Evaluation of the Nordic Public Private Partnership (PPP) for pre-breeding in plants, pilot phase 2011-2013.
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Pollination of apple in the NordApp project.
1. Conclusions & recommendations

This evaluation has been conducted during spring 2013 by an evaluation panel. The evaluation terms of reference were approved by the Nordic Council of Ministers. The evaluation is based on interviews with the Steering Committee, the NordGen secretariat, the secretariat of Nordic Council of Ministers and self-assessments from the above mentioned stakeholders and the individual projects. The evaluation panel has met three times.

The EP recommends that the PPP is continued as an established partnership.

Despite the fact that the plant breeding sectors differ a lot between countries – from relatively large commercial breeders in some countries (including a world market leader within grass and clover) to 100% public breeding in Iceland - the PPP creates significant Nordic added value. In the Nordic area climatic north-south and east–west gradients are strong, and we will inevitably have a fragmented market. Precisely for this reason there is a need for collaboration where the commercial plant breeding incentives are inadequate. Long-term investments in pre-breeding include development of niche or underutilized crops, specific traits (e.g. resistance genes) in major crops or introduction of new technologies.

The EP recommends that Nordic markets are thoroughly analyzed to identify which crops and agro-climatic zones need specific Nordic attention and where we may rely on research and breeding work elsewhere. The good message is that common challenges are best met by common solutions, beyond what companies or countries may be able to achieve alone.

The establishment of PPP was met with some skepticism. However, much has been achieved in a short time. Until the PPP collaboration, a similar close collaboration between plant breeding entities was unrealistic. Now competing plant breeding programs are sharing advanced germplasm and core data.

It is the overall assessment of the EP that the organization, secretariat and the procedures developed form an adequate basis for further development of the PPP. A simple and little bureaucratic administration of the projects is important. The SC and the close involvement of NordGen ensures that the Nordic Council of Ministers receives the full benefit and Nordic added value of the conserving activities in the gene bank. It should be considered to make pre-breeding a core task of NordGen and develop its coordinating role in the PPPs.

The limited number of projects reflects the first “Targeted Call”, a term that is a self-contradiction. In fact the projects were established through discussions based on consensus, which was a good procedure when the PPP should be established.
By nature funding requirements of pre-breeding projects will grow after a couple of years. This is also the case for the established projects. For the pilot phase the budgets have been adequate and will allow the projects to develop according to the respective project plans up to approximately mid to late 2014.

The EP recommends that reliable funding of the three pilot projects is provided for a new PPP program phase from 2014-17.

As to the budget for the next phase of the PPP, the initial proposal recommended a level of DKK 25 m/year in public funding + DKK 25 m/year in additional funding. The need for efforts has not been reduced since the initial proposal. The EP recommends, that the next phase is with the full public funding on DKK 25 m/year, when new high level projects are established and in full operation. A full increase of the budget would make it possible to continue the three projects and to establish a new call. The EP recommends an open call that demands collaboration from breeders and academics in at least three countries. The call should be based on a joint strategy made by the SC and the mentioned market analysis. When new projects for PPP are selected the market side should be emphasized so that results can be adopted fast into the commercial side and help the breeders, farmers and the rest of the value chain to perform better and more profitable in their very competitive environment.

Alternatively (but not preferable) one might consider a step-wise build-up from 2014-17 with funding of three new projects. As a principle 50/50% funding is adequate, but there is a need for a flexible system. It is important that the public funding can show a similar long-term engagement in order to keep the attention of the plant breeding entities.

To ensure that the PPP will get its full budgetary amount from each participating state a more open approach has to be established. The EP recommends that in the beginning of each country’s budgetary year a payment schedule would be submitted to the PPP secretariat, so that a follow up can be done. This system would ensure a more transparent and secure finance structure to the PPP in the future.

