to -2.399 | Yes | **** | <0.0001 | A-M |
| **C_2x_D vs. C_4x_F** | -4.35 | -6.376 to -2.313 | Yes | **** | <0.0001 | A-N |
| **C_2x_D vs. E_2x_F** | -4.10 | -5.696 to -2.496 | Yes | **** | <0.0001 | A-O |
| **C_2x_D vs. E_4x_F** | -5.21 | -9.803 to -0.6134 | Yes | * | 0.0102 | A-P |
| **C_4x_D vs. E_2x_D** | 1.06 | -0.7983 to 2.922 | No | ns | 0.847 | B-C |
| **C_4x_D vs. E_4x_D** | -1.60 | -6.293 to 3.094 | No | ns | 0.9987 | B-D |
| **C_4x_D vs. C_2x_S** | 2.19 | 0.1693 to 4.208 | Yes | * | 0.019 | B-E |
| **C_4x_D vs. C_4x_S** | 0.55 | -1.701 to 2.791 | No | ns | >0.9999 | B-F |
| **C_4x_D vs. E_2x_S** | 2.22 | 0.3455 to 4.086 | Yes | ** | 0.0051 | B-G |
| **C_4x_D vs. E_4x_S** | -0.35 | -5.043 to 4.344 | No | ns | >0.9999 | B-H |
| **C_4x_D vs. C_2x_N** | -13.17 | -15.19 to -11.16 | Yes | **** | <0.0001 | B-I |
| **C_4x_D vs. C_4x_N** | -14.10 | -16.33 to -11.86 | Yes | **** | <0.0001 | B-J |
| **C_4x_D vs. E_2x_N** | -12.98 | -14.86 to -11.11 | Yes | **** | <0.0001 | B-K |
| **C_4x_D vs. E_4x_N** | -14.32 | -19.02 to -9.631 | Yes | **** | <0.0001 | B-L |
| **C_4x_D vs. C_2x_F** | -3.29 | -5.312 to -1.274 | Yes | **** | <0.0001 | B-M |
| **C_4x_D vs. C_4x_F** | -3.46 | -5.708 to -1.215 | Yes | **** | <0.0001 | B-N |
| **C_4x_D vs. E_2x_F** | -3.21 | -5.077 to -1.347 | Yes | **** | <0.0001 | B-O |
| **C_4x_D vs. E_4x_F** | -4.33 | -9.018 to 0.3689 | No | ns | 0.1111 | B-P |
| **E_2x_D vs. E_4x_D** | -2.66 | -7.192 to 1.869 | No | ns | 0.8159 | C-D |
| **E_2x_D vs. C_2x_S** | 1.13 | -0.4771 to 2.731 | No | ns | 0.5388 | C-E |
| **E_2x_D vs. C_4x_S** | -0.52 | -2.398 to 1.365 | No | ns | >0.9999 | C-F |
| **E_2x_D vs. E_2x_S** | 1.15 | -0.2576 to 2.566 | No | ns | 0.2665 | C-G |
| **E_2x_D vs. E_4x_S** | -1.41 | -5.942 to 3.119 | No | ns | 0.9996 | C-H |
| **E_2x_D vs. C_2x_N** | -14.23 | -15.83 to -12.63 | Yes | **** | <0.0001 | C-I |
| **E_2x_D vs. C_4x_N** | -15.16 | -17.03 to -13.29 | Yes | **** | <0.0001 | C-J |
| **E_2x_D vs. E_2x_N** | -14.05 | -15.47 to -12.62 | Yes | **** | <0.0001 | C-K |
| **E_2x_D vs. E_4x_N** | -15.39 | -19.92 to -10.86 | Yes | **** | <0.0001 | C-L |
| **E_2x_D vs. C_2x_F** | -4.36 | -5.959 to -2.751 | Yes | **** | <0.0001 | C-M |
| **E_2x_D vs. C_4x_F** | -4.52 | -6.405 to -2.641 | Yes | **** | <0.0001 | C-N |
| **E_2x_D vs. E_2x_F** | -4.27 | -5.679 to -2.869 | Yes | **** | <0.0001 | C-O |
| **E_2x_D vs. E_4x_F** | -5.39 | -9.917 to -0.8559 | Yes | ** | 0.0048 | C-P |
| **E_4x_D vs. C_2x_S** | 3.79 | -0.8099 to 8.386 | No | ns | 0.2541 | D-E |
| **E_4x_D vs. C_4x_S** | 2.15 | -2.558 to 6.847 | No | ns | 0.974 | D-F |
| **E_4x_D vs. E_2x_S** | 3.82 | -0.7193 to 8.350 | No | ns | 0.2222 | D-G |
| **E_4x_D vs. E_4x_S** | 1.25 | -5.003 to 7.503 | No | ns | >0.9999 | D-H |
| **E_4x_D vs. C_2x_N** | -11.57 | -16.17 to -6.976 | Yes | **** | <0.0001 | D-I |
| **E_4x_D vs. C_4x_N** | -12.50 | -17.20 to -7.800 | Yes | **** | <0.0001 | D-J |
| **E_4x_D vs. E_2x_N** | -11.39 | -15.92 to -6.847 | Yes | **** | <0.0001 | D-K |
| **E_4x_D vs. E_4x_N** | -12.73 | -18.98 to -6.472 | Yes | **** | <0.0001 | D-L |
| **E_4x_D vs. C_2x_F** | -1.69 | -6.291 to 2.905 | No | ns | 0.997 | D-M |
| **E_4x_D vs. C_4x_F** | -1.86 | -6.564 to 2.840 | No | ns | 0.9934 | D-N |
| **E_4x_D vs. E_2x_F** | -1.61 | -6.145 to 2.920 | No | ns | 0.9979 | D-O |
| **E_4x_D vs. E_4x_F** | -2.73 | -8.978 to 3.528 | No | ns | 0.983 | D-P |
| **C_2x_S vs. C_4x_S** | -1.64 | -3.683 to 0.3958 | No | ns | 0.2898 | E-F |
| **C_2x_S vs. E_2x_S** | 0.03 | -1.589 to 1.643 | No | ns | >0.9999 | E-G |
| **C_2x_S vs. E_4x_S** | -2.54 | -7.136 to 2.060 | No | ns | 0.8782 | E-H |
| **C_2x_S vs. C_2x_N** | -15.36 | -17.14 to -13.58 | Yes | **** | <0.0001 | E-I |
| **C_2x_S vs. C_4x_N** | -16.29 | -18.32 to -14.26 | Yes | **** | <0.0001 | E-J |
| **C_2x_S vs. E_2x_N** | -15.17 | -16.80 to -13.55 | Yes | **** | <0.0001 | E-K |
| **C_2x_S vs. E_4x_N** | -16.51 | -21.11 to -11.92 | Yes | **** | <0.0001 | E-L |
| **C_2x_S vs. C_2x_F** | -5.48 | -7.268 to -3.695 | Yes | **** | <0.0001 | E-M |
| **C_2x_S vs. C_4x_F** | -5.65 | -7.690 to -3.611 | Yes | **** | <0.0001 | E-N |
| **C_2x_S vs. E_2x_F** | -5.40 | -7.011 to -3.791 | Yes | **** | <0.0001 | E-O |
| **C_2x_S vs. E_4x_F** | -6.51 | -11.11 to -1.915 | Yes | *** | 0.0001 | E-P |

# Appendix 5

## Heading day 2013

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| C_4x_S vs. E_2x_S | 1.67 | -0.2212 to 3.562 | No | ns | 0.1573 | F-G |
| C_4x_S vs. E_4x_S | -0.89 | -5.597 to 3.808 | No | ns | >0.9999 | F-H |
| C_4x_S vs. C_2x_N | -13.72 | -15.75 to -11.68 | Yes | **** | <0.0001 | F-I |
| C_4x_S vs. C_4x_N | -14.64 | -16.90 to -12.39 | Yes | **** | <0.0001 | F-J |
| C_4x_S vs. E_2x_N | -13.53 | -15.43 to -11.63 | Yes | **** | <0.0001 | F-K |
| C_4x_S vs. E_4x_N | -14.87 | -19.57 to -10.17 | Yes | **** | <0.0001 | F-L |
| C_4x_S vs. C_2x_F | -3.84 | -5.877 to -1.799 | Yes | **** | <0.0001 | F-M |
| C_4x_S vs. C_4x_F | -4.01 | -6.271 to -1.742 | Yes | **** | <0.0001 | F-N |
| C_4x_S vs. E_2x_F | -3.76 | -5.644 to -1.871 | Yes | **** | <0.0001 | F-O |
| C_4x_S vs. E_4x_F | -4.87 | -9.572 to -0.1675 | Yes | * | 0.0336 | F-P |
| E_2x_S vs. E_4x_S | -2.57 | -7.100 to 1.969 | No | ns | 0.8558 | G-H |
| E_2x_S vs. C_2x_N | -15.39 | -17.00 to -13.78 | Yes | **** | <0.0001 | G-I |
| E_2x_S vs. C_4x_N | -16.31 | -18.19 to -14.43 | Yes | **** | <0.0001 | G-J |
| E_2x_S vs. E_2x_N | -15.20 | -16.64 to -13.76 | Yes | **** | <0.0001 | G-K |
| E_2x_S vs. E_4x_N | -16.54 | -21.07 to -12.01 | Yes | **** | <0.0001 | G-L |
| E_2x_S vs. C_2x_F | -5.51 | -7.125 to -3.893 | Yes | **** | <0.0001 | G-M |
| E_2x_S vs. C_4x_F | -5.68 | -7.569 to -3.785 | Yes | **** | <0.0001 | G-N |
| E_2x_S vs. E_2x_F | -5.43 | -6.846 to -4.010 | Yes | **** | <0.0001 | G-O |
| E_2x_S vs. E_4x_F | -6.54 | -11.07 to -2.006 | Yes | **** | <0.0001 | G-P |
| E_4x_S vs. C_2x_N | -12.82 | -17.42 to -8.226 | Yes | **** | <0.0001 | H-I |
| E_4x_S vs. C_4x_N | -13.75 | -18.45 to -9.050 | Yes | **** | <0.0001 | H-J |
| E_4x_S vs. E_2x_N | -12.64 | -17.17 to -8.097 | Yes | **** | <0.0001 | H-K |
| E_4x_S vs. E_4x_N | -13.98 | -20.23 to -7.722 | Yes | **** | <0.0001 | H-L |
| E_4x_S vs. C_2x_F | -2.94 | -7.541 to 1.655 | No | ns | 0.6989 | H-M |
| E_4x_S vs. C_4x_F | -3.11 | -7.814 to 1.590 | No | ns | 0.6448 | H-N |
| E_4x_S vs. E_2x_F | -2.86 | -7.395 to 1.670 | No | ns | 0.7195 | H-O |
| E_4x_S vs. E_4x_F | -3.98 | -10.23 to 2.278 | No | ns | 0.7095 | H-P |
| C_2x_N vs. C_4x_N | -0.93 | -2.951 to 1.100 | No | ns | 0.9735 | I-J |
| C_2x_N vs. E_2x_N | 0.19 | -1.435 to 1.808 | No | ns | >0.9999 | I-K |
| C_2x_N vs. E_4x_N | -1.15 | -5.749 to 3.443 | No | ns | >0.9999 | I-L |
| C_2x_N vs. C_2x_F | 9.88 | 8.097 to 11.66 | Yes | **** | <0.0001 | I-M |
| C_2x_N vs. C_4x_F | 9.71 | 7.675 to 11.75 | Yes | **** | <0.0001 | I-N |
| C_2x_N vs. E_2x_F | 9.96 | 8.355 to 11.56 | Yes | **** | <0.0001 | I-O |
| C_2x_N vs. E_4x_F | 8.85 | 4.251 to 13.44 | Yes | **** | <0.0001 | I-P |
| C_4x_N vs. E_2x_N | 1.11 | -0.7774 to 3.002 | No | ns | 0.8134 | J-K |
| C_4x_N vs. E_4x_N | -0.23 | -4.925 to 4.470 | No | ns | >0.9999 | J-L |
| C_4x_N vs. C_2x_F | 10.80 | 8.775 to 12.83 | Yes | **** | <0.0001 | J-M |
| C_4x_N vs. C_4x_F | 10.64 | 8.381 to 12.89 | Yes | **** | <0.0001 | J-N |
| C_4x_N vs. E_2x_F | 10.89 | 9.009 to 12.76 | Yes | **** | <0.0001 | J-O |
| C_4x_N vs. E_4x_F | 9.77 | 5.075 to 14.47 | Yes | **** | <0.0001 | J-P |
| E_2x_N vs. E_4x_N | -1.34 | -5.878 to 3.198 | No | ns | 0.9998 | K-L |
| E_2x_N vs. C_2x_F | 9.69 | 8.065 to 11.32 | Yes | **** | <0.0001 | K-M |
| E_2x_N vs. C_4x_F | 9.52 | 7.622 to 11.42 | Yes | **** | <0.0001 | K-N |
| E_2x_N vs. E_2x_F | 9.77 | 8.342 to 11.20 | Yes | **** | <0.0001 | K-O |
| E_2x_N vs. E_4x_F | 8.66 | 4.122 to 13.20 | Yes | **** | <0.0001 | K-P |
| E_4x_N vs. C_2x_F | 11.03 | 6.434 to 15.63 | Yes | **** | <0.0001 | L-M |
| E_4x_N vs. C_4x_F | 10.86 | 6.161 to 15.57 | Yes | **** | <0.0001 | L-N |
| E_4x_N vs. E_2x_F | 11.11 | 6.580 to 15.64 | Yes | **** | <0.0001 | L-O |
| E_4x_N vs. E_4x_F | 10.00 | 3.747 to 16.25 | Yes | **** | <0.0001 | L-P |
| C_2x_F vs. C_4x_F | -0.17 | -2.208 to 1.871 | No | ns | >0.9999 | M-N |
| C_2x_F vs. E_2x_F | 0.08 | -1.529 to 1.691 | No | ns | >0.9999 | M-O |
| C_2x_F vs. E_4x_F | -1.03 | -5.630 to 3.566 | No | ns | >0.9999 | M-P |
| C_4x_F vs. E_2x_F | 0.25 | -1.637 to 2.136 | No | ns | >0.9999 | N-O |
| C_4x_F vs. E_4x_F | -0.86 | -5.565 to 3.839 | No | ns | >0.9999 | N-P |
| E_2x_F vs. E_4x_F | -1.11 | -5.645 to 3.420 | No | ns | >0.9999 | O-P |

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| C_2x_D vs. C_4x_D | 151.30 | 152.20 | -0.88 | 0.59 | 100 | 63 | 2.13 | 1278 |
| C_2x_D vs. E_2x_D | 151.30 | 151.20 | 0.18 | 0.46 | 100 | 160 | 0.54 | 1278 |
| C_2x_D vs. E_4x_D | 151.30 | 153.80 | -2.48 | 1.34 | 100 | 8 | 2.62 | 1278 |
| C_2x_D vs. C_2x_S | 151.30 | 150.00 | 1.31 | 0.52 | 100 | 98 | 3.57 | 1278 |
| C_2x_D vs. C_4x_S | 151.30 | 151.70 | -0.34 | 0.59 | 100 | 61 | 0.81 | 1278 |
| C_2x_D vs. E_2x_S | 151.30 | 150.00 | 1.33 | 0.47 | 100 | 154 | 4.03 | 1278 |
| C_2x_D vs. E_4x_S | 151.30 | 152.60 | -1.23 | 1.34 | 100 | 8 | 1.30 | 1278 |
| C_2x_D vs. C_2x_N | 151.30 | 165.40 | -14.05 | 0.52 | 100 | 99 | 38.49 | 1278 |
| C_2x_D vs. C_4x_N | 151.30 | 166.30 | -14.98 | 0.59 | 100 | 62 | 35.98 | 1278 |

# Appendix 5

## Heading day 2013

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| C_2x_D vs. E_2x_N | 151.30 | 165.20 | -13.87 | 0.47 | 100 | 149 | 41.65 | 1278 |
| C_2x_D vs. E_4x_N | 151.30 | 166.60 | -15.21 | 1.34 | 100 | 8 | 16.07 | 1278 |
| C_2x_D vs. C_2x_F | 151.30 | 155.50 | -4.18 | 0.52 | 100 | 98 | 11.41 | 1278 |
| C_2x_D vs. C_4x_F | 151.30 | 155.70 | -4.35 | 0.59 | 100 | 61 | 10.38 | 1278 |
| C_2x_D vs. E_2x_F | 151.30 | 155.40 | -4.10 | 0.47 | 100 | 157 | 12.43 | 1278 |
| C_2x_D vs. E_4x_F | 151.30 | 156.60 | -5.21 | 1.34 | 100 | 8 | 5.50 | 1278 |
| C_4x_D vs. E_2x_D | 152.20 | 151.20 | 1.06 | 0.54 | 63 | 160 | 2.77 | 1278 |
| C_4x_D vs. E_4x_D | 152.20 | 153.80 | -1.60 | 1.37 | 63 | 8 | 1.66 | 1278 |
| C_4x_D vs. C_2x_S | 152.20 | 150.00 | 2.19 | 0.59 | 63 | 98 | 5.26 | 1278 |
| C_4x_D vs. C_4x_S | 152.20 | 151.70 | 0.55 | 0.65 | 63 | 61 | 1.18 | 1278 |
| C_4x_D vs. E_2x_S | 152.20 | 150.00 | 2.22 | 0.54 | 63 | 154 | 5.75 | 1278 |
| C_4x_D vs. E_4x_S | 152.20 | 152.60 | -0.35 | 1.37 | 63 | 8 | 0.36 | 1278 |
| C_4x_D vs. C_2x_N | 152.20 | 165.40 | -13.17 | 0.59 | 63 | 99 | 31.73 | 1278 |
| C_4x_D vs. C_4x_N | 152.20 | 166.30 | -14.10 | 0.65 | 63 | 62 | 30.59 | 1278 |
| C_4x_D vs. E_2x_N | 152.20 | 165.20 | -12.98 | 0.55 | 63 | 149 | 33.54 | 1278 |
| C_4x_D vs. E_4x_N | 152.20 | 166.60 | -14.32 | 1.37 | 63 | 8 | 14.82 | 1278 |
| C_4x_D vs. C_2x_F | 152.20 | 155.50 | -3.29 | 0.59 | 63 | 98 | 7.92 | 1278 |
| C_4x_D vs. C_4x_F | 152.20 | 155.70 | -3.46 | 0.65 | 63 | 61 | 7.48 | 1278 |
| C_4x_D vs. E_2x_F | 152.20 | 155.40 | -3.21 | 0.54 | 63 | 157 | 8.36 | 1278 |
| C_4x_D vs. E_4x_F | 152.20 | 156.60 | -4.33 | 1.37 | 63 | 8 | 4.47 | 1278 |
| E_2x_D vs. E_4x_D | 151.20 | 153.80 | -2.66 | 1.32 | 160 | 8 | 2.85 | 1278 |
| E_2x_D vs. C_2x_S | 151.20 | 150.00 | 1.13 | 0.47 | 160 | 98 | 3.41 | 1278 |
| E_2x_D vs. C_4x_S | 151.20 | 151.70 | -0.52 | 0.55 | 160 | 61 | 1.33 | 1278 |
| E_2x_D vs. E_2x_S | 151.20 | 150.00 | 1.15 | 0.41 | 160 | 154 | 3.97 | 1278 |
| E_2x_D vs. E_4x_S | 151.20 | 152.60 | -1.41 | 1.32 | 160 | 8 | 1.51 | 1278 |
| E_2x_D vs. C_2x_N | 151.20 | 165.40 | -14.23 | 0.47 | 160 | 99 | 43.21 | 1278 |
| E_2x_D vs. C_4x_N | 151.20 | 166.30 | -15.16 | 0.54 | 160 | 62 | 39.34 | 1278 |
| E_2x_D vs. E_2x_N | 151.20 | 165.20 | -14.05 | 0.41 | 160 | 149 | 47.90 | 1278 |
| E_2x_D vs. E_4x_N | 151.20 | 166.60 | -15.39 | 1.32 | 160 | 8 | 16.49 | 1278 |
| E_2x_D vs. C_2x_F | 151.20 | 155.50 | -4.36 | 0.47 | 160 | 98 | 13.18 | 1278 |
| E_2x_D vs. C_4x_F | 151.20 | 155.70 | -4.52 | 0.55 | 160 | 61 | 11.67 | 1278 |
| E_2x_D vs. E_2x_F | 151.20 | 155.40 | -4.27 | 0.41 | 160 | 157 | 14.77 | 1278 |
| E_2x_D vs. E_4x_F | 151.20 | 156.60 | -5.39 | 1.32 | 160 | 8 | 5.77 | 1278 |
| E_4x_D vs. C_2x_S | 153.80 | 150.00 | 3.79 | 1.34 | 8 | 98 | 4.00 | 1278 |
| E_4x_D vs. C_4x_S | 153.80 | 151.70 | 2.15 | 1.37 | 8 | 61 | 2.21 | 1278 |
| E_4x_D vs. E_2x_S | 153.80 | 150.00 | 3.82 | 1.32 | 8 | 154 | 4.09 | 1278 |
| E_4x_D vs. E_4x_S | 153.80 | 152.60 | 1.25 | 1.82 | 8 | 8 | 0.97 | 1278 |
| E_4x_D vs. C_2x_N | 153.80 | 165.40 | -11.57 | 1.34 | 8 | 99 | 12.22 | 1278 |
| E_4x_D vs. C_4x_N | 153.80 | 166.30 | -12.50 | 1.37 | 8 | 62 | 12.92 | 1278 |
| E_4x_D vs. E_2x_N | 153.80 | 165.20 | -11.39 | 1.32 | 8 | 149 | 12.18 | 1278 |
| E_4x_D vs. E_4x_N | 153.80 | 166.60 | -12.73 | 1.82 | 8 | 8 | 9.88 | 1278 |
| E_4x_D vs. C_2x_F | 153.80 | 155.50 | -1.69 | 1.34 | 8 | 98 | 1.79 | 1278 |
| E_4x_D vs. C_4x_F | 153.80 | 155.70 | -1.86 | 1.37 | 8 | 61 | 1.92 | 1278 |
| E_4x_D vs. E_2x_F | 153.80 | 155.40 | -1.61 | 1.32 | 8 | 157 | 1.73 | 1278 |
| E_4x_D vs. E_4x_F | 153.80 | 156.60 | -2.73 | 1.82 | 8 | 8 | 2.12 | 1278 |
| C_2x_S vs. C_4x_S | 150.00 | 151.70 | -1.64 | 0.59 | 98 | 61 | 3.91 | 1278 |
| C_2x_S vs. E_2x_S | 150.00 | 150.00 | 0.03 | 0.47 | 98 | 154 | 0.08 | 1278 |
| C_2x_S vs. E_4x_S | 150.00 | 152.60 | -2.54 | 1.34 | 98 | 8 | 2.68 | 1278 |
| C_2x_S vs. C_2x_N | 150.00 | 165.40 | -15.36 | 0.52 | 98 | 99 | 41.85 | 1278 |
| C_2x_S vs. C_4x_N | 150.00 | 166.30 | -16.29 | 0.59 | 98 | 62 | 38.96 | 1278 |
| C_2x_S vs. E_2x_N | 150.00 | 165.20 | -15.17 | 0.47 | 98 | 149 | 45.29 | 1278 |
| C_2x_S vs. E_4x_N | 150.00 | 166.60 | -16.51 | 1.34 | 98 | 8 | 17.44 | 1278 |
| C_2x_S vs. C_2x_F | 150.00 | 155.50 | -5.48 | 0.52 | 98 | 98 | 14.90 | 1278 |
| C_2x_S vs. C_4x_F | 150.00 | 155.70 | -5.65 | 0.59 | 98 | 61 | 13.45 | 1278 |
| C_2x_S vs. E_2x_F | 150.00 | 155.40 | -5.40 | 0.47 | 98 | 157 | 16.29 | 1278 |
| C_2x_S vs. E_4x_F | 150.00 | 156.60 | -6.51 | 1.34 | 98 | 8 | 6.88 | 1278 |
| C_4x_S vs. E_2x_S | 151.70 | 150.00 | 1.67 | 0.55 | 61 | 154 | 4.29 | 1278 |
| C_4x_S vs. E_4x_S | 151.70 | 152.60 | -0.89 | 1.37 | 61 | 8 | 0.92 | 1278 |
| C_4x_S vs. C_2x_N | 151.70 | 165.40 | -13.72 | 0.59 | 61 | 99 | 32.72 | 1278 |
| C_4x_S vs. C_4x_N | 151.70 | 166.30 | -14.64 | 0.66 | 61 | 62 | 31.52 | 1278 |
| C_4x_S vs. E_2x_N | 151.70 | 165.20 | -13.53 | 0.55 | 61 | 149 | 34.56 | 1278 |
| C_4x_S vs. E_4x_N | 151.70 | 166.60 | -14.87 | 1.37 | 61 | 8 | 15.35 | 1278 |
| C_4x_S vs. C_2x_F | 151.70 | 155.50 | -3.84 | 0.59 | 61 | 98 | 9.14 | 1278 |
| C_4x_S vs. C_4x_F | 151.70 | 155.70 | -4.01 | 0.66 | 61 | 61 | 8.59 | 1278 |
| C_4x_S vs. E_2x_F | 151.70 | 155.40 | -3.76 | 0.55 | 61 | 157 | 9.67 | 1278 |
| C_4x_S vs. E_4x_F | 151.70 | 156.60 | -4.87 | 1.37 | 61 | 8 | 5.03 | 1278 |

