

Ultrasonic Plant Height System for High-Throughput Plant Phenotyping

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Summary

Plant height is a key trait studied in breeding and research programs. Measurements in the field are time-consuming as they require manual measurements with several replicates. We will build a phenotyping device that will provide a significant improvement in sampling time and sample size. We will use a low-cost ultrasonic sensor to screen the field canopy and obtain an accurate biological sample of this trait.

Proposal

The problem

Plant height, in cereal crops, is a key morphological trait strongly related to carbohydrate storage capacity. Current standard protocols require for manual measurements using a ruler to sample up to 10 individual plants per plot, to obtain a representative height value. This is a laborious and time-consuming task when implemented in large field trials, e.g. in segregating populations.

Biological system

We focus on wheat due to its worldwide importance and productivity-improvement potential. It is also a crop in which yield complexity has not been fully unravel, and where current research requires the acquisition of data from different traits. Hence the need to development an open-source tools capable of improving phenotyping time and accuracy.

Design goals of the hardware

The instrument is intended to be use in the field, therefore it should be portable, reliable, weatherproof, and easy to operate. We will use an Arduino microcontroller and ultrasonic sensors to acquire plant height data. The ultrasonic sensor will emit a sound wave that will bounce back from the canopy. An initial read or manual input can be used as baseline (sensor height from the ground). This will be possible using a screen and at least three buttons. Once height zero is stored, we can calculate height from each data point and average a value from hundreds of data points collected in just a few seconds.

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An important part of the hardware is the communication port or data storage component. To address this, we will talk with phenotyping experts in John Innes Centre and CIMMYT to determine the optimal way to retrieve the data. the main possibilities are (i) a removable SD Card, or (ii) Bluetooth connection to a mobile device (existing free phenotyping applications allow for this type of communication).

Implementation

In order to produce a useful tool, we will build at least 2 working prototypes that can be distributed to a breeding company and/or research group for independent testing and feedback.

Outcomes and benefits

We expect to produce a phenotyping tool that at the press of a button will accurately sample plant height. This tool will benefit not only crop researchers, but potentially also plant breeders.

Estimated Budget

Initial prototyping can be done with the provided Biomaker Challenge kit and the following items:

supplier	catalogue number	description	Qty	per unit	price (£)
Farnell	1302262	Heat Shrink Tubing Kit, ShrinKit 321 Basic	1	18.67	18.67
Farnell	2450661	Pocket Size Digital Multimeter	1	12.5	12.5
Farnell	1297224	PETBK5BG5 - Sleeving, Expandable, Braided, 5 m, 16.4 ft, 5 mm, PE (Polyester), Black	1	5	5
CPC OneCall	EN82830	ABS CASE, IP65, DARK GREY, 115X65X55MM - SE-212-0-0-D-0	3	7.49	22.47
CPC OneCall	SN36696	Ultrasonic distance sensor - HC-SR04	6	2.25	13.5
RS Components	666-4584	RS Pro Black PVC Cable Grommet Kit, Kit incl. Easy Fit Type Grommets, 3 → 19mm dia.	1	25.01	25.01
RS Components	724-4314	Lapp H05VK Black Single Core Control Cable, 0.5 mm² CSA 500 V, 100m	1	15.69	15.69
RS Components	761-3313	RS Pro Aluminium Alloy Strut 40 x 40 mm, 8mm Groove , 2000mm L, Series Profile 8	2	25.37	50.74
RS Components	767-5695	RS Pro Connector Bracket & Joint Angle Bracket, strut profile 40 x 40 x 40 mm, Groove Size 8mm	4	5.09	20.36
RS Components	767-5601	RS Pro Black Glass Filled Reinforced Nylon PA End Cap, 40 x 40 mm strut profile , Groove 8mm	6	5.75	34.5
RS Components	761-3319	RS Pro Aluminium Alloy Strut 40 x 40 mm, 8mm Groove , 1000mm L, Series Profile 8	2	12.99	25.98
RS Components	767-5623	RS Pro Cover Strip, PP, 8mm Slot, Black, 10pcs x 2m	1	11.14	11.14
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