

A diversity study of the Danish and Norwegian collections of hops (*Humulus lupulus* L.)

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Hops have been cultivated in the Nordic region since the medieval times for conservation and flavouring of beer. (photo Gitte K. Bjørn).

Main results - conclusions

A significant genetic variation in the Norwegian and the Danish hop collections was found, both between and within the countries.

Association of AFLP data and chemical characteristics was detected. If the band can be confirmed in further studies, a PCR based marker could be developed for diagnostic use in hop breeding.

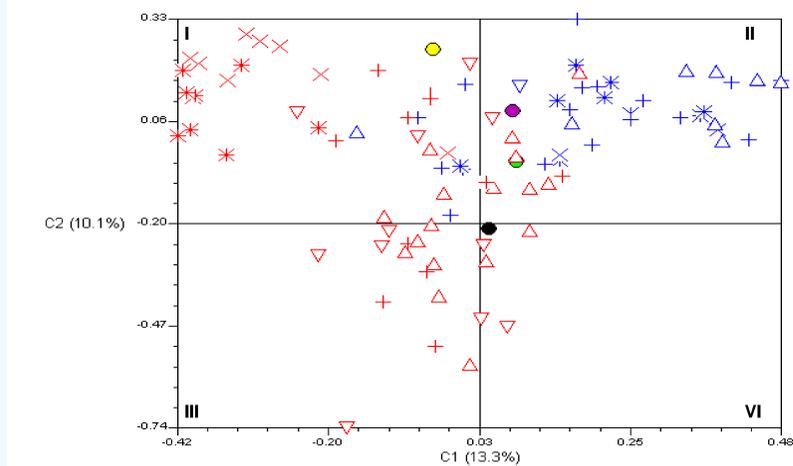


Figure 1: PCOORD based on AFLP data of hops from Denmark (red symbols), Norway (blue), Sweden (yellow), Finland (black), Germany (pink), England (green). Regions: Sørlandet (x), Østlandet (+), Vestlandet (*), Nord Norge (Δ), Midt Norge (▽), Sjælland (Carlsberg) (x), Fyn (Δ), Sjælland (Winge Fuglebjergergaard) (*)

Results and discussion

The AFLP data could separate the majority of Danish and Norwegian accessions (see Figure 1). The references from Sweden, Germany, England and Finland could not be clearly separated from the rest of material. However, regional differences within Norwegian and Danish material were revealed.

The material from Carlsberg and Winge differed from the rest of the Danish material and demonstrated the lowest diversity values (see Table 1).

For the Norwegian material the chemical analysis has previously been carried out on the accessions now studied with AFLP markers. Association was found between the chemical composition in fruits and AFLP data (an example is shown in Figure 2).



Clusters separating accessions with higher and lower relative values of Colupulon were revealed. The Cohumulon % (by weight) and the relative Cohumulon content were well correlating to the relative Colupulon content (0.641, <math>p < 0.0001</math>; 0.866, <math>p < 0.0001</math>). The implication of these findings should be examined further.

Table 1. Overview of the material and the results from the AFLP study.

Origin of material (Region and Country)	Number of clones tested	Shannon- Weaver diversity index (I)	Number of polymorphic bands
Fyn	17	0.377	29
Jylland	11	0.319	24
Sjælland	11	0.387	29
Sjælland (Carlsberg)	12	0.138	14
Sjælland (Winge)	9	0.109	10
DENMARK (total)	60	0.369	33
Midt- Nord Norge	9	0.290	25
Sørlandet	2	0.152	9
Vestlandet	9	0.338	27
Østlandet	17	0.355	33
NORWAY (total)	37	0.373	37

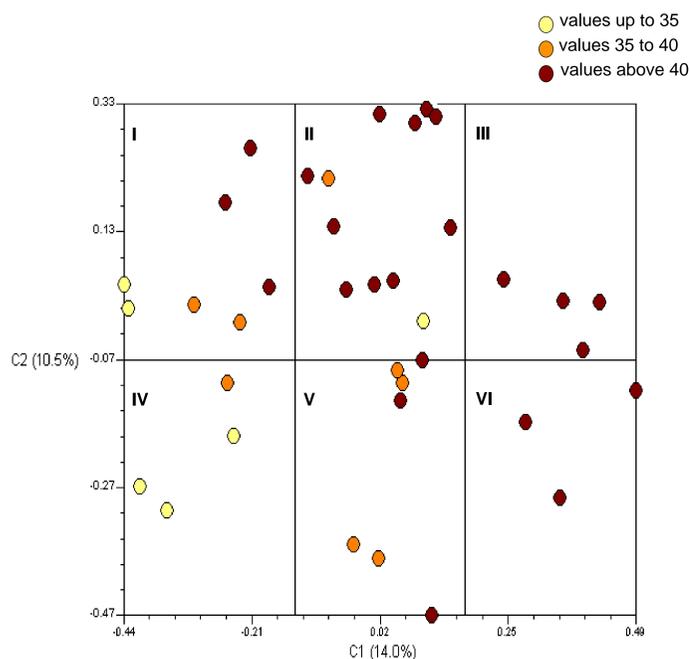


Figure 2. Colupulon (Rel % to total Alpha acids) distribution of material in PCOORD based on all AFLP primer data

Background

Over the past years more than 130 hops plants have been collected from breeding companies, gardens and semi-wild areas in Denmark and Norway and kept and maintained in clonal archives.

The objectives of this study were to:

- Search for any duplicates in these collections.
- Search for any correlation between molecular characteristics and geographical or chemical data.

Material and methods

A molecular study was started in 2009 by Nordic Genetic Resource Centre on the Norwegian and Danish hops. The study included 108 samples from clones. The primers were selected based on information given by Patzak (2001) and own studies. AFLP analyses with the following primers were used: E38/M47, E36/M49, E37/M62, and E37/M47. The results were compared to chemical characters and geographical origin (Dragland et al. 2003, Dragland 2004).

References

- Dragland, S., G.K. Bjørn, T. Suojala, E. Pennanen, & E.M. Strese, 2003. Nordisk humleprosjekt (*Humulus lupulus* L.), Sluttrapport til NGB.
- Dragland, S. 2004. Humledyrking var påbudt ved lov - nå har Nordisk Genbank tatt vare på mangfoldet. Grønn Kunnskap 8 (108), 8p.
- Patzak, J., 2001. Comparison of RAPD, STS, ISSR and AFLP molecular methods used for assessment of genetic diversity in hop (*Humulus lupulus* L.). *Euphytica* 121: 9-18.

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The vegetable working group has been responsible for the present work on hops.

Clonal archives and National programs

In Denmark the hops are kept at Aarhus University, Årsløv, while in Norway the hops are at Bioforsk Øst, Apelsvoll. In Sweden the national collections are at Nordiska Museet, Julita and in Finland at MTT Agrifood. The clonal archives are coordinated by each National program. Nordic Genetic Resource Center hosts different working groups and have the seed collection of all crops.

NordGen

The Nordic Genetic Resource Center is an organization dedicated to conservation and sustainable use of plants, farm animals and forest trees. Biological diversity is the foundation of human existence and adaptation to constantly changing environmental conditions. NordGen secures the biological livelihood of present and future generations.

NordGen Plants

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