# Appendix 5

## Heading day 2013

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| **E_2x_S vs. E_4x_S** | 150.00 | 152.60 | -2.57 | 1.32 | 154 | 8 | 2.75 | 1278 |
| **E_2x_S vs. C_2x_N** | 150.00 | 165.40 | -15.39 | 0.47 | 154 | 99 | 46.37 | 1278 |
| **E_2x_S vs. C_4x_N** | 150.00 | 166.30 | -16.31 | 0.55 | 154 | 62 | 42.11 | 1278 |
| **E_2x_S vs. E_2x_N** | 150.00 | 165.20 | -15.20 | 0.42 | 154 | 149 | 51.36 | 1278 |
| **E_2x_S vs. E_4x_N** | 150.00 | 166.60 | -16.54 | 1.32 | 154 | 8 | 17.71 | 1278 |
| **E_2x_S vs. C_2x_F** | 150.00 | 155.50 | -5.51 | 0.47 | 154 | 98 | 16.55 | 1278 |
| **E_2x_S vs. C_4x_F** | 150.00 | 155.70 | -5.68 | 0.55 | 154 | 61 | 14.57 | 1278 |
| **E_2x_S vs. E_2x_F** | 150.00 | 155.40 | -5.43 | 0.41 | 154 | 157 | 18.58 | 1278 |
| **E_2x_S vs. E_4x_F** | 150.00 | 156.60 | -6.54 | 1.32 | 154 | 8 | 7.00 | 1278 |
| **E_4x_S vs. C_2x_N** | 152.60 | 165.40 | -12.82 | 1.34 | 8 | 99 | 13.54 | 1278 |
| **E_4x_S vs. C_4x_N** | 152.60 | 166.30 | -13.75 | 1.37 | 8 | 62 | 14.21 | 1278 |
| **E_4x_S vs. E_2x_N** | 152.60 | 165.20 | -12.64 | 1.32 | 8 | 149 | 13.52 | 1278 |
| **E_4x_S vs. E_4x_N** | 152.60 | 166.60 | -13.98 | 1.82 | 8 | 8 | 10.85 | 1278 |
| **E_4x_S vs. C_2x_F** | 152.60 | 155.50 | -2.94 | 1.34 | 8 | 98 | 3.11 | 1278 |
| **E_4x_S vs. C_4x_F** | 152.60 | 155.70 | -3.11 | 1.37 | 8 | 61 | 3.21 | 1278 |
| **E_4x_S vs. E_2x_F** | 152.60 | 155.40 | -2.86 | 1.32 | 8 | 157 | 3.07 | 1278 |
| **E_4x_S vs. E_4x_F** | 152.60 | 156.60 | -3.98 | 1.82 | 8 | 8 | 3.09 | 1278 |
| **C_2x_N vs. C_4x_N** | 165.40 | 166.30 | -0.93 | 0.59 | 99 | 62 | 2.22 | 1278 |
| **C_2x_N vs. E_2x_N** | 165.40 | 165.20 | 0.19 | 0.47 | 99 | 149 | 0.56 | 1278 |
| **C_2x_N vs. E_4x_N** | 165.40 | 166.60 | -1.15 | 1.34 | 99 | 8 | 1.22 | 1278 |
| **C_2x_N vs. C_2x_F** | 165.40 | 155.50 | 9.88 | 0.52 | 99 | 98 | 26.91 | 1278 |
| **C_2x_N vs. C_4x_F** | 165.40 | 155.70 | 9.71 | 0.59 | 99 | 61 | 23.16 | 1278 |
| **C_2x_N vs. E_2x_F** | 165.40 | 155.40 | 9.96 | 0.47 | 99 | 157 | 30.13 | 1278 |
| **C_2x_N vs. E_4x_F** | 165.40 | 156.60 | 8.85 | 1.34 | 99 | 8 | 9.35 | 1278 |
| **C_4x_N vs. E_2x_N** | 166.30 | 165.20 | 1.11 | 0.55 | 62 | 149 | 2.86 | 1278 |
| **C_4x_N vs. E_4x_N** | 166.30 | 166.60 | -0.23 | 1.37 | 62 | 8 | 0.24 | 1278 |
| **C_4x_N vs. C_2x_F** | 166.30 | 155.50 | 10.80 | 0.59 | 62 | 98 | 25.85 | 1278 |
| **C_4x_N vs. C_4x_F** | 166.30 | 155.70 | 10.64 | 0.66 | 62 | 61 | 22.90 | 1278 |
| **C_4x_N vs. E_2x_F** | 166.30 | 155.40 | 10.89 | 0.55 | 62 | 157 | 28.17 | 1278 |
| **C_4x_N vs. E_4x_F** | 166.30 | 156.60 | 9.77 | 1.37 | 62 | 8 | 10.10 | 1278 |
| **E_2x_N vs. E_4x_N** | 165.20 | 166.60 | -1.34 | 1.32 | 149 | 8 | 1.43 | 1278 |
| **E_2x_N vs. C_2x_F** | 165.20 | 155.50 | 9.69 | 0.47 | 149 | 98 | 28.93 | 1278 |
| **E_2x_N vs. C_4x_F** | 165.20 | 155.70 | 9.52 | 0.55 | 149 | 61 | 24.32 | 1278 |
| **E_2x_N vs. E_2x_F** | 165.20 | 155.40 | 9.77 | 0.42 | 149 | 157 | 33.17 | 1278 |
| **E_2x_N vs. E_4x_F** | 165.20 | 156.60 | 8.66 | 1.32 | 149 | 8 | 9.26 | 1278 |
| **E_4x_N vs. C_2x_F** | 166.60 | 155.50 | 11.03 | 1.34 | 8 | 98 | 11.65 | 1278 |
| **E_4x_N vs. C_4x_F** | 166.60 | 155.70 | 10.86 | 1.37 | 8 | 61 | 11.22 | 1278 |
| **E_4x_N vs. E_2x_F** | 166.60 | 155.40 | 11.11 | 1.32 | 8 | 157 | 11.90 | 1278 |
| **E_4x_N vs. E_4x_F** | 166.60 | 156.60 | 10.00 | 1.82 | 8 | 8 | 7.77 | 1278 |
| **C_2x_F vs. C_4x_F** | 155.50 | 155.70 | -0.17 | 0.59 | 98 | 61 | 0.40 | 1278 |
| **C_2x_F vs. E_2x_F** | 155.50 | 155.40 | 0.08 | 0.47 | 98 | 157 | 0.24 | 1278 |
| **C_2x_F vs. E_4x_F** | 155.50 | 156.60 | -1.03 | 1.34 | 98 | 8 | 1.09 | 1278 |
| **C_4x_F vs. E_2x_F** | 155.70 | 155.40 | 0.25 | 0.55 | 61 | 157 | 0.64 | 1278 |
| **C_4x_F vs. E_4x_F** | 155.70 | 156.60 | -0.86 | 1.37 | 61 | 8 | 0.89 | 1278 |
| **E_2x_F vs. E_4x_F** | 155.40 | 156.60 | -1.11 | 1.32 | 157 | 8 | 1.19 | 1278 |

# Appendix 5

## Plant height 2013

Table 2: Tukey's multiple comparisons test for Plant height 2013

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| **C_2x_D vs. C_4x_D** | -7.15 | -11.19 to -3.119 | Yes | **** | <0.0001 | A-B |
| **C_2x_D vs. E_2x_D** | 2.88 | -0.3772 to 6.137 | No | ns | 0.1557 | A-C |
| **C_2x_D vs. E_4x_D** | -4.83 | -13.62 to 3.957 | No | ns | 0.8814 | A-D |
| **C_2x_D vs. C_2x_S** | -0.18 | -3.685 to 3.325 | No | ns | >0.9999 | A-E |
| **C_2x_D vs. C_4x_S** | -3.60 | -7.569 to 0.3783 | No | ns | 0.1296 | A-F |
| **C_2x_D vs. E_2x_S** | 3.05 | -0.1442 to 6.246 | No | ns | 0.0801 | A-G |
| **C_2x_D vs. E_4x_S** | -5.27 | -14.06 to 3.520 | No | ns | 0.791 | A-H |
| **C_2x_D vs. C_2x_N** | -28.79 | -32.31 to -25.27 | Yes | **** | <0.0001 | A-I |
| **C_2x_D vs. C_4x_N** | -32.67 | -36.64 to -28.70 | Yes | **** | <0.0001 | A-J |
| **C_2x_D vs. E_2x_N** | -26.99 | -30.22 to -23.77 | Yes | **** | <0.0001 | A-K |
| **C_2x_D vs. E_4x_N** | -34.47 | -43.26 to -25.68 | Yes | **** | <0.0001 | A-L |
| **C_2x_D vs. C_2x_F** | 13.90 | 10.40 to 17.41 | Yes | **** | <0.0001 | A-M |
| **C_2x_D vs. C_4x_F** | 10.55 | 6.572 to 14.52 | Yes | **** | <0.0001 | A-N |
| **C_2x_D vs. E_2x_F** | 15.58 | 12.40 to 18.76 | Yes | **** | <0.0001 | A-O |
| **C_2x_D vs. E_4x_F** | 10.02 | 1.226 to 18.81 | Yes | ** | 0.0094 | A-P |
| **C_4x_D vs. E_2x_D** | 10.03 | 6.310 to 13.76 | Yes | **** | <0.0001 | B-C |
| **C_4x_D vs. E_4x_D** | 2.32 | -6.654 to 11.29 | No | ns | >0.9999 | B-D |
| **C_4x_D vs. C_2x_S** | 6.97 | 3.031 to 10.92 | Yes | **** | <0.0001 | B-E |
| **C_4x_D vs. C_4x_S** | 3.56 | -0.8060 to 7.921 | No | ns | 0.2708 | B-F |
| **C_4x_D vs. E_2x_S** | 10.20 | 6.535 to 13.87 | Yes | **** | <0.0001 | B-G |
| **C_4x_D vs. E_4x_S** | 1.88 | -7.092 to 10.86 | No | ns | >0.9999 | B-H |
| **C_4x_D vs. C_2x_N** | -21.64 | -25.60 to -17.68 | Yes | **** | <0.0001 | B-I |
| **C_4x_D vs. C_4x_N** | -25.52 | -29.88 to -21.15 | Yes | **** | <0.0001 | B-J |
| **C_4x_D vs. E_2x_N** | -19.84 | -23.53 to -16.15 | Yes | **** | <0.0001 | B-K |
| **C_4x_D vs. E_4x_N** | -27.32 | -36.29 to -18.34 | Yes | **** | <0.0001 | B-L |
| **C_4x_D vs. C_2x_F** | 21.06 | 17.12 to 25.00 | Yes | **** | <0.0001 | B-M |
| **C_4x_D vs. C_4x_F** | 17.70 | 13.33 to 22.06 | Yes | **** | <0.0001 | B-N |
| **C_4x_D vs. E_2x_F** | 22.74 | 19.08 to 26.39 | Yes | **** | <0.0001 | B-O |
| **C_4x_D vs. E_4x_F** | 17.17 | 8.196 to 26.14 | Yes | **** | <0.0001 | B-P |
| **E_2x_D vs. E_4x_D** | -7.71 | -16.37 to 0.9392 | No | ns | 0.1461 | C-D |
| **E_2x_D vs. C_2x_S** | -3.06 | -6.203 to 0.08340 | No | ns | 0.0663 | C-E |
| **E_2x_D vs. C_4x_S** | -6.48 | -10.13 to -2.817 | Yes | **** | <0.0001 | C-F |
| **E_2x_D vs. E_2x_S** | 0.17 | -2.623 to 2.964 | No | ns | >0.9999 | C-G |
| **E_2x_D vs. E_4x_S** | -8.15 | -16.80 to 0.5017 | No | ns | 0.0911 | C-H |
| **E_2x_D vs. C_2x_N** | -31.67 | -34.83 to -28.51 | Yes | **** | <0.0001 | C-I |
| **E_2x_D vs. C_4x_N** | -35.55 | -39.21 to -31.89 | Yes | **** | <0.0001 | C-J |
| **E_2x_D vs. E_2x_N** | -29.87 | -32.70 to -27.05 | Yes | **** | <0.0001 | C-K |
| **E_2x_D vs. E_4x_N** | -37.35 | -46.00 to -28.70 | Yes | **** | <0.0001 | C-L |
| **E_2x_D vs. C_2x_F** | 11.02 | 7.881 to 14.17 | Yes | **** | <0.0001 | C-M |
| **E_2x_D vs. C_4x_F** | 7.67 | 4.007 to 11.32 | Yes | **** | <0.0001 | C-N |
| **E_2x_D vs. E_2x_F** | 12.70 | 9.927 to 15.48 | Yes | **** | <0.0001 | C-O |
| **E_2x_D vs. E_4x_F** | 7.14 | -1.516 to 15.79 | No | ns | 0.2524 | C-P |
| **E_4x_D vs. C_2x_S** | 4.65 | -4.095 to 13.40 | No | ns | 0.9068 | D-E |
| **E_4x_D vs. C_4x_S** | 1.24 | -7.709 to 10.19 | No | ns | >0.9999 | D-F |
| **E_4x_D vs. E_2x_S** | 7.88 | -0.7453 to 16.51 | No | ns | 0.1194 | D-G |
| **E_4x_D vs. E_4x_S** | -0.44 | -12.33 to 11.46 | No | ns | >0.9999 | D-H |
| **E_4x_D vs. C_2x_N** | -23.96 | -32.71 to -15.20 | Yes | **** | <0.0001 | D-I |
| **E_4x_D vs. C_4x_N** | -27.84 | -36.78 to -18.89 | Yes | **** | <0.0001 | D-J |
| **E_4x_D vs. E_2x_N** | -22.16 | -30.80 to -13.52 | Yes | **** | <0.0001 | D-K |
| **E_4x_D vs. E_4x_N** | -29.64 | -41.53 to -17.74 | Yes | **** | <0.0001 | D-L |
| **E_4x_D vs. C_2x_F** | 18.74 | 9.989 to 27.49 | Yes | **** | <0.0001 | D-M |
| **E_4x_D vs. C_4x_F** | 15.38 | 6.432 to 24.33 | Yes | **** | <0.0001 | D-N |
| **E_4x_D vs. E_2x_F** | 20.42 | 11.79 to 29.04 | Yes | **** | <0.0001 | D-O |
| **E_4x_D vs. E_4x_F** | 14.85 | 2.953 to 26.75 | Yes | ** | 0.0021 | D-P |
| **C_2x_S vs. C_4x_S** | -3.42 | -7.296 to 0.4650 | No | ns | 0.1612 | E-F |
| **C_2x_S vs. E_2x_S** | 3.23 | 0.1519 to 6.309 | Yes | * | 0.0287 | E-G |
| **C_2x_S vs. E_4x_S** | -5.09 | -13.84 to 3.658 | No | ns | 0.8264 | E-H |
| **C_2x_S vs. C_2x_N** | -28.61 | -32.03 to -25.20 | Yes | **** | <0.0001 | E-I |
| **C_2x_S vs. C_4x_N** | -32.49 | -36.37 to -28.61 | Yes | **** | <0.0001 | E-J |
| **C_2x_S vs. E_2x_N** | -26.81 | -29.92 to -23.71 | Yes | **** | <0.0001 | E-K |
| **C_2x_S vs. E_4x_N** | -34.29 | -43.04 to -25.54 | Yes | **** | <0.0001 | E-L |
| **C_2x_S vs. C_2x_F** | 14.08 | 10.68 to 17.48 | Yes | **** | <0.0001 | E-M |
| **C_2x_S vs. C_4x_F** | 10.73 | 6.845 to 14.61 | Yes | **** | <0.0001 | E-N |
| **C_2x_S vs. E_2x_F** | 15.76 | 12.70 to 18.83 | Yes | **** | <0.0001 | E-O |
| **C_2x_S vs. E_4x_F** | 10.20 | 1.447 to 18.95 | Yes | ** | 0.0067 | E-P |

# Appendix 5

## Plant height 2013

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| C_4x_S vs. E_2x_S | 6.65 | 3.043 to 10.25 | Yes | **** | <0.0001 | F-G |
| C_4x_S vs. E_4x_S | -1.68 | -10.62 to 7.271 | No | ns | >0.9999 | F-H |
| C_4x_S vs. C_2x_N | -25.20 | -29.09 to -21.30 | Yes | **** | <0.0001 | F-I |
| C_4x_S vs. C_4x_N | -29.08 | -33.38 to -24.77 | Yes | **** | <0.0001 | F-J |
| C_4x_S vs. E_2x_N | -23.40 | -27.03 to -19.77 | Yes | **** | <0.0001 | F-K |
| C_4x_S vs. E_4x_N | -30.88 | -39.82 to -21.93 | Yes | **** | <0.0001 | F-L |
| C_4x_S vs. C_2x_F | 17.50 | 13.62 to 21.38 | Yes | **** | <0.0001 | F-M |
| C_4x_S vs. C_4x_F | 14.14 | 9.833 to 18.45 | Yes | **** | <0.0001 | F-N |
| C_4x_S vs. E_2x_F | 19.18 | 15.59 to 22.77 | Yes | **** | <0.0001 | F-O |
| C_4x_S vs. E_4x_F | 13.61 | 4.665 to 22.56 | Yes | **** | <0.0001 | F-P |
| E_2x_S vs. E_4x_S | -8.32 | -16.95 to 0.3078 | No | ns | 0.0728 | G-H |
| E_2x_S vs. C_2x_N | -31.84 | -34.94 to -28.74 | Yes | **** | <0.0001 | G-I |
| E_2x_S vs. C_4x_N | -35.72 | -39.32 to -32.12 | Yes | **** | <0.0001 | G-J |
| E_2x_S vs. E_2x_N | -30.05 | -32.80 to -27.29 | Yes | **** | <0.0001 | G-K |
| E_2x_S vs. E_4x_N | -37.52 | -46.15 to -28.89 | Yes | **** | <0.0001 | G-L |
| E_2x_S vs. C_2x_F | 10.85 | 7.775 to 13.93 | Yes | **** | <0.0001 | G-M |
| E_2x_S vs. C_4x_F | 7.50 | 3.892 to 11.10 | Yes | **** | <0.0001 | G-N |
| E_2x_S vs. E_2x_F | 12.53 | 9.830 to 15.24 | Yes | **** | <0.0001 | G-O |
| E_2x_S vs. E_4x_F | 6.97 | -1.664 to 15.60 | No | ns | 0.2871 | G-P |
| E_4x_S vs. C_2x_N | -23.52 | -32.28 to -14.76 | Yes | **** | <0.0001 | H-I |
| E_4x_S vs. C_4x_N | -27.40 | -36.35 to -18.45 | Yes | **** | <0.0001 | H-J |
| E_4x_S vs. E_2x_N | -21.72 | -30.36 to -13.08 | Yes | **** | <0.0001 | H-K |
| E_4x_S vs. E_4x_N | -29.20 | -41.10 to -17.30 | Yes | **** | <0.0001 | H-L |
| E_4x_S vs. C_2x_F | 19.18 | 10.43 to 27.92 | Yes | **** | <0.0001 | H-M |
| E_4x_S vs. C_4x_F | 15.82 | 6.870 to 24.76 | Yes | **** | <0.0001 | H-N |
| E_4x_S vs. E_2x_F | 20.85 | 12.23 to 29.48 | Yes | **** | <0.0001 | H-O |
| E_4x_S vs. E_4x_F | 15.29 | 3.391 to 27.18 | Yes | ** | 0.0012 | H-P |
| C_2x_N vs. C_4x_N | -3.88 | -7.775 to 0.01719 | No | ns | 0.0524 | I-J |
| C_2x_N vs. E_2x_N | 1.80 | -1.329 to 4.924 | No | ns | 0.8396 | I-K |
| C_2x_N vs. E_4x_N | -5.68 | -14.44 to 3.077 | No | ns | 0.6779 | I-L |
| C_2x_N vs. C_2x_F | 42.70 | 39.28 to 46.11 | Yes | **** | <0.0001 | I-M |
| C_2x_N vs. C_4x_F | 39.34 | 35.44 to 43.23 | Yes | **** | <0.0001 | I-N |
| C_2x_N vs. E_2x_F | 44.38 | 41.29 to 47.46 | Yes | **** | <0.0001 | I-O |
| C_2x_N vs. E_4x_F | 38.81 | 30.05 to 47.56 | Yes | **** | <0.0001 | I-P |
| C_4x_N vs. E_2x_N | 5.68 | 2.048 to 9.303 | Yes | **** | <0.0001 | J-K |
| C_4x_N vs. E_4x_N | -1.80 | -10.75 to 7.147 | No | ns | >0.9999 | J-L |
| C_4x_N vs. C_2x_F | 46.57 | 42.69 to 50.46 | Yes | **** | <0.0001 | J-M |
| C_4x_N vs. C_4x_F | 43.22 | 38.91 to 47.52 | Yes | **** | <0.0001 | J-N |
| C_4x_N vs. E_2x_F | 48.25 | 44.66 to 51.84 | Yes | **** | <0.0001 | J-O |
| C_4x_N vs. E_4x_F | 42.69 | 33.74 to 51.63 | Yes | **** | <0.0001 | J-P |
| E_2x_N vs. E_4x_N | -7.48 | -16.12 to 1.163 | No | ns | 0.1829 | K-L |
| E_2x_N vs. C_2x_F | 40.90 | 37.79 to 44.01 | Yes | **** | <0.0001 | K-M |
| E_2x_N vs. C_4x_F | 37.54 | 33.91 to 41.17 | Yes | **** | <0.0001 | K-N |
| E_2x_N vs. E_2x_F | 42.58 | 39.84 to 45.31 | Yes | **** | <0.0001 | K-O |
| E_2x_N vs. E_4x_F | 37.01 | 28.37 to 45.65 | Yes | **** | <0.0001 | K-P |
| E_4x_N vs. C_2x_F | 48.38 | 39.63 to 57.12 | Yes | **** | <0.0001 | L-M |
| E_4x_N vs. C_4x_F | 45.02 | 36.07 to 53.96 | Yes | **** | <0.0001 | L-N |
| E_4x_N vs. E_2x_F | 50.05 | 41.43 to 58.68 | Yes | **** | <0.0001 | L-O |
| E_4x_N vs. E_4x_F | 44.49 | 32.59 to 56.38 | Yes | **** | <0.0001 | L-P |
| C_2x_F vs. C_4x_F | -3.36 | -7.239 to 0.5223 | No | ns | 0.1828 | M-N |
| C_2x_F vs. E_2x_F | 1.68 | -1.383 to 4.743 | No | ns | 0.8836 | M-O |
| C_2x_F vs. E_4x_F | -3.89 | -12.64 to 4.861 | No | ns | 0.9795 | M-P |
| C_4x_F vs. E_2x_F | 5.04 | 1.448 to 8.628 | Yes | *** | 0.0002 | N-O |
| C_4x_F vs. E_4x_F | -0.53 | -9.476 to 8.418 | No | ns | >0.9999 | N-P |
| E_2x_F vs. E_4x_F | -5.57 | -14.19 to 3.057 | No | ns | 0.6855 | O-P |

