





# Measures to promote Nordic plant breeding

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## Nordic co-operation

*Nordic cooperation* is one of the world's most extensive forms of regional collaboration, involving Denmark, Finland, Iceland, Norway, Sweden, and three autonomous areas: the Faroe Islands, Greenland, and Åland.

*Nordic cooperation* has firm traditions in politics, the economy, and culture. It plays an important role in European and international collaboration, and aims at creating a strong Nordic community in a strong Europe.

*Nordic cooperation* seeks to safeguard Nordic and regional interests and principles in the global community. Common Nordic values help the region solidify its position as one of the world's most innovative and competitive.

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# Preface

In its preparations for the Swedish presidency in the Nordic Council of Ministers in 2008 the Swedish Ministry of Agriculture decided to focus on two issues, Climate Change and Bioenergy. Climate Change will have profound impact on the conditions for Nordic agriculture and the need for plant varieties adapted to changed conditions had been identified. Thus, a commission was given to investigate the need for collaborative efforts to strengthen Nordic plant breeding.

This report has been delivered to the Nordic Council of Ministers in June 2009. At the summer meeting of the Nordic Ministers of Agriculture in Isafjörður, Iceland 2 July 2009 it was decided to give a working group the task to consider issues on the implementation of proposals given in this report.



# Summary

Climate change will lead to increased temperatures and changed precipitation patterns with foreseen changes more pronounced in the Nordic countries than in many other parts of the world. As a consequence, seeds and plants need to be adapted to new agro-climatic conditions. Resistances of varieties to pathogens and pests need to be continuously improved. Changed production systems and expansion of certain crops to new regions will also imply needs for efforts in the entire plant breeding chain.

In comparison with the situation a few years ago, efforts in the Nordic countries in plant breeding and research in connection with the breeding have been reduced. Commercial as well as public breeding has been reduced due to commercial considerations and less support.

Viewpoints put forward from the plant breeding community and stakeholders indicate worry about the present situation in plant breeding and a willingness to collaborate. In the political sphere there is an awareness of plant breeding as a strategic activity and that the Nordic countries have good reasons to collaborate in giving plant breeding good preconditions for its long-term development as part of Nordic initiatives to meet Climate Change.

Pre-commercial development in plant breeding, or pre-breeding, has considerable support in other EU countries. Thus, joint Nordic efforts could also level the competitive situation for Nordic plant breeding.

In the report the following measures are proposed:

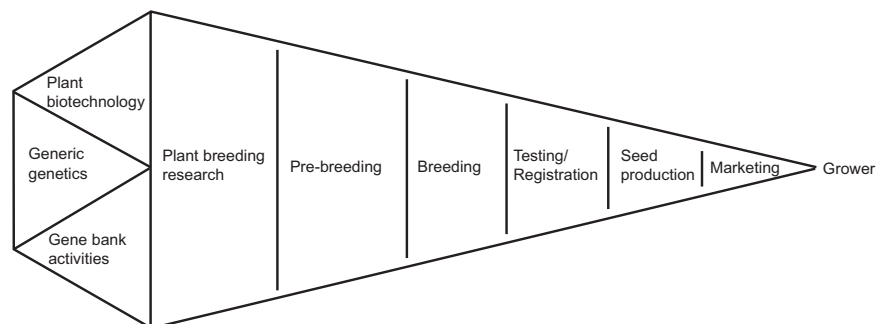
- Re-vitalization of the collaboration in research education in plant breeding
- Establishment of a PublicPrivatePartnership (PPP) for Plant breeding
- Initiatives to organize collaboration in breeding of fruits and berries

The PPP should be administered by NordGen and support pre-breeding activities with a budget of 50 MDKR/year, funded with 60% from NMR and 40% from breeding entities engaged as partners in a specific project. The PPP should support long-term development of plant breeding to meet long-term needs of agriculture and horticulture – adaptation to Climate Change, environmental policies, demands from consumers and markets, etc. A description of projects on barley and wheat of joint interest for the Nordic plant breeding companies, listed in priority, is included in the report as one of the appendices.



# 1. Background

Climate Change will lead to increased temperatures and changed precipitation patterns with foreseen changes more pronounced in the Nordic countries than in many other parts of the world. As a consequence, seeds and plants need to be adapted to new agro-climatic conditions. Pathogens and pests will be favoured and resistances of varieties need to be continuously improved in order to meet targets on reduced use of pesticides. Climate Change will lead to needs for changed production systems, certain crops will expand to new regions and completely new crops will become introduced, in all aspects implying needs for new varieties for the competitiveness in traditional markets and for the development of new business opportunities. Due to time requirements for the adaptation of genetic material, such development must be initiated now, not when the predictions of Climate Change have been realized. Efforts in the entire plant breeding chain are a prerequisite to meet these demands on access to well adapted genetic material. Further, the development over the last years has underlined the need for sustained activities in agricultural research, aiming at sustainable and increased production.



*Fig. 1. The plant breeding chain*

- Generic genetics – research on genetics of crops and related species
- Plant biotechnology – research on GMO's, biotech based technologies, etc
- Gene bank activities – preservation and characterization of genetic material for future use
- Plant breeding research – research that can be directly applied in breeding and pre-breeding
- Pre-breeding – broadening of the genetic base for breeding introduction of specific genetic variation in adapted genetic background development of tools for breeding

- Breeding – creation of new genetic variation followed by selection of potential new varieties
- Testing – assessment of technical value of varieties in different agroclimatic conditions
- Registration – notification of rights for commercial use of a new variety
- Seed production – propagation of seed in steps from basic source to market volumes
- Marketing – offering for sale
- Grower – professional and amateur growers of agricultural and horticultural crops

## 2. The commission

The Nordic Council of Ministers (NMR) has commissioned prof Roland von Bothmer, former Dean of the LTJ faculty, Swedish University of Agricultural Sciences (SLU), and research adviser Anders Nilsson, LTJ faculty, SLU, former Research director at Svalöf Weibull, to investigate the need for collaborative efforts to strengthen Nordic plant breeding as a specific project. The commission was given in view of demand for new genetic material linked to effects of Climate Change as well as the structural changes that have taken place in plant breeding over the last decade. The project plan (in Swedish) is added as appendix 1.

During the course of the project the mandate has been expanded on two issues. One concerns the breeding of fruit and berries, which is conducted on the basis of public funding, and the possibilities not only for increased collaboration, but also split of responsibilities and tasks. This additional issue was first raised in discussions with our contact persons at the Ministry of Agriculture (MMM) in Finland, and has thereafter been acknowledged in discussions with our contact persons at Landbrugs- og matdepartementet (LMD) in Oslo and Jordbruksdepartementet (Jo dep) in Sweden.

The other issue comprises increased collaboration concerning certain prerequisites for registration of new varieties which relates to so-called DUS (Distinctness, Uniformity and Stability) and VCU (Value for Cultivation and Utility) testing. In this context it is explicitly mentioned that there is an ambition to be able to maintain DUS testing of new varieties in the climatic region for which the new varieties have been developed on condition that this can be accomplished at reasonable costs. This issue will be dealt with separately in a report planned to be delivered in the first half of 2010.



### 3. The accomplishment of the commission

The mandate for the investigation was established in February, 2008. Shortly thereafter a first meeting with a reference group (appendix 1) was held for discussions on how to set up the investigation, which contacts to take in the plant breeding community and for preliminary assessments of the situation for Nordic plant breeding.

Contacts were also established with assigned persons in the Ministry of Agriculture of the respective country (appendix 1). A workshop in early June 2008 with the reference group, two of the contact persons and invited participants from plant breeding and research provided valuable input.

A report on the development of the investigation, including preliminary assessments, was presented at the summer meeting of the Nordic Ministers of Agriculture in Växjö, June, 2008.

Already during spring 2008, but more intensively in summer and autumn, we have had close to 40 meetings with our reference group, assigned contact persons and different members of the plant breeding community and stake holders (appendix 2). From autumn 2008 focus has been more and more on the ensuring of the support to our proposals from society as well as the plant breeding community and stake holders. Meetings with all the larger Nordic plant breeding companies have taken place in December 2008 and March 2009. Contacts with the respective Ministry of Agriculture, in particular with Sweden having the chairmanship of NMR in 2008 and Iceland in 2009 as well as with the secretariat of NMR, have been followed by a joint workshop for the final adjustment of this report and our proposals on May 26, 2009. This report will be discussed at the summer meeting of the Nordic Ministers of Agriculture in Iceland, July, 2009.



## 4. Presentation of Nordic plant breeding

All plant breeding of agricultural crops in Denmark is conducted in privately owned companies. The largest plant breeding company is *DLF Trifolium* based on its position as the leading company for forage and turf seeds in Europe. The company is owned by Danish seed growers. The plant breeding encompasses several grass species, red and white clover and forage beets with a focus on perennial rye grass, including certain pre-breeding and plant biotech efforts for the development of tools for genetic analysis and for improved quality. The pre-breeding and plant biotech is conducted in collaboration with mainly Danish universities, partly funded within the Danish system for support to development of industries. The main breeding site is at Store Heddinge, south of Copenhagen, but also with breeding stations in the Netherlands, France and Czech Republic.