Beyond pre-breeding addressing long term breeding goals, other areas of possible Nordic synergies are in testing of varieties and in coordinating breeding programs for marginal areas along climatic zones, rather than (as now) within each country. Plant breeding is a highly complex subject requiring well-trained academic and technical staff and education critical. Nordic collaboration through joint Nordic PhD courses in plant breeding was the first to be established in 1975. This pioneering role of plant breeding was seminal in developing e.g. NOVA and Nordforsk courses. However, both the commercial and the academic sectors have changed deeply over this time period. For broader recruitment to this sector it needs to encompass the MSc level, with internships in the companies and targeted use of industrial PhDs. The EP suggests that the SC may approach NOVA in this regard.
2 Introduction

What is pre-breeding?

The quality and quantity of agricultural production are optimized by better genes or better environments (husbandry), often interacting with each other. Breeding of plants and animals are therefore cornerstones of agricultural production. However, in practical aspects they differ. In the Nordic countries many dairy farmers are involved in the breeding through artificial insemination and recording of data. The breeding gene pool – the germplasm – is the variation among the production animals. In plants farmers will choose a ready-made cultivar from a recommended list based on the combination of desirable properties. Their choices represent a fraction of the genetic diversity in the breeders’ fields, even less of the one found in gene banks. The limited choice at the farm level results from an often baffling diversity.

Now, farmers do not choose varieties for diversity, but for productivity. Recently bred cultivars are also preferred when breeders make crosses. In case of the emergence of a new disease, all may lack resistance. To develop resistant varieties, the breeder has to search for new genes, but it takes years before new varieties are marketed. This process of pre-commercial development is called pre-breeding.

We may distinguish between three methods:

- **Base broadening**: To broaden genetic diversity in a crop to allow new combinations in the long term
- **Gene introduction**: To identify single new genes in often exotic germplasm and transfer them to adapted material in a semi-long perspective
- **Development of tools and methods**: Current biotechnologies may speed up the breeding process and give results in the short term, but they may be too costly for small or medium enterprises.

Nordic added value

The Nordic cultivar market is not self-sufficient. Many crops are served by breeders further south, often with the Nordic region as the margin of bigger markets. The genetics of a crop decides what is marginal: Maize in southern Sweden, barley north of the Arctic Circle. We cannot expect others to adapt crops - be they apples, rye grass or barley - to Northern conditions nor to the specific climate change expected in our region. Adaptation follows agro-climate rather than countries, this has been realized by variety markets for >100 years. Studies of barley in Norrland or Trøndelag show that public returns on investments in breeding for such areas are in the range from 10-50 times. The Nordic countries (excl. Denmark) therefore give public support to breeding for markets too small for commercial breeding. Conversely, without competitive cultivars, a crop or a region will decline. A historical case is oats. From covering half of the agricultural area of cereals around 1900, it declined with the replacement of the horse. Breeding was neglected for 50 years. Many variety types disappeared. In the last half of the century, commercial breeding was revived, based on a fraction of the original Nordic oat diversity and no pre-breeding. Since the *Fusarium* problem emerged about 10 years ago, the need for better resistance has become urgent. In this preeminently Nordic crop we cannot rely on others to help us.
3 Background of the Nordic Public – Private Partnership

Active exchange of varieties and breeding methods at least dates back to the late 19th century. Until the 1990s pre-breeding (in Norway, Iceland and Finland all breeding) was mainly done by public research. New genes or methods flowed into breeding companies/programs without any fees or licenses. A formal Nordic collaboration in pre-breeding, Samnordisk planteforedling (SNP) was initiated in 1981 with support from NMR. It organized joint projects on pre-commercial breeding. In 1993 SNP became a mandate of the Nordic Gene Bank, but disappeared after a few years, due to lack of funding, the wave of privatization, and to the lack of a well-defined framework.

Although most private breeders continued to pre-breed to expand their choices, commercial pressures have not favored such long term investments. In larger European countries public research has also declined, but models like PPP have reinvigorated this basic, long term and unglamorous task.

