

Research Application Summary

Development of improved scald tolerant barley varieties with superior end-use (malt) and nutritional quality for dry land areas of the northern Ethiopia

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Abstract

Barley is an important cash crop for resource-poor farmers in Tigray region of northern Ethiopian where options are very limited, and barley is often the only possible crop. Biotic stresses plus a harsh environment have contributed to low productivity of barley leading to widespread food insecurity in the Tigray area. Unfortunately, efforts to deploy improved varieties in barley have not taken root in Tigray. The approach in this study is to combine molecular and client-oriented plant improvement techniques to improve efficiency of selection and fasten release of varieties. A fundamental problem in plant breeding is the relationship between selection environment and target environment. Plant breeders have had notable successes in favorable environments, but they are often addressing the problems of poor farmers living in unfavorable environments by simply extending the same methodologies and philosophies applied to favorable, high-potential environments. At the same time, achieving food security and poverty alleviation in northern Ethiopia will require a large cadre of well-trained agriculturists. In this project, we will target training MSc level plant breeders to strengthen research and teaching capacity at Mekelle University. The research and graduate training will be done in collaboration with Makerere University in Uganda. Importantly, this study will adopt participatory plant breeding approach to develop scald tolerant varieties adaptable to Tigray agro-ecology.

Key words: Ethiopia, *Hordeum vulgare*, participatory plant breeding, *Rhynchosporium secalis*

Résumé

L'orge est une importante culture commerciale pour les agriculteurs pauvres en ressources dans la région du Tigré au nord de l'Éthiopie où les possibilités sont très limitées et l'orge est souvent la seule culture réalisable. Les stress biotiques et l'environnement difficile ont contribué à la faible productivité

de l'orge conduisant à l'insécurité alimentaire généralisée dans la région de Tigré. Malheureusement, les efforts pour déployer des variétés améliorées d'orge n'ont pas pris racine dans le Tigré. L'approche de cette étude est de combiner des techniques moléculaires et axées sur le client d'amélioration des plantes pour la sélection de l'efficacité améliorée et fixer la diffusion des variétés. Un problème fondamental dans la phytosélection est la relation entre l'environnement de sélection et l'environnement cible. Les sélectionneurs ont eu des succès notables dans des environnements favorables, mais ils résolvent souvent les problèmes des paysans pauvres vivant dans des environnements défavorables en étendant tout simplement les mêmes méthodes et philosophies appliquées à des environnements à fort potentiel et favorables. En même temps, assurer la sécurité alimentaire et la réduction de la pauvreté en Éthiopie du Nord exigera un large cadre d'agriculteurs bien formés. Dans ce projet, nous allons cibler la formation des phytosélectionneurs de niveau de maîtrise pour renforcer la recherche et la capacité d'enseignement à l'Université Makerere. La recherche et la formation des diplômés se feront en collaboration avec l'Université Makerere en Ouganda. Surtout, cette étude va adopter l'approche de la phytosélection participative pour développer des variétés tolérantes de l'échaudure adaptables à l'agro-écologie du Tigré.

Mots clés: Éthiopie, *Hordeum vulgare*, phytosélection participative, *Rhynchosporium secalis*

Background

Barley (*Hordeum vulgare*) is a major staple cereal crop in the northern Ethiopian region of Tigray. This region is characterized by harsh living conditions and is home to some of the poorest farmers in the world who depend on low production systems. Food security can be very substantially improved here if stress resilient and superior end-use barley varieties are developed and grown. Commonly in this region, barley grain is used as feed for animals, malt and human food. Additionally, barley straw is used as animal feed, for animal bedding and as cover material for hut roofs. Of the several uses of barley, malt is the second most important. Malting barley is grown as a cash crop. The most popular use of malt is the production of alcoholic beverages, but malt and malt extracts are increasingly becoming very important in the bakery and baby food industry. Globally, the demand for beer is rapidly growing, particularly in many developing countries. This makes malting barley an important

cash crop for resource-poor farmers in areas where options are very limited, and barley is often the only possible crop.

Breeding methodologies developed for more favourable conditions have been ineffective in generating improved varieties of barley for marginal areas such as Tingrey. Officially recommended 'improved' varieties have not been accepted by farmers living in marginal, low-input conditions. Often, farmers resort to their own knowledge and selection strategies. Participatory Plant Breeding (PPB) has been introduced in northern Ethiopia as an approach to specifically address the marginal environments where GE interactions are repeatable and large, precluding the adaptation of one or few varieties, or where there is a variety of different requirements (quality, crop duration, management, etc). One specific advantage of decentralized participatory plant breeding is to rapidly adapt the crops to a changing agronomic management.