*Sejet* is owned by Dansk Landbrugs Grovvareselskab (DLG), a farmers' cooperative, and situated in the eastern part of Jutland. *Sejet* is the leading Danish breeder of cereals with programs in winter wheat, winter barley and spring barley. In recent years the rather small pre-breeding effort has mainly concerned development of specific disease resistance and feed quality in winter wheat. *Nordic Seed* is the other breeding company in Denmark engaged in breeding of wheat and barley. The company is the result of a merger last year of the breeding of the Pajbjerg and Abed foundations, two breeding entities with a long tradition. The company is owned by DLA Agro, also trading inputs to and produce from agriculture on a cooperative basis, and the two foundations. *LKF-Vandel*, owned by Danespo. is breeding potatoes close to Billund, aimed at development of varieties for Danish export of seed potatoes. *Flakkebjerg*, Århus University is breeding sour cherries.

In Iceland there is a small public breeding in the *Agricultural University* aimed at development of varieties in barley and grasses suited for the specific conditions in Iceland. *ORF Genetics* is a plant biotech company developing genetically modified barley for the production of specific enzymes.

In Norway all breeding has been brought together in *Graminor*, at Bjørke, close to Hamar, with the Norwegian state and the farmers' cooperative as the main owners. *Graminor* has Svalöf Weibull in Sweden as a minority owner and the two companies are cooperating in the breeding of cereals and forages. *Graminor* is breeding barley, wheat, oats, forage grasses and clover, potatoes, fruits and berries. The breeding of forages,

potatoes, fruits and berries is based on public funding and there is also public support to certain pre-breeding efforts in several crops in collaboration with university researchers.

In Finland breeding of agricultural crops is done by *Boreal* (Jokioinen) which has the Finnish state as its majority owner. The breeding program is diversified and includes wheat, rye, barley, oats, spring turnip rape, forage grasses and clover, peas, field beans and potatoes, aimed at development of varieties for the specific Finnish conditions. The breeding of minor crops receives public support, as well as some pre-breeding efforts in collaboration with MTT, the Finnish institute for applied research for agriculture and food. The breeding of fruits and berries is done at MTT Piikkiö, close to Turku, and is based on public funding.

*Svalöf Weibull* in Svalöv, Sweden and owned by Lantmännen, a farmers' cooperative, has the largest Nordic plant breeding efforts even after reductions of its operations in recent years. The breeding in Svalöv includes wheat, barley, oats, spring oilseed rape, forage grasses, red and white clover and lucerne, supplemented with a small program in mid-Norrland for barley and forages, partly with public funding. Abroad Svalöf Weibull is breeding winter wheat and winter oilseed rape in Germany and triticale and potatoes in the Netherlands. The pre-breeding efforts have been reduced and are now focused on oilseed rape, wheat and barley.

*Syngenta Seeds* has its breeding of sugarbeets in Landskrona for the global market of this crop. The breeding is supported by plant biotech and research. *SLU* is conducting public breeding of potatoes (Alnarp) and fruits and berries (Balsgård).

In comparison with the situation a few years ago the overall efforts in pre-breeding and research in connection to the breeding have been reduced considerably, perhaps excluding the investments made by Syngenta Seeds in sugarbeets. The plant biotech efforts by Nordic companies are also considerably reduced. The structural changes with mergers and closed operations have continued. Several smaller breeding programs have been closed as a result of commercial considerations. Also, the national public support to breeding of minor crops has been reduced. Thus, there is no longer any breeding of vegetables in the Nordic countries.

## 5. Viewpoints put forward to the investigators

As mentioned above we have had a number of contacts with representatives for the plant breeding community at large in the Nordic countries, including stake holders in the results of plant breeding, such as organizations of farmers in the Nordic countries. In order to focus on the needs of the plant breeding community and the stake holders, rather than the possibilities offered by research, we have refrained from more extensive discussions with the different research environments engaged in plant breeding research.

Notes have been taken from meetings and contacts with plant breeding companies, entities at institutes/universities and stake holders.

The viewpoints put forward from *the plant breeding community and stakeholders* can be summarized as follows:

- All breeding companies and entities expressed their *worry for their possibilities to recruit future plant breeders*. There is a need for strengthened research education in plant breeding, combining more traditional methods and quantitative genetics with different aspects of plant biotechnology. Only few candidates have this general agricultural/horticultural profile including necessary aspects on practical breeding and genetics. Candidates with a background in plant biotech normally lack these skills in their training.
- The plant breeding companies are only prepared to *collaborate in practical plant breeding in agricultural crops on a bilateral basis* between concerned companies linked to market considerations, also regarding breeding of agricultural crops based on public funding. Regarding breeding of fruit and berries the breeding entities are more open to discuss collaboration.
- All breeding companies and entities identify *pre-breeding as an area where the present efforts are far too low* in view of the possibilities given by research and the needs for new genetic material as the effects of Climate Change become more obvious. The breeding companies also identify this as an area where plant breeding companies in the Nordic countries have a competitive disadvantage in comparison to plant breeding in other parts of Europe with extensive national programs supporting pre-breeding activities, e.g. Germany, UK and France (appendix 3). Further, the breeding companies and entities express that they are fully prepared to collaborate with their competitors in pre-breeding efforts with examples on activities such as devel-

opment of tools for selection, introduction of new variation in an adapted genetic background, broadening of the genetic basis for breeding, etc.

- The *stake holders* have expressed their concern regarding the future competitiveness of Nordic plant breeding. Also they have *expressed their dependency on varieties adapted to Nordic conditions*, underlining that imported varieties from other areas in many agricultural and horticultural crops are less adapted to day length and other specific conditions for Nordic plant production.

Excerpt of the minutes from a meeting with representatives from the Nordic Plant breeding companies from March 9, 2009 are included (appendix 4). At this meeting our preliminary proposals were discussed, resulting in the following statements from the companies:

- The plant breeding community should have a strong influence on the proposed Public Private Partnership.
- Funding from companies of projects should be linked to participation in a project and allow for considerable contributions in-kind.
- Execution of a project at a company should be possible.

The political background for the commission was outlined in the project plan (appendix 1). In the course of the investigation we have also had several discussions with *our contact persons at the respective Ministries of Agriculture*. These discussions have brought the attention to the following aspects on plant breeding and related issues:

- *Plant breeding is a strategic activity* ensuring growers in agriculture and horticulture access to well adapted and suitable varieties which can not be left only to commercial interests to carry out. This is underlined by the structural changes in the plant breeding industry with its emphasis on meeting short-term demands in the breeding of major crops combined with plant biotechnology, while breeding for specific segments (regions, specific qualities, etc.) or of minor crops to a large extent receives low attention. National funding is used to support short- and mid-term development of varieties in minor crops and for specific regions (public breeding) to a various degree in the respective Nordic countries.
- The Nordic countries have jointly taken responsibility for the preservation of certain genetic resources through *NordGen*. However, *the low level of utilization of these resources is a concern*. Support to the production of certain old varieties of specific interests for regional production could be considered on a joint Nordic basis with arctic cabbage as an example.

- The Nordic countries have good reasons *to collaborate in giving plant breeding good preconditions for its long-term development* even if the regional differences and the demands on the varieties differ considerably. Such collaboration *would be an important part of Nordic initiatives to meet Climate Change. The proposed Public Private Partnership (PPP) for pre-breeding fits well into this frame.* However, the results of the proposed PPP need to be incorporated in the breeding of new varieties, preferably in a commercial context by plant breeding companies, but supplemented with public breeding in minor crops and for specific regions. *The public breeding should be based on national considerations, avoiding overlap* between different national activities.
- For society in the Nordic countries it is important to base support to long-term development of plant breeding on the long-term needs of agriculture and horticulture – adaptation to Climate Change, meeting targets for environmental policies, meeting demands from consumers and markets, etc. The fact that the Nordic countries now are belonging to the same region in Europe when it comes to registration of pesticides has strengthened the arguments for joint efforts in this respect.
- A joint program must allow for a balance between regional interests and development of major crops, between political initiatives and bottom-up proposals from the plant breeding community. There should be a focus on activities that would support long-term development of production systems that combine political ambitions and commercial possibilities.
- The administration of the proposed PPP should be resource efficient.

These aspects on plant breeding have been discussed at a workshop with our contact persons at the respective Ministries of Agriculture on May 26, 2009.