The Nordic PPP is the first formal attempt to reestablish this in our region. As proposed in the report Measures to promote Nordic plant breeding (TemaNord 2010:518), breeding companies, universities and ministries agreed on a common model. The companies were prepared to cooperate in non-commercial pre-breeding. In variety breeding they preferred bilateral agreements (also breeding of crops supported by public (national) funds). In March 2011 a partnership was launched involving 12 of the 13 Nordic breeding companies. The partnership was funded for a pilot phase, designed to last until the end of 2013. This allowed for funding of 3 collaborative pre-breeding projects over 2 years. This report evaluates the first pilot phase of this collaboration.

4 Secretariat and Steering Committee

Following the March 2011 agreement in (EK-FJLS) of NMR, a Steering Committee (SC) and a secretariat for the PPP were set up.
Steering Committee

In order to balance the favorable conditions for the breeding entities as to funding and proposing activities, representatives of all the ministries formed the majority of the SC, also having the chairman. The plant breeding entities were offered four seats, representing all the entities that had joined the PPP. These members of the SC balanced private and public entities as well as countries. Finally, one member of the SC, representing academia, was appointed by NOVA.

The SC has functioned well and all members have given meetings high priority. Decisions have been based on consensus, which is natural when initiating collaboration. The SC developed the PPP based on the discussions in EK-FJLS, endorsed the handling of contractual and IP issues, as well as development of collaboration with the Baltic countries, and provided the preparations for the present evaluation.
Nordic Rules and guidelines have been applied wherever they were found applicable in order to be more efficient. However in PPP many procedures are established for the first time, and it is natural that details are discussed in the SC while trust is being built up.

Based on the interviews the EP finds that the SC is well balanced. The EP finds it important, that the ministry representatives in the SC have had direct access to their national political agenda to make decision processes regarding PPP as effective as possible.

Funding of projects

The agreement stipulates that funding of PPP activities shall be carried 50/50 by the states and the plant breeding entities. The funding from the states is split according to the standard NMR formula and was set at DKK 4m/year for a pilot phase of 2011-2013 plus DKK 4m/year in co-financing. The proposed funding scheme was DKK 50m/year including 50% co-financing. The contributions from the plant breeding entities are split project-by-project among the participating entities and are chiefly in-kind. The complex process of public funding and different procedures and decisions in the Nordic countries has caused some uncertainties for the PPP and also for the individual projects.

Secretariat

NordGen holds the secretarial functions for the partnership, and are the contractual partner for the individual PPP projects, funded by NMR not to burden the project funding from the 5 Nordic ministries.

NordGen has also been instrumental to involve the plant breeding entities and facilitated the appointment of representatives to the SC.

The EP finds that the secretariat has carried out the PPP tasks in a satisfactory manner. The challenges raised by the different budgeting procedures, political systems etc. have been handled smoothly on behalf of the three projects. As more routines are developed, it is the expectation of the EP, that the secretariat will be able to carry more responsibility, and dedicate more time to proactively support the further development of the PPP, for example through communication activities, international co-operation and contacts to the funding ministries.

The EP finds that it is of high importance that simple and clear routines for requisition can be obtained from all participating countries, in order not to burden the administration unnecessarily, and keeping the corresponding administrative costs to a minimum.

Involvement of academia and breeding entities

The fact that eleven of twelve breeding entities that have joined the agreement are involved as active partners is also a positive aspect of the pilot phase. The involvement of academia varies between the three projects, as will be clear in the reviews later.

Recommendations regarding organization

In the past the companies have collaborated bilaterally on various levels, e.g. in research projects and marketing. Through the PPP there is a new trust between public and private actors as a group.
We consider this the most important achievement during the first two years. When starting up the collaboration in pre-breeding, they expressed the will to collaborate in pre-commercial R&D. However, in the barley project they have gone further. Through clear agreements about how to handle the materials of a competitor, they have collaborated on materials closer to market level. Due to the long term nature of the projects, it is very critical that this collaboration can continue.

