Altering Canopy Architecture to Increase Crop Photosynthesis and Yield

Introduction

Field results in Australia over two years have demonstrated a yield advantage of up to 25% for lines with a desirable canopy architecture. This largely neglected trait is not common in the CIMMYT bread wheat breeding program and it is also not common in spring wheat varieties that farmer's grow. In studies so far, significant increases in yield through an improved canopy architecture are associated with greater biomass at maturity and therefore by implication greater canopy photosynthesis. Improved yields were not associated with differences in crop duration. A desirable canopy architecture was also associated with other yield enhancing traits such as less lodging, greater storage of reserve photosynthate, stay green and heat tolerance.

Project Description

Materials and Methods

About 80 extreme lines differing in canopy architecture at the pre-flowering stage were identified from an initial population of about 800 lines. These 800 lines were from the CSIRO 4-way MAGIC population which is an intercrossed population using four highly diverse Australian commercial spring wheat parents. After a complex crossing procedure a large random set of individuals were selfed to near homozygosity. Resulting lines are extremely diverse as they may have one of four alleles at any locus and there has been substantial opportunity for recombination. These lines were planted in the field in plots in Australia and about 80 extremes for canopy architecture were selected for further experimentation. These represent 40 high extremes and 40 low extremes. Selected lines are very stable for the canopy architecture trait and have now been tested over several years. Extreme lines for height and flowering time were eliminated.

Seed from these lines will be increased in Mexico by the IWYP Hub. A selection of around 60 lines (30 high and 30 low) will be grown. Firstly, in a 'Proof of Concept' experiment and secondly in a 'Density' experiment. The purpose of the 'Density' experiment is to determine whether crop management can be used to further increase yield and so achieve additional benefits through genotype x management. Both experiments will be run over two years at Obregon.

<u>Proof of Concept experiment.</u> The aim of this experiment is to grow 30 highs and 30 lows in a 2-replicate experiment together with some check lines at the IWYP Hub. Visual scores of canopy architecture will be taken at several times from flag leaf emergence through to anthesis plus 7 days. Time of anthesis and height will be measured and at maturity a sub sample of each plot will be used to measure harvest index, above-ground biomass, grain number and grain size. Grain yield of the full plot will be measured. Plots will not be grown on beds and inter-row spacing will be about 20 cm. Proof of concept will come from comparing the average of the 30

high lines with the average of the 30 low lines for grain yield, biomass, harvest index etc. This is a very robust proof of concept.

Density experiment. Five high and five low lines will be identified from the 30 highs and 30 lows to grow at different crop density configurations at the IWYP Hub. Densities could be formed from different row spacings or different plant numbers. It could include beds. The same measurements as for the 'Proof of Concept' experiment will be made. Additional measurements will be on plant density after emergence and NDVI up to canopy cover.

Deliverables

1. Proof of concept that selection for canopy architecture can be a fast and simple way to increase crop biomass, crop photosynthesis and grain yield.
2. Evidence for whether crop management can be used as an additional tool to maximise the genetic potential and further increase crop biomass and yield.

A design for a simple breeding and selection strategy for canopy architecture that can be used by national breeding programs