The average time from cross to commercial release of a barley variety in well established breeding programs is about 14 years (Jefferies, 2001). This is because combining wide adaptation and desirable agronomic characteristics into a single variety is a highly demanding and tedious process for breeders. Molecular markers, however, have the potential to vastly improve the timeliness and efficiency of conventional breeding approaches such as PPB. This study will validate a set of DNA markers previously shown to be closely linked to RrsI scald locus (Williams *et al.*, 2001).

Achieving food security and poverty alleviation in northern Ethiopia will require a large cadre of well-trained agriculturists, and development of partnerships that derive their agenda from the needs and voices of the continent's populace (Bharati *et al.*, 2004). Because of the diverse needs of Africa's farming community and persistent poverty and food insecurity, investing in plant breeding is a matter of necessity. This project proposes to train two plant breeders to improve on the very limited capacity of high level trained plant breeders in Tigray. This is essential for crop variety releases and ensuring strong innovations systems critical for enhancing productivity to address food insecurity and livelihood issues especially in sub-Saharan Africa (FAO, 2005).

The overall goal of this project is to contribute to improved food security in drought prone areas through the development,

dissemination and promotion of improved barley varieties. Specifically, this project seeks to (1) Validate a set of DNA markers for use in accelerating resistance breeding for scald in Ethiopian barley lines, (2) Develop and promote improved scald tolerant barley varieties in drought prone areas of northern Ethiopia, and (3) train two nationals of Ethiopia in M.Sc. Plant breeding and seed systems.

Literature Summary

Scald disease of barley is caused by the fungus *Rhynchosporium secalis*. Yield of affected plants exhibit primarily through reduced kernel weight. In severe infections, both the number of kernels per head and the number of heads per plant may be reduced. The pathogen is carried from season to season on infected plant debris and through infected seed. Good control of the scald disease can be achieved by rotation with non-host crops such as a forage legume or plowing under infected residue. However, the most cost effective option for resource poor farmers is the use of resistant varieties. Barley varieties with high resistance against the pathogen race of scald disease such as those derived from the F₁ of disease-resistant lineage “Hokuriku No.35” and 5 varieties have been identified (Seiji et al., 2003).

Differential responses have been observed between genotypes tested in the highlands of Ethiopia where scald is a major problem (Ceccarelli et al., 1996; Abay and Bjornstad, 2009). Through the co-operation with ICARDA, a wider array of crosses have been made available for field testing in Ethiopia. These crosses are now awaiting evaluation for adaptation and reaction to biotic stresses (e.g. scald).

Bulked segregant analysis has been used to identify amplified fragment length polymorphisms (AFLPs) with close linkage to the resistance locus. Fully mapped populations not segregating for scald resistance located these AFLP markers on chromosome 3H, possibly within the complex RrsI scald locus. Microsatellite and restriction fragment length polymorphism markers adjacent to the AFLP markers were identified and validated for their linkage to scald resistance in a second segregating population, with the closest marker 2.2 cM from the resistance locus. These markers can be used for selection of the Rrs.B87 scald-resistance locus, and other genes at the chromosome 3H Rrs1 locus.

Research Approach

The approach will combine molecular and client-oriented plant improvement techniques to improve efficiency of selection and

fasten release of varieties. Two studies will be undertaken as described below.

Development and promotion of scald resistant varieties.

This study will set out participatory variety selection (PVS) sites in three of the barley growing areas in northern Tigray region of Ethiopia. Included in the PPB trials will be several promising barleys lines derived through crosses between 'Himbil' (most farmers preferred variety) and another likeable farmer variety in Tigray known as 'Saesa'. Participating farmers will be allowed to make their own observations of the performance of the lines on display and rank them according to their criteria (yield, growth habit, pod colour, seed colour, yield, cookability, taste, etc). Where promising lines have been identified individuals or groups will be encouraged to grow them in their fields. Identified superior and promising varieties will be fronted for promotion and release as varieties in Ethiopia

Validation of molecular markers. Rapid introgression of premium qualities in barley has been achieved through the use of molecular markers. A set of AFLP, RFLP and SSRs markers were previous identified for use in efficiently introgressing resistance loci for scald in an Australian line. However, their use in populations other those in which they were initially tested need to be tested. Standard DNA procedure will be used to validate the use of these markers with Ethiopian barley lines.

Research Application

It is planned that field trials for variety selections will be conducted in different locations in fields easily accessible to many farmers. This will enable selection to be done with many farmers as well as the fields to act as demonstrations to the non participating farmers. These will likely lead to wider adoption of farmer desired varieties. The joint research and training of graduate students by Mekelle and Makerere Universities will lead to stronger inter-institutional collaboration and building research and training networks among African Universities. Linkage with the Norwegian University of Life Sciences will also strengthen south-north partnership to address food security concerns in Africa.

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