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| C_2x_D vs. C_4x_D | 65.55 | 72.71 | -7.15 | 1.18 | 87 | 58 | 8.61 | 1230 |
| C_2x_D vs. E_2x_D | 65.55 | 62.67 | 2.88 | 0.95 | 87 | 138 | 4.29 | 1230 |
| C_2x_D vs. E_4x_D | 65.55 | 70.39 | -4.83 | 2.56 | 87 | 8 | 2.67 | 1230 |
| C_2x_D vs. C_2x_S | 65.55 | 65.73 | -0.18 | 1.02 | 87 | 98 | 0.25 | 1230 |
| C_2x_D vs. C_4x_S | 65.55 | 69.15 | -3.60 | 1.16 | 87 | 61 | 4.39 | 1230 |
| C_2x_D vs. E_2x_S | 65.55 | 62.50 | 3.05 | 0.93 | 87 | 153 | 4.64 | 1230 |
| C_2x_D vs. E_4x_S | 65.55 | 70.83 | -5.27 | 2.56 | 87 | 8 | 2.91 | 1230 |
| C_2x_D vs. C_2x_N | 65.55 | 94.35 | -28.79 | 1.03 | 87 | 96 | 39.69 | 1230 |
| C_2x_D vs. C_4x_N | 65.55 | 98.22 | -32.67 | 1.16 | 87 | 61 | 39.92 | 1230 |

# Appendix 5

## Plant height 2013

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| C_2x_D vs. E_2x_N | 65.55 | 92.55 | -26.99 | 0.94 | 87 | 146 | 40.67 | 1230 |
| C_2x_D vs. E_4x_N | 65.55 | 100.00 | -34.47 | 2.56 | 87 | 8 | 19.04 | 1230 |
| C_2x_D vs. C_2x_F | 65.55 | 51.65 | 13.90 | 1.02 | 87 | 98 | 19.26 | 1230 |
| C_2x_D vs. C_4x_F | 65.55 | 55.01 | 10.55 | 1.16 | 87 | 61 | 12.89 | 1230 |
| C_2x_D vs. E_2x_F | 65.55 | 49.97 | 15.58 | 0.93 | 87 | 157 | 23.79 | 1230 |
| C_2x_D vs. E_4x_F | 65.55 | 55.54 | 10.02 | 2.56 | 87 | 8 | 5.53 | 1230 |
| C_4x_D vs. E_2x_D | 72.71 | 62.67 | 10.03 | 1.09 | 58 | 138 | 13.08 | 1230 |
| C_4x_D vs. E_4x_D | 72.71 | 70.39 | 2.32 | 2.61 | 58 | 8 | 1.26 | 1230 |
| C_4x_D vs. C_2x_S | 72.71 | 65.73 | 6.97 | 1.15 | 58 | 98 | 8.59 | 1230 |
| C_4x_D vs. C_4x_S | 72.71 | 69.15 | 3.56 | 1.27 | 58 | 61 | 3.96 | 1230 |
| C_4x_D vs. E_2x_S | 72.71 | 62.50 | 10.20 | 1.07 | 58 | 153 | 13.50 | 1230 |
| C_4x_D vs. E_4x_S | 72.71 | 70.83 | 1.88 | 2.61 | 58 | 8 | 1.02 | 1230 |
| C_4x_D vs. C_2x_N | 72.71 | 94.35 | -21.64 | 1.15 | 58 | 96 | 26.55 | 1230 |
| C_4x_D vs. C_4x_N | 72.71 | 98.22 | -25.52 | 1.27 | 58 | 61 | 28.39 | 1230 |
| C_4x_D vs. E_2x_N | 72.71 | 92.55 | -19.84 | 1.08 | 58 | 146 | 26.09 | 1230 |
| C_4x_D vs. E_4x_N | 72.71 | 100.00 | -27.32 | 2.61 | 58 | 8 | 14.78 | 1230 |
| C_4x_D vs. C_2x_F | 72.71 | 51.65 | 21.06 | 1.15 | 58 | 98 | 25.94 | 1230 |
| C_4x_D vs. C_4x_F | 72.71 | 55.01 | 17.70 | 1.27 | 58 | 61 | 19.69 | 1230 |
| C_4x_D vs. E_2x_F | 72.71 | 49.97 | 22.74 | 1.07 | 58 | 157 | 30.19 | 1230 |
| C_4x_D vs. E_4x_F | 72.71 | 55.54 | 17.17 | 2.61 | 58 | 8 | 9.29 | 1230 |
| E_2x_D vs. E_4x_D | 62.67 | 70.39 | -7.71 | 2.52 | 138 | 8 | 4.33 | 1230 |
| E_2x_D vs. C_2x_S | 62.67 | 65.73 | -3.06 | 0.92 | 138 | 98 | 4.73 | 1230 |
| E_2x_D vs. C_4x_S | 62.67 | 69.15 | -6.48 | 1.07 | 138 | 61 | 8.59 | 1230 |
| E_2x_D vs. E_2x_S | 62.67 | 62.50 | 0.17 | 0.81 | 138 | 153 | 0.30 | 1230 |
| E_2x_D vs. E_4x_S | 62.67 | 70.83 | -8.15 | 2.52 | 138 | 8 | 4.57 | 1230 |
| E_2x_D vs. C_2x_N | 62.67 | 94.35 | -31.67 | 0.92 | 138 | 96 | 48.63 | 1230 |
| E_2x_D vs. C_4x_N | 62.67 | 98.22 | -35.55 | 1.07 | 138 | 61 | 47.18 | 1230 |
| E_2x_D vs. E_2x_N | 62.67 | 92.55 | -29.87 | 0.82 | 138 | 146 | 51.35 | 1230 |
| E_2x_D vs. E_4x_N | 62.67 | 100.00 | -37.35 | 2.52 | 138 | 8 | 20.96 | 1230 |
| E_2x_D vs. C_2x_F | 62.67 | 51.65 | 11.02 | 0.92 | 138 | 98 | 17.03 | 1230 |
| E_2x_D vs. C_4x_F | 62.67 | 55.01 | 7.67 | 1.07 | 138 | 61 | 10.17 | 1230 |
| E_2x_D vs. E_2x_F | 62.67 | 49.97 | 12.70 | 0.81 | 138 | 157 | 22.22 | 1230 |
| E_2x_D vs. E_4x_F | 62.67 | 55.54 | 7.14 | 2.52 | 138 | 8 | 4.00 | 1230 |
| E_4x_D vs. C_2x_S | 70.39 | 65.73 | 4.65 | 2.55 | 8 | 98 | 2.58 | 1230 |
| E_4x_D vs. C_4x_S | 70.39 | 69.15 | 1.24 | 2.61 | 8 | 61 | 0.67 | 1230 |
| E_4x_D vs. E_2x_S | 70.39 | 62.50 | 7.88 | 2.51 | 8 | 153 | 4.44 | 1230 |
| E_4x_D vs. E_4x_S | 70.39 | 70.83 | -0.44 | 3.47 | 8 | 8 | 0.18 | 1230 |
| E_4x_D vs. C_2x_N | 70.39 | 94.35 | -23.96 | 2.55 | 8 | 96 | 13.29 | 1230 |
| E_4x_D vs. C_4x_N | 70.39 | 98.22 | -27.84 | 2.61 | 8 | 61 | 15.11 | 1230 |
| E_4x_D vs. E_2x_N | 70.39 | 92.55 | -22.16 | 2.52 | 8 | 146 | 12.45 | 1230 |
| E_4x_D vs. E_4x_N | 70.39 | 100.00 | -29.64 | 3.47 | 8 | 8 | 12.10 | 1230 |
| E_4x_D vs. C_2x_F | 70.39 | 51.65 | 18.74 | 2.55 | 8 | 98 | 10.40 | 1230 |
| E_4x_D vs. C_4x_F | 70.39 | 55.01 | 15.38 | 2.61 | 8 | 61 | 8.35 | 1230 |
| E_4x_D vs. E_2x_F | 70.39 | 49.97 | 20.42 | 2.51 | 8 | 157 | 11.49 | 1230 |
| E_4x_D vs. E_4x_F | 70.39 | 55.54 | 14.85 | 3.47 | 8 | 8 | 6.06 | 1230 |
| C_2x_S vs. C_4x_S | 65.73 | 69.15 | -3.42 | 1.13 | 98 | 61 | 4.27 | 1230 |
| C_2x_S vs. E_2x_S | 65.73 | 62.50 | 3.23 | 0.90 | 98 | 153 | 5.10 | 1230 |
| C_2x_S vs. E_4x_S | 65.73 | 70.83 | -5.09 | 2.55 | 98 | 8 | 2.83 | 1230 |
| C_2x_S vs. C_2x_N | 65.73 | 94.35 | -28.61 | 1.00 | 98 | 96 | 40.66 | 1230 |
| C_2x_S vs. C_4x_N | 65.73 | 98.22 | -32.49 | 1.13 | 98 | 61 | 40.65 | 1230 |
| C_2x_S vs. E_2x_N | 65.73 | 92.55 | -26.81 | 0.91 | 98 | 146 | 41.90 | 1230 |
| C_2x_S vs. E_4x_N | 65.73 | 100.00 | -34.29 | 2.55 | 98 | 8 | 19.03 | 1230 |
| C_2x_S vs. C_2x_F | 65.73 | 51.65 | 14.08 | 0.99 | 98 | 98 | 20.12 | 1230 |
| C_2x_S vs. C_4x_F | 65.73 | 55.01 | 10.73 | 1.13 | 98 | 61 | 13.42 | 1230 |
| C_2x_S vs. E_2x_F | 65.73 | 49.97 | 15.76 | 0.89 | 98 | 157 | 24.99 | 1230 |
| C_2x_S vs. E_4x_F | 65.73 | 55.54 | 10.20 | 2.55 | 98 | 8 | 5.66 | 1230 |
| C_4x_S vs. E_2x_S | 69.15 | 62.50 | 6.65 | 1.05 | 61 | 153 | 8.96 | 1230 |
| C_4x_S vs. E_4x_S | 69.15 | 70.83 | -1.68 | 2.61 | 61 | 8 | 0.91 | 1230 |
| C_4x_S vs. C_2x_N | 69.15 | 94.35 | -25.20 | 1.14 | 61 | 96 | 31.40 | 1230 |
| C_4x_S vs. C_4x_N | 69.15 | 98.22 | -29.08 | 1.26 | 61 | 61 | 32.77 | 1230 |
| C_4x_S vs. E_2x_N | 69.15 | 92.55 | -23.40 | 1.06 | 61 | 146 | 31.32 | 1230 |
| C_4x_S vs. E_4x_N | 69.15 | 100.00 | -30.88 | 2.61 | 61 | 8 | 16.76 | 1230 |
| C_4x_S vs. C_2x_F | 69.15 | 51.65 | 17.50 | 1.13 | 61 | 98 | 21.90 | 1230 |
| C_4x_S vs. C_4x_F | 69.15 | 55.01 | 14.14 | 1.26 | 61 | 61 | 15.94 | 1230 |
| C_4x_S vs. E_2x_F | 69.15 | 49.97 | 19.18 | 1.05 | 61 | 157 | 25.94 | 1230 |
| C_4x_S vs. E_4x_F | 69.15 | 55.54 | 13.61 | 2.61 | 61 | 8 | 7.39 | 1230 |

# Appendix 5

## Plant height 2013

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| **E_2x_S vs. E_4x_S** | 62.50 | 70.83 | -8.32 | 2.51 | 153 | 8 | 4.68 | 1230 |
| **E_2x_S vs. C_2x_N** | 62.50 | 94.35 | -31.84 | 0.90 | 153 | 96 | 49.90 | 1230 |
| **E_2x_S vs. C_4x_N** | 62.50 | 98.22 | -35.72 | 1.05 | 153 | 61 | 48.14 | 1230 |
| **E_2x_S vs. E_2x_N** | 62.50 | 92.55 | -30.05 | 0.80 | 153 | 146 | 52.99 | 1230 |
| **E_2x_S vs. E_4x_N** | 62.50 | 100.00 | -37.52 | 2.51 | 153 | 8 | 21.11 | 1230 |
| **E_2x_S vs. C_2x_F** | 62.50 | 51.65 | 10.85 | 0.90 | 153 | 98 | 17.12 | 1230 |
| **E_2x_S vs. C_4x_F** | 62.50 | 55.01 | 7.50 | 1.05 | 153 | 61 | 10.10 | 1230 |
| **E_2x_S vs. E_2x_F** | 62.50 | 49.97 | 12.53 | 0.79 | 153 | 157 | 22.51 | 1230 |
| **E_2x_S vs. E_4x_F** | 62.50 | 55.54 | 6.97 | 2.51 | 153 | 8 | 3.92 | 1230 |
| **E_4x_S vs. C_2x_N** | 70.83 | 94.35 | -23.52 | 2.55 | 8 | 96 | 13.04 | 1230 |
| **E_4x_S vs. C_4x_N** | 70.83 | 98.22 | -27.40 | 2.61 | 8 | 61 | 14.87 | 1230 |
| **E_4x_S vs. E_2x_N** | 70.83 | 92.55 | -21.72 | 2.52 | 8 | 146 | 12.21 | 1230 |
| **E_4x_S vs. E_4x_N** | 70.83 | 100.00 | -29.20 | 3.47 | 8 | 8 | 11.92 | 1230 |
| **E_4x_S vs. C_2x_F** | 70.83 | 51.65 | 19.18 | 2.55 | 8 | 98 | 10.64 | 1230 |
| **E_4x_S vs. C_4x_F** | 70.83 | 55.01 | 15.82 | 2.61 | 8 | 61 | 8.58 | 1230 |
| **E_4x_S vs. E_2x_F** | 70.83 | 49.97 | 20.85 | 2.51 | 8 | 157 | 11.74 | 1230 |
| **E_4x_S vs. E_4x_F** | 70.83 | 55.54 | 15.29 | 3.47 | 8 | 8 | 6.24 | 1230 |
| **C_2x_N vs. C_4x_N** | 94.35 | 98.22 | -3.88 | 1.14 | 96 | 61 | 4.83 | 1230 |
| **C_2x_N vs. E_2x_N** | 94.35 | 92.55 | 1.80 | 0.91 | 96 | 146 | 2.79 | 1230 |
| **C_2x_N vs. E_4x_N** | 94.35 | 100.00 | -5.68 | 2.55 | 96 | 8 | 3.15 | 1230 |
| **C_2x_N vs. C_2x_F** | 94.35 | 51.65 | 42.70 | 1.00 | 96 | 98 | 60.67 | 1230 |
| **C_2x_N vs. C_4x_F** | 94.35 | 55.01 | 39.34 | 1.14 | 96 | 61 | 49.02 | 1230 |
| **C_2x_N vs. E_2x_F** | 94.35 | 49.97 | 44.38 | 0.90 | 96 | 157 | 69.89 | 1230 |
| **C_2x_N vs. E_4x_F** | 94.35 | 55.54 | 38.81 | 2.55 | 96 | 8 | 21.52 | 1230 |
| **C_4x_N vs. E_2x_N** | 98.22 | 92.55 | 5.68 | 1.06 | 61 | 146 | 7.60 | 1230 |
| **C_4x_N vs. E_4x_N** | 98.22 | 100.00 | -1.80 | 2.61 | 61 | 8 | 0.98 | 1230 |
| **C_4x_N vs. C_2x_F** | 98.22 | 51.65 | 46.57 | 1.13 | 61 | 98 | 58.28 | 1230 |
| **C_4x_N vs. C_4x_F** | 98.22 | 55.01 | 43.22 | 1.26 | 61 | 61 | 48.70 | 1230 |
| **C_4x_N vs. E_2x_F** | 98.22 | 49.97 | 48.25 | 1.05 | 61 | 157 | 65.26 | 1230 |
| **C_4x_N vs. E_4x_F** | 98.22 | 55.54 | 42.69 | 2.61 | 61 | 8 | 23.17 | 1230 |
| **E_2x_N vs. E_4x_N** | 92.55 | 100.00 | -7.48 | 2.52 | 146 | 8 | 4.20 | 1230 |
| **E_2x_N vs. C_2x_F** | 92.55 | 51.65 | 40.90 | 0.91 | 146 | 98 | 63.91 | 1230 |
| **E_2x_N vs. C_4x_F** | 92.55 | 55.01 | 37.54 | 1.06 | 146 | 61 | 50.25 | 1230 |
| **E_2x_N vs. E_2x_F** | 92.55 | 49.97 | 42.58 | 0.80 | 146 | 157 | 75.57 | 1230 |
| **E_2x_N vs. E_4x_F** | 92.55 | 55.54 | 37.01 | 2.52 | 146 | 8 | 20.80 | 1230 |
| **E_4x_N vs. C_2x_F** | 100.00 | 51.65 | 48.38 | 2.55 | 8 | 98 | 26.85 | 1230 |
| **E_4x_N vs. C_4x_F** | 100.00 | 55.01 | 45.02 | 2.61 | 8 | 61 | 24.43 | 1230 |
| **E_4x_N vs. E_2x_F** | 100.00 | 49.97 | 50.05 | 2.51 | 8 | 157 | 28.18 | 1230 |
| **E_4x_N vs. E_4x_F** | 100.00 | 55.54 | 44.49 | 3.47 | 8 | 8 | 18.16 | 1230 |
| **C_2x_F vs. C_4x_F** | 51.65 | 55.01 | -3.36 | 1.13 | 98 | 61 | 4.20 | 1230 |
| **C_2x_F vs. E_2x_F** | 51.65 | 49.97 | 1.68 | 0.89 | 98 | 157 | 2.66 | 1230 |
| **C_2x_F vs. E_4x_F** | 51.65 | 55.54 | -3.89 | 2.55 | 98 | 8 | 2.16 | 1230 |
| **C_4x_F vs. E_2x_F** | 55.01 | 49.97 | 5.04 | 1.05 | 61 | 157 | 6.81 | 1230 |
| **C_4x_F vs. E_4x_F** | 55.01 | 55.54 | -0.53 | 2.61 | 61 | 8 | 0.29 | 1230 |
| **E_2x_F vs. E_4x_F** | 49.97 | 55.54 | -5.57 | 2.51 | 157 | 8 | 3.13 | 1230 |