At the moment, the PPP secretariat is a supplementary activity for NordGen, and the PPP system with joint national project funding and secretariat funding via NMR is a rather complicated structure. The EP suggests that it could be simplified, if (following the SNP example) the PPP became a core activity in NordGen. Given some reorganization the different Working Groups at NordGen could be steering groups for the specific projects, in time replacing the SC in this role. For example a pre-breeding project in barley might be coordinated by an extended Cereal WG also containing representatives from breeders and universities.
If the PPP in time becomes a fully and integrated part of NordGen, the partnership will oblige the countries to dedicate funding.

International perspectives

The PPP is developed from the perspective of development of the plant breeding chain for Nordic food and agriculture, and is addressing also the specific needs in the Nordic region. The collaboration with Estonia is now well established, and the PPP should also try to include Latvia and Lithuania. The challenges faced are for many parts general and will for some cases fit all European regions, even if minor regional specificities will occur. The Nordic PPP collaboration can serve as a model for other pre-breeding collaboration at regional or EU level. An informal dialogue with the EU Commission has already been initiated.

For this reason, funding of collaborative programs covering the gaps between plant genetic research, practical plant breeding and increased use of the genetic potential hidden in the conserved germplasm across Europe, could benefit both in a Pan-European format as well as in regional, Sub-European formats. Working on regional levels will however allow a higher degree of tailor-made solutions, which could secure a much needed faster implementation of sustainable use of genetic variation. Furthermore, the regional character of some challenges must be taken into account, as e.g. increased salinity and heat stress tolerance in southern regions and tolerance to wet harvest conditions and cold-spells in the Northern regions.
5 A review of the PPP projects

General comments

Agriculture in major parts of the Nordic region is confronted with environmental conditions which require specific stress resistant varieties. The selection of crops made for the present PPP projects is considered very useful, since they include some of the major crops of the region such as apple (fruit crop), spring barley (cereal) and perennial ryegrass (forage plant). In addition, these plants are representatives of different modes of propagation, i.e. self-pollination (barley), outcrossing (ryegrass), and clonal propagation (apple), which deserve the application of different breeding strategies and specific techniques. (Pre-)breeding is a long-lasting process, due to time-consuming screening of potential parents and repeated, multi-location field testing and variety development during several years. The whole process can take 15 years or more. Therefore, it is essential to run alone the trials of the present PPP projects for a minimum of three years to obtain reproducible results (the reproducibility of field data is directly related to the number of environments tested.

5.1. PPP 01: NordApp – Prebreeding for Future Challenges in Nordic Apples

Short introduction of the project

Based on their long-term contact through NordGen, participants in PPP 01 have earlier started to consider a project on pre-breeding of fruits and berries. During the workshop “Measures to Promote Nordic Plant Breeding”, Finland, 2011, apple was identified as a suitable object for a joint Nordic activity, since it is the economically most important fruit crop. However, due to harsh and often marginal conditions in Nordic countries, fruit production is often not competitive. Therefore, pre-breeding is urgently needed to develop disease and cold resistant high-quality germplasm as a basis for successful variety breeding. Although indigenous apple cultivars are available, little is known about the genetics of their major adaptive and quality traits. Pre-breeding activities in PPP 01 will be the basis for providing commercial breeders with suitable parents for future development of new and improved apple varieties combining stable productivity, high product quality and food safety. The market potential of such varieties is considered very high due to very high domestic consumption and increasing global consumption.