## 6. Conclusions from the investigation

The following conclusions are drawn from the investigation and the discussions we have had with the plant breeding community, stake holders and our contact persons:

- Higher education in plant breeding should be strengthened in order to meet the needs of the plant breeding community as well as other parts of society, including authorities. The need for these competences increases with Climate Change. The plant breeding community, other parts of the agricultural sector, institutes, extension service and authorities must also make obvious that higher education in plant breeding offers attractive career possibilities.
- Climate Change will have strong impact on the need for development of new varieties of agricultural and horticultural crops for the Nordic countries, and in particular in crops where these needs can't be met with import of varieties from other regions due to specific demands on adaptation to Nordic conditions. In order to meet these demands it is *recommended that pre-breeding* in collaboration between companies and universities in a Nordic context *is supported*.
- Pre-commercial development in plant breeding, or *pre-breeding*, has considerable public support in other EU countries (appendix 3). The pre-breeding efforts in Germany, UK and France are focused on the specific demands for the respective countries and aim at the development of genetic materials adapted for their agroclimatic conditions and supporting tools for breeding. *Joint Nordic efforts could level the competitive situation for Nordic plant breeding*, and at the same time make possible the practical utilization of results from Nordic plant breeding research.
- The Nordic countries are a small and fragmented market for international plant breeding. Thus, it can't be expected that international plant breeding companies will develop varieties aiming specifically for the needs of these market fragments. Generation of new cultivars in agricultural crops is performed by breeding companies in a competitive environment. The activities in major crops have been reduced over time due to rationalisation and structural changes. Generation of new cultivars in minor crops or for niche markets in major crops is done in this competitive environment by breeding companies, partly with public funding. *The Nordic plant breeding companies have established bilateral agreements for certain collaborations regarding*

*agricultural crops*, including split of responsibilities etc in the development of new varieties, based on their respective market channels. It is difficult to influence these bilateral agreements from public bodies and authorities, even if the breeding activities in some of these agricultural crops receive partial public funding.

- *Collaboration in breeding of fruit and berries should be increased.* Over time, it will become difficult to justify corresponding, and even overlapping activities for these crops in the respective countries, since these are completely based on public funding.
- There is a need for initiatives on joint evaluation and *testing of vegetable varieties* for the Nordic countries in order to clarify the adaptation of available varieties to different climatic zones.
- Nordic plant breeders are disfavoured by the setup of the *DUS testing* in certain species.
- *NordGen* is the only Nordic institution that could host proposals on joint Nordic efforts in support of plant breeding.
- There is a need to clarify which *efforts* are best performed *on the respective Nordic, bilateral and national levels*. Gene bank activities and pre-breeding are well suited for joint efforts on the Nordic level since the results can be used in the entire Nordic region for more specific developments. It should be observed that the day-length conditions in a large part of the Nordic region are unique for agricultural and horticultural production in a global comparison. Testing of varieties for registration and of their performance could be developed on a bilateral, regional basis, following natural agroclimatic zones, for more consistent results compared to how these activities are organized at present. Collaborations between companies are by nature developed bilaterally. Support to public breeding is best handled at a national level taking into account national considerations, avoiding overlaps between countries. Support which is aiming to enable access for growers to specific requirements of seed, i.e. seed of historic varieties (arctic cabbage etc.), or to markets which are too small to function in a market economy, such as Iceland, is also best handled at the national level.

## 7. Proposals for measures to promote Nordic plant breeding

The following measures to promote the ability of Nordic plant breeding to meet requirements on genetic material, adapted to Climate Change and other needs expressed from society and stake holders, are proposed:

- Recommend NOVA to aim at re-vitalization of the research education in plant breeding, combining quantitative genetics, breeding technologies and plant biotechnology. Open up for calls specifically on industrial PhD-positions in plant breeding through NordForsk, similar to the program recently established. Other examples to follow are the research school linked to Umeå Plant Science Centre for industrial PhD students in plant breeding of forest trees and the scheme supporting Biotech Denmark.
- Establishment of a PublicPrivatePartnership (PPP) for Plant breeding administered by NordGen and with its public funding from NMR. The PPP for Plant breeding should be a tool for the funding of pre-breeding activities based mainly on initiatives from the plant breeding community, but also on initiatives from public bodies or academy meeting targets on environmental policies, with a budget of 50 MDKR/year, funded with 60% from NMR and with 40% from breeding companies and entities, engaged as partners in a specific project or activity. The program should be opened as of January 1st, 2010 and be fully established over a 3 year period. The PPP should be open for support to commercial breeding as well as to breeding based on public funding. The PPP for Plant breeding is presented more in detail in appendix 5–7.
- The PPP should be administered by NordGen. A specific Steering committee should be responsible for the PPP, reporting directly to NMR. Its composition has to be balanced between society (including chairman), the plant breeding community and academy. There should be a rolling scheme for the renewal of terms for the committee. The Steering committee should be supplemented by a Reference group with representation from academy (including chairman) and the plant breeding community. The composition of the Steering committee and the Reference group should allow for all concerned Nordic countries to be represented in any of the two bodies, and likewise for major members of the plant breeding community.
- The proposed setup will allow public interests to influence the long-term directions of the PPP, while at the same time the engagement of the plant breeding community is ensured. It will also allow proper

handling of conflicting interests in the prioritization of and decisions on project proposals.

- *The PPP should support long-term development of plant breeding to meet the long-term needs of agriculture and horticulture* – adaptation to Climate Change, meeting targets for environmental policies, meeting demands from consumers and markets, etc. It must allow for a balance between regional interests and development of major crops, between political initiatives and bottom-up proposals from the plant breeding community. There should be a focus on activities that would support long-term development of production systems that combine political ambitions and commercial possibilities.
- If successful, the PPP could be expanded in the future or serve as an example for similar Nordic efforts in other areas connected to agricultural R&D.
- *Initiatives to initiate collaboration between the entities engaged in plant breeding of fruits and berries* with the ambition to divide responsibilities in the practical breeding between the concerned parties. We propose that Graminor has the responsibility for the genetic development of strawberries (molecular breeding tools), raspberries and plums; MTT Piikkiö has the responsibility for strawberries (day length neutral genetic material), blueberries and pear; and SLU Balsgård has the responsibility for apple, currants and sea buckthorne, while all three entities and an appropriate entity in Denmark are engaged in the selection and testing of lines and varieties in all species of interest (appendix 8). Further, the public breeding of sour cherries performed by Flakkebjerg, Århus University should be linked to this trilateral agreement.
- *Plant breeding of vegetables* is no longer being performed in the Nordic countries. The vegetable seeds required by growers of vegetables in the Nordic countries are mainly supplied from the large global vegetable seed companies. The only group of vegetables for which a certain restarted plant breeding could be motivated are the leafy vegetables. The reason for this is the relative low input to plant breeding in parts of this segment from the large vegetable breeding companies in combination with future commercial production possibilities in Nordic countries. Plant breeding of herbs and medicinal plants is also of interest, taking into account the opportunities to improve the basis for such economically interesting production in the Nordic countries. In order to have such activities established it is necessary to ensure long-term public funding on a national basis. The breeding could preferably be connected to an entity engaged in public breeding of fruits and berries, avoiding overlaps.
- *DUS and VCU testing*. In order to receive protection with European plant breeders' rights of developed varieties it is necessary to have the new variety analysed in so called DUS testing for its distinctness, uniformity and stability, which is conducted on contract from the European

authority on Plant breeders' rights (CPVO). Initiatives have been taken from Finland to improve the possibilities for plant breeders to have the DUS testing performed in Finland in some species. In a second report from the project (first half of 2010) we will develop viewpoints from stakeholders on the DUS testing and our conclusions and proposals on this issue, as well as on the possibilities for extended collaboration in the testing of the value for cultivation of new varieties.

Alnarp, June 15, 2009  
*Roland von Bothmer*

*Anders Nilsson*



# Sammanfattning

Klimatförändringarna kommer att leda till höjda temperaturer och förändrade mönster för nederbörden med mer omfattande förändringar förutsedda i Norden än i många andra områden i världen. Som en följd av detta kommer utsäden och plantor att behöva anpassas till nya agroklimatologiska förhållanden. Sorters resistens mot svampar och andra skadegörare behöver kontinuerligt förbättras. Ändrade odlingssystem och expansion av vissa grödor till nya områden kommer att innebära behov av insatser i hela växtförädlingskedjan.

I jämförelse med situationen för några år sedan har omfattningen av växtförädlingen i Norden, och forskning i anslutning till förädling, reducerats. Kommersiell och publik växtförädling har reducerats med hänvisning till kommersiella överväganden och minskat stöd.

Synpunkter framförda från växtförädlingsgemenskapen och intressenter indikerar en oro över den aktuella situationen i växtförädlingen och en beredskap att samarbeta. På det politiska området finns det en medvetenhet om växtförädling som en strategisk verksamhet och att de nordiska länderna har goda motiv att samarbeta för att ge växtförädling goda förutsättningar för sin långsiktiga utveckling som en komponent i nordiska initiativ för att möta ett förändrat klimat.

Prekommersiell utveckling inom växtförädling, eller pre-breeding, har betydande stöd inom andra EU-länder. Gemensamma nordiska insatser kan därför också utjämna konkurrensförhållandena för nordisk växtförädling.