# Appendix 5

## Regrowth 2013

**Table 3: Tukey's multiple comparisons test for Regrowth 2013**

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| C_2x_D vs. C_4x_D | -0.46 | -0.8868 to -0.03391 | Yes | * | 0.02 | A-B |
| C_2x_D vs. E_2x_D | 0.25 | -0.08781 to 0.5873 | No | ns | 0.4426 | A-C |
| C_2x_D vs. E_4x_D | -0.35 | -1.320 to 0.6287 | No | ns | 0.998 | A-D |
| C_2x_D vs. C_2x_S | 0.86 | 0.4835 to 1.237 | Yes | **** | <0.0001 | A-E |
| C_2x_D vs. C_4x_S | 0.91 | 0.4777 to 1.339 | Yes | **** | <0.0001 | A-F |
| C_2x_D vs. E_2x_S | 0.92 | 0.5801 to 1.261 | Yes | **** | <0.0001 | A-G |
| C_2x_D vs. E_4x_S | 0.93 | -0.04466 to 1.904 | No | ns | 0.0807 | A-H |
| C_2x_D vs. C_2x_N | -0.53 | -0.9071 to -0.1553 | Yes | *** | 0.0002 | A-I |
| C_2x_D vs. C_4x_N | -1.06 | -1.485 to -0.6278 | Yes | **** | <0.0001 | A-J |
| C_2x_D vs. E_2x_N | -0.36 | -0.6997 to -0.01954 | Yes | * | 0.0261 | A-K |
| C_2x_D vs. E_4x_N | -1.33 | -2.307 to -0.3588 | Yes | *** | 0.0003 | A-L |
| C_2x_D vs. C_2x_F | 0.91 | 0.5325 to 1.286 | Yes | **** | <0.0001 | A-M |
| C_2x_D vs. C_4x_F | 0.26 | -0.1748 to 0.6867 | No | ns | 0.8024 | A-N |
| C_2x_D vs. E_2x_F | 0.92 | 0.5846 to 1.263 | Yes | **** | <0.0001 | A-O |
| C_2x_D vs. E_4x_F | -0.47 | -1.445 to 0.5037 | No | ns | 0.9569 | A-P |
| C_4x_D vs. E_2x_D | 0.71 | 0.3161 to 1.104 | Yes | **** | <0.0001 | B-C |
| C_4x_D vs. E_4x_D | 0.11 | -0.8802 to 1.110 | No | ns | >0.9999 | B-D |
| C_4x_D vs. C_2x_S | 1.32 | 0.8926 to 1.749 | Yes | **** | <0.0001 | B-E |
| C_4x_D vs. C_4x_S | 1.37 | 0.8925 to 1.845 | Yes | **** | <0.0001 | B-F |
| C_4x_D vs. E_2x_S | 1.38 | 0.9844 to 1.777 | Yes | **** | <0.0001 | B-G |
| C_4x_D vs. E_4x_S | 1.39 | 0.3948 to 2.385 | Yes | *** | 0.0002 | B-H |
| C_4x_D vs. C_2x_N | -0.07 | -0.4982 to 0.3564 | No | ns | >0.9999 | B-I |
| C_4x_D vs. C_4x_N | -0.6 | -1.070 to -0.1217 | Yes | ** | 0.0018 | B-J |
| C_4x_D vs. E_2x_N | 0.1 | -0.2954 to 0.4969 | No | ns | >0.9999 | B-K |
| C_4x_D vs. E_4x_N | -0.87 | -1.868 to 0.1225 | No | ns | 0.1659 | B-L |
| C_4x_D vs. C_2x_F | 1.37 | 0.9416 to 1.798 | Yes | **** | <0.0001 | B-M |
| C_4x_D vs. C_4x_F | 0.72 | 0.2401 to 1.193 | Yes | **** | <0.0001 | B-N |
| C_4x_D vs. E_2x_F | 1.38 | 0.9888 to 1.780 | Yes | **** | <0.0001 | B-O |
| C_4x_D vs. E_4x_F | -0.01 | -1.005 to 0.9850 | No | ns | >0.9999 | B-P |
| E_2x_D vs. E_4x_D | -0.6 | -1.556 to 0.3651 | No | ns | 0.7469 | C-D |
| E_2x_D vs. C_2x_S | 0.61 | 0.2709 to 0.9503 | Yes | **** | <0.0001 | C-E |
| E_2x_D vs. C_4x_S | 0.66 | 0.2600 to 1.057 | Yes | **** | <0.0001 | C-F |
| E_2x_D vs. E_2x_S | 0.67 | 0.3720 to 0.9697 | Yes | **** | <0.0001 | C-G |
| E_2x_D vs. E_4x_S | 0.68 | -0.2807 to 1.640 | No | ns | 0.5253 | C-H |
| E_2x_D vs. C_2x_N | -0.78 | -1.120 to -0.4424 | Yes | **** | <0.0001 | C-I |
| E_2x_D vs. C_4x_N | -1.31 | -1.702 to -0.9099 | Yes | **** | <0.0001 | C-J |
| E_2x_D vs. E_2x_N | -0.61 | -0.9077 to -0.3110 | Yes | **** | <0.0001 | C-K |
| E_2x_D vs. E_4x_N | -1.58 | -2.543 to -0.6224 | Yes | **** | <0.0001 | C-L |
| E_2x_D vs. C_2x_F | 0.66 | 0.3199 to 0.9993 | Yes | **** | <0.0001 | C-M |
| E_2x_D vs. C_4x_F | 0.01 | -0.3925 to 0.4048 | No | ns | >0.9999 | C-N |
| E_2x_D vs. E_2x_F | 0.67 | 0.3767 to 0.9715 | Yes | **** | <0.0001 | C-O |
| E_2x_D vs. E_4x_F | -0.72 | -1.681 to 0.2401 | No | ns | 0.4175 | C-P |
| E_4x_D vs. C_2x_S | 1.21 | 0.2310 to 2.181 | Yes | ** | 0.0025 | D-E |
| E_4x_D vs. C_4x_S | 1.25 | 0.2569 to 2.251 | Yes | ** | 0.0018 | D-F |
| E_4x_D vs. E_2x_S | 1.27 | 0.3046 to 2.227 | Yes | *** | 0.0007 | D-G |
| E_4x_D vs. E_4x_S | 1.28 | -0.05066 to 2.601 | No | ns | 0.0747 | D-H |
| E_4x_D vs. C_2x_N | -0.19 | -1.160 to 0.7888 | No | ns | >0.9999 | D-I |
| E_4x_D vs. C_4x_N | -0.71 | -1.707 to 0.2851 | No | ns | 0.5097 | D-J |
| E_4x_D vs. E_2x_N | -0.01 | -0.9754 to 0.9472 | No | ns | >0.9999 | D-K |
| E_4x_D vs. E_4x_N | -0.99 | -2.313 to 0.3382 | No | ns | 0.43 | D-L |
| E_4x_D vs. C_2x_F | 1.26 | 0.2800 to 2.230 | Yes | ** | 0.0012 | D-M |
| E_4x_D vs. C_4x_F | 0.6 | -0.3955 to 1.598 | No | ns | 0.7835 | D-N |
| E_4x_D vs. E_2x_F | 1.27 | 0.3084 to 2.230 | Yes | *** | 0.0007 | D-O |
| E_4x_D vs. E_4x_F | -0.13 | -1.451 to 1.201 | No | ns | >0.9999 | D-P |
| C_2x_S vs. C_4x_S | 0.05 | -0.3844 to 0.4804 | No | ns | >0.9999 | E-F |
| C_2x_S vs. E_2x_S | 0.06 | -0.2824 to 0.4028 | No | ns | >0.9999 | E-G |
| C_2x_S vs. E_4x_S | 0.07 | -0.9058 to 1.044 | No | ns | >0.9999 | E-H |
| C_2x_S vs. C_2x_N | -1.39 | -1.769 to -1.014 | Yes | **** | <0.0001 | E-I |
| C_2x_S vs. C_4x_N | -1.92 | -2.347 to -1.487 | Yes | **** | <0.0001 | E-J |
| C_2x_S vs. E_2x_N | -1.22 | -1.562 to -0.8778 | Yes | **** | <0.0001 | E-K |
| C_2x_S vs. E_4x_N | -2.19 | -3.168 to -1.218 | Yes | **** | <0.0001 | E-L |
| C_2x_S vs. C_2x_F | 0.05 | -0.3298 to 0.4277 | No | ns | >0.9999 | E-M |
| C_2x_S vs. C_4x_F | -0.6 | -1.037 to -0.1720 | Yes | *** | 0.0002 | E-N |
| C_2x_S vs. E_2x_F | 0.06 | -0.2778 to 0.4048 | No | ns | >0.9999 | E-O |
| C_2x_S vs. E_4x_F | -1.33 | -2.306 to -0.3560 | Yes | *** | 0.0003 | E-P |

# Appendix 5

## Regrowth 2013

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| C_4x_S vs. E_2x_S | 0.01 | -0.3889 to 0.4133 | No | ns | >0.9999 | F-G |
| C_4x_S vs. E_4x_S | 0.02 | -0.9759 to 1.018 | No | ns | >0.9999 | F-H |
| C_4x_S vs. C_2x_N | -1.44 | -1.871 to -1.008 | Yes | **** | <0.0001 | F-I |
| C_4x_S vs. C_4x_N | -1.97 | -2.443 to -1.487 | Yes | **** | <0.0001 | F-J |
| C_4x_S vs. E_2x_N | -1.27 | -1.669 to -0.8673 | Yes | **** | <0.0001 | F-K |
| C_4x_S vs. E_4x_N | -2.24 | -3.238 to -1.244 | Yes | **** | <0.0001 | F-L |
| C_4x_S vs. C_2x_F | 0 | -0.4314 to 0.4334 | No | ns | >0.9999 | F-M |
| C_4x_S vs. C_4x_F | -0.65 | -1.133 to -0.1724 | Yes | *** | 0.0004 | F-N |
| C_4x_S vs. E_2x_F | 0.02 | -0.3846 to 0.4155 | No | ns | >0.9999 | F-O |
| C_4x_S vs. E_4x_F | -1.38 | -2.376 to -0.3819 | Yes | *** | 0.0003 | F-P |
| E_2x_S vs. E_4x_S | 0.01 | -0.9525 to 0.9704 | No | ns | >0.9999 | G-H |
| E_2x_S vs. C_2x_N | -1.45 | -1.793 to -1.110 | Yes | **** | <0.0001 | G-I |
| E_2x_S vs. C_4x_N | -1.98 | -2.376 to -1.578 | Yes | **** | <0.0001 | G-J |
| E_2x_S vs. E_2x_N | -1.28 | -1.582 to -0.9785 | Yes | **** | <0.0001 | G-K |
| E_2x_S vs. E_4x_N | -2.25 | -3.215 to -1.292 | Yes | **** | <0.0001 | G-L |
| E_2x_S vs. C_2x_F | -0.01 | -0.3538 to 0.3314 | No | ns | >0.9999 | G-M |
| E_2x_S vs. C_4x_F | -0.66 | -1.066 to -0.2635 | Yes | **** | <0.0001 | G-N |
| E_2x_S vs. E_2x_F | 0 | -0.2974 to 0.3040 | No | ns | >0.9999 | G-O |
| E_2x_S vs. E_4x_F | -1.39 | -2.352 to -0.4296 | Yes | **** | <0.0001 | G-P |
| E_4x_S vs. C_2x_N | -1.46 | -2.435 to -0.4862 | Yes | **** | <0.0001 | H-I |
| E_4x_S vs. C_4x_N | -1.99 | -2.982 to -0.9899 | Yes | **** | <0.0001 | H-J |
| E_4x_S vs. E_2x_N | -1.29 | -2.250 to -0.3278 | Yes | *** | 0.0005 | H-K |
| E_4x_S vs. E_4x_N | -2.26 | -3.588 to -0.9368 | Yes | **** | <0.0001 | H-L |
| E_4x_S vs. C_2x_F | -0.02 | -0.9950 to 0.9547 | No | ns | >0.9999 | H-M |
| E_4x_S vs. C_4x_F | -0.67 | -1.671 to 0.3234 | No | ns | 0.6093 | H-N |
| E_4x_S vs. E_2x_F | -0.01 | -0.9666 to 0.9553 | No | ns | >0.9999 | H-O |
| E_4x_S vs. E_4x_F | -1.4 | -2.726 to -0.07434 | Yes | * | 0.0265 | H-P |
| C_2x_N vs. C_4x_N | -0.53 | -0.9546 to -0.09575 | Yes | ** | 0.003 | I-J |
| C_2x_N vs. E_2x_N | 0.17 | -0.1695 to 0.5127 | No | ns | 0.9396 | I-K |
| C_2x_N vs. E_4x_N | -0.8 | -1.776 to 0.1728 | No | ns | 0.2564 | I-L |
| C_2x_N vs. C_2x_F | 1.44 | 1.063 to 1.818 | Yes | **** | <0.0001 | I-M |
| C_2x_N vs. C_4x_F | 0.79 | 0.3556 to 1.219 | Yes | **** | <0.0001 | I-N |
| C_2x_N vs. E_2x_F | 1.46 | 1.115 to 1.795 | Yes | **** | <0.0001 | I-O |
| C_2x_N vs. E_4x_F | 0.06 | -0.9138 to 1.035 | No | ns | >0.9999 | I-P |
| C_4x_N vs. E_2x_N | 0.7 | 0.2984 to 1.095 | Yes | **** | <0.0001 | J-K |
| C_4x_N vs. E_4x_N | -0.28 | -1.273 to 0.7194 | No | ns | 0.9999 | J-L |
| C_4x_N vs. C_2x_F | 1.97 | 1.535 to 2.396 | Yes | **** | <0.0001 | J-M |
| C_4x_N vs. C_4x_F | 1.31 | 0.8342 to 1.790 | Yes | **** | <0.0001 | J-N |
| C_4x_N vs. E_2x_F | 1.98 | 1.583 to 2.378 | Yes | **** | <0.0001 | J-O |
| C_4x_N vs. E_4x_F | 0.59 | -0.4101 to 1.582 | No | ns | 0.8143 | J-P |
| E_2x_N vs. E_4x_N | -0.97 | -1.935 to -0.01211 | Yes | * | 0.0436 | K-L |
| E_2x_N vs. C_2x_F | 1.27 | 0.9268 to 1.611 | Yes | **** | <0.0001 | K-M |
| E_2x_N vs. C_4x_F | 0.62 | 0.2148 to 1.016 | Yes | **** | <0.0001 | K-N |
| E_2x_N vs. E_2x_F | 1.28 | 0.9832 to 1.584 | Yes | **** | <0.0001 | K-O |
| E_2x_N vs. E_4x_F | -0.11 | -1.072 to 0.8504 | No | ns | >0.9999 | K-P |
| E_4x_N vs. C_2x_F | 2.24 | 1.267 to 3.217 | Yes | **** | <0.0001 | L-M |
| E_4x_N vs. C_4x_F | 1.59 | 0.5920 to 2.586 | Yes | **** | <0.0001 | L-N |
| E_4x_N vs. E_2x_F | 2.26 | 1.296 to 3.218 | Yes | **** | <0.0001 | L-O |
| E_4x_N vs. E_4x_F | 0.86 | -0.4632 to 2.188 | No | ns | 0.6731 | L-P |
| C_2x_F vs. C_4x_F | -0.65 | -1.086 to -0.2210 | Yes | **** | <0.0001 | M-N |
| C_2x_F vs. E_2x_F | 0.01 | -0.3268 to 0.3558 | No | ns | >0.9999 | M-O |
| C_2x_F vs. E_4x_F | -1.38 | -2.355 to -0.4050 | Yes | *** | 0.0002 | M-P |
| C_4x_F vs. E_2x_F | 0.67 | 0.2679 to 1.068 | Yes | **** | <0.0001 | N-O |
| C_4x_F vs. E_4x_F | -0.73 | -1.723 to 0.2705 | No | ns | 0.4712 | N-P |
| E_2x_F vs. E_4x_F | -1.39 | -2.355 to -0.4334 | Yes | **** | <0.0001 | O-P |

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| C_2x_D vs. C_4x_D | 5.19 | 5.65 | -0.46 | 0.12 | 100 | 63 | 5.24 | 1285 |
| C_2x_D vs. E_2x_D | 5.19 | 4.94 | 0.25 | 0.1 | 100 | 161 | 3.59 | 1285 |
| C_2x_D vs. E_4x_D | 5.19 | 5.54 | -0.35 | 0.28 | 100 | 8 | 1.72 | 1285 |
| C_2x_D vs. C_2x_S | 5.19 | 4.33 | 0.86 | 0.11 | 100 | 98 | 11.08 | 1285 |
| C_2x_D vs. C_4x_S | 5.19 | 4.28 | 0.91 | 0.13 | 100 | 61 | 10.24 | 1285 |
| C_2x_D vs. E_2x_S | 5.19 | 4.27 | 0.92 | 0.1 | 100 | 154 | 13.13 | 1285 |
| C_2x_D vs. E_4x_S | 5.19 | 4.26 | 0.93 | 0.28 | 100 | 8 | 4.63 | 1285 |
| C_2x_D vs. C_2x_N | 5.19 | 5.72 | -0.53 | 0.11 | 100 | 99 | 6.86 | 1285 |
| C_2x_D vs. C_4x_N | 5.19 | 6.25 | -1.06 | 0.12 | 100 | 62 | 11.97 | 1285 |

# Appendix 5

## Regrowth 2013

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| C_2x_D vs. E_2x_N | 5.19 | 5.55 | -0.36 | 0.1 | 100 | 155 | 5.13 | 1285 |
| C_2x_D vs. E_4x_N | 5.19 | 6.53 | -1.33 | 0.28 | 100 | 8 | 6.64 | 1285 |
| C_2x_D vs. C_2x_F | 5.19 | 4.28 | 0.91 | 0.11 | 100 | 98 | 11.71 | 1285 |
| C_2x_D vs. C_4x_F | 5.19 | 4.94 | 0.26 | 0.13 | 100 | 61 | 2.89 | 1285 |
| C_2x_D vs. E_2x_F | 5.19 | 4.27 | 0.92 | 0.1 | 100 | 157 | 13.22 | 1285 |
| C_2x_D vs. E_4x_F | 5.19 | 5.66 | -0.47 | 0.28 | 100 | 8 | 2.35 | 1285 |
| C_4x_D vs. E_2x_D | 5.65 | 4.94 | 0.71 | 0.11 | 63 | 161 | 8.75 | 1285 |
| C_4x_D vs. E_4x_D | 5.65 | 5.54 | 0.11 | 0.29 | 63 | 8 | 0.56 | 1285 |
| C_4x_D vs. C_2x_S | 5.65 | 4.33 | 1.32 | 0.12 | 63 | 98 | 14.98 | 1285 |
| C_4x_D vs. C_4x_S | 5.65 | 4.28 | 1.37 | 0.14 | 63 | 61 | 13.95 | 1285 |
| C_4x_D vs. E_2x_S | 5.65 | 4.27 | 1.38 | 0.12 | 63 | 154 | 16.91 | 1285 |
| C_4x_D vs. E_4x_S | 5.65 | 4.26 | 1.39 | 0.29 | 63 | 8 | 6.78 | 1285 |
| C_4x_D vs. C_2x_N | 5.65 | 5.72 | -0.07 | 0.12 | 63 | 99 | 0.81 | 1285 |
| C_4x_D vs. C_4x_N | 5.65 | 6.25 | -0.6 | 0.14 | 63 | 62 | 6.1 | 1285 |
| C_4x_D vs. E_2x_N | 5.65 | 5.55 | 0.1 | 0.12 | 63 | 155 | 1.24 | 1285 |
| C_4x_D vs. E_4x_N | 5.65 | 6.53 | -0.87 | 0.29 | 63 | 8 | 4.26 | 1285 |
| C_4x_D vs. C_2x_F | 5.65 | 4.28 | 1.37 | 0.12 | 63 | 98 | 15.53 | 1285 |
| C_4x_D vs. C_4x_F | 5.65 | 4.94 | 0.72 | 0.14 | 63 | 61 | 7.3 | 1285 |
| C_4x_D vs. E_2x_F | 5.65 | 4.27 | 1.38 | 0.12 | 63 | 157 | 17 | 1285 |
| C_4x_D vs. E_4x_F | 5.65 | 5.66 | -0.01 | 0.29 | 63 | 8 | 0.05 | 1285 |
| E_2x_D vs. E_4x_D | 4.94 | 5.54 | -0.6 | 0.28 | 161 | 8 | 3.01 | 1285 |
| E_2x_D vs. C_2x_S | 4.94 | 4.33 | 0.61 | 0.1 | 161 | 98 | 8.73 | 1285 |
| E_2x_D vs. C_4x_S | 4.94 | 4.28 | 0.66 | 0.12 | 161 | 61 | 8.02 | 1285 |
| E_2x_D vs. E_2x_S | 4.94 | 4.27 | 0.67 | 0.09 | 161 | 154 | 10.9 | 1285 |
| E_2x_D vs. E_4x_S | 4.94 | 4.26 | 0.68 | 0.28 | 161 | 8 | 3.44 | 1285 |
| E_2x_D vs. C_2x_N | 4.94 | 5.72 | -0.78 | 0.1 | 161 | 99 | 11.2 | 1285 |
| E_2x_D vs. C_4x_N | 4.94 | 6.25 | -1.31 | 0.12 | 161 | 62 | 16 | 1285 |
| E_2x_D vs. E_2x_N | 4.94 | 5.55 | -0.61 | 0.09 | 161 | 155 | 9.92 | 1285 |
| E_2x_D vs. E_4x_N | 4.94 | 6.53 | -1.58 | 0.28 | 161 | 8 | 8 | 1285 |
| E_2x_D vs. C_2x_F | 4.94 | 4.28 | 0.66 | 0.1 | 161 | 98 | 9.43 | 1285 |
| E_2x_D vs. C_4x_F | 4.94 | 4.94 | 0.01 | 0.12 | 161 | 61 | 0.08 | 1285 |
| E_2x_D vs. E_2x_F | 4.94 | 4.27 | 0.67 | 0.09 | 161 | 157 | 11 | 1285 |
| E_2x_D vs. E_4x_F | 4.94 | 5.66 | -0.72 | 0.28 | 161 | 8 | 3.64 | 1285 |
| E_4x_D vs. C_2x_S | 5.54 | 4.33 | 1.21 | 0.28 | 8 | 98 | 6.01 | 1285 |
| E_4x_D vs. C_4x_S | 5.54 | 4.28 | 1.25 | 0.29 | 8 | 61 | 6.11 | 1285 |
| E_4x_D vs. E_2x_S | 5.54 | 4.27 | 1.27 | 0.28 | 8 | 154 | 6.39 | 1285 |
| E_4x_D vs. E_4x_S | 5.54 | 4.26 | 1.28 | 0.39 | 8 | 8 | 4.67 | 1285 |
| E_4x_D vs. C_2x_N | 5.54 | 5.72 | -0.19 | 0.28 | 8 | 99 | 0.93 | 1285 |
| E_4x_D vs. C_4x_N | 5.54 | 6.25 | -0.71 | 0.29 | 8 | 62 | 3.47 | 1285 |
| E_4x_D vs. E_2x_N | 5.54 | 5.55 | -0.01 | 0.28 | 8 | 155 | 0.07 | 1285 |
| E_4x_D vs. E_4x_N | 5.54 | 6.53 | -0.99 | 0.39 | 8 | 8 | 3.62 | 1285 |
| E_4x_D vs. C_2x_F | 5.54 | 4.28 | 1.26 | 0.28 | 8 | 98 | 6.25 | 1285 |
| E_4x_D vs. C_4x_F | 5.54 | 4.94 | 0.6 | 0.29 | 8 | 61 | 2.93 | 1285 |
| E_4x_D vs. E_2x_F | 5.54 | 4.27 | 1.27 | 0.28 | 8 | 157 | 6.41 | 1285 |
| E_4x_D vs. E_4x_F | 5.54 | 5.66 | -0.13 | 0.39 | 8 | 8 | 0.46 | 1285 |
| C_2x_S vs. C_4x_S | 4.33 | 4.28 | 0.05 | 0.13 | 98 | 61 | 0.54 | 1285 |
| C_2x_S vs. E_2x_S | 4.33 | 4.27 | 0.06 | 0.1 | 98 | 154 | 0.85 | 1285 |
| C_2x_S vs. E_4x_S | 4.33 | 4.26 | 0.07 | 0.28 | 98 | 8 | 0.34 | 1285 |
| C_2x_S vs. C_2x_N | 4.33 | 5.72 | -1.39 | 0.11 | 98 | 99 | 17.88 | 1285 |
| C_2x_S vs. C_4x_N | 4.33 | 6.25 | -1.92 | 0.13 | 98 | 62 | 21.63 | 1285 |
| C_2x_S vs. E_2x_N | 4.33 | 5.55 | -1.22 | 0.1 | 98 | 155 | 17.31 | 1285 |
| C_2x_S vs. E_4x_N | 4.33 | 6.53 | -2.19 | 0.28 | 98 | 8 | 10.92 | 1285 |
| C_2x_S vs. C_2x_F | 4.33 | 4.28 | 0.05 | 0.11 | 98 | 98 | 0.63 | 1285 |
| C_2x_S vs. C_4x_F | 4.33 | 4.94 | -0.6 | 0.13 | 98 | 61 | 6.79 | 1285 |
| C_2x_S vs. E_2x_F | 4.33 | 4.27 | 0.06 | 0.1 | 98 | 157 | 0.9 | 1285 |
| C_2x_S vs. E_4x_F | 4.33 | 5.66 | -1.33 | 0.28 | 98 | 8 | 6.63 | 1285 |
| C_4x_S vs. E_2x_S | 4.28 | 4.27 | 0.01 | 0.12 | 61 | 154 | 0.15 | 1285 |
| C_4x_S vs. E_4x_S | 4.28 | 4.26 | 0.02 | 0.29 | 61 | 8 | 0.1 | 1285 |
| C_4x_S vs. C_2x_N | 4.28 | 5.72 | -1.44 | 0.13 | 61 | 99 | 16.2 | 1285 |
| C_4x_S vs. C_4x_N | 4.28 | 6.25 | -1.97 | 0.14 | 61 | 62 | 19.95 | 1285 |
| C_4x_S vs. E_2x_N | 4.28 | 5.55 | -1.27 | 0.12 | 61 | 155 | 15.36 | 1285 |
| C_4x_S vs. E_4x_N | 4.28 | 6.53 | -2.24 | 0.29 | 61 | 8 | 10.91 | 1285 |
| C_4x_S vs. C_2x_F | 4.28 | 4.28 | 0 | 0.13 | 61 | 98 | 0.01 | 1285 |
| C_4x_S vs. C_4x_F | 4.28 | 4.94 | -0.65 | 0.14 | 61 | 61 | 6.6 | 1285 |
| C_4x_S vs. E_2x_F | 4.28 | 4.27 | 0.02 | 0.12 | 61 | 157 | 0.19 | 1285 |
| C_4x_S vs. E_4x_F | 4.28 | 5.66 | -1.38 | 0.29 | 61 | 8 | 6.72 | 1285 |