Listing concrete project results (network, data, meetings, publications, practical outputs)

Identification of apple materials resistant against canker and fungal storage diseases have been initiated by Hilde Nybom and coworkers at SLU, including pre-breeding activities like screening of cultivar collections for diseases and associated quality traits like fruit firmness and softening during storage, harvest date and chemical composition. Furthermore, in-depth genetic analyses are carried out using transcriptomics for identification of genes involved in resistance or tolerance to storage diseases, and using advanced microscopy and DNA-based methods for detection of disease establishment (apple canker) and pathogen identification (storage diseases). In addition, large-scale field observations of the occurrence of different storage diseases have also been carried out, where these diseases cause major problems (e.g. in Norway). The team is also in closer co-operation with the international EU-funded “Fruitbreedomics” research project. Joint disease resistance evaluation together with DNA samples of apple cultivars investigated in the NordApp project will be used to investigate the genetic background of resistance or tolerance to the mentioned diseases. This is
considered a particularly valuable and promising activity definitely leading to additional synergistic
effects for future Nordic apple breeding.

Scientific level of projects & work carried out

The scientific level of the apple research carried out with PPP 01 is very significant and the
reputation of participating scientists is particularly high as demonstrated by their extensive
international collaborations and scientific output in terms of communications and publications.

Fulfillment of project plans, level of implementation

In the short time available, a lot has been achieved already: Data on artificial inoculations of an
apple collection in Norway and Sweden have been collected (2012) and will again be done in 2013.
Preliminary results on the genetic identity of apple cultivars and clones have been obtained using
SSR and SNP markers (partly in collaboration). This kind of genetic analysis of apple germplasm
will be substantially extended further on.

Commitment from project partners, financial, other input, integration of project results in breeding
programs

Project meetings have been held regarding the preparation and application of inoculum on apple at
Balsgård, SLU (August 2012), and related research projects and breeding programs at Njøs,
Graminor (November 2012). A new public webpage for the NordApp project has been implemented
with the assistance of the secretariat. The publication record of scientists involved is very good.
The results achieved in PPP 01 are being implemented in applied apple breeding. It is far too early
now, to come to a final conclusion on the integration of (basic) results in breeding programs,
particularly considering a perennial plant such as apple. The good point is that the PPP is linked to
programs with clones at both early and advanced stages and tests can give information about
currently grown cultivars.

Funding mechanism

As far as can be seen from the project report the funding mechanism seems to be appropriate and
has allowed activities often not funded through e.g. research grants. Nevertheless, the administrative
load seems to be significant (“not too little”).

Project leadership, project coordinator, project groups and advisory groups

There are no obvious problems regarding project coordination and leadership in NordApp. If the
decision by SLU to move apple breeding from Balsgård to Alnarp may affect the PPP, is unclear.

Perspective of the collaboration, potential effects on long term

The own results of PPP 01 are complemented by additional data on gene expression
(transcriptomics) and fruit quality from other ongoing projects. This will extend the possibilities for
joint phenotypic and genotypic evaluations. Based on the current and intended results the
perspectives for future collaboration are very promising: Available apple cultivars and clones, new
plant populations and screening methods (phenotyping/genotyping) focusing on field and storage
diseases will be valuable for the launch of new breeding programs and can eventually be very useful for growers and consumers in the Nordic region. However, it would obviously been desirable to include more Finnish apple germplasm into the project and to enhance the transfer of plant material and technology. The project is obviously very relevant for Nordic fruit and apple breeding, thereby also affecting sustainability of agriculture and food security in the whole target region and beyond (e.g. Baltic countries).

Proposals for future development (extension, timeline, focus, partners)

Breeding activities are necessarily long-term due to the time needed for i) identification of suitable parents, ii) selection for numerous traits in segregating populations, and iii) multi-annual, repeated testing of experimental clones or variety candidates under varying conditions at different locations. This is particularly the case for a perennial plant such as apple. Therefore, the scheduled project time is certainly not enough to meet the envisaged goal of providing (elite) plant material to the (applied) breeders. The project will need extension of timeline, but also of focus and partners. Additional competence in the fields of plant pathology (e.g. pathogen identification of other storage diseases) and molecular technologies should be incorporated in PPP 01. Continuation of the project funding is strongly recommended. In addition to the activities on apple as a major fruit tree it would certainly be interesting to extend the studies to strawberry as the most important berry crop in Nordic countries. Ongoing applied breeding activities in Finland and Norway could serve as a good basis for such an activity.

