Genotypic variation in root traits involved in phosphorus utilization by barley

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ABSTRACT

In Scotland the major cereal crop is barley and here we investigate the variation between barley mutants in relation to root characteristics and their ability to respond to phosphorus deficiency. A screen of a mutant population in an Optic genetic background has identified variation in rooting characteristics (root hairs, root length and root angle) and a sub sample of mutants demonstrating variation in root hair characteristics (no root hairs, short root hairs and long root hairs) has been grown in a pot experiment to establish links between specific root hair characteristics and phosphorus utilization. This will help us to identify candidate genes for root traits which improve phosphorus use efficiency in barley allowing their introduction into commercial varieties which will be beneficial to the long term sustainability of agriculture.

KEYWORDS: agricultural sustainability, forward genetics, *Hordeum vulgare* L., mutant population, root hairs.

INTRODUCTION

Phosphorus (P) is an essential plant nutrient that limits agricultural production on a global scale. It is therefore desirable that the P-use efficiency of agricultural plants be improved. Many plant species are adapted to P-deficiency and have developed a range of mechanisms that enhance their ability to acquire P from soil (Vance et al. 2003). One of these mechanisms is through modifications to root structure. Several studies have demonstrated that root phenotypes differ between cereal genotypes (Haling et al. 2009, Gahoonia and Nielsen, 1997) but few have established the effect of specific root traits on the ability of the plant to acquire phosphorus or ultimately their effect on yield. Induced mutation artificially increases the genetic variation within a species, and collections of induced mutants can be used to identify genotypes with increased efficiency to acquire mineral elements from the soil. One approach (forward genetics) is to screen these collections directly for an improved phenotype and, subsequently, to identify the genetic origin of the phenotype. A population of induced mutants in barley (cv. Optic) has been developed at SCRI. This paper assesses the breadth of root mutations in the population and investigates the effects of root hair variation on P-use efficiency in barley.

METHODS

A screen for rooting characteristics in a mutant population of barley (*Hordeum vulgare* L. cv Optic) was carried out by germinating 12 seeds of each of 458 mutant lines in a petri dish containing blue blotting paper (for ease of visualization) and 6 mL distilled water. These were kept in the dark by wrapping in foil and placed in an incubator at 15^{o} C. After 4 days the dishes were removed, photographed and any variation from the control cultivar (Optic) was recorded producing a database of rooting characteristics. Each phenotypic characteristic was then assigned a positive or negative classification based on their hypothesized ability to improve resource capture. A sub-sample of mutants demonstrating differences in root hair characteristics were then selected for a growth experiment. In this experiment we grew a range of "hairless", "short haired" and "long haired" mutants in a P-deficient soil with and without the addition of P fertilizer. Plants were harvested after 7 d growth, with roots being carefully separated from soil and their length quantified (Haling et al. 2009). In addition, the lengths of 10 root hairs were measured at 4 to 6 cm from the root tip using a compound microscope. Shoot and root mass was also determined.

RESULTS AND DISCUSSION

The initial screen of 458 mutants revealed 14 visible root phenotypes (Fig.1). Of the mutant lines screened, 25% were as the standard cultivar Optic (=), 9% were positive (+) in their potential to improve resource capture and 66% were negative (-). The most common trait was "short roots" at 30%. Other variations included differences in root hair numbers and root hair lengths. The resulting database of mutational phenotypes, enhanced by the photographic record (Fig.2), provides a valuable resource for future investigations of relationships between specific root traits and nutrient acquisition. The complimentary growth study described in the methods will look at the impact of root hair length on root function in relation to nutrient acquisition. The results of this pilot study will be presented in the poster. Subsequently, a further experiment will repeat this pilot study, but plants will be grown to maturity, providing additional data on yield and shoot P levels in relation to rooting characteristics. This will help to establish an understanding of the genetic control of these traits, assisting in the identification of candidate genes and ultimately in the introduction of beneficial traits into commercial varieties with a positive impact on the long term sustainability of agriculture.

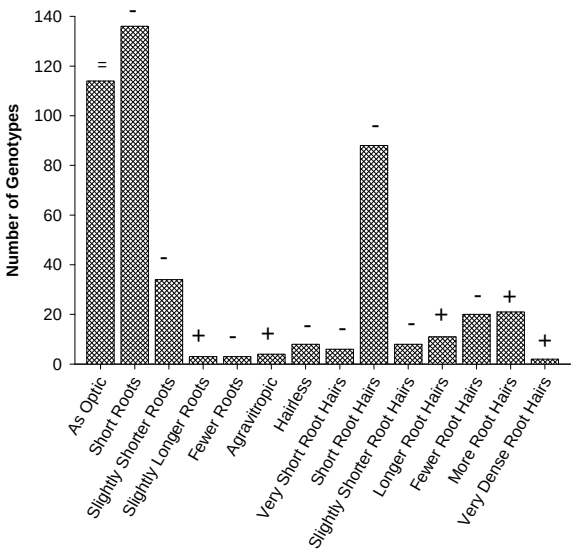

Figure 1. Distribution of mutants.

071_17 "Hairless"

074_44 "Shorter Root Hairs"

065_03 "Longer Hairs"

Figure 2. Photographic record of three mutant phenotypes and lines used in the growth study.

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