
# Implementation of a CAN bus system to monitor hydroponic systems

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**Abstract.** Controlled Area Network (CAN) bus systems designed for greenhouse monitoring have been proposed to measure soil moisture content, yet they are still absent from hydroponic systems. In this study, irrigation control, monitoring of substrate moisture levels and temperature were achieved using a CAN bus system connected to hydroponic beds. In total, five nodes were mounted on five hydroponic beds and two irrigation methods were compared on lettuce and kale: first, where a pre-set timer activated the irrigation pump, and then, when irrigation pumps were activated, then stopped, using predetermined minimum and maximum moisture levels. A statistically significant effect ($p<0.01$) on plant height, dry and wet mass was achieved after 29 days of growth. Highest yield was measured in the control treatment and lowest in the 25%-85% treatment. Overall, the CAN bus system can improve moisture and temperature monitoring in hydroponic beds and can optimize irrigation for individual crops species to achieve higher yield and to minimize the risk of water stress.

*Keywords. hydroponic, CAN bus, irrigation*

## Introduction

Hydroponic systems are commonly used to study plant response to biotic and abiotic stresses (Both, Albright, Langhans, Reiser, & Vinzant, 1994). They are easily implemented and offer better environmental control and are easier to monitor than experiments conducted in agricultural fields. Irrigation timing and nutrients concentration are some of the numerous features that can be modified in hydroponic systems to optimise yield or to determine the impact of varying environmental parameters on a plant. The most common irrigation method in greenhouses relies on pre-set timers to water plants, however, it is uncertain if this approach is optimal for plant growth or if it creates water stress. Controlled Area Network (CAN) bus systems designed for greenhouse monitoring have been proposed to measure soil moisture, yet they are still absent from hydroponic systems (Li & Zhang, 2010; Lihong, Lei, Shufen, & Weina, 2011; Liu, Meng, & Cui, 2007).

## Materials and Methods

In this study, irrigation control and monitoring of substrate moisture levels and temperature were achieved using a CAN bus system linked to hydroponic beds. The CAN bus system consisted of a PC host (JBC311U93 computing system, Intel Atom, 2GB RAM, 32GB SSD from Jetway Computer Corporation, Newark, CA, USA), outside the CAN bus (Jaycon systems Can Bus Shield v1.1, Melbourne, USA), that worked as the main monitoring system, and a node attached to each hydroponic bed, which collected the temperature (#81-ADA Waterproof DS18B20, Adafruit, USA) and moisture information (SEN0114 Gravity: analog soil moisture sensor, DFRobot, Shanghai, China) (Figure 1). One node collected information from the substrate where one plant was grown. Data collected from the moisture sensors were used by the node to activate water pumps and to maintain the moisture levels in the rockwool substrate within a pre-determined threshold (Table 1).

Table 1. Moisture content set-up to activate the water pumps in the ebb and flow hydroponic systems.

| Node ID | Min moisture | Max moisture |
|---|---|---|
| 1 | 50% | 85% |
| 2 | 50% | 100% |
| 3 | 25% | 85% |
| 4 | 50% | 75% |
| 5 (Control) | Automated system, water pump active 15 min every hour. | |