5.2. PPP 02: Combining Knowledge from Field and from Laboratory for Pre-breeding in Barley

Short introduction of the project

The PPP 02 project traces back to long-lasting discussions on the need for pre-breeding in cereals and the implementation of PPP, initiated by R. v. Bothmer and A. Nilsson, leading to a fruitful Nordic seminar on pre-breeding in Finland arranged by NordGen. On this ground an initiative on pre-breeding in spring barley was submitted by Ahmed Jahoor. Barley is a well-studied, self-pollinating cereal of global relevance and high importance in Nordic countries. Therefore, barley is an excellent example for the creation of PPP on pre-breeding in the target region. Although this pilot project is not expected to deliver commercial varieties, it is mainly based on advanced breeding material (rather than exotic germplasm) from the participating breeders. This starting material will be collectively tested for agronomic traits including disease and stress resistances. These phenotyping activities will be used for developing new tools (e.g. markers) both for gathering genetic knowledge and improvement of the traits for future variety development. The project is expected to enhance the competitiveness of Nordic breeding enterprises.

Listing concrete project results (network, data, meetings, publications, practical outputs)

Based on long-lasting contacts and cooperation in the Nordic barley community, a strong network has been developed. Each private breeding enterprise has contributed 30 advanced breeding lines (together 180) for joint testing and screening at the different breeders’ locations. The same material is genotyped by a high-density marker system. Until now, phenotypic field data for physiological and yield traits have been collected on two locations. Disease resistance nurseries were planted in
the first year at 4 locations. Nematode resistance tests were successfully conducted. All 180 lines have been genotyped with SSR markers linked to important traits and using the 9K iSELECT illumina SNPs platform resulting in more than 6200 markers. Marker data were used to study genetic diversity and structure of the collection as a basis for association mapping. Results on genetic diversity were presented in the project meeting held at Boreal, Finland (November 2012). Closely linked, diagnostic SNP markers for nematode resistance were identified and used for marker assisted selection at Sejet and Nordic Seed. Regarding early flowering and maturity, SNP analysis was used to detect markers for the Ppd-H1 gene important for breeding early maturity barley cultivars for Nordic conditions. In addition two diagnostic SNPs have been detected for the mlo powdery mildew resistance gene. These markers are valuable to identify SNPs that enable breeders to check the presence of mlo in their breeding materials. Regarding quantitative disease resistance putative QTLs have been identified for scald, net blotch, Ramularia leaf blotch, Bipolaris spot blotch and Fusarium head blight reaction. Further, putative QTL for agronomic traits such as straw breaking, ear breaking and seed shattering by wind have been identified. At this moment and state of the PPP 02 project it is certainly too early to expect practical results. But such an output can definitely be expected in the not too far future.

Scientific level of projects & work carried out

The scientific level of this project is definitely good using state-of-the-art breeding technologies which have been developed in the global barley scientific community. The project is considered unique in providing agronomic data for Nordic breeding lines from multiple years and locations representing the diversity of spring barley in the whole Nordic region with state of the art molecular and genomic techniques. The academic “cost” of close collaboration between breeders is that data and materials are surrounded by more secrecy than in the other PPPs. Although a wise step to initiate collaboration, the EP considers this a dilemma using 50% public funds and it should be discussed in the next round.

Involvement of relevant scientific expertise

Two academic partners are involved representing areas of expertise required in the project, i.e. the Agricultural University of Iceland and the University of Copenhagen. Academic partners complement each other and run a PhD student together in PPP 02 in collaboration with the Norwegian University of Life Sciences; they provide the equipment for molecular marker analysis. Supplementary competence needed for nematode tests is provided by Plantedirektoratet (today Naturerhvervsstyrelsen) in Denmark.