# Appendix 5

## Regrowth 2013

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| E_2x_S vs. E_4x_S | 4.27 | 4.26 | 0.01 | 0.28 | 154 | 8 | 0.05 | 1285 |
| E_2x_S vs. C_2x_N | 4.27 | 5.72 | -1.45 | 0.1 | 154 | 99 | 20.64 | 1285 |
| E_2x_S vs. C_4x_N | 4.27 | 6.25 | -1.98 | 0.12 | 154 | 62 | 24.07 | 1285 |
| E_2x_S vs. E_2x_N | 4.27 | 5.55 | -1.28 | 0.09 | 154 | 155 | 20.6 | 1285 |
| E_2x_S vs. E_4x_N | 4.27 | 6.53 | -2.25 | 0.28 | 154 | 8 | 11.38 | 1285 |
| E_2x_S vs. C_2x_F | 4.27 | 4.28 | -0.01 | 0.1 | 154 | 98 | 0.16 | 1285 |
| E_2x_S vs. C_4x_F | 4.27 | 4.94 | -0.66 | 0.12 | 154 | 61 | 8.05 | 1285 |
| E_2x_S vs. E_2x_F | 4.27 | 4.27 | 0 | 0.09 | 154 | 157 | 0.05 | 1285 |
| E_2x_S vs. E_4x_F | 4.27 | 5.66 | -1.39 | 0.28 | 154 | 8 | 7.02 | 1285 |
| E_4x_S vs. C_2x_N | 4.26 | 5.72 | -1.46 | 0.28 | 8 | 99 | 7.28 | 1285 |
| E_4x_S vs. C_4x_N | 4.26 | 6.25 | -1.99 | 0.29 | 8 | 62 | 9.68 | 1285 |
| E_4x_S vs. E_2x_N | 4.26 | 5.55 | -1.29 | 0.28 | 8 | 155 | 6.51 | 1285 |
| E_4x_S vs. E_4x_N | 4.26 | 6.53 | -2.26 | 0.39 | 8 | 8 | 8.29 | 1285 |
| E_4x_S vs. C_2x_F | 4.26 | 4.28 | -0.02 | 0.28 | 8 | 98 | 0.1 | 1285 |
| E_4x_S vs. C_4x_F | 4.26 | 4.94 | -0.67 | 0.29 | 8 | 61 | 3.28 | 1285 |
| E_4x_S vs. E_2x_F | 4.26 | 4.27 | -0.01 | 0.28 | 8 | 157 | 0.03 | 1285 |
| E_4x_S vs. E_4x_F | 4.26 | 5.66 | -1.4 | 0.39 | 8 | 8 | 5.13 | 1285 |
| C_2x_N vs. C_4x_N | 5.72 | 6.25 | -0.53 | 0.13 | 99 | 62 | 5.94 | 1285 |
| C_2x_N vs. E_2x_N | 5.72 | 5.55 | 0.17 | 0.1 | 99 | 155 | 2.44 | 1285 |
| C_2x_N vs. E_4x_N | 5.72 | 6.53 | -0.8 | 0.28 | 99 | 8 | 3.99 | 1285 |
| C_2x_N vs. C_2x_F | 5.72 | 4.28 | 1.44 | 0.11 | 99 | 98 | 18.51 | 1285 |
| C_2x_N vs. C_4x_F | 5.72 | 4.94 | 0.79 | 0.13 | 99 | 61 | 8.86 | 1285 |
| C_2x_N vs. E_2x_F | 5.72 | 4.27 | 1.46 | 0.1 | 99 | 157 | 20.76 | 1285 |
| C_2x_N vs. E_4x_F | 5.72 | 5.66 | 0.06 | 0.28 | 99 | 8 | 0.3 | 1285 |
| C_4x_N vs. E_2x_N | 6.25 | 5.55 | 0.7 | 0.12 | 62 | 155 | 8.49 | 1285 |
| C_4x_N vs. E_4x_N | 6.25 | 6.53 | -0.28 | 0.29 | 62 | 8 | 1.35 | 1285 |
| C_4x_N vs. C_2x_F | 6.25 | 4.28 | 1.97 | 0.13 | 62 | 98 | 22.18 | 1285 |
| C_4x_N vs. C_4x_F | 6.25 | 4.94 | 1.31 | 0.14 | 62 | 61 | 13.32 | 1285 |
| C_4x_N vs. E_2x_F | 6.25 | 4.27 | 1.98 | 0.12 | 62 | 157 | 24.17 | 1285 |
| C_4x_N vs. E_4x_F | 6.25 | 5.66 | 0.59 | 0.29 | 62 | 8 | 2.86 | 1285 |
| E_2x_N vs. E_4x_N | 5.55 | 6.53 | -0.97 | 0.28 | 155 | 8 | 4.92 | 1285 |
| E_2x_N vs. C_2x_F | 5.55 | 4.28 | 1.27 | 0.1 | 155 | 98 | 18 | 1285 |
| E_2x_N vs. C_4x_F | 5.55 | 4.94 | 0.62 | 0.12 | 155 | 61 | 7.46 | 1285 |
| E_2x_N vs. E_2x_F | 5.55 | 4.27 | 1.28 | 0.09 | 155 | 157 | 20.76 | 1285 |
| E_2x_N vs. E_4x_F | 5.55 | 5.66 | -0.11 | 0.28 | 155 | 8 | 0.56 | 1285 |
| E_4x_N vs. C_2x_F | 6.53 | 4.28 | 2.24 | 0.28 | 8 | 98 | 11.17 | 1285 |
| E_4x_N vs. C_4x_F | 6.53 | 4.94 | 1.59 | 0.29 | 8 | 61 | 7.74 | 1285 |
| E_4x_N vs. E_2x_F | 6.53 | 4.27 | 2.26 | 0.28 | 8 | 157 | 11.4 | 1285 |
| E_4x_N vs. E_4x_F | 6.53 | 5.66 | 0.86 | 0.39 | 8 | 8 | 3.16 | 1285 |
| C_2x_F vs. C_4x_F | 4.28 | 4.94 | -0.65 | 0.13 | 98 | 61 | 7.34 | 1285 |
| C_2x_F vs. E_2x_F | 4.28 | 4.27 | 0.01 | 0.1 | 98 | 157 | 0.21 | 1285 |
| C_2x_F vs. E_4x_F | 4.28 | 5.66 | -1.38 | 0.28 | 98 | 8 | 6.87 | 1285 |
| C_4x_F vs. E_2x_F | 4.94 | 4.27 | 0.67 | 0.12 | 61 | 157 | 8.11 | 1285 |
| C_4x_F vs. E_4x_F | 4.94 | 5.66 | -0.73 | 0.29 | 61 | 8 | 3.54 | 1285 |
| E_2x_F vs. E_4x_F | 4.27 | 5.66 | -1.39 | 0.28 | 157 | 8 | 7.04 | 1285 |

# Appendix 5

## Crown rust 2013

Table 4: Tukey's multiple comparisons test for Crown rust

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| **C_2x_D vs. C_4x_D** | -0.40 | -0.8165 to 0.01828 | No | ns | 0.0727 | A-B |
| **C_2x_D vs. E_2x_D** | 0.37 | 0.02180 to 0.7127 | Yes | * | 0.0281 | A-C |
| **C_2x_D vs. E_4x_D** | -0.12 | -1.091 to 0.8436 | No | ns | >0.9999 | A-D |
| **C_2x_D vs. C_2x_N** | -0.06 | -0.4310 to 0.3153 | No | ns | 0.9998 | A-E |
| **C_2x_D vs. C_4x_N** | -1.01 | -1.435 to -0.5837 | Yes | **** | <0.0001 | A-F |
| **C_2x_D vs. E_2x_N** | -0.02 | -0.3641 to 0.3192 | No | ns | >0.9999 | A-G |
| **C_2x_D vs. E_4x_N** | -0.55 | -1.462 to 0.3576 | No | ns | 0.5882 | A-H |
| **C_4x_D vs. E_2x_D** | 0.77 | 0.3838 to 1.149 | Yes | **** | <0.0001 | B-C |
| **C_4x_D vs. E_4x_D** | 0.28 | -0.7060 to 1.257 | No | ns | 0.9898 | B-D |
| **C_4x_D vs. C_2x_N** | 0.34 | -0.06646 to 0.7489 | No | ns | 0.1784 | B-E |
| **C_4x_D vs. C_4x_N** | -0.61 | -1.067 to -0.1540 | Yes | ** | 0.0014 | B-F |
| **C_4x_D vs. E_2x_N** | 0.38 | -0.002435 to 0.7558 | No | ns | 0.0529 | B-G |
| **C_4x_D vs. E_4x_N** | -0.15 | -1.078 to 0.7714 | No | ns | 0.9996 | B-H |
| **E_2x_D vs. E_4x_D** | -0.49 | -1.444 to 0.4618 | No | ns | 0.7693 | C-D |
| **E_2x_D vs. C_2x_N** | -0.43 | -0.7588 to -0.09146 | Yes | ** | 0.003 | C-E |
| **E_2x_D vs. C_4x_N** | -1.38 | -1.769 to -0.9850 | Yes | **** | <0.0001 | C-F |
| **E_2x_D vs. E_2x_N** | -0.39 | -0.6878 to -0.09163 | Yes | ** | 0.002 | C-G |
| **E_2x_D vs. E_4x_N** | -0.92 | -1.814 to -0.02513 | Yes | * | 0.0389 | C-H |
| **E_4x_D vs. C_2x_N** | 0.07 | -0.8973 to 1.029 | No | ns | >0.9999 | D-E |
| **E_4x_D vs. C_4x_N** | -0.89 | -1.871 to 0.09922 | No | ns | 0.1141 | D-F |
| **E_4x_D vs. E_2x_N** | 0.10 | -0.8501 to 1.053 | No | ns | >0.9999 | D-G |
| **E_4x_D vs. E_4x_N** | -0.43 | -1.700 to 0.8430 | No | ns | 0.9705 | D-H |
| **C_2x_N vs. C_4x_N** | -0.95 | -1.368 to -0.5353 | Yes | **** | <0.0001 | E-F |
| **C_2x_N vs. E_2x_N** | 0.04 | -0.2943 to 0.3652 | No | ns | >0.9999 | E-G |
| **C_2x_N vs. E_4x_N** | -0.49 | -1.400 to 0.4110 | No | ns | 0.7122 | E-H |
| **C_4x_N vs. E_2x_N** | 0.99 | 0.5987 to 1.376 | Yes | **** | <0.0001 | F-G |
| **C_4x_N vs. E_4x_N** | 0.46 | -0.4715 to 1.386 | No | ns | 0.8087 | F-H |
| **E_2x_N vs. E_4x_N** | -0.53 | -1.423 to 0.3631 | No | ns | 0.6167 | G-H |

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| **C_2x_D vs. C_4x_D** | 6.15 | 6.55 | -0.40 | 0.14 | 82 | 60 | 4.11 | 569 |
| **C_2x_D vs. E_2x_D** | 6.15 | 5.78 | 0.37 | 0.11 | 82 | 132 | 4.57 | 569 |
| **C_2x_D vs. E_4x_D** | 6.15 | 6.27 | -0.12 | 0.32 | 82 | 7 | 0.55 | 569 |
| **C_2x_D vs. C_2x_N** | 6.15 | 6.21 | -0.06 | 0.12 | 82 | 92 | 0.67 | 569 |
| **C_2x_D vs. C_4x_N** | 6.15 | 7.16 | -1.01 | 0.14 | 82 | 56 | 10.20 | 569 |
| **C_2x_D vs. E_2x_N** | 6.15 | 6.17 | -0.02 | 0.11 | 82 | 140 | 0.28 | 569 |
| **C_2x_D vs. E_4x_N** | 6.15 | 6.70 | -0.55 | 0.30 | 82 | 8 | 2.61 | 569 |
| **C_4x_D vs. E_2x_D** | 6.55 | 5.78 | 0.77 | 0.13 | 60 | 132 | 8.62 | 569 |
| **C_4x_D vs. E_4x_D** | 6.55 | 6.27 | 0.28 | 0.32 | 60 | 7 | 1.21 | 569 |
| **C_4x_D vs. C_2x_N** | 6.55 | 6.21 | 0.34 | 0.13 | 60 | 92 | 3.60 | 569 |
| **C_4x_D vs. C_4x_N** | 6.55 | 7.16 | -0.61 | 0.15 | 60 | 56 | 5.75 | 569 |
| **C_4x_D vs. E_2x_N** | 6.55 | 6.17 | 0.38 | 0.12 | 60 | 140 | 4.28 | 569 |
| **C_4x_D vs. E_4x_N** | 6.55 | 6.70 | -0.15 | 0.30 | 60 | 8 | 0.71 | 569 |
| **E_2x_D vs. E_4x_D** | 5.78 | 6.27 | -0.49 | 0.31 | 132 | 7 | 2.22 | 569 |
| **E_2x_D vs. C_2x_N** | 5.78 | 6.21 | -0.43 | 0.11 | 132 | 92 | 5.48 | 569 |
| **E_2x_D vs. C_4x_N** | 5.78 | 7.16 | -1.38 | 0.13 | 132 | 56 | 15.12 | 569 |
| **E_2x_D vs. E_2x_N** | 5.78 | 6.17 | -0.39 | 0.10 | 132 | 140 | 5.63 | 569 |
| **E_2x_D vs. E_4x_N** | 5.78 | 6.70 | -0.92 | 0.29 | 132 | 8 | 4.42 | 569 |

# Appendix 5

## Crown rust 2013

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| **E_4x_D vs. C_2x_N** | 6.27 | 6.21 | 0.07 | 0.32 | 7 | 92 | 0.29 | 569 |
| **E_4x_D vs. C_4x_N** | 6.27 | 7.16 | -0.89 | 0.32 | 7 | 56 | 3.87 | 569 |
| **E_4x_D vs. E_2x_N** | 6.27 | 6.17 | 0.10 | 0.31 | 7 | 140 | 0.46 | 569 |
| **E_4x_D vs. E_4x_N** | 6.27 | 6.70 | -0.43 | 0.42 | 7 | 8 | 1.45 | 569 |
| **C_2x_N vs. C_4x_N** | 6.21 | 7.16 | -0.95 | 0.14 | 92 | 56 | 9.83 | 569 |
| **C_2x_N vs. E_2x_N** | 6.21 | 6.17 | 0.04 | 0.11 | 92 | 140 | 0.46 | 569 |
| **C_2x_N vs. E_4x_N** | 6.21 | 6.70 | -0.49 | 0.30 | 92 | 8 | 2.35 | 569 |
| **C_4x_N vs. E_2x_N** | 7.16 | 6.17 | 0.99 | 0.13 | 56 | 140 | 10.93 | 569 |
| **C_4x_N vs. E_4x_N** | 7.16 | 6.70 | 0.46 | 0.31 | 56 | 8 | 2.12 | 569 |
| **E_2x_N vs. E_4x_N** | 6.17 | 6.70 | -0.53 | 0.29 | 140 | 8 | 2.55 | 569 |

# Appendix 5

## Winter survival 2013

**Table 5: Tuckey's multiple comparison test: Winter survival 2013**

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| C_2x_S vs. C_4x_S | 0.44 | -0.1733 to 1.063 | No | ns | 0.44 | A-B |
| C_2x_S vs. E_2x_S | -0.01 | -0.4984 to 0.4799 | No | ns | >0.9999 | A-C |
| C_2x_S vs. E_4x_S | 0.24 | -1.153 to 1.634 | No | ns | >0.9999 | A-D |
| C_2x_S vs. C_2x_N | 3.96 | 3.420 to 4.495 | Yes | **** | <0.0001 | A-E |
| C_2x_S vs. C_4x_N | 4.37 | 3.755 to 4.985 | Yes | **** | <0.0001 | A-F |
| C_2x_S vs. E_2x_N | 3.93 | 3.443 to 4.415 | Yes | **** | <0.0001 | A-G |
| C_2x_S vs. E_4x_N | 3.8 | 2.409 to 5.196 | Yes | **** | <0.0001 | A-H |
| C_2x_S vs. C_2x_F | 4.36 | 3.825 to 4.902 | Yes | **** | <0.0001 | A-I |
| C_2x_S vs. C_4x_F | 3.62 | 2.997 to 4.233 | Yes | **** | <0.0001 | A-J |
| C_2x_S vs. E_2x_F | 4.18 | 3.689 to 4.663 | Yes | **** | <0.0001 | A-K |
| C_2x_S vs. E_4x_F | 3.52 | 2.122 to 4.909 | Yes | **** | <0.0001 | A-L |
| C_4x_S vs. E_2x_S | -0.45 | -1.027 to 0.1188 | No | ns | 0.28 | B-C |
| C_4x_S vs. E_4x_S | -0.2 | -1.630 to 1.221 | No | ns | >0.9999 | B-D |
| C_4x_S vs. C_2x_N | 3.51 | 2.898 to 4.128 | Yes | **** | <0.0001 | B-E |
| C_4x_S vs. C_4x_N | 3.93 | 3.242 to 4.609 | Yes | **** | <0.0001 | B-F |
| C_4x_S vs. E_2x_N | 3.48 | 2.914 to 4.055 | Yes | **** | <0.0001 | B-G |
| C_4x_S vs. E_4x_N | 3.36 | 1.933 to 4.783 | Yes | **** | <0.0001 | B-H |
| C_4x_S vs. C_2x_F | 3.92 | 3.303 to 4.534 | Yes | **** | <0.0001 | B-I |
| C_4x_S vs. C_4x_F | 3.17 | 2.484 to 3.857 | Yes | **** | <0.0001 | B-J |
| C_4x_S vs. E_2x_F | 3.73 | 3.160 to 4.303 | Yes | **** | <0.0001 | B-K |
| C_4x_S vs. E_4x_F | 3.07 | 1.645 to 4.496 | Yes | **** | <0.0001 | B-L |
| E_2x_S vs. E_4x_S | 0.25 | -1.125 to 1.624 | No | ns | >0.9999 | C-D |
| E_2x_S vs. C_2x_N | 3.97 | 3.482 to 4.452 | Yes | **** | <0.0001 | C-E |
| E_2x_S vs. C_4x_N | 4.38 | 3.810 to 4.949 | Yes | **** | <0.0001 | C-F |
| E_2x_S vs. E_2x_N | 3.94 | 3.511 to 4.365 | Yes | **** | <0.0001 | C-G |
| E_2x_S vs. E_4x_N | 3.81 | 2.438 to 5.186 | Yes | **** | <0.0001 | C-H |
| E_2x_S vs. C_2x_F | 4.37 | 3.886 to 4.859 | Yes | **** | <0.0001 | C-I |
| E_2x_S vs. C_4x_F | 3.63 | 3.052 to 4.197 | Yes | **** | <0.0001 | C-J |
| E_2x_S vs. E_2x_F | 4.19 | 3.757 to 4.614 | Yes | **** | <0.0001 | C-K |
| E_2x_S vs. E_4x_F | 3.53 | 2.150 to 4.899 | Yes | **** | <0.0001 | C-L |
| E_4x_S vs. C_2x_N | 3.72 | 2.326 to 5.110 | Yes | **** | <0.0001 | D-E |
| E_4x_S vs. C_4x_N | 4.13 | 2.706 to 5.554 | Yes | **** | <0.0001 | D-F |
| E_4x_S vs. E_2x_N | 3.69 | 2.316 to 5.062 | Yes | **** | <0.0001 | D-G |
| E_4x_S vs. E_4x_N | 3.56 | 1.667 to 5.458 | Yes | **** | <0.0001 | D-H |
| E_4x_S vs. C_2x_F | 4.12 | 2.730 to 5.516 | Yes | **** | <0.0001 | D-I |
| E_4x_S vs. C_4x_F | 3.38 | 1.950 to 4.800 | Yes | **** | <0.0001 | D-J |
| E_4x_S vs. E_2x_F | 3.94 | 2.562 to 5.309 | Yes | **** | <0.0001 | D-K |
| E_4x_S vs. E_4x_F | 3.28 | 1.380 to 5.170 | Yes | **** | <0.0001 | D-L |
| C_2x_N vs. C_4x_N | 0.41 | -0.1992 to 1.024 | No | ns | 0.54 | E-F |
| C_2x_N vs. E_2x_N | -0.03 | -0.5105 to 0.4528 | No | ns | >0.9999 | E-G |
| C_2x_N vs. E_4x_N | -0.16 | -1.547 to 1.237 | No | ns | >0.9999 | E-H |
| C_2x_N vs. C_2x_F | 0.41 | -0.1292 to 0.9401 | No | ns | 0.35 | E-I |
| C_2x_N vs. C_4x_F | -0.34 | -0.9572 to 0.2720 | No | ns | 0.8 | E-J |
| C_2x_N vs. E_2x_F | 0.22 | -0.2647 to 0.7010 | No | ns | 0.95 | E-K |
| C_2x_N vs. E_4x_F | -0.44 | -1.835 to 0.9495 | No | ns | 1 | E-L |
| C_4x_N vs. E_2x_N | -0.44 | -1.008 to 0.1259 | No | ns | 0.31 | F-G |
| C_4x_N vs. E_4x_N | -0.57 | -1.991 to 0.8565 | No | ns | 0.98 | F-H |
| C_4x_N vs. C_2x_F | -0.01 | -0.6195 to 0.6058 | No | ns | >0.9999 | F-I |
| C_4x_N vs. C_4x_F | -0.75 | -1.438 to -0.07133 | Yes | * | 0.02 | F-J |
| C_4x_N vs. E_2x_F | -0.19 | -0.7621 to 0.3739 | No | ns | 0.99 | F-K |
| C_4x_N vs. E_4x_F | -0.85 | -2.279 to 0.5690 | No | ns | 0.72 | F-L |
| E_2x_N vs. E_4x_N | -0.13 | -1.499 to 1.247 | No | ns | >0.9999 | G-H |
| E_2x_N vs. C_2x_F | 0.43 | -0.04890 to 0.9174 | No | ns | 0.13 | G-I |
| E_2x_N vs. C_4x_F | -0.31 | -0.8841 to 0.2566 | No | ns | 0.82 | G-J |
| E_2x_N vs. E_2x_F | 0.25 | -0.1781 to 0.6721 | No | ns | 0.76 | G-K |
| E_2x_N vs. E_4x_F | -0.41 | -1.787 to 0.9594 | No | ns | 1 | G-L |
| E_4x_N vs. C_2x_F | 0.56 | -0.8321 to 1.953 | No | ns | 0.98 | H-I |
| E_4x_N vs. C_4x_F | -0.19 | -1.613 to 1.238 | No | ns | >0.9999 | H-J |
| E_4x_N vs. E_2x_F | 0.37 | -1.000 to 1.747 | No | ns | 1 | H-K |
| E_4x_N vs. E_4x_F | -0.29 | -2.183 to 1.608 | No | ns | >0.9999 | H-L |
| C_2x_F vs. C_4x_F | -0.75 | -1.364 to -0.1323 | Yes | ** | 0 | I-J |
| C_2x_F vs. E_2x_F | -0.19 | -0.6716 to 0.2971 | No | ns | 0.98 | I-K |
| C_2x_F vs. E_4x_F | -0.85 | -2.241 to 0.5446 | No | ns | 0.7 | I-L |
| C_4x_F vs. E_2x_F | 0.56 | -0.01056 to 1.132 | No | ns | 0.06 | J-K |
| C_4x_F vs. E_4x_F | -0.1 | -1.525 to 1.325 | No | ns | >0.9999 | J-L |