I rapporten föreslås följande åtgärder:

- Vitalisering av samarbetet i forskarutbildningen inom växtförädling
- Etablering av ett PubliktPrivatPartnerskap (PPP) för växtförädling
- Initiativ för att organisera samarbete i förädlingen av frukt och bär

Partnerskapet för växtförädling bör administreras av NordGen och ge stöd till aktiviteter inom pre-breeding med en budget av 50 MDKR/år. Dess finansiering bör ske till 60 % genom NMR och till 40 % från förädlingsverksamheter som är engagerade som parter i specifika projekt. Partnerskapet i växtförädling bör stödja långsiktig utveckling av växtförädling som kan möta de långsiktiga behoven för jordbruk och trädgård – anpassning till förändringar av klimatet, miljöpolitik, krav från konsumenter och marknader etc. En beskrivning av projekt i korn och vete av gemensamt intresse för de nordiska växtförädlingsföretagen, uppställda i prioritetsordning, har inkluderats i rapporten som en av bilagorna.



# Appendices

## Appendix 1. Växtförädling för Norden – projektplan

Summary: Plant breeding in the Nordic countries has a long and successful history. Over the last decades activities in public institutions have been privatized to a large extent. The private sector has, as a consequence of globalization and opened markets, focused on the more profitable segments of the market, which has had the effect that the practical plant breeding is mainly directed towards major crops and more Central European conditions. The possible implications for countries on Northern latitudes shall be invented and long term consequences analyzed. In this context the potential consequences of climate change for global agriculture and, specifically, for continued competitive conditions for agriculture in the Nordic region shall be considered. It is foreseen that measures for a more efficient development of plant varieties for the Nordic area will become a result of the project, where supplementary efforts are sought and possible overlaps are avoided as regards publicly funded activities. Proposals will also be put forward on co-ordination of other publicly funded activities within plant breeding at large (pre-breeding and plant breeding research). In this context the mandate for and the activities of the Nordic Gene Bank will be taken into account. The initiative on this project has been taken by the Swedish Ministry of Agriculture as a part of the preparations for the Swedish Chairmanship in NMR in 2008.

Nordisk växtförädling – sortframställning, pre-breeding och resistensförädling – har en lång tradition och har haft betydande framgång. Dessa verksamheter har varit betydelsefulla för utvecklingen av de areella näringarnas förmåga att ge sina utövare rimliga möjligheter att konkurrera med lantbruk och trädgårdsnäring i områden med mer gynnsamma förutsättningar än i förhållandevis kärva nordliga lägen. Växtförädlings- och utsädesföretag med hemvist i Norden har haft och har en långt mer framträdande plats i internationell marknadsföring av sorter och utsäde än vad nordiskt jordbruk svarar för. Och nordisk växtförädlingsforskning har varit och är på motsvarande sätt internationellt mer framgångsrik inom detta område än många andra naturvetenskapliga discipliner.

Inledningsvis kom verksamheten inom nordisk växtförädling att byggas upp i starka miljöer i samverkan mellan samhälle och näringsliv, till betydande del i offentliga strukturer men redan från början med privata inslag, inte bara i utsädesverksamhet utan också i sortframställning, framför allt i Danmark. För utvecklingen kom orter och företagsnamn som Apelsvold, Jokioinen, Lännäs, Hilleshög, Weibulls, Pajbjerg, Jögeva m fl att bli synonyma med framsteg inom växtförädlingen.

Under senare decennier har verksamheter inom växtförädling i de nordiska länderna till största delen privatiserats eller bolagiserats, i Norge och Finland med staten fortsatt som en huvudintressent. Samtidigt har de offentliga resurser som avsatts för växtförädling i vid mening kunnat dras ner i resp land. I de baltiska republikerna bedrivs växtförädlingen fortfarande vid statliga institut.

Den internationella växtförädlings- och utsädesindustrin har genomgått stora förändringar under de senaste 10 åren. Strukturuomvandlingen har varit snabb och många mindre företag har köpts upp eller lagts ner. Detta har haft samband med att dels en allt större del av tillgängliga utvecklingsresurser har lagts på genteknik, särskilt inom de sex ledande växtbio-tekniska företagen med Monsanto i spetsen, dels en svag utveckling av världsmarknaden för vegetabilier.

Som en effekt av globaliseringen och den ovan beskrivna internationella utvecklingen har också växtförädlingen i och för de nordiska länderna minskat kraftigt under senare år. De återstående växtförädlingsföretagen satsar först och främst på de ekonomiskt mer lönsamma segmenten av marknaden, vilket innebär att sortframställningen i huvudsak inriktas på de stora växtslagen och på centraleuropeiska förhållanden. Ledande växtförädlingsföretag är nu Svalöf Weibull och Syngenta (sockerbetor) i Sverige, DLF och Sejet i Danmark, Graminor i Norge och Boreal i Finland. Sortframställningen vid Svalöf Weibull, Graminor och Boreal är till viss del finansierad med offentliga medel.

Växtförädling – sortframställning, pre-breeding och växtförädlingsforskning – samt växtbio-teknik bedrivs också i offentliga organ. Umeå Plant Science Center hör till de internationellt ledande på växtbioteknisk forskning med avseende på skogsträd. Andra viktiga aktörer är SLU i Sverige, NLH i Norge, Köpenhamns och Århus universitet i Danmark, Helsingfors universitet, MTT och VTT i Finland, Jögeva i Estland m fl. Nordiska genbanken (NGB) svarar för bevarande och karakterisering av genresurser av fröförökade växtslag och potatis.

Internationellt bedöms växtförädlingen bidra till ökade skördar med minst 0,5 %/år, en takt som förväntas öka med introduktioner av förbättrade egenskaper med hjälp av genteknik, genomanalys och andra nya tekniker. Tillgång till sorter för Norden som är väl anpassade till odling i olika områden med avseende på ljusförhållanden, temperatur, vegetationsperiod, resistens mot skadegörare m fl egenskaper är därför central för odlingens konkurrenskraft i vår region. Den nu pågående förändringen av vårt klimat kan komma att accentuera dess behov. Det är i vart fall troligt att klimatförändringen kommer att innebära krav på snabbare förändringar och anpassningar av odlingsmaterialet till nya förhållanden och för fortsatt goda villkor för odling i Norden än vad som tidigare varit fallet där det handlat mer om att enbart tillse att sorter för Norden som ett mer perifert odlingsområde i ett globalt perspektiv följer med i den allmänna teknologiutvecklingen. Sorter primärt framtagna för andra od-

lingsområden med t ex annat ljusklimat kan inte förväntas svara mot föreliggande behov av anpassning för nordliga odlingsområden. Klimatförändringen kan även komma att innebära att det kan bli aktuellt med specifik anpassning av odlingsmaterial i helt nya växtslag för odling i Norden.

Mot bakgrund av denna utveckling föreligger ett starkt behov av att som ett särskilt projekt utreda förutsättningarna för en fördjupad nordisk samverkan inom växtförädling i vid mening. Projektledningen bör därvid till sitt stöd ha en särskild referensgrupp som är sammansatt av personer som kan representera olika aspekter på växtförädling i de nordiska länderna och NGBs verksamhet. De eventuella problem som kombinationen av strukturförändringar inom kommersiell växtförädling och den pågående klimatförändringen kan medföra för odling på nordliga breddgrader ska inventeras inom projektet och dess konsekvenser i det långa perspektivet analyseras. I denna del ska det faktiska behovet av sortutveckling för Norden i olika växtslag förtydligas, särskilt för Nordkalotten. Nyckelord för denna analysdel bör vara gemensamma förädlingsmål i vissa växtslag, storleken av agroklimatologiska zoner, samspel mellan genotyp och miljö, fytosanitära förhållanden och relationer till kommersiella verksamheter. I sammanhanget ska också EUs myndighet för frågor om växtförädlarrätt (CPVO) och dess roll och möjligheter att underlätta registrering av nya sorter för Norden belysas.

### *Appendix 1.2 Projektet kommer att delas in i tre faser:*

#### *1. Inventering*

I inventeringsfasen kommer nuvarande verksamheter inom växtförädling – sortframställning, pre-breeding och växtförädlingsforskning – i Norden inkl de baltiska republikerna att inventeras och beskrivas. Inventeringen kommer till betydande del att bygga på uppgifter från de olika aktörerna. Verksamhet inom växtbioteknik kommer att inkluderas till den del som sådan verksamhet bedöms vara nära knuten till försörjningen med odlingsmaterial i ett medellångt perspektiv (praktiskt utnyttjande inom 15 år). För inventeringen kan besök av vissa företag och offentliga organ komma att behövas men denna del ska huvudsakligen kunna genomföras per telefon och e-post.