Fulfillment of project plans, level of implementation

Based on the early collaboration between partners in PPP 02, the project could be implemented quickly and is on its good way. So far, the project is run according to schedule and has made more than the expected progress.
Commitment from project partners, financial, other input and integration of project results in breeding programs

The results of PPP 02 are being implemented in applied spring barley breeding. The novel molecular tools will be of interest for the whole barley community (spring and winter types). However it is too early to come to final conclusions on the future full potential for integration of results in breeding programs.

Involvement of non-Nordic partners

Until now non-Nordic plant breeding entities have not been included because of the late integration of Baltic countries in the process, the short funding period and the first and major project aim to build and strengthen the “trust and share” in Nordic collaboration. Collaboration with Baltic States should be implemented at a later project phase. Collaboration with a German University is initiated due to the fact that one of the project participants has changed job, and is now employed at this University.

Funding mechanism

Financing such a long-term project is always a challenge. Nevertheless, funding has finally been established. The administrative work load is considered as “adequate”.

Efficiency of collaboration

Different legal situations in the Nordic countries are seen as a major obstacle also leading to a substantial load of paper work. However, due to earlier existing contacts and exchange, the collaboration between the breeding entities in PPP 02 is considered to work very well.

Project leadership, project coordinator, project groups and advisory groups

There are no obvious problems regarding coordination and leadership in project PPP 02.

Perspective of the collaboration, potential effects on long term

This project has very good perspectives and long-term impact.

Relevance of projects for Nordic plant breeding and plant production

The PPP 02 project is highly relevant for Nordic plant breeding due to the outstanding importance of barley as a major cereal crop in the region. Therefore, it is relevant for feed and food security as well as sustainability of agriculture as a whole in the target region (and beyond).

Proposals for future development (extension, timeline, focus, partners?)

The scheduled experiments have now been conducted for one year and are planned to be repeated in a second year. The second year is absolutely necessary to confirm the one-year field phenotyping data and verify the putative QTL for agronomic traits and disease resistances.
For the future, it is planned to include exotic material and landraces into the project to enhance disease resistance and agronomic traits, particularly related to adaptation (climate change). Crosses are made between advanced lines and exotic/landraces which will not directly lead to new varieties; instead, several backcrosses will have to be made to sufficiently adapt the material to the Nordic conditions, identify superior elite lines and develop new barley cultivars. It is strongly recommended to continue the barley PPP project and extend the funding period.

5.3. PPP 03: PPP for Pre-breeding in perennial ryegrass (*Lolium perenne* L.)

**Short introduction of the project**

This clear and well-described, long-term base broadening project is based on first discussions in a pre-breeding workshop in 2011. Perennial ryegrass, an outcrossing, persistent (frequent cutting), high-yielding and high-quality, grazing-resistant forage grass important for livestock husbandry is considered attractive and very useful as a component of the PPP program. The major challenge for cultivation of this crop in (Northern) Scandinavia is its limited winter hardiness. New varieties to be developed need to be resistant against biotic and abiotic stress and adapted to Nordic conditions (e.g. photoperiod). Collaborators include all commercial companies working on ryegrass in Nordic countries, i.e. Denmark, Finland, Sweden and Norway and also testing in Iceland, as well as three academic partners including Odd Arne Rognli (Norwegian Univ. Life Sci.), who acts as a coordinator and project leader. Materials for evaluation also include germplasm from Estonia, as well as association of the Estonian grass breeders, which is considered useful for acquiring additional germplasm from other countries such as Russia.