# Appendix 5

## Winter survival 2013

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| **E_2x_F vs. E_4x_F** | -0.66 | -2.034 to 0.7128 | No | ns | 0.92 | K-L |

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| **C_2x_S vs. C_4x_S** | 8.22 | 7.77 | 0.44 | 0.19 | 98 | 61 | 3.33 | 968 |
| **C_2x_S vs. E_2x_S** | 8.22 | 8.23 | -0.01 | 0.15 | 98 | 155 | 0.09 | 968 |
| **C_2x_S vs. E_4x_S** | 8.22 | 7.98 | 0.24 | 0.43 | 98 | 8 | 0.8 | 968 |
| **C_2x_S vs. C_2x_N** | 8.22 | 4.26 | 3.96 | 0.16 | 98 | 101 | 34.12 | 968 |
| **C_2x_S vs. C_4x_N** | 8.22 | 3.85 | 4.37 | 0.19 | 98 | 62 | 32.92 | 968 |
| **C_2x_S vs. E_2x_N** | 8.22 | 4.29 | 3.93 | 0.15 | 98 | 160 | 37.44 | 968 |
| **C_2x_S vs. E_4x_N** | 8.22 | 4.41 | 3.8 | 0.43 | 98 | 8 | 12.64 | 968 |
| **C_2x_S vs. C_2x_F** | 8.22 | 3.85 | 4.36 | 0.16 | 98 | 100 | 37.52 | 968 |
| **C_2x_S vs. C_4x_F** | 8.22 | 4.6 | 3.62 | 0.19 | 98 | 61 | 27.1 | 968 |
| **C_2x_S vs. E_2x_F** | 8.22 | 4.04 | 4.18 | 0.15 | 98 | 158 | 39.7 | 968 |
| **C_2x_S vs. E_4x_F** | 8.22 | 4.7 | 3.52 | 0.43 | 98 | 8 | 11.69 | 968 |
| **C_4x_S vs. E_2x_S** | 7.77 | 8.23 | -0.45 | 0.17 | 61 | 155 | 3.67 | 968 |
| **C_4x_S vs. E_4x_S** | 7.77 | 7.98 | -0.2 | 0.44 | 61 | 8 | 0.66 | 968 |
| **C_4x_S vs. C_2x_N** | 7.77 | 4.26 | 3.51 | 0.19 | 61 | 101 | 26.48 | 968 |
| **C_4x_S vs. C_4x_N** | 7.77 | 3.85 | 3.93 | 0.21 | 61 | 62 | 26.61 | 968 |
| **C_4x_S vs. E_2x_N** | 7.77 | 4.29 | 3.48 | 0.17 | 61 | 160 | 28.3 | 968 |
| **C_4x_S vs. E_4x_N** | 7.77 | 4.41 | 3.36 | 0.44 | 61 | 8 | 10.92 | 968 |
| **C_4x_S vs. C_2x_F** | 7.77 | 3.85 | 3.92 | 0.19 | 61 | 100 | 29.48 | 968 |
| **C_4x_S vs. C_4x_F** | 7.77 | 4.6 | 3.17 | 0.21 | 61 | 61 | 21.4 | 968 |
| **C_4x_S vs. E_2x_F** | 7.77 | 4.04 | 3.73 | 0.17 | 61 | 158 | 30.26 | 968 |
| **C_4x_S vs. E_4x_F** | 7.77 | 4.7 | 3.07 | 0.44 | 61 | 8 | 9.98 | 968 |
| **E_2x_S vs. E_4x_S** | 8.23 | 7.98 | 0.25 | 0.42 | 155 | 8 | 0.84 | 968 |
| **E_2x_S vs. C_2x_N** | 8.23 | 4.26 | 3.97 | 0.15 | 155 | 101 | 37.92 | 968 |
| **E_2x_S vs. C_4x_N** | 8.23 | 3.85 | 4.38 | 0.17 | 155 | 62 | 35.63 | 968 |
| **E_2x_S vs. E_2x_N** | 8.23 | 4.29 | 3.94 | 0.13 | 155 | 160 | 42.72 | 968 |
| **E_2x_S vs. E_4x_N** | 8.23 | 4.41 | 3.81 | 0.42 | 155 | 8 | 12.85 | 968 |
| **E_2x_S vs. C_2x_F** | 8.23 | 3.85 | 4.37 | 0.15 | 155 | 100 | 41.67 | 968 |
| **E_2x_S vs. C_4x_F** | 8.23 | 4.6 | 3.63 | 0.17 | 155 | 61 | 29.31 | 968 |
| **E_2x_S vs. E_2x_F** | 8.23 | 4.04 | 4.19 | 0.13 | 155 | 158 | 45.25 | 968 |
| **E_2x_S vs. E_4x_F** | 8.23 | 4.7 | 3.53 | 0.42 | 155 | 8 | 11.88 | 968 |
| **E_4x_S vs. C_2x_N** | 7.98 | 4.26 | 3.72 | 0.42 | 8 | 101 | 12.37 | 968 |
| **E_4x_S vs. C_4x_N** | 7.98 | 3.85 | 4.13 | 0.43 | 8 | 62 | 13.44 | 968 |
| **E_4x_S vs. E_2x_N** | 7.98 | 4.29 | 3.69 | 0.42 | 8 | 160 | 12.45 | 968 |
| **E_4x_S vs. E_4x_N** | 7.98 | 4.41 | 3.56 | 0.58 | 8 | 8 | 8.71 | 968 |
| **E_4x_S vs. C_2x_F** | 7.98 | 3.85 | 4.12 | 0.43 | 8 | 100 | 13.72 | 968 |
| **E_4x_S vs. C_4x_F** | 7.98 | 4.6 | 3.38 | 0.44 | 8 | 61 | 10.97 | 968 |
| **E_4x_S vs. E_2x_F** | 7.98 | 4.04 | 3.94 | 0.42 | 8 | 158 | 13.28 | 968 |
| **E_4x_S vs. E_4x_F** | 7.98 | 4.7 | 3.28 | 0.58 | 8 | 8 | 8.01 | 968 |
| **C_2x_N vs. C_4x_N** | 4.26 | 3.85 | 0.41 | 0.19 | 101 | 62 | 3.12 | 968 |
| **C_2x_N vs. E_2x_N** | 4.26 | 4.29 | -0.03 | 0.15 | 101 | 160 | 0.28 | 968 |
| **C_2x_N vs. E_4x_N** | 4.26 | 4.41 | -0.16 | 0.42 | 101 | 8 | 0.52 | 968 |
| **C_2x_N vs. C_2x_F** | 4.26 | 3.85 | 0.41 | 0.16 | 101 | 100 | 3.51 | 968 |
| **C_2x_N vs. C_4x_F** | 4.26 | 4.6 | -0.34 | 0.19 | 101 | 61 | 2.58 | 968 |
| **C_2x_N vs. E_2x_F** | 4.26 | 4.04 | 0.22 | 0.15 | 101 | 158 | 2.09 | 968 |
| **C_2x_N vs. E_4x_F** | 4.26 | 4.7 | -0.44 | 0.42 | 101 | 8 | 1.47 | 968 |
| **C_4x_N vs. E_2x_N** | 3.85 | 4.29 | -0.44 | 0.17 | 62 | 160 | 3.6 | 968 |
| **C_4x_N vs. E_4x_N** | 3.85 | 4.41 | -0.57 | 0.43 | 62 | 8 | 1.85 | 968 |
| **C_4x_N vs. C_2x_F** | 3.85 | 3.85 | -0.01 | 0.19 | 62 | 100 | 0.05 | 968 |
| **C_4x_N vs. C_4x_F** | 3.85 | 4.6 | -0.75 | 0.21 | 62 | 61 | 5.12 | 968 |
| **C_4x_N vs. E_2x_F** | 3.85 | 4.04 | -0.19 | 0.17 | 62 | 158 | 1.58 | 968 |
| **C_4x_N vs. E_4x_F** | 3.85 | 4.7 | -0.85 | 0.43 | 62 | 8 | 2.78 | 968 |
| **E_2x_N vs. E_4x_N** | 4.29 | 4.41 | -0.13 | 0.42 | 160 | 8 | 0.43 | 968 |
| **E_2x_N vs. C_2x_F** | 4.29 | 3.85 | 0.43 | 0.15 | 160 | 100 | 4.16 | 968 |
| **E_2x_N vs. C_4x_F** | 4.29 | 4.6 | -0.31 | 0.17 | 160 | 61 | 2.55 | 968 |
| **E_2x_N vs. E_2x_F** | 4.29 | 4.04 | 0.25 | 0.13 | 160 | 158 | 2.69 | 968 |
| **E_2x_N vs. E_4x_F** | 4.29 | 4.7 | -0.41 | 0.42 | 160 | 8 | 1.4 | 968 |
| **E_4x_N vs. C_2x_F** | 4.41 | 3.85 | 0.56 | 0.43 | 8 | 100 | 1.87 | 968 |
| **E_4x_N vs. C_4x_F** | 4.41 | 4.6 | -0.19 | 0.44 | 8 | 61 | 0.61 | 968 |
| **E_4x_N vs. E_2x_F** | 4.41 | 4.04 | 0.37 | 0.42 | 8 | 158 | 1.26 | 968 |
| **E_4x_N vs. E_4x_F** | 4.41 | 4.7 | -0.29 | 0.58 | 8 | 8 | 0.7 | 968 |
| **C_2x_F vs. C_4x_F** | 3.85 | 4.6 | -0.75 | 0.19 | 100 | 61 | 5.63 | 968 |
| **C_2x_F vs. E_2x_F** | 3.85 | 4.04 | -0.19 | 0.15 | 100 | 158 | 1.79 | 968 |
| **C_2x_F vs. E_4x_F** | 3.85 | 4.7 | -0.85 | 0.43 | 100 | 8 | 2.82 | 968 |

# Appendix 5

## Winter survival 2013

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| **C_4x_F vs. E_2x_F** | 4.6 | 4.04 | 0.56 | 0.17 | 61 | 158 | 4.55 | 968 |
| **C_4x_F vs. E_4x_F** | 4.6 | 4.7 | -0.1 | 0.44 | 61 | 8 | 0.33 | 968 |
| **E_2x_F vs. E_4x_F** | 4.04 | 4.7 | -0.66 | 0.42 | 158 | 8 | 2.23 | 968 |

# Appendix 5

## Winter survival 2014

**Table 6: Tukey's multiple comparisons test: Winter survival 2014**

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| C_2x_D vs. C_4x_D | -0.98 | -1.316 to -0.6440 | Yes | **** | <0.0001 | A-B |
| C_2x_D vs. E_2x_D | 0.30 | 0.03881 to 0.5707 | Yes | ** | 0.01 | A-C |
| C_2x_D vs. E_4x_D | -0.75 | -1.518 to 0.01954 | No | ns | 0.0642 | A-D |
| C_2x_D vs. C_2x_N | -1.17 | -1.461 to -0.8687 | Yes | **** | <0.0001 | A-E |
| C_2x_D vs. C_4x_N | -1.59 | -1.930 to -1.255 | Yes | **** | <0.0001 | A-F |
| C_2x_D vs. E_2x_N | -0.95 | -1.217 to -0.6818 | Yes | **** | <0.0001 | A-G |
| C_2x_D vs. E_4x_N | -1.42 | -2.193 to -0.6555 | Yes | **** | <0.0001 | A-H |
| C_2x_D vs. C_2x_F | 1.86 | 1.563 to 2.153 | Yes | **** | <0.0001 | A-I |
| C_2x_D vs. C_4x_F | 1.76 | 1.419 to 2.098 | Yes | **** | <0.0001 | A-J |
| C_2x_D vs. E_2x_F | 1.82 | 1.558 to 2.091 | Yes | **** | <0.0001 | A-K |
| C_2x_D vs. E_4x_F | 1.95 | 1.182 to 2.720 | Yes | **** | <0.0001 | A-L |
| C_4x_D vs. E_2x_D | 1.29 | 0.9735 to 1.596 | Yes | **** | <0.0001 | B-C |
| C_4x_D vs. E_4x_D | 0.23 | -0.5544 to 1.016 | No | ns | 0.9984 | B-D |
| C_4x_D vs. C_2x_N | -0.18 | -0.5219 to 0.1525 | No | ns | 0.8211 | B-E |
| C_4x_D vs. C_4x_N | -0.61 | -0.9869 to -0.2383 | Yes | **** | <0.0001 | B-F |
| C_4x_D vs. E_2x_N | 0.03 | -0.2820 to 0.3433 | No | ns | >0.9999 | B-G |
| C_4x_D vs. E_4x_N | -0.44 | -1.229 to 0.3413 | No | ns | 0.7883 | B-H |
| C_4x_D vs. C_2x_F | 2.84 | 2.501 to 3.175 | Yes | **** | <0.0001 | B-I |
| C_4x_D vs. C_4x_F | 2.74 | 2.362 to 3.114 | Yes | **** | <0.0001 | B-J |
| C_4x_D vs. E_2x_F | 2.80 | 2.493 to 3.116 | Yes | **** | <0.0001 | B-K |
| C_4x_D vs. E_4x_F | 2.93 | 2.146 to 3.716 | Yes | **** | <0.0001 | B-L |
| E_2x_D vs. E_4x_D | -1.05 | -1.812 to -0.2957 | Yes | *** | 0.0004 | C-D |
| E_2x_D vs. C_2x_N | -1.47 | -1.737 to -1.202 | Yes | **** | <0.0001 | C-E |
| E_2x_D vs. C_4x_N | -1.90 | -2.210 to -1.584 | Yes | **** | <0.0001 | C-F |
| E_2x_D vs. E_2x_N | -1.25 | -1.490 to -1.018 | Yes | **** | <0.0001 | C-G |
| E_2x_D vs. E_4x_N | -1.73 | -2.487 to -0.9707 | Yes | **** | <0.0001 | C-H |
| E_2x_D vs. C_2x_F | 1.55 | 1.287 to 1.820 | Yes | **** | <0.0001 | C-I |
| E_2x_D vs. C_4x_F | 1.45 | 1.139 to 1.769 | Yes | **** | <0.0001 | C-J |
| E_2x_D vs. E_2x_F | 1.52 | 1.285 to 1.754 | Yes | **** | <0.0001 | C-K |
| E_2x_D vs. E_4x_F | 1.65 | 0.8882 to 2.404 | Yes | **** | <0.0001 | C-L |
| E_4x_D vs. C_2x_N | -0.42 | -1.185 to 0.3535 | No | ns | 0.8338 | D-E |
| E_4x_D vs. C_4x_N | -0.84 | -1.630 to -0.05746 | Yes | * | 0.0232 | D-F |
| E_4x_D vs. E_2x_N | -0.20 | -0.9590 to 0.5583 | No | ns | 0.9994 | D-G |
| E_4x_D vs. E_4x_N | -0.68 | -1.721 to 0.3712 | No | ns | 0.6131 | D-H |
| E_4x_D vs. C_2x_F | 2.61 | 1.838 to 3.376 | Yes | **** | <0.0001 | D-I |
| E_4x_D vs. C_4x_F | 2.51 | 1.721 to 3.294 | Yes | **** | <0.0001 | D-J |
| E_4x_D vs. E_2x_F | 2.57 | 1.815 to 3.331 | Yes | **** | <0.0001 | D-K |
| E_4x_D vs. E_4x_F | 2.70 | 1.654 to 3.746 | Yes | **** | <0.0001 | D-L |
| C_2x_N vs. C_4x_N | -0.43 | -0.7668 to -0.08900 | Yes | ** | 0.0023 | E-F |
| C_2x_N vs. E_2x_N | 0.22 | -0.05388 to 0.4845 | No | ns | 0.2696 | E-G |
| C_2x_N vs. E_4x_N | -0.26 | -1.028 to 0.5098 | No | ns | 0.9945 | E-H |
| C_2x_N vs. C_2x_F | 3.02 | 2.726 to 3.319 | Yes | **** | <0.0001 | E-I |
| C_2x_N vs. C_4x_F | 2.92 | 2.582 to 3.264 | Yes | **** | <0.0001 | E-J |
| C_2x_N vs. E_2x_F | 2.99 | 2.721 to 3.257 | Yes | **** | <0.0001 | E-K |
| C_2x_N vs. E_4x_F | 3.12 | 2.347 to 3.885 | Yes | **** | <0.0001 | E-L |
| C_4x_N vs. E_2x_N | 0.64 | 0.3288 to 0.9577 | Yes | **** | <0.0001 | F-G |
| C_4x_N vs. E_4x_N | 0.17 | -0.6175 to 0.9546 | No | ns | >0.9999 | F-H |
| C_4x_N vs. C_2x_F | 3.45 | 3.112 to 3.789 | Yes | **** | <0.0001 | F-I |
| C_4x_N vs. C_4x_F | 3.35 | 2.974 to 3.728 | Yes | **** | <0.0001 | F-J |
| C_4x_N vs. E_2x_F | 3.42 | 3.104 to 3.730 | Yes | **** | <0.0001 | F-K |
| C_4x_N vs. E_4x_F | 3.54 | 2.757 to 4.330 | Yes | **** | <0.0001 | F-L |
| E_2x_N vs. E_4x_N | -0.47 | -1.233 to 0.2840 | No | ns | 0.6588 | G-H |
| E_2x_N vs. C_2x_F | 2.81 | 2.539 to 3.076 | Yes | **** | <0.0001 | G-I |
| E_2x_N vs. C_4x_F | 2.71 | 2.391 to 3.024 | Yes | **** | <0.0001 | G-J |
| E_2x_N vs. E_2x_F | 2.77 | 2.537 to 3.010 | Yes | **** | <0.0001 | G-K |
| E_2x_N vs. E_4x_F | 2.90 | 2.142 to 3.659 | Yes | **** | <0.0001 | G-L |
| E_4x_N vs. C_2x_F | 3.28 | 2.513 to 4.051 | Yes | **** | <0.0001 | H-I |
| E_4x_N vs. C_4x_F | 3.18 | 2.396 to 3.969 | Yes | **** | <0.0001 | H-J |
| E_4x_N vs. E_2x_F | 3.25 | 2.490 to 4.006 | Yes | **** | <0.0001 | H-K |
| E_4x_N vs. E_4x_F | 3.38 | 2.329 to 4.421 | Yes | **** | <0.0001 | H-L |
| C_2x_F vs. C_4x_F | -0.10 | -0.4396 to 0.2403 | No | ns | 0.9984 | I-J |
| C_2x_F vs. E_2x_F | -0.03 | -0.3008 to 0.2333 | No | ns | >0.9999 | I-K |
| C_2x_F vs. E_4x_F | 0.09 | -0.6758 to 0.8618 | No | ns | >0.9999 | I-L |
| C_4x_F vs. E_2x_F | 0.07 | -0.2493 to 0.3810 | No | ns | >0.9999 | J-K |
| C_4x_F vs. E_4x_F | 0.19 | -0.5942 to 0.9794 | No | ns | 0.9997 | J-L |

# Appendix 5

## Winter survival 2014

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| E_2x_F vs. E_4x_F | 0.13 | -0.6315 to 0.8849 | No | ns | >0.9999 | K-L |