#### *2. Analys*

Analysfasen kommer att inledas av diskussioner med expertis inom växtodling och med företrädare för lantbruksmyndigheter och lantbruksorganisationer av hur behov av och krav på odlingsmaterial kan förväntas bli förändrat i ett medellångt (10–15 år) resp längre (>25 år) perspektiv. Kravbilden kommer därefter att analyseras tillsammans med inventeringen av pågående växtförädlingsaktiviteter. Möjligheter att utnyttja växtbiotekniken i sortframställningen med avseende på specifika behov för odling i Norden ska därvid översiktligt analyseras.

Denna del kommer att förutsätta resor för möten med viktigare aktörer inom växtförädlingen. I detta sammanhang är det också lämpligt att kalibrera uppgifter som inhämtats i inventeringsfasen. Syftet med analysdelen är att kunna ange angelägna insatser för offentlig finansiering i Norden inom växtförädling med avseende på sortframställning och pre-breeding.

### 3. Förslag

Förslag på åtgärder för en mer effektiv sortförsörjning för Norden ska tas fram i denna fas där komplementära insatser eftersträvas och där eventuella överlappningar i fråga om offentligt finansierade verksamheter med avseende på sortframställning undviks. Förslag ska även redovisas beträffande samordning av andra offentligt finansierade verksamheter inom växtförädling, främst pre-breeding men även växtförädlingsforskning. I sammanhanget ska verksamhet, mandat och övriga förhållanden för NGB beaktas. De förslag som tas fram ska diskuteras med berörda aktörer. En strävan kommer att vara att dels tillgodose specifika nationella intressen, dels åstadkomma en lämplig mix av samordning och arbetsdelning.

Genom att analys- och förslagsdelarna av projektet delvis ska utföras efter samråd med olika aktörer inom nordisk växtförädling, kommer utvärderingen av projektet att kunna påbörjas redan inom projektets ram. Detta är också helt nödvändigt eftersom det inte torde finnas möjligheter att nå koncensus om förslag om nordisk samordning och arbetsdelning på detta för de areella näringarna centrala område utan att flertalet aktörer står bakom de förslag som framförs. Den fortsatta utvärderingen av projektet kan lämpligen ske i form av en workshop där beslutsfattare och centrala aktörer diskuterar projektets resultat och förslag, följt av en normal politisk beredning av de förslag som därefter är aktuella.

#### Projektledning:

<b>Projektledare</b>	
f d dekanus Roland von Bothmer	prof i växtförädling, SLU
<b>Bitr projektledare</b>	
forskningssekr Anders Nilsson	SLU
f d forskningschef Svalöf Weibull	
<b>Referensgrupp:</b>	
Sven Bode Andersen	prof Köpenhamns univ, Danmark växtförädlingsforskning
Magne Gullord	VD Graminor, Norge off finansierad växtförädl
Eva Pettersson	Stiftelsen lantbruksforskning, Sverige intressent, nyttjare
Morten Rasmussen	NGB genbanksverks, förädling
Aslaug Helgadóttir	Agricultural University, Island förädling Nordkalotten
Merja Veteläinen	MTT Jokioinen, Finland pre-breeding
<b>Kontaktpersoner i resp land:</b>	
Lars Landbo	Plantedirektoratet, Danmark
Thorsteinn	Tomasson, Ministry of Fisheries and Agriculture, Island
Kirsi Heinonen	Ministry of Agriculture and Forestry, Finland
Marja Savonmäki	Ministry of Agriculture and Forestry, Finland
Elisabeth Koren	Landbruks- og matdepartementet, Norge
Grethe Evjen	Landbruks- og matdepartementet, Norge
Catharina Stenborg-Blom	Jordbruksdepartementet, Sverige
Marianne Sjöblom	Jordbruksdepartementet, Sverige

## Appendix 2. Meetings during the course of the investigation

2008		
April	15	Catharina Stenborg et al, Jo dep, Stockholm
May	5	Thorsteinn Tomasson, Aslaug Helgadóttir et al, Reykjavik
	7	Elisabeth Koren et al, LMD, Oslo
	12	Reference group in Alnarp
	13	Eskil Erlandsson et al, Jo dep, Stockholm
	19	Kurt Hjortsholm et al, Sejet
	20	Niels Roulund et al, DLF-Trifolium
June	2	Risto Tahvonen et al, MTT Piikkiö
	12–13	Workshop in Alnarp with extended reference group
	26	NMR summer meeting in Växjö
	30	Magne Gullord et al, Graminor
July	2	Ulf Kjellström et al, Swedish Seed Control Unit
	2	Monika Lekander et al, Svalöf Weibull
	4	Morten Helt Poulsen, Nordic Seed
	7	Gerhard Steinrücken et al, Syngenta Seeds
Aug	20	Markku Äijälä et al, Boreal
	21	Kirsi Heinonen et al, MMM, Helsinki
	28	Lars-Erik Gradin et al, Svalöf Weibull, Lännäs
	28	Ulla Bång et al, SLU Röbbäcksdalen
	29	Lars Ericson, SLU Röbbäcksdalen
	29	Elisabeth Öberg, Hs Norrbotten, Öjebyn
Sep	17	Morten Andersen Linnet, Landbruksraadet
	23	Reference group in Alnarp
	24	Hilde Nybom et al, SLU Balsgård
Oct	17	Anne Marie Zinck, Dansk Landbrug and Eva Pettersson, LRF
Nov	11	Markbrugets Innovationsforum, Landbruksraadet
	19	Nina Heiberg, Gartnerhallen (tel)
Dec	1	Annette Hägnefelt et al, Weibulls Horto
	5	Per Harald Grue et al, LMD, Oslo
	17	Nordic plant breeding companies, Copenhagen
2009		
Feb	10	Magne Gullord, Risto Tahvonen, Hilde Nybom in Alnarp
	16	Max Schulman, MTK (tel)
	16	Irsi Heinonen et al, MMM, Helsinki
Mar	9	Nordic plant breeding companies, Copenhagen
Apr	24	Morten Torp, Weibulls Horto
May	14	Dorrit Krabbe et al, Fødevaredepartementet, Copenhagen
	26	Workshop with contact persons at respective Ministries of Agriculture and discussions per telephone with our assigned contact persons at the Ministries of Agriculture and the NMR secretariat

## Appendix 3. Pre-breeding efforts in selected countries

*Germany* – The German plant breeding industry and the German state are collaborating in a special program – Gemeinschaft zur Förderung der privaten deutschen Pflanzenzüchtung (GFP) – for the funding of pre-breeding and plant breeding research which is conducted at research institutes as well as breeding companies. This program is funded 50/50 by the state and Bundesverband Deutscher Pflanzenzüchter (BDP), the organiza-

tion of the German plant breeding industry. The use of available resources is strongly influenced by the breeding companies with interests in the respective crops. There has been an emphasis on projects related to resistance to diseases and quality characters, as well as the broadening of the genetic base for breeding. Examples on efforts over the last years include projects on improved quality of winter oilseed rape and resistance to *Fusarium* in winter wheat. Besides, the German state is funding considerable efforts in genomic research in the program Genomanalyse im biologischen System Pflanze (GABI), also in collaboration with the plant breeding and plant biotechnology industries.

*UK* – Breeding up through registration of new varieties in less commercially interesting crops, such as oats, forage crops, fruits and berries, is done in research institutes with public support. IGER Aberystwyth, Scottish Crop Institute, Rothamstead and East Malling are important institutes in this undertaking. The support includes pre-breeding efforts in such crops. In major crops more sizeable LINK programs have been established for collaboration between university research and the UK plant breeding industry, coordinated by John Innes Institute. Examples on such programs include resistance to *Septoria* in winter wheat and to *Ramularia* in barley as well as improved quality of UK winter wheat. The LINK programs have mainly been initiated from academy. Industry participation is mostly based on in-kind contributions.

*France* – INRA, the French institute for agricultural research has large efforts in pre-breeding of more or less all agricultural and horticultural crops cultivated in France. Results from the pre-breeding are made available to French plant breeding companies. Besides, INRA is breeding minor crops as a supplement to the commercial breeding. Genoplant is comparable to GABI in Germany for large efforts supporting the breeding of major crops.

*USA and Canada* – The commercial plant breeding is focused on maize, cotton, soy beans and rape seed and includes pre-breeding efforts, except in spring oilseed rape. Ag Canada, Saskatoon is doing pre-breeding in this crop in collaboration with Canadian plant breeding with respect to resistance, i.e. to *Phoma*, and for quality. The responsibility for development of cereals, forage crops and other crops of minor commercial interest, including pre-breeding, has mainly been left to public breeding at land grant colleges, universities and institutes. Among the more prominent the following can be mentioned: Washington State University (wheat), Kansas State University (wheat), Rutgers University (forage and turf grasses) and Crop Development Center, Saskatoon (wheat, barley, peas, linseed, forage crops).