**Listing concrete project results (network, data, meetings, publications, practical outputs)**

Exotic material was collected from gene banks for multiplication and field observation (phenotyping, e.g. for winter hardiness). Crossing blocks have been established to create novel breeding populations. Genomic DNA has been isolated for sequencing, SNP allele identification, description of genetic diversity and architecture of the ryegrass material. The scientists involved have a very good publication record; The current work will definitely lead to both further scientific output and novel breeding material for the Nordic target region.

**Involvement of relevant scientific expertise**

Three academic partners from Denmark, Iceland and Norway are involved and make substantial contributions on phenotyping (field evaluations) as well as genotyping. Obviously, no major competence is missing here.

**Fulfillment of project plans, level of implementation**

There were some initial problems reported regarding the availability of required seeds. This was solved with the assistance from NordGen. Nevertheless, the project is on its way and has made the expected progress.

**Commitment from project partners, financial, other input, integration of project results in breeding programs**
The results achieved in PPP 03 will be implemented in applied breeding activities of grasses. While the material will be relevant for ryegrass breeding, the novel molecular tools will be of interest for all grass species grown in the Nordic area. At this moment, it is far too early, to come to a final conclusion on the integration of (basic) results in breeding programs, particularly for a perennial plant such as ryegrass.

Involvement of non-Nordic partners

This is a project with a strong focus on Nordic countries and their agriculture. The Estonian plant breeding company Jõgeva is associated to the project, and participates on similar conditions as the Nordic participants, but the corresponding public funding is provided by the Estonian ministry of agriculture. However, further cooperation of PPP 03 with Baltic countries would be welcome.

Funding mechanism

The wording of the consortium agreement is considered somewhat complicated by the applicants. Due to the complex funding mechanism the framework is perceived as somewhat bureaucratic causing some administrative barriers. Nevertheless, project meetings are said to be focused and concise. For future investments the uncertain funding situation is considered as an obstacle.

Efficiency of collaboration

Collaborations also include other projects, e.g. for On-farm conservation of forage crops, including evaluation of germplasm (ryegrass, legumes) and thereby creating synergistic effects.

Project leadership, project coordinator, project groups and advisory groups

There are obviously no problems regarding project coordination and leadership in PPP 03.

Perspective of the collaboration, potential effects on long term

This project has very good perspectives and long-term impact. This is not only due to the PPP 03 project alone but also the participation of partners in other programs, e.g. NordForsk NOFOCGRAN, the VARCLIM project and the project ‘On-farm conservation of the forage species timothy, meadow fescue and red clover: Generation of new landraces in Norway’. Such international collaborations inevitably lead to synergistic effects.

Relevance of projects for Nordic plant breeding and plant production

The project is obviously highly relevant for Nordic grass breeding, thereby also influencing feed security and sustainability of agriculture in the whole target region and beyond.

Proposals for future development (extension, timeline, focus, partners)

The PPP 03 project is expected to generate valuable ryegrass breeding populations for the target region. Furthermore, the genotypic and phenotypic data generated will be used for association analysis to develop molecular tools suitable for marker-assisted selection. Both aspects will be
highly attractive for the breeding companies involved to create novel ryegrass varieties well adapted to Nordic growing conditions. Therefore, continuation of the PPP project on ryegrass and extension of the funding period is strongly recommended.

Copenhagen June 4th 2013

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Research director, Danish Agriculture and Food Council, Denmark, chair and on behalf of the Evaluation Panel

Åsmund Bjørnstad
Professor of plant breeding, Norwegian University of Life Sciences

Wolfgang Friedt
Professor of plant breeding, University of Giessen, Chair of the scientific advisory board of GFP

Max Schulman; Advisor, Cereals & Oil seeds MTK, Chairman for the Cereals and oilseeds Working Group, Copa-Cogeca

Dr. Prof. Ahmed Jahoor, Breeding manager, Nordic Seed, coordinator of the PPP barley project.
Project participants of the PPP barley project

Prof. Odd Arne Rognli, UMB, coordinator of the PPP ryegrass project

Apple canker, one of the target diseases of the PPP apple project