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| C_2x_D vs. C_4x_D | 3.40 | 4.38 | -0.98 | 0.10 | 101 | 63 | 13.52 | 972 |
| C_2x_D vs. E_2x_D | 3.40 | 3.10 | 0.30 | 0.08 | 101 | 160 | 5.31 | 972 |
| C_2x_D vs. E_4x_D | 3.40 | 4.15 | -0.75 | 0.23 | 101 | 8 | 4.52 | 972 |
| C_2x_D vs. C_2x_N | 3.40 | 4.57 | -1.17 | 0.09 | 101 | 99 | 18.23 | 972 |
| C_2x_D vs. C_4x_N | 3.40 | 4.99 | -1.59 | 0.10 | 101 | 62 | 21.86 | 972 |
| C_2x_D vs. E_2x_N | 3.40 | 4.35 | -0.95 | 0.08 | 101 | 155 | 16.44 | 972 |
| C_2x_D vs. E_4x_N | 3.40 | 4.83 | -1.42 | 0.23 | 101 | 8 | 8.58 | 972 |
| C_2x_D vs. C_2x_F | 3.40 | 1.54 | 1.86 | 0.09 | 101 | 100 | 29.16 | 972 |
| C_2x_D vs. C_4x_F | 3.40 | 1.64 | 1.76 | 0.10 | 101 | 61 | 24.01 | 972 |
| C_2x_D vs. E_2x_F | 3.40 | 1.58 | 1.82 | 0.08 | 101 | 159 | 31.74 | 972 |
| C_2x_D vs. E_4x_F | 3.40 | 1.45 | 1.95 | 0.23 | 101 | 8 | 11.76 | 972 |
| C_4x_D vs. E_2x_D | 4.38 | 3.10 | 1.29 | 0.10 | 63 | 160 | 19.12 | 972 |
| C_4x_D vs. E_4x_D | 4.38 | 4.15 | 0.23 | 0.24 | 63 | 8 | 1.36 | 972 |
| C_4x_D vs. C_2x_N | 4.38 | 4.57 | -0.18 | 0.10 | 63 | 99 | 2.54 | 972 |
| C_4x_D vs. C_4x_N | 4.38 | 4.99 | -0.61 | 0.11 | 63 | 62 | 7.58 | 972 |
| C_4x_D vs. E_2x_N | 4.38 | 4.35 | 0.03 | 0.10 | 63 | 155 | 0.45 | 972 |
| C_4x_D vs. E_4x_N | 4.38 | 4.83 | -0.44 | 0.24 | 63 | 8 | 2.62 | 972 |
| C_4x_D vs. C_2x_F | 4.38 | 1.54 | 2.84 | 0.10 | 63 | 100 | 39.06 | 972 |
| C_4x_D vs. C_4x_F | 4.38 | 1.64 | 2.74 | 0.11 | 63 | 61 | 33.75 | 972 |
| C_4x_D vs. E_2x_F | 4.38 | 1.58 | 2.80 | 0.10 | 63 | 159 | 41.71 | 972 |
| C_4x_D vs. E_4x_F | 4.38 | 1.45 | 2.93 | 0.24 | 63 | 8 | 17.29 | 972 |
| E_2x_D vs. E_4x_D | 3.10 | 4.15 | -1.05 | 0.23 | 160 | 8 | 6.44 | 972 |
| E_2x_D vs. C_2x_N | 3.10 | 4.57 | -1.47 | 0.08 | 160 | 99 | 25.44 | 972 |
| E_2x_D vs. C_4x_N | 3.10 | 4.99 | -1.90 | 0.10 | 160 | 62 | 28.08 | 972 |
| E_2x_D vs. E_2x_N | 3.10 | 4.35 | -1.25 | 0.07 | 160 | 155 | 24.64 | 972 |
| E_2x_D vs. E_4x_N | 3.10 | 4.83 | -1.73 | 0.23 | 160 | 8 | 10.57 | 972 |
| E_2x_D vs. C_2x_F | 3.10 | 1.54 | 1.55 | 0.08 | 160 | 100 | 26.98 | 972 |
| E_2x_D vs. C_4x_F | 3.10 | 1.64 | 1.45 | 0.10 | 160 | 61 | 21.39 | 972 |
| E_2x_D vs. E_2x_F | 3.10 | 1.58 | 1.52 | 0.07 | 160 | 159 | 30.04 | 972 |
| E_2x_D vs. E_4x_F | 3.10 | 1.45 | 1.65 | 0.23 | 160 | 8 | 10.06 | 972 |
| E_4x_D vs. C_2x_N | 4.15 | 4.57 | -0.42 | 0.23 | 8 | 99 | 2.50 | 972 |
| E_4x_D vs. C_4x_N | 4.15 | 4.99 | -0.84 | 0.24 | 8 | 62 | 4.97 | 972 |
| E_4x_D vs. E_2x_N | 4.15 | 4.35 | -0.20 | 0.23 | 8 | 155 | 1.22 | 972 |
| E_4x_D vs. E_4x_N | 4.15 | 4.83 | -0.68 | 0.32 | 8 | 8 | 2.99 | 972 |
| E_4x_D vs. C_2x_F | 4.15 | 1.54 | 2.61 | 0.23 | 8 | 100 | 15.71 | 972 |
| E_4x_D vs. C_4x_F | 4.15 | 1.64 | 2.51 | 0.24 | 8 | 61 | 14.76 | 972 |
| E_4x_D vs. E_2x_F | 4.15 | 1.58 | 2.57 | 0.23 | 8 | 159 | 15.72 | 972 |
| E_4x_D vs. E_4x_F | 4.15 | 1.45 | 2.70 | 0.32 | 8 | 8 | 11.96 | 972 |
| C_2x_N vs. C_4x_N | 4.57 | 4.99 | -0.43 | 0.10 | 99 | 62 | 5.85 | 972 |
| C_2x_N vs. E_2x_N | 4.57 | 4.35 | 0.22 | 0.08 | 99 | 155 | 3.71 | 972 |
| C_2x_N vs. E_4x_N | 4.57 | 4.83 | -0.26 | 0.23 | 99 | 8 | 1.56 | 972 |
| C_2x_N vs. C_2x_F | 4.57 | 1.54 | 3.02 | 0.09 | 99 | 100 | 47.20 | 972 |
| C_2x_N vs. C_4x_F | 4.57 | 1.64 | 2.92 | 0.10 | 99 | 61 | 39.76 | 972 |
| C_2x_N vs. E_2x_F | 4.57 | 1.58 | 2.99 | 0.08 | 99 | 159 | 51.69 | 972 |
| C_2x_N vs. E_4x_F | 4.57 | 1.45 | 3.12 | 0.23 | 99 | 8 | 18.77 | 972 |
| C_4x_N vs. E_2x_N | 4.99 | 4.35 | 0.64 | 0.10 | 62 | 155 | 9.48 | 972 |
| C_4x_N vs. E_4x_N | 4.99 | 4.83 | 0.17 | 0.24 | 62 | 8 | 0.99 | 972 |
| C_4x_N vs. C_2x_F | 4.99 | 1.54 | 3.45 | 0.10 | 62 | 100 | 47.26 | 972 |
| C_4x_N vs. C_4x_F | 4.99 | 1.64 | 3.35 | 0.12 | 62 | 61 | 41.14 | 972 |
| C_4x_N vs. E_2x_F | 4.99 | 1.58 | 3.42 | 0.10 | 62 | 159 | 50.53 | 972 |
| C_4x_N vs. E_4x_F | 4.99 | 1.45 | 3.54 | 0.24 | 62 | 8 | 20.88 | 972 |
| E_2x_N vs. E_4x_N | 4.35 | 4.83 | -0.47 | 0.23 | 155 | 8 | 2.90 | 972 |
| E_2x_N vs. C_2x_F | 4.35 | 1.54 | 2.81 | 0.08 | 155 | 100 | 48.46 | 972 |
| E_2x_N vs. C_4x_F | 4.35 | 1.64 | 2.71 | 0.10 | 155 | 61 | 39.66 | 972 |
| E_2x_N vs. E_2x_F | 4.35 | 1.58 | 2.77 | 0.07 | 155 | 159 | 54.41 | 972 |
| E_2x_N vs. E_4x_F | 4.35 | 1.45 | 2.90 | 0.23 | 155 | 8 | 17.71 | 972 |
| E_4x_N vs. C_2x_F | 4.83 | 1.54 | 3.28 | 0.23 | 8 | 100 | 19.78 | 972 |
| E_4x_N vs. C_4x_F | 4.83 | 1.64 | 3.18 | 0.24 | 8 | 61 | 18.74 | 972 |
| E_4x_N vs. E_2x_F | 4.83 | 1.58 | 3.25 | 0.23 | 8 | 159 | 19.85 | 972 |
| E_4x_N vs. E_4x_F | 4.83 | 1.45 | 3.38 | 0.32 | 8 | 8 | 14.95 | 972 |
| C_2x_F vs. C_4x_F | 1.54 | 1.64 | -0.10 | 0.10 | 100 | 61 | 1.36 | 972 |
| C_2x_F vs. E_2x_F | 1.54 | 1.58 | -0.03 | 0.08 | 100 | 159 | 0.59 | 972 |
| C_2x_F vs. E_4x_F | 1.54 | 1.45 | 0.09 | 0.23 | 100 | 8 | 0.56 | 972 |

# Appendix 5

## Winter survival 2014

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| **C_4x_F vs. E_2x_F** | 1.64 | 1.58 | 0.07 | 0.10 | 61 | 159 | 0.97 | 972 |
| **C_4x_F vs. E_4x_F** | 1.64 | 1.45 | 0.19 | 0.24 | 61 | 8 | 1.13 | 972 |
| **E_2x_F vs. E_4x_F** | 1.58 | 1.45 | 0.13 | 0.23 | 159 | 8 | 0.77 | 972 |

# Appendix 5

## Winter survival 2013, 2014

**Table 7: Tukey's multiple comparison test: Winter survival 2013 2014**

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| C_2x_N13 vs. C_2x_N14 | -0.31 | -0.7514 to 0.1349 | No | ns | 0.5572 | A-B |
| C_2x_N13 vs. C_4x_N13 | 0.41 | -0.09324 to 0.9178 | No | ns | 0.2703 | A-C |
| C_2x_N13 vs. C_4x_N14 | -0.74 | -1.242 to -0.2306 | Yes | **** | <0.0001 | A-D |
| C_2x_N13 vs. E_2x_N13 | -0.03 | -0.4270 to 0.3694 | No | ns | >0.9999 | A-E |
| C_2x_N13 vs. E_2x_N14 | -0.09 | -0.4936 to 0.3078 | No | ns | >0.9999 | A-F |
| C_2x_N13 vs. E_4x_N13 | -0.16 | -1.306 to 0.9957 | No | ns | >0.9999 | A-G |
| C_2x_N13 vs. E_4x_N14 | -0.57 | -1.718 to 0.5832 | No | ns | 0.9487 | A-H |
| C_2x_N13 vs. C_2x_F13 | 0.41 | -0.03657 to 0.8474 | No | ns | 0.1155 | A-I |
| C_2x_N13 vs. C_2x_F14 | 2.71 | 2.272 to 3.156 | Yes | **** | <0.0001 | A-J |
| C_2x_N13 vs. C_4x_F13 | -0.34 | -0.8506 to 0.1655 | No | ns | 0.6128 | A-K |
| C_2x_N13 vs. C_4x_F14 | 2.62 | 2.107 to 3.123 | Yes | **** | <0.0001 | A-L |
| C_2x_N13 vs. E_2x_F13 | 0.22 | -0.1810 to 0.6173 | No | ns | 0.8864 | A-M |
| C_2x_N13 vs. E_2x_F14 | 2.68 | 2.282 to 3.079 | Yes | **** | <0.0001 | A-N |
| C_2x_N13 vs. E_4x_F13 | -0.44 | -1.593 to 0.7082 | No | ns | 0.9952 | A-O |
| C_2x_N13 vs. E_4x_F14 | 2.81 | 1.657 to 3.958 | Yes | **** | <0.0001 | A-P |
| C_2x_N14 vs. C_4x_N13 | 0.72 | 0.2131 to 1.228 | Yes | *** | 0.0001 | B-C |
| C_2x_N14 vs. C_4x_N14 | -0.43 | -0.9353 to 0.07955 | No | ns | 0.2189 | B-D |
| C_2x_N14 vs. E_2x_N13 | 0.28 | -0.1212 to 0.6800 | No | ns | 0.5524 | B-E |
| C_2x_N14 vs. E_2x_N14 | 0.22 | -0.1878 to 0.6184 | No | ns | 0.9039 | B-F |
| C_2x_N14 vs. E_4x_N13 | 0.15 | -0.9985 to 1.305 | No | ns | >0.9999 | B-G |
| C_2x_N14 vs. E_4x_N14 | -0.26 | -1.411 to 0.8923 | No | ns | >0.9999 | B-H |
| C_2x_N14 vs. C_2x_F13 | 0.71 | 0.2694 to 1.158 | Yes | **** | <0.0001 | B-I |
| C_2x_N14 vs. C_2x_F14 | 3.02 | 2.578 to 3.467 | Yes | **** | <0.0001 | B-J |
| C_2x_N14 vs. C_4x_F13 | -0.03 | -0.5443 to 0.4756 | No | ns | >0.9999 | B-K |
| C_2x_N14 vs. C_4x_F14 | 2.92 | 2.413 to 3.433 | Yes | **** | <0.0001 | B-L |
| C_2x_N14 vs. E_2x_F13 | 0.53 | 0.1248 to 0.9280 | Yes | *** | 0.0008 | B-M |
| C_2x_N14 vs. E_2x_F14 | 2.99 | 2.588 to 3.390 | Yes | **** | <0.0001 | B-N |
| C_2x_N14 vs. E_4x_F13 | -0.13 | -1.286 to 1.017 | No | ns | >0.9999 | B-O |
| C_2x_N14 vs. E_4x_F14 | 3.12 | 1.964 to 4.267 | Yes | **** | <0.0001 | B-P |
| C_4x_N13 vs. C_4x_N14 | -1.15 | -1.711 to -0.5857 | Yes | **** | <0.0001 | C-D |
| C_4x_N13 vs. E_2x_N13 | -0.44 | -0.9098 to 0.02762 | No | ns | 0.0919 | C-E |
| C_4x_N13 vs. E_2x_N14 | -0.51 | -0.9760 to -0.03434 | Yes | * | 0.0217 | C-F |
| C_4x_N13 vs. E_4x_N13 | -0.57 | -1.744 to 0.6097 | No | ns | 0.9577 | C-G |
| C_4x_N13 vs. E_4x_N14 | -0.98 | -2.157 to 0.1972 | No | ns | 0.2381 | C-H |
| C_4x_N13 vs. C_2x_F13 | -0.01 | -0.5133 to 0.4996 | No | ns | >0.9999 | C-I |
| C_4x_N13 vs. C_2x_F14 | 2.3 | 1.796 to 2.809 | Yes | **** | <0.0001 | C-J |
| C_4x_N13 vs. C_4x_F13 | -0.75 | -1.320 to -0.1898 | Yes | *** | 0.0006 | C-K |
| C_4x_N13 vs. C_4x_F14 | 2.2 | 1.638 to 2.768 | Yes | **** | <0.0001 | C-L |
| C_4x_N13 vs. E_2x_F13 | -0.19 | -0.6636 to 0.2755 | No | ns | 0.9899 | C-M |
| C_4x_N13 vs. E_2x_F14 | 2.27 | 1.799 to 2.738 | Yes | **** | <0.0001 | C-N |
| C_4x_N13 vs. E_4x_F13 | -0.85 | -2.032 to 0.3222 | No | ns | 0.4773 | C-O |
| C_4x_N13 vs. E_4x_F14 | 2.4 | 1.218 to 3.572 | Yes | **** | <0.0001 | C-P |
| C_4x_N14 vs. E_2x_N13 | 0.71 | 0.2386 to 1.176 | Yes | **** | <0.0001 | D-E |
| C_4x_N14 vs. E_2x_N14 | 0.64 | 0.1724 to 1.114 | Yes | *** | 0.0003 | D-F |
| C_4x_N14 vs. E_4x_N13 | 0.58 | -0.5960 to 1.758 | No | ns | 0.9483 | D-G |
| C_4x_N14 vs. E_4x_N14 | 0.17 | -1.008 to 1.346 | No | ns | >0.9999 | D-H |
| C_4x_N14 vs. C_2x_F13 | 1.14 | 0.6351 to 1.648 | Yes | **** | <0.0001 | D-I |
| C_4x_N14 vs. C_2x_F14 | 3.45 | 2.944 to 3.957 | Yes | **** | <0.0001 | D-J |
| C_4x_N14 vs. C_4x_F13 | 0.39 | -0.1715 to 0.9586 | No | ns | 0.5548 | D-K |
| C_4x_N14 vs. C_4x_F14 | 3.35 | 2.786 to 3.916 | Yes | **** | <0.0001 | D-L |
| C_4x_N14 vs. E_2x_F13 | 0.95 | 0.4848 to 1.424 | Yes | **** | <0.0001 | D-M |
| C_4x_N14 vs. E_2x_F14 | 3.42 | 2.948 to 3.886 | Yes | **** | <0.0001 | D-N |
| C_4x_N14 vs. E_4x_F13 | 0.29 | -0.8835 to 1.471 | No | ns | >0.9999 | D-O |
| C_4x_N14 vs. E_4x_F14 | 3.54 | 2.367 to 4.721 | Yes | **** | <0.0001 | D-P |
| E_2x_N13 vs. E_2x_N14 | -0.06 | -0.4172 to 0.2890 | No | ns | >0.9999 | E-F |
| E_2x_N13 vs. E_4x_N13 | -0.13 | -1.261 to 1.009 | No | ns | >0.9999 | E-G |
| E_2x_N13 vs. E_4x_N14 | -0.54 | -1.674 to 0.5964 | No | ns | 0.963 | E-H |
| E_2x_N13 vs. C_2x_F13 | 0.43 | 0.03485 to 0.8337 | Yes | * | 0.0182 | E-I |
| E_2x_N13 vs. C_2x_F14 | 2.74 | 2.344 to 3.143 | Yes | **** | <0.0001 | E-J |
| E_2x_N13 vs. C_4x_F13 | -0.31 | -0.7852 to 0.1577 | No | ns | 0.6355 | E-K |
| E_2x_N13 vs. C_4x_F14 | 2.64 | 2.172 to 3.115 | Yes | **** | <0.0001 | E-L |
| E_2x_N13 vs. E_2x_F13 | 0.25 | -0.1044 to 0.5984 | No | ns | 0.538 | E-M |
| E_2x_N13 vs. E_2x_F14 | 2.71 | 2.359 to 3.060 | Yes | **** | <0.0001 | E-N |
| E_2x_N13 vs. E_4x_F13 | -0.41 | -1.549 to 0.7214 | No | ns | 0.9973 | E-O |
| E_2x_N13 vs. E_4x_F14 | 2.84 | 1.701 to 3.971 | Yes | **** | <0.0001 | E-P |

# Appendix 5

## Winter survival 2013, 2014

| Tukey's multiple c.t. | Mean Diff. | 95.00% CI of diff. | Significant? | Summary | Adjusted P Value | |
|---|---|---|---|---|---|---|
| E_2x_N14 vs. E_4x_N13 | -0.06 | -1.198 to 1.074 | No | ns | >0.9999 | F-G |
| E_2x_N14 vs. E_4x_N14 | -0.47 | -1.611 to 0.6613 | No | ns | 0.9887 | F-H |
| E_2x_N14 vs. C_2x_F13 | 0.5 | 0.09645 to 0.9002 | Yes | ** | 0.0023 | F-I |
| E_2x_N14 vs. C_2x_F14 | 2.81 | 2.405 to 3.209 | Yes | **** | <0.0001 | F-J |
| E_2x_N14 vs. C_4x_F13 | -0.25 | -0.7232 to 0.2239 | No | ns | 0.9129 | F-K |
| E_2x_N14 vs. C_4x_F14 | 2.71 | 2.234 to 3.181 | Yes | **** | <0.0001 | F-L |
| E_2x_N14 vs. E_2x_F13 | 0.31 | -0.04313 to 0.6653 | No | ns | 0.164 | F-M |
| E_2x_N14 vs. E_2x_F14 | 2.77 | 2.420 to 3.127 | Yes | **** | <0.0001 | F-N |
| E_2x_N14 vs. E_4x_F13 | -0.35 | -1.486 to 0.7863 | No | ns | 0.9996 | F-O |
| E_2x_N14 vs. E_4x_F14 | 2.9 | 1.764 to 4.036 | Yes | **** | <0.0001 | F-P |
| E_4x_N13 vs. E_4x_N14 | -0.41 | -1.979 to 1.154 | No | ns | >0.9999 | G-H |
| E_4x_N13 vs. C_2x_F13 | 0.56 | -0.5907 to 1.712 | No | ns | 0.9539 | G-I |
| E_4x_N13 vs. C_2x_F14 | 2.87 | 1.718 to 4.021 | Yes | **** | <0.0001 | G-J |
| E_4x_N13 vs. C_4x_F13 | -0.19 | -1.366 to 0.9906 | No | ns | >0.9999 | G-K |
| E_4x_N13 vs. C_4x_F14 | 2.77 | 1.592 to 3.948 | Yes | **** | <0.0001 | G-L |
| E_4x_N13 vs. E_2x_F13 | 0.37 | -0.7622 to 1.509 | No | ns | 0.9992 | G-M |
| E_4x_N13 vs. E_2x_F14 | 2.84 | 1.700 to 3.971 | Yes | **** | <0.0001 | G-N |
| E_4x_N13 vs. E_4x_F13 | -0.29 | -1.854 to 1.279 | No | ns | >0.9999 | G-O |
| E_4x_N13 vs. E_4x_F14 | 2.96 | 1.396 to 4.529 | Yes | **** | <0.0001 | G-P |
| E_4x_N14 vs. C_2x_F13 | 0.97 | -0.1782 to 2.124 | No | ns | 0.2156 | H-I |
| E_4x_N14 vs. C_2x_F14 | 3.28 | 2.131 to 4.433 | Yes | **** | <0.0001 | H-J |
| E_4x_N14 vs. C_4x_F13 | 0.23 | -0.9531 to 1.403 | No | ns | >0.9999 | H-K |
| E_4x_N14 vs. C_4x_F14 | 3.18 | 2.004 to 4.361 | Yes | **** | <0.0001 | H-L |
| E_4x_N14 vs. E_2x_F13 | 0.79 | -0.3497 to 1.921 | No | ns | 0.5665 | H-M |
| E_4x_N14 vs. E_2x_F14 | 3.25 | 2.113 to 4.384 | Yes | **** | <0.0001 | H-N |
| E_4x_N14 vs. E_4x_F13 | 0.13 | -1.442 to 1.692 | No | ns | >0.9999 | H-O |
| E_4x_N14 vs. E_4x_F14 | 3.38 | 1.808 to 4.942 | Yes | **** | <0.0001 | H-P |
| C_2x_F13 vs. C_2x_F14 | 2.31 | 1.866 to 2.752 | Yes | **** | <0.0001 | I-J |
| C_2x_F13 vs. C_4x_F13 | -0.75 | -1.257 to -0.2390 | Yes | **** | <0.0001 | I-K |
| C_2x_F13 vs. C_4x_F14 | 2.21 | 1.700 to 2.718 | Yes | **** | <0.0001 | I-L |
| C_2x_F13 vs. E_2x_F13 | -0.19 | -0.5876 to 0.2131 | No | ns | 0.9675 | I-M |
| C_2x_F13 vs. E_2x_F14 | 2.28 | 1.875 to 2.675 | Yes | **** | <0.0001 | I-N |
| C_2x_F13 vs. E_4x_F13 | -0.85 | -1.999 to 0.3032 | No | ns | 0.4509 | I-O |
| C_2x_F13 vs. E_4x_F14 | 2.4 | 1.251 to 3.553 | Yes | **** | <0.0001 | I-P |
| C_2x_F14 vs. C_4x_F13 | -3.06 | -3.566 to -2.548 | Yes | **** | <0.0001 | J-K |
| C_2x_F14 vs. C_4x_F14 | -0.1 | -0.6086 to 0.4094 | No | ns | >0.9999 | J-L |
| C_2x_F14 vs. E_2x_F13 | -2.5 | -2.897 to -2.096 | Yes | **** | <0.0001 | J-M |
| C_2x_F14 vs. E_2x_F14 | -0.03 | -0.4336 to 0.3662 | No | ns | >0.9999 | J-N |
| C_2x_F14 vs. E_4x_F13 | -3.16 | -4.308 to -2.006 | Yes | **** | <0.0001 | J-O |
| C_2x_F14 vs. E_4x_F14 | 0.09 | -1.058 to 1.244 | No | ns | >0.9999 | J-P |
| C_4x_F13 vs. C_4x_F14 | 2.96 | 2.390 to 3.525 | Yes | **** | <0.0001 | K-L |
| C_4x_F13 vs. E_2x_F13 | 0.56 | 0.08846 to 1.033 | Yes | ** | 0.0049 | K-M |
| C_4x_F13 vs. E_2x_F14 | 3.02 | 2.551 to 3.495 | Yes | **** | <0.0001 | K-N |
| C_4x_F13 vs. E_4x_F13 | -0.1 | -1.278 to 1.078 | No | ns | >0.9999 | K-O |
| C_4x_F13 vs. E_4x_F14 | 3.15 | 1.972 to 4.328 | Yes | **** | <0.0001 | K-P |
| C_4x_F14 vs. E_2x_F13 | -2.4 | -2.869 to -1.924 | Yes | **** | <0.0001 | L-M |
| C_4x_F14 vs. E_2x_F14 | 0.07 | -0.4060 to 0.5378 | No | ns | >0.9999 | L-N |
| C_4x_F14 vs. E_4x_F13 | -3.06 | -4.236 to -1.879 | Yes | **** | <0.0001 | L-O |
| C_4x_F14 vs. E_4x_F14 | 0.19 | -0.9855 to 1.371 | No | ns | >0.9999 | L-P |
| E_2x_F13 vs. E_2x_F14 | 2.46 | 2.111 to 2.814 | Yes | **** | <0.0001 | M-N |
| E_2x_F13 vs. E_4x_F13 | -0.66 | -1.796 to 0.4747 | No | ns | 0.8265 | M-O |
| E_2x_F13 vs. E_4x_F14 | 2.59 | 1.454 to 3.725 | Yes | **** | <0.0001 | M-P |
| E_2x_F14 vs. E_4x_F13 | -3.12 | -4.259 to -1.988 | Yes | **** | <0.0001 | N-O |
| E_2x_F14 vs. E_4x_F14 | 0.13 | -1.009 to 1.262 | No | ns | >0.9999 | N-P |
| E_4x_F13 vs. E_4x_F14 | 3.25 | 1.683 to 4.817 | Yes | **** | <0.0001 | O-P |