## Appendix 4. Minutes from meeting with Nordic plant breeding companies

Time and place: March 9th, 2009 in the offices of NMR

Present: Roland von Bothmer  
 Mads Randbøll Wolff, NMR (§1)  
 Klaus K. Nielsen, DLF Trifolium  
 Christian Jensen, DLF Trifolium  
 Ahmed Jahoor, Nordic Seed  
 Kurt Hjortsholm, Sejet Planteforædling  
 Lars Eriksen, Sejet Planteforædling  
 Monika Lekander, Svalöf Weibull  
 Annette Olesen, Svalöf Weibull  
 Thomas Kraft, Syngenta Seeds  
 Magne Gullord, Graminor  
 Per Henriksson, Graminor  
 Morten Rasmussen, NordGen  
 Anders Nilsson

Absent: Markku Äijälä, Boreal Plant Breeding

### *Appendix 4.1 Proposals on Higher education*

The plant breeding companies continued to express their need for strengthened higher education in plant breeding with a broad basis, starting with adequate inclusion on undergraduate level. PhD courses and an appropriate Master program in plant breeding were also mentioned in this context.

It was agreed that the investigators should propose that the Nordic agricultural universities (and faculties) should cooperate for an improved education on undergraduate level, addressing the needs of the breeding industry. Further, in dialogue with the practical breeding the possibilities for collaboration in the education on advanced level (MSc and PhD level) should be explored. This includes improved possibilities for Nordic industrial PhD's and participation in annual, renewed Nordic PhD courses in plant breeding.

### *Appendix 4.2 Proposals on plant breeding of horticultural crops*

Roland von Bothmer gave an orientation on the findings and proposals of the investigators on plant breeding of horticultural crops. These proposals include a recommendation on split of responsibilities and work packages in the breeding of fruit and berries between the concerned breeding units in Graminor, MTT Piikkiö and SLU Balsgård, all having their respective national, public funding for these activities. Further, that a renewed

breeding of vegetables should focus on leafy vegetables and herbs, if initiated on national basis.

It was noted to the minutes that some of the breeding companies viewed national funding of breeding in vegetable species to be of very limited value in view of the efforts made by the large international seed companies focusing on vegetable seeds.

#### *Appendix 4.3 Proposals on a Nordic PPP for Plant breeding*

Details on the proposed framework for a Nordic PPP on Plant breeding were discussed. The representatives of the companies reached consensus on their position of the following changes, modifications and clarifications of the proposed framework. These are also included in the version of the framework for the PPP, added as appendix to the minutes.

- The administration of the PPP by NordGen was accepted on condition that cost efficiency characterized the administration and that appropriate details on tasks for the administration, including cost breakdown, could be presented. A total cost for the administration, including compensations and travel costs for the Steering committee and the Reference group, of 1 mDKK was viewed as an upper limit. It was recommended that the cost for the administration would be taken from the public funding to the PPP.
- The plant breeding community should have half the seats of the Steering committee.
- The Reference group should have an expressed active role on the development of the PPP.
- The framework should not specify how large a proportion of available funds are used for major agricultural crops v. minor and non-commercial crops. Instead, the merits of the projects should be decisive for the allocation of support.
- The framework should not specify how the contributions from the partners of 40% of a project budget are split between cash and in-kind.
- It should be clarified that proposals on projects and programs are to be developed bottom-up from plant breeding companies and units in order to be eligible for support.
- It should be clarified that funding from industry will only take place connected to the specific project or activity in which a specific company is participating (based on comment from Markku Äijälä, Boreal Plant Breeding in writing)
- There is no need for specific alignment with national public funding of pre-breeding efforts.
- During the establishment of the PPP it's appropriate to invite proposals twice/year in order to ensure a swift decision process from the initiation of a project proposal.

- It should be possible to conduct a project completely in a commercial environment, i.e. without the support of universities and /or research institutes. Similarly, it should be possible to involve service providers from outside the Nordic countries.
- Consortium agreements on how to handle developed intellectual properties (IP) have to be signed before the start of a project or program.

Minutes taken by                      Approved by  
*Anders Nilsson*                      *Roland von Bothmer*

## Appendix 5. PublicPrivatePartnership (PPP) for Plant breeding

Establishment:	as of 100101
Scope:	<ul style="list-style-type: none"> <li>• Broadening of the genetic base for adaptation to Climate Change</li> <li>• Introduction of specific genetic variation in adapted background</li> <li>• Development of tools for breeding and selection</li> </ul>
Administration:	<ul style="list-style-type: none"> <li>• NordGen, details on tasks and budget for the administration to be decided by the Steering committee</li> </ul>
Steering committee:	<ul style="list-style-type: none"> <li>• Measures to initiate projects or programs</li> <li>• Decide to start/terminate a project or program</li> <li>• Representation from society (2–4 incl chairman), academy (2) and plant breeding community (2–4); balanced between the Nordic countries and rolling scheme for renewal of terms</li> </ul>
Reference group:	<ul style="list-style-type: none"> <li>• Measures to initiate projects or programs</li> <li>• Evaluation of proposals and of progress in projects and programs Representation from academy (2–3 incl chairman) and plant breeding community (3–4); balanced between the Nordic countries and rolling scheme for renewal of terms</li> </ul>

- Budget:
- 50 MDKR/year, fully established latest from year 3
  - Max 1 MDKR of public funding for the administration of the PPP
- Funding:
- 60% public through the NMR budget, Nordic formula for the split of national commitment
  - 40% from breeding companies/entities engaged as partners in the respective project/program, whereof up to 20% in kind in total from contributing partners
- Re-evaluation:
- Every 2nd year of funded projects/ programs
- Review:
- Every 5th year of the PPP
- Proposals:
- Proposals from plant breeding companies/ public breeding entities or with declared commitments of contributions from companies/entities, eligible if at least half of companies/ entities engaged in practical breeding of the crop in question are participating as contributing partners (1 of 1; 1 of 2; 2 of 3; 2 of 4; 3 of 5)
  - Proposals from public bodies or academy meeting targets for environmental policies, etc, eligible if at least one company/ entity engaged in practical breeding is participating as contributing partner
  - Annual call for proposals, Oct 1st (also April 1st in the first 2 years)
  - Aiming at support to commercial as well as public breeding
  - Nordic profile in contents and targets
  - Shorter projects, restricted in time as well as more long-term activities/programs
- Execution:
- At Nordic universities, institutes and/or companies
  - No funding of new, larger infrastructures
  - Consortium Agreement to be established before start of project and include policy on publications and access to IP

- International cooperation:
- Open for non-Nordic breeding companies/ public breeding entities to participate if this brings value to the project/program
  - Ambition to establish collaboration with corresponding PPP projects/programs, e.g. in Germany, UK and Canada

The Steering committee should have 6–10 members and the Reference group 5–7 members, the higher numbers reflecting the need for representation at the start-up of the PPP and the lower number the situation in perhaps 5 years as the PPP is hopefully well established. The plant breeding companies have put forward that the plant breeding community should have equal representation to society and academy in the Steering committee. However, it is considered that the originally proposed balance between society, academy and the plant breeding community is appropriate, bearing in mind the proposed funding mechanism, the proper handling of conflicting interests and the public interests in this area.

It is assumed that the administration of the PPP will demand ca 50% of a position, whereof 40% for the coordination and administration of the PPP at NordGen and 10% for the chairman of the Reference group. The estimated need of resources for the administration (max 1 MDKR) includes compensations and travel costs for members from academy of the Steering committee and the Reference group.

The scope of the PPP is foreseen to enable Nordic plant breeding to improve its possibilities to deliver the results expected from its activities – well adapted, new varieties meeting the challenges resulting from Climate Change. The scope relates to the broadening of the genetic base for the breeding, to introduction of new specific genetic variation, and to development of tools for breeding and selection. In all aspects this PPP could be of interest also for non-Nordic plant breeding and such participation should be possible, provided that the non-Nordic partner will bring value to the project or activity and that the Nordic partners are in favour of this. Similarly, non-Nordic service providers can be engaged in a project. Participation from the Baltic republics in specific projects or activities within the PPP should be dealt with positively, but its forms need further considerations. It is foreseen that the establishment of this Nordic PPP will open up possibilities of collaboration with corresponding activities with national funding in for instance Germany and UK. Also, the PPP will be an excellent basis for development of proposals for funding within EUs Framework Programs and such extensions could constitute valuable positive effects.

Proposals on projects and activities should develop bottom-up from the plant breeding companies and public breeding entities, not excluding initiatives taken by Steering Committee, Reference group, academy etc, but in such cases in combination with a firm commitment on contribu-

tions in cash and/or in kind from intended participating partners from the plant breeding community. The flow chart below describes how projects can be established and executed.

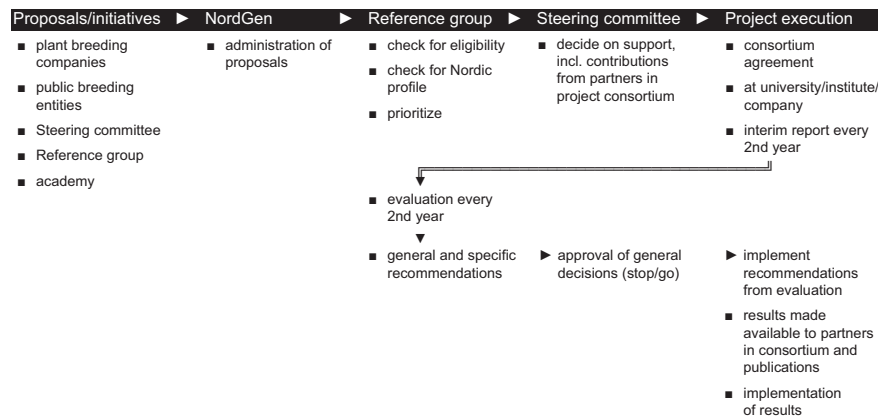


Fig. 2. Flow chart for projects in the PPP for Plant breeding

The five plant breeding companies engaged in the breeding of cereals have jointly presented examples of pre-breeding projects and activities which they would want to see realized within the PPP (appendix 6). The examples include development of nutrient use efficiency in barley and wheat, efficient technology for early quality selection, resistance to major and emerging diseases of barley and wheat, drought tolerance in barley and a joint development centre for the development and use of molecular markers. Similar proposals can be foreseen with respect to pre-breeding in other crops, i.e. forages, potatoes and fruits and berries.

There should be an annual call as of October 1<sup>st</sup> for proposals on new projects or activities. During the start-up of the PPP it's appropriate to have two calls per year, also as of April 1<sup>st</sup>, in order to ensure a swift decision process from the initiation of a project to its possible establishment. The process of establishing pre-breeding projects and activities within the PPP has started with the pre-proposals added to the report. For a proposal to be eligible it has to be proposed by a consortium of plant breeding companies or public breeding entities, or include a firm commitment of support in cash and/or in kind from participating plant breeding companies /entities. Further, the consortium must be composed by at least half of the companies or entities engaged in breeding of the crop in question and the target of the proposal must have a Nordic profile. It would also be possible for public breeding entities with permanent funding of their breeding activity, such as the Agricultural University of Iceland and MTT Piikkiö, to present eligible proposals. A proposal could also relate to a crop where there only is one company or entity engaged in practical breeding in the Nordic countries, i.e. sugar beets or spring turnip rape, on condition that the proposal has a clear Nordic profile in its targets and accomplishment. There should also be a possibility for proposals

from for instance academy meeting specific political targets for environmental policies, provided that there is participation from practical breeding in the proposed project. The proposals would be assessed by the Reference group for their scientific quality and how the different prerequisites are met before a decision on possible funding could be made by the Steering committee. It is assumed that the Steering committee will allocate funding to projects and activities for major commercial crops as well as for minor and non-commercial crops, finding a proper balance between these areas.

The PPP is supposed to encompass pre-commercial pre-breeding activities. It is assumed that projects and programs will involve competences and resources at universities and research institutes as well as breeding companies and entities. In total, at least 50% of the contributions from the partners in a project consortium should be in cash, but deviations from this target should be possible. The breeding companies have expressed a wish to have the entire activity of a project or program to be executed by one or more participating partners. Such a set-up could be appropriate under certain conditions, i.e. when access to a specific infrastructure necessary for the project only is available at competitive terms from a participating partner. A similar situation could motivate the use of non-Nordic service providers. The ambition should, though, be that a major part of the activities of a project are conducted at Nordic universities and/or research institutes in order to promote public-private collaboration.

Financial contributions from a breeding company will only become an issue for the specific project or activity in which this company is participating. It is also assumed that the funding will not be used for extensive investments in facilities and equipment.

It is foreseen that the results of the PPP will be used in a commercial context by the plant breeding companies which are participating as partners in a specific project or activity. Also, the partners and the participating universities and/or institutes will have certain obligations to each other. Thus, it is appropriate to clarify in a Consortium Agreement the conditions under which the results and possible intellectual properties are owned and can be used, including how the use of genetic material owned by one or several partners has an effect on these matters, at the start of a project or program. This agreement should also regulate issues such as scientific publication of results and terms for access to genetic materials and other results for Nordic non-participating plant breeding entities. Key features of a Consortium Agreement are added as appendix 7. The Consortium Agreement has to be signed before any contribution to a project or program is paid.

## Appendix 6. Examples of pre-breeding projects

The following pre-breeding projects have been suggested to the investigation jointly by the Nordic plant breeding companies engaged in breeding of cereals. They are listed in priority.

### *Appendix 6.1 Nutrient use efficiency of barley and wheat*

In Nordic / European modern farming systems nutrient use efficiency first became an issue as a consequence of the established EU-regulations limiting the use of fertilisers with the target to lower nutrient emissions to the environment. More recently fertiliser prices have risen to substantially higher levels, having now a strong impact on the economy of crop production. It is predicted that these developments (use limitations, higher prices) will continue to affect the Nordic crop production long term. This will influence not only the profitability of cultivation, but will also challenge maintaining sustainable high yield levels.

It is well established with many species that there exist differences in nutrient use efficiency between varieties; therefore plant breeding is recognised as having a key input in overcoming the impending threat of a downward trend in yield levels resulting from the reduced use of fertilisers.

For effective breeding for nutrient use efficiency (nue), it must be recognised that there exist know-how gaps at least in the following areas: i) specific phenotypic traits behind nue and their relative importance (“nue-traits” like root architecture, rhizosphere, etc.), ii) genetic variation in a species in the nue-traits, iii) core donor germplasm for breeding, iv) genetic control of nue-traits and v) effective selection tools with a focus on DNA-markers.

Within this research area there is competence available at University of Copenhagen through the research teams of Prof. Jan K. Schjoerring (Plant nutrition) and Prof. Søren K. Rasmussen (Molecular plant breeding), Dept. of Agriculture and Ecology. Their activities focus on enzymes in nitrogen metabolism, where in particular isoforms of cytosolic glutamine synthetase (GS1) seem to be key elements in controlling plant productivity and nitrogen use efficiency. GS genes have recently been cloned, characterized and mapped in wheat and a cisgenetic approach is currently undertaken to over-express GS1 isoforms and other genes in nitrogen and carbon metabolism in barley. In parallel, variability among genotypes in the dynamics of N re-distribution and the underlying allelic variations in GS1 genes and other candidate genes for nitrogen use efficiency (nitrogen transporters, nitrate reductase, glutamate synthase) are investigated. With respect to phosphorus utilization in barley, panels of respectively low-phytate and root hair barley mutants are available. The knowledge gained will provide molecular markers associated with efficient accumulation of nitrogen in cereal grains to assist in marker-assisted

selection and breeding of genotypes with improved nitrogen use efficiency in barley and wheat.

The NordGen Plants has a large collection of germplasm, which will be used to screen and characterize novel sources for efficient nutrient uptake, with emphasis on nitrogen and phosphorus. This includes both mutation material and collections of *H. spontaneum* backcrosses derived from the research by Louis Lehman, SW. In the second phase the knowledge gained will be applied also to wheat.

Screening germplasm in NordGen for natural variation in genes involved in nitrogen and phosphorus use efficiency will be a very valuable extension of the ongoing activities.

If the available variation is not sufficient to achieve the goal of improved nue, new genetic variation may be created by target specific mutations (TILLING).

In summary we propose a Joint Nordic pre-breeding project which is focused primarily on nitrogen and secondarily on phosphorous use efficiency. The specific project targets are the areas of know-how listed above from i) to v). The project will use spring barley as a model crop and in the second phase the knowledge gained will be applied also to wheat.

#### *Appendix 6.2 Efficient technology for early quality selection.*

The proposal for a joint project is to develop and implement a simplified analysis method for early breeding material relying on the use of NIR/NIT analysis instruments. The NIR/NIT method can be used in plant breeding to identify differences in composition of quality parameters. The benefit with a reliable NIR/NIT calibration is that the sample size required for these instruments is much smaller than for the laboratory run and the cost per sample is considerable less than the full scale test. However, this method is mostly used to analyze the water content and the total protein content. Theoretically, this method can be used to analyze most of the baking, malting and feed quality parameters, as well as micro and macro elements in a small sample, or even a single seed, of wheat and barley. The aim of this project is to develop practical application of the technology for use in plant breeding programs for products with enhanced quality traits.

One particular example is to develop NIR/NIT technology for feed utilisation. Feed quality and feed utilisation potential will have an increasing importance as world market prices on food and feed most likely will continue to be on a significantly higher level than in the past.

A method to analyse the potential energy content and utilisation level has been established through the analysis of the enzymatic degrading of organic material in a feed sample in the intestine of productive life stock (EFOS / EFOSi analysis). The cost involved and sample size needed for

an EFOS analysis makes this laboratory method less suited for early generation selection of pre-breeding/ breeding material.

The proposed project will need to develop segregating populations of suitable combinations of barley and wheat. The populations need to be maintained allowing enough lines to cover the variation and multiplied to generate enough seed for a standard EFOS analysis in an established laboratory. The result from these analyses will then be utilised as a tool to generate a reliable NIR/NIT calibration. Once the calibration is established, pre-breeding efforts will be cheaper and more efficient, since the selection of suitable genotypes can be done in segregating breeding populations.