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| C_2x_N13 vs. C_2x_N14 | 4.26 | 4.57 | -0.31 | 0.13 | 101 | 99 | 3.38 | 1294 |
| C_2x_N13 vs. C_4x_N13 | 4.26 | 3.85 | 0.41 | 0.15 | 101 | 62 | 3.96 | 1294 |
| C_2x_N13 vs. C_4x_N14 | 4.26 | 4.99 | -0.74 | 0.15 | 101 | 62 | 7.07 | 1294 |
| C_2x_N13 vs. E_2x_N13 | 4.26 | 4.29 | -0.03 | 0.12 | 101 | 160 | 0.35 | 1294 |
| C_2x_N13 vs. E_2x_N14 | 4.26 | 4.35 | -0.09 | 0.12 | 101 | 155 | 1.13 | 1294 |
| C_2x_N13 vs. E_4x_N13 | 4.26 | 4.41 | -0.16 | 0.34 | 101 | 8 | 0.65 | 1294 |
| C_2x_N13 vs. E_4x_N14 | 4.26 | 4.83 | -0.57 | 0.34 | 101 | 8 | 2.39 | 1294 |
| C_2x_N13 vs. C_2x_F13 | 4.26 | 3.85 | 0.41 | 0.13 | 101 | 100 | 4.45 | 1294 |
| C_2x_N13 vs. C_2x_F14 | 4.26 | 1.54 | 2.71 | 0.13 | 101 | 100 | 29.81 | 1294 |

# Appendix 5

## Winter survival 2013, 2014

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| **C_2x_N13 vs. C_4x_F13** | 4.26 | 4.6 | -0.34 | 0.15 | 101 | 61 | 3.27 | 1294 |
| **C_2x_N13 vs. C_4x_F14** | 4.26 | 1.64 | 2.62 | 0.15 | 101 | 61 | 24.99 | 1294 |
| **C_2x_N13 vs. E_2x_F13** | 4.26 | 4.04 | 0.22 | 0.12 | 101 | 158 | 2.65 | 1294 |
| **C_2x_N13 vs. E_2x_F14** | 4.26 | 1.58 | 2.68 | 0.12 | 101 | 159 | 32.64 | 1294 |
| **C_2x_N13 vs. E_4x_F13** | 4.26 | 4.7 | -0.44 | 0.34 | 101 | 8 | 1.87 | 1294 |
| **C_2x_N13 vs. E_4x_F14** | 4.26 | 1.45 | 2.81 | 0.34 | 101 | 8 | 11.84 | 1294 |
| **C_2x_N14 vs. C_4x_N13** | 4.57 | 3.85 | 0.72 | 0.15 | 99 | 62 | 6.89 | 1294 |
| **C_2x_N14 vs. C_4x_N14** | 4.57 | 4.99 | -0.43 | 0.15 | 99 | 62 | 4.09 | 1294 |
| **C_2x_N14 vs. E_2x_N13** | 4.57 | 4.29 | 0.28 | 0.12 | 99 | 160 | 3.39 | 1294 |
| **C_2x_N14 vs. E_2x_N14** | 4.57 | 4.35 | 0.22 | 0.12 | 99 | 155 | 2.59 | 1294 |
| **C_2x_N14 vs. E_4x_N13** | 4.57 | 4.41 | 0.15 | 0.34 | 99 | 8 | 0.65 | 1294 |
| **C_2x_N14 vs. E_4x_N14** | 4.57 | 4.83 | -0.26 | 0.34 | 99 | 8 | 1.09 | 1294 |
| **C_2x_N14 vs. C_2x_F13** | 4.57 | 3.85 | 0.71 | 0.13 | 99 | 100 | 7.8 | 1294 |
| **C_2x_N14 vs. C_2x_F14** | 4.57 | 1.54 | 3.02 | 0.13 | 99 | 100 | 33.03 | 1294 |
| **C_2x_N14 vs. C_4x_F13** | 4.57 | 4.6 | -0.03 | 0.15 | 99 | 61 | 0.33 | 1294 |
| **C_2x_N14 vs. C_4x_F14** | 4.57 | 1.64 | 2.92 | 0.15 | 99 | 61 | 27.83 | 1294 |
| **C_2x_N14 vs. E_2x_F13** | 4.57 | 4.04 | 0.53 | 0.12 | 99 | 158 | 6.36 | 1294 |
| **C_2x_N14 vs. E_2x_F14** | 4.57 | 1.58 | 2.99 | 0.12 | 99 | 159 | 36.18 | 1294 |
| **C_2x_N14 vs. E_4x_F13** | 4.57 | 4.7 | -0.13 | 0.34 | 99 | 8 | 0.57 | 1294 |
| **C_2x_N14 vs. E_4x_F14** | 4.57 | 1.45 | 3.12 | 0.34 | 99 | 8 | 13.13 | 1294 |
| **C_4x_N13 vs. C_4x_N14** | 3.85 | 4.99 | -1.15 | 0.16 | 62 | 62 | 9.91 | 1294 |
| **C_4x_N13 vs. E_2x_N13** | 3.85 | 4.29 | -0.44 | 0.14 | 62 | 160 | 4.57 | 1294 |
| **C_4x_N13 vs. E_2x_N14** | 3.85 | 4.35 | -0.51 | 0.14 | 62 | 155 | 5.21 | 1294 |
| **C_4x_N13 vs. E_4x_N13** | 3.85 | 4.41 | -0.57 | 0.34 | 62 | 8 | 2.34 | 1294 |
| **C_4x_N13 vs. E_4x_N14** | 3.85 | 4.83 | -0.98 | 0.34 | 62 | 8 | 4.04 | 1294 |
| **C_4x_N13 vs. C_2x_F13** | 3.85 | 3.85 | -0.01 | 0.15 | 62 | 100 | 0.07 | 1294 |
| **C_4x_N13 vs. C_2x_F14** | 3.85 | 1.54 | 2.3 | 0.15 | 62 | 100 | 22.07 | 1294 |
| **C_4x_N13 vs. C_4x_F13** | 3.85 | 4.6 | -0.75 | 0.16 | 62 | 61 | 6.49 | 1294 |
| **C_4x_N13 vs. C_4x_F14** | 3.85 | 1.64 | 2.2 | 0.16 | 62 | 61 | 18.92 | 1294 |
| **C_4x_N13 vs. E_2x_F13** | 3.85 | 4.04 | -0.19 | 0.14 | 62 | 158 | 2.01 | 1294 |
| **C_4x_N13 vs. E_2x_F14** | 3.85 | 1.58 | 2.27 | 0.14 | 62 | 159 | 23.48 | 1294 |
| **C_4x_N13 vs. E_4x_F13** | 3.85 | 4.7 | -0.85 | 0.34 | 62 | 8 | 3.53 | 1294 |
| **C_4x_N13 vs. E_4x_F14** | 3.85 | 1.45 | 2.4 | 0.34 | 62 | 8 | 9.88 | 1294 |
| **C_4x_N14 vs. E_2x_N13** | 4.99 | 4.29 | 0.71 | 0.14 | 62 | 160 | 7.33 | 1294 |
| **C_4x_N14 vs. E_2x_N14** | 4.99 | 4.35 | 0.64 | 0.14 | 62 | 155 | 6.63 | 1294 |
| **C_4x_N14 vs. E_4x_N13** | 4.99 | 4.41 | 0.58 | 0.34 | 62 | 8 | 2.4 | 1294 |
| **C_4x_N14 vs. E_4x_N14** | 4.99 | 4.83 | 0.17 | 0.34 | 62 | 8 | 0.7 | 1294 |
| **C_4x_N14 vs. C_2x_F13** | 4.99 | 3.85 | 1.14 | 0.15 | 62 | 100 | 10.94 | 1294 |
| **C_4x_N14 vs. C_2x_F14** | 4.99 | 1.54 | 3.45 | 0.15 | 62 | 100 | 33.08 | 1294 |
| **C_4x_N14 vs. C_4x_F13** | 4.99 | 4.6 | 0.39 | 0.16 | 62 | 61 | 3.38 | 1294 |
| **C_4x_N14 vs. C_4x_F14** | 4.99 | 1.64 | 3.35 | 0.16 | 62 | 61 | 28.79 | 1294 |
| **C_4x_N14 vs. E_2x_F13** | 4.99 | 4.04 | 0.95 | 0.14 | 62 | 158 | 9.87 | 1294 |
| **C_4x_N14 vs. E_2x_F14** | 4.99 | 1.58 | 3.42 | 0.14 | 62 | 159 | 35.36 | 1294 |
| **C_4x_N14 vs. E_4x_F13** | 4.99 | 4.7 | 0.29 | 0.34 | 62 | 8 | 1.21 | 1294 |
| **C_4x_N14 vs. E_4x_F14** | 4.99 | 1.45 | 3.54 | 0.34 | 62 | 8 | 14.62 | 1294 |
| **E_2x_N13 vs. E_2x_N14** | 4.29 | 4.35 | -0.06 | 0.1 | 160 | 155 | 0.88 | 1294 |
| **E_2x_N13 vs. E_4x_N13** | 4.29 | 4.41 | -0.13 | 0.33 | 160 | 8 | 0.54 | 1294 |
| **E_2x_N13 vs. E_4x_N14** | 4.29 | 4.83 | -0.54 | 0.33 | 160 | 8 | 2.3 | 1294 |
| **E_2x_N13 vs. C_2x_F13** | 4.29 | 3.85 | 0.43 | 0.12 | 160 | 100 | 5.28 | 1294 |
| **E_2x_N13 vs. C_2x_F14** | 4.29 | 1.54 | 2.74 | 0.12 | 160 | 100 | 33.34 | 1294 |
| **E_2x_N13 vs. C_4x_F13** | 4.29 | 4.6 | -0.31 | 0.14 | 160 | 61 | 3.23 | 1294 |
| **E_2x_N13 vs. C_4x_F14** | 4.29 | 1.64 | 2.64 | 0.14 | 160 | 61 | 27.22 | 1294 |
| **E_2x_N13 vs. E_2x_F13** | 4.29 | 4.04 | 0.25 | 0.1 | 160 | 158 | 3.41 | 1294 |
| **E_2x_N13 vs. E_2x_F14** | 4.29 | 1.58 | 2.71 | 0.1 | 160 | 159 | 37.49 | 1294 |
| **E_2x_N13 vs. E_4x_F13** | 4.29 | 4.7 | -0.41 | 0.33 | 160 | 8 | 1.77 | 1294 |
| **E_2x_N13 vs. E_4x_F14** | 4.29 | 1.45 | 2.84 | 0.33 | 160 | 8 | 12.13 | 1294 |
| **E_2x_N14 vs. E_4x_N13** | 4.35 | 4.41 | -0.06 | 0.33 | 155 | 8 | 0.27 | 1294 |
| **E_2x_N14 vs. E_4x_N14** | 4.35 | 4.83 | -0.47 | 0.33 | 155 | 8 | 2.03 | 1294 |
| **E_2x_N14 vs. C_2x_F13** | 4.35 | 3.85 | 0.5 | 0.12 | 155 | 100 | 6.02 | 1294 |
| **E_2x_N14 vs. C_2x_F14** | 4.35 | 1.54 | 2.81 | 0.12 | 155 | 100 | 33.91 | 1294 |
| **E_2x_N14 vs. C_4x_F13** | 4.35 | 4.6 | -0.25 | 0.14 | 155 | 61 | 2.56 | 1294 |
| **E_2x_N14 vs. C_4x_F14** | 4.35 | 1.64 | 2.71 | 0.14 | 155 | 61 | 27.76 | 1294 |
| **E_2x_N14 vs. E_2x_F13** | 4.35 | 4.04 | 0.31 | 0.1 | 155 | 158 | 4.26 | 1294 |
| **E_2x_N14 vs. E_2x_F14** | 4.35 | 1.58 | 2.77 | 0.1 | 155 | 159 | 38.07 | 1294 |
| **E_2x_N14 vs. E_4x_F13** | 4.35 | 4.7 | -0.35 | 0.33 | 155 | 8 | 1.49 | 1294 |
| **E_2x_N14 vs. E_4x_F14** | 4.35 | 1.45 | 2.9 | 0.33 | 155 | 8 | 12.4 | 1294 |

# Appendix 5

## Winter survival 2013, 2014

| Test details | Mean 1 | Mean 2 | Mean Diff. | SE of diff. | n1 | n2 | q | DF |
|---|---|---|---|---|---|---|---|---|
| **E_4x_N13 vs. E_4x_N14** | 4.41 | 4.83 | -0.41 | 0.46 | 8 | 8 | 1.28 | 1294 |
| **E_4x_N13 vs. C_2x_F13** | 4.41 | 3.85 | 0.56 | 0.34 | 8 | 100 | 2.36 | 1294 |
| **E_4x_N13 vs. C_2x_F14** | 4.41 | 1.54 | 2.87 | 0.34 | 8 | 100 | 12.1 | 1294 |
| **E_4x_N13 vs. C_4x_F13** | 4.41 | 4.6 | -0.19 | 0.34 | 8 | 61 | 0.77 | 1294 |
| **E_4x_N13 vs. C_4x_F14** | 4.41 | 1.64 | 2.77 | 0.34 | 8 | 61 | 11.41 | 1294 |
| **E_4x_N13 vs. E_2x_F13** | 4.41 | 4.04 | 0.37 | 0.33 | 8 | 158 | 1.6 | 1294 |
| **E_4x_N13 vs. E_2x_F14** | 4.41 | 1.58 | 2.84 | 0.33 | 8 | 159 | 12.13 | 1294 |
| **E_4x_N13 vs. E_4x_F13** | 4.41 | 4.7 | -0.29 | 0.46 | 8 | 8 | 0.89 | 1294 |
| **E_4x_N13 vs. E_4x_F14** | 4.41 | 1.45 | 2.96 | 0.46 | 8 | 8 | 9.18 | 1294 |
| **E_4x_N14 vs. C_2x_F13** | 4.83 | 3.85 | 0.97 | 0.34 | 8 | 100 | 4.1 | 1294 |
| **E_4x_N14 vs. C_2x_F14** | 4.83 | 1.54 | 3.28 | 0.34 | 8 | 100 | 13.84 | 1294 |
| **E_4x_N14 vs. C_4x_F13** | 4.83 | 4.6 | 0.23 | 0.34 | 8 | 61 | 0.93 | 1294 |
| **E_4x_N14 vs. C_4x_F14** | 4.83 | 1.64 | 3.18 | 0.34 | 8 | 61 | 13.11 | 1294 |
| **E_4x_N14 vs. E_2x_F13** | 4.83 | 4.04 | 0.79 | 0.33 | 8 | 158 | 3.36 | 1294 |
| **E_4x_N14 vs. E_2x_F14** | 4.83 | 1.58 | 3.25 | 0.33 | 8 | 159 | 13.89 | 1294 |
| **E_4x_N14 vs. E_4x_F13** | 4.83 | 4.7 | 0.13 | 0.46 | 8 | 8 | 0.39 | 1294 |
| **E_4x_N14 vs. E_4x_F14** | 4.83 | 1.45 | 3.38 | 0.46 | 8 | 8 | 10.46 | 1294 |
| **C_2x_F13 vs. C_2x_F14** | 3.85 | 1.54 | 2.31 | 0.13 | 100 | 100 | 25.3 | 1294 |
| **C_2x_F13 vs. C_4x_F13** | 3.85 | 4.6 | -0.75 | 0.15 | 100 | 61 | 7.13 | 1294 |
| **C_2x_F13 vs. C_4x_F14** | 3.85 | 1.64 | 2.21 | 0.15 | 100 | 61 | 21.07 | 1294 |
| **C_2x_F13 vs. E_2x_F13** | 3.85 | 4.04 | -0.19 | 0.12 | 100 | 158 | 2.27 | 1294 |
| **C_2x_F13 vs. E_2x_F14** | 3.85 | 1.58 | 2.28 | 0.12 | 100 | 159 | 27.62 | 1294 |
| **C_2x_F13 vs. E_4x_F13** | 3.85 | 4.7 | -0.85 | 0.34 | 100 | 8 | 3.58 | 1294 |
| **C_2x_F13 vs. E_4x_F14** | 3.85 | 1.45 | 2.4 | 0.34 | 100 | 8 | 10.13 | 1294 |
| **C_2x_F14 vs. C_4x_F13** | 1.54 | 4.6 | -3.06 | 0.15 | 100 | 61 | 29.16 | 1294 |
| **C_2x_F14 vs. C_4x_F14** | 1.54 | 1.64 | -0.1 | 0.15 | 100 | 61 | 0.95 | 1294 |
| **C_2x_F14 vs. E_2x_F13** | 1.54 | 4.04 | -2.5 | 0.12 | 100 | 158 | 30.27 | 1294 |
| **C_2x_F14 vs. E_2x_F14** | 1.54 | 1.58 | -0.03 | 0.12 | 100 | 159 | 0.41 | 1294 |
| **C_2x_F14 vs. E_4x_F13** | 1.54 | 4.7 | -3.16 | 0.34 | 100 | 8 | 13.31 | 1294 |
| **C_2x_F14 vs. E_4x_F14** | 1.54 | 1.45 | 0.09 | 0.34 | 100 | 8 | 0.39 | 1294 |
| **C_4x_F13 vs. C_4x_F14** | 4.6 | 1.64 | 2.96 | 0.17 | 61 | 61 | 25.31 | 1294 |
| **C_4x_F13 vs. E_2x_F13** | 4.6 | 4.04 | 0.56 | 0.14 | 61 | 158 | 5.76 | 1294 |
| **C_4x_F13 vs. E_2x_F14** | 4.6 | 1.58 | 3.02 | 0.14 | 61 | 159 | 31.1 | 1294 |
| **C_4x_F13 vs. E_4x_F13** | 4.6 | 4.7 | -0.1 | 0.34 | 61 | 8 | 0.41 | 1294 |
| **C_4x_F13 vs. E_4x_F14** | 4.6 | 1.45 | 3.15 | 0.34 | 61 | 8 | 12.98 | 1294 |
| **C_4x_F14 vs. E_2x_F13** | 1.64 | 4.04 | -2.4 | 0.14 | 61 | 158 | 24.64 | 1294 |
| **C_4x_F14 vs. E_2x_F14** | 1.64 | 1.58 | 0.07 | 0.14 | 61 | 159 | 0.68 | 1294 |
| **C_4x_F14 vs. E_4x_F13** | 1.64 | 4.7 | -3.06 | 0.34 | 61 | 8 | 12.6 | 1294 |
| **C_4x_F14 vs. E_4x_F14** | 1.64 | 1.45 | 0.19 | 0.34 | 61 | 8 | 0.79 | 1294 |
| **E_2x_F13 vs. E_2x_F14** | 4.04 | 1.58 | 2.46 | 0.1 | 158 | 159 | 33.97 | 1294 |
| **E_2x_F13 vs. E_4x_F13** | 4.04 | 4.7 | -0.66 | 0.33 | 158 | 8 | 2.83 | 1294 |
| **E_2x_F13 vs. E_4x_F14** | 4.04 | 1.45 | 2.59 | 0.33 | 158 | 8 | 11.07 | 1294 |
| **E_2x_F14 vs. E_4x_F13** | 1.58 | 4.7 | -3.12 | 0.33 | 159 | 8 | 13.36 | 1294 |
| **E_2x_F14 vs. E_4x_F14** | 1.58 | 1.45 | 0.13 | 0.33 | 159 | 8 | 0.54 | 1294 |
| **E_4x_F13 vs. E_4x_F14** | 4.7 | 1.45 | 3.25 | 0.46 | 8 | 8 | 10.07 | 1294 |

# Appendix 6

| Eigenvectors for environment in PC1 vs PC2 plot | | | | | |
|---|---|---|---|---|---|
| | **Loc_year** | **WS_mean** | **pc1** | **pc2** | **pc3** |
| **ENV** | DEN_14 | 3.46 | 0.81 | 0.14 | 0.69 |
| **ENV** | FIN_13 | 4.16 | 0.13 | 0.04 | -0.43 |
| **ENV** | FIN_14 | 1.58 | 0.22 | 0.01 | -0.36 |
| **ENV** | NOR_13 | 4.31 | -1.00 | 0.57 | 0.20 |
| **ENV** | NOR_14 | 4.59 | 0.37 | 0.06 | -0.30 |
| **ENV** | SWE_13 | 8.20 | -0.52 | -0.82 | 0.21 |

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