### *Appendix 6.3 Major and emerging diseases of barley and wheat*

In all Nordic countries the commercial breeding programmes have focused long term on the current main diseases of wheat and barley. There have also been several research projects, some of them inter-Nordic, in this area but there is still need for a deeper and more structured collaboration to prepare for the future. The climatic change, in combination with the goal to reduce fungicide use for a sustainable agriculture, would justify further Nordic projects.

One of the most significant negative effects of climate change to crop production is predicted to be the increasing importance of pests and diseases. Climatic change is also likely to change agricultural practise towards cultivation technologies such as direct sowing, which favour carry over of diseases and pests. It has been reported that the consequences of these changes are already ongoing and observable: for instance NJF's expert group (2007) reported in Denmark 19, Finland 13 and in Sweden 9 pathogen species which have become an increased risk in crop production. In the Nordic countries the emerging new pathogens are predominantly diseases of the main cereals – barley and wheat: for instance from the new pathogens reported in Denmark 12 out of 19, in Finland 5 out of 13 and in Sweden 5 out of 9 are wheat or barley diseases.

Improvement of disease resistance is also important in order to increase yield stability and quality in cereals. Resistance towards *Septoria* is important in order to increase yield stability and quality of wheat. Similarly improvement of resistance towards Fusarium Head Blight/tolerance to *Fusarium* toxins is important in order to increase yield stability and quality of wheat and barley, as well as resistance to *Ramularia* in barley.

Additionally, the EU is currently in the process of further regulating (i.e. further restricting) the use of chemicals in crop production with the aim of reducing negative environmental effects by replacing chemical plant protection with other methods. Genetic improvement of resistance in crops is a sustainable way to achieve this goal.

A Joint Nordic pre-breeding project on diseases of wheat and barley should be focused on identifying the most important (major as well as

new emerging) diseases, their virulence structure in northern Europe and potential germplasm for breeding. Interesting material from gene banks and previous research programs will be characterized for the resistance traits. As an example studies in Germany have identified *T. dicoccum* as a potential source of fusarium-resistance. NordGen Plants harbours collections of old cultivars and isogenic lines derived from McKey, which may be relevant to include in the study. Selected gene sources will then be introgressed in adapted wheat and barley lines by repeated backcrosses and by use of the most efficient tools (e.g. DNA markers if available).

To be successful in the proposed project there is furthermore a need to develop and establish optimal facilities for resistance selection in greenhouse and under field conditions, in optimal locations among the participating companies. Selected locations need to have enough capacity to test segregating populations and material from interested companies in the group. To establish as good infection conditions as possible, the selected sites need to have humidifiers and other technical equipment to secure even and sufficiently severe infection pressure independent of weather conditions. Greenhouse should be utilised in the case reliable infections can't be established outdoors.

*Appendix 6.4 Marker based technology and marker assisted selection, potentially associated with creation of novel genomic variation*

The proposal is to establish a joint development centre staffed with personnel with scientific edge competence in molecular based selection of interesting genes/traits. Alternatively, initiate close collaboration with a well established third party commercial laboratory, where the practical laboratory work could be executed in close collaboration with the Project Manager. Part of the project will be to establish joint laboratory practises with high capacity and cost efficient marker analysis with sufficient capacity to perform marker based plant selection in several parallel backcrossing programs. This will enhance the speed and efficiency of transferring interesting novel traits into elite breeding material. The project will implement and utilise the latest analytical technologies, such as DArT (Diversity Arrays Technology) or equivalent methods to be able to, in a time and cost efficient manner, produce a clear molecular picture of the genetic distance and variation in used breeding material and to identify interesting differences which potentially could contribute to, for example, improved yield potential in general.

The project will establish good contacts and potential collaboration with the sequencing projects which are currently ongoing in several different scientific consortia world wide. The main effort is currently in wheat genome sequencing, but work with the barley genome is also ongoing. The sequencing projects will, if successful, identify trait genes and be able to produce markers directly associated with an interesting trait.

These markers will significantly increase the performance and reliability on produced results. Good contacts and close link to the sequencing groups will potentially secure early access to newly identified traits and markers for these traits.

A second step or part of the molecular project could potentially be connected to investigate and establish the existing variation for a trait in the breeding material. If there is no variation for a trait identified the option could be to create new variation through point mutation of the genome, followed by molecular selection for single basepair changes. This technology called TILLING (Targeting Induced Lesion in Genome) has been used primarily in maize and rice but works as well in wheat and barley. The TILLING process mainly turns genes of and will primarily be used for traits associated with quality traits or disease resistance.

The overall potential with a project along these lines will be to make as early selection as possible in a breeding population to increase the quality and the frequency of promising plants/lines reaching the step of field selection.

#### *Appendix 6.5 Drought resistance in barley*

Drought events occurring at the beginning of a growing season are the single most important environmental factor influencing yield level, especially in spring cereals. In the more continental areas of the Nordic countries (certain parts of Sweden and Finland) spring drought is already a frequent problem. In the predicted global climate change, spring drought events are predicted to get more severe and more frequent, and will gradually influence crop production also in all parts of Scandinavia.

In order to maintain significant genetic gains in breeding of yield for drought prone conditions, it seems clear that there is a need to prioritise drought resistance much higher among the various traits currently in the focus of Nordic breeders.

There are/have been many research projects and breeding programmes, mainly outside of Europe, focusing on drought resistance of cereals. Although we can assume that quite a lot of their experience can be generally exploited, there are also several circumstances which make drought resistance in the Nordic countries different: here issues such as timing of the drought event (early spring), combining drought resistance with other main agronomical traits (such as straw length/lodging resistance) and high yield are considered to be very important.

We propose a Joint Nordic pre-breeding project which focuses on spring drought resistance of 2-row spring barley. The work plan of the project contains the main elements: specific phenotypic traits behind drought resistance, genetic variation and core donor germplasm for breeding, genetic control of drought resistance, and effective selection tools with a focus on DNA-markers.

## Appendix 7. Key Features of a Consortium Agreement

### Issues to be addressed in the Consortium Agreement

- Section 1: Definitions
- Section 2: Purpose
- Section 3: Entry into force, duration and termination  
Survival of rights and obligations
- Section 4: Responsibilities of Parties  
Breach  
Involvement of third parties
- Section 5: Liability towards each other
- Section 6: Governance structure (only for large projects)  
Decisions on changes to the Consortium Plan, Affiliated Entities and other issues of high importance
- Section 7: Financial provisions  
Contributions in kind and in cash from the respective partner
- Section 8: Foreground  
Ownership, Transfer of Foreground  
Publication policy including a time limit for a Party to object to dissemination
- Section 9: Access Rights  
Regulations on access to Background for the accomplishment of the Project  
Access Rights for Use of Foreground and for Affiliated Entities  
Additional Access Rights, e.g. for a Third Party  
Access Rights for Parties entering or leaving the Consortium
- Section 10: Non-disclosure of information  
Handling of genetic material

## Appendix 8. Scheme for cooperation in Nordic breeding of fruits and berries

At a meeting in Alnarp on February 10, 2009, with the respective managers of MTT Piikkiö, Graminor and SLU Balsgård the possibilities of developing the collaboration in the breeding of fruits and berries were discussed. The meeting was initiated to accomplish that present overlaps in the breeding of fruits and berries with national funding in Finland, Norway and Sweden were minimized. As a result of the discussions a preliminary agreement was reached on the following split of responsibilities and work packages. The preliminary agreement will be formalized in a trilateral agreement between the three breeding entities.

	Responsible for genetics	Comments
Strawberries	N/F	N for molecular breeding tools, F for day length neutral material, + selections in S, not possible to move biologic material to/from Norway due to regulation
Raspberries	N	
Blueberries	F	
Apple	S	+ selections in N, F
Pear	F	+ late selections in N, S
Plums	N	+ crossings for hardiness in F, + selections in F, N
Currants	S	+ selections in F, N
Sea buckthorne	S	

Selections will be made for Climatic adaptation, Quality fresh market, Quality processing,

Pathogen resistance. Identification of general targets included in the responsibility for the respective species

Selection sites: Staur, Njös, Piikkiö, Balsgård, Öjebyn

Testing sites: above + Åland, Mikkeli, Shotkamo, Kvithammar, + further in N, Rånna, Uppsala, Torslunda, Årslev

DUS- testing: no technical problems, but costs are prohibitive for many small markets, 4–5 k€

PBR protection pending on the attractiveness of the market and if needed for marketing

Owner of varieties: Party that makes the original selection, licensing to other part that wants to go to market, split of royalties in relation to made effort and costs for DUS and propagation/marketing

Pathogen free propagation: Sagaplant (N), MTT Laukka (F) and Elit-plantstationen + SLU Alnarp; should develop their collaboration