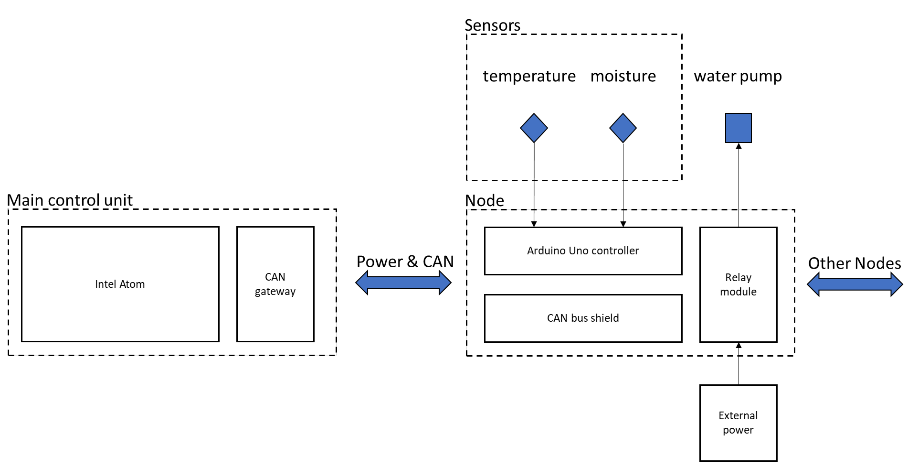


Figure 1. CAN bus system setup

## Results and DIscussions

In total, five nodes were mounted on five hydroponic beds to create different water stress environments for lettuce and kale. The nodes were operated independently and were fully functional even when the main computer was off. For both lettuce and kale, the aboveground wet mass was significantly ($p<0.01$) higher for the control treatment where the irrigation was turned on with a timer for 15 min every hour (Figure 2 and 3). The average wet mass in the control treatment was 28.9 ± 2.3 g for lettuce and 20.8 ± 1.5 g for kale. Lowest yield for kale was in the 50%-85% treatment with 5.3 ± 0.7, while it was in the 25%-85% treatment for lettuce with 7.7 ± 0.8 g. These results showed that crops have different irrigation requirements and that a high moisture environment is preferred. This also shows why hydroponic systems, where water stress is lower, have higher yield than traditional agriculture where watering fluctuates constantly. Karam et al. (2002) conducted field research and showed that water stress has a significant effect on the mass of lettuce (Karam, Mounzer, Sarkis, & Lahoud, 2002). Control treatments for both crops, where moisture was the highest, also had the highest yield.

Significant difference was measured for the aboveground dry mass for both plants ($p<0.01$). The control treatment had the highest dry mass with 1.4 ± 0.1 g and 1.8 ± 0.2 g for kale and lettuce respectively. Karam et al. (2002) found a reduction of 30 to 38% in dry mass of lettuce created in a water stressed environment. In this experiment, lowest yield was recorded in the 50%-85% treatment for kale with 0.4 ± 0.0 g, while it was in the 25%-85% for lettuce with 0.6 ± 0.1 g. Irrigation treatment had a direct effect on height for both crops ($p<0.01$). Highest extended height was recorded for both plants in the control treatment with 28.2 ± 0.5 cm and 24.4 ± 0.5 cm, and lowest in the 25%-85% treatment with 17.4 ± 1.2 cm and 17.3 ± 0.7 cm for kale and lettuce respectively.

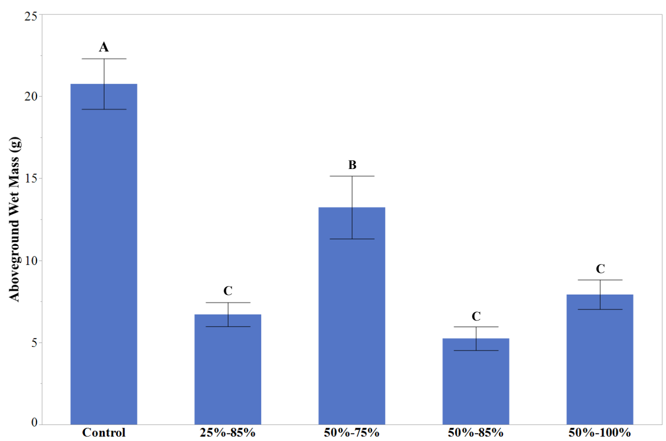


Figure 2. Mean aboveground wet mass for kale (Brassica napus) for each treatment (with standard error). A timer was used to control the watering in the control treatment. Letters above the columns show HSD statistical significance ($p<0.01$). Highest yield for kale was recorded with the control treatment, followed by the 50%-75%.

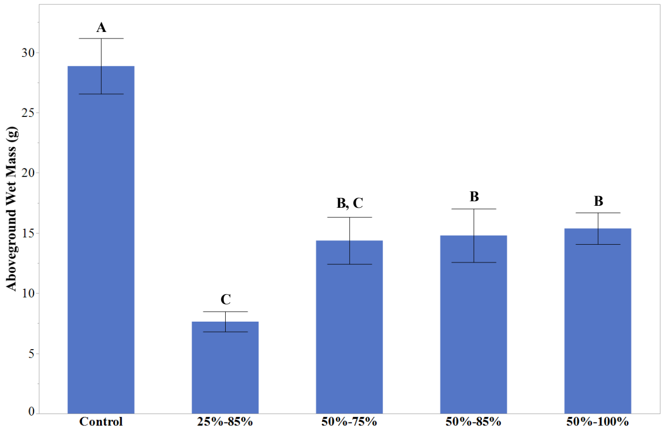


Figure 3. Mean aboveground wet mass for lettuce (Lactuca sativa var. longifolia) for each treatment (with standard error). A timer was used to control the watering in the control treatment. Letters above the columns show HSD statistical significance ($p<0.01$). Highest yield for lettuce was recorded with the control treatment, followed by treatments which started watering at 50%. Lowest yield was measured with the 25%-85% treatment.

## Conclusion

Moisture and temperature monitoring of hydroponic beds with a CAN bus system allows to optimize irrigation to achieve higher yield and to minimize the risk of water stress. For both crops, the lower the moisture to initiate irrigation, the lower was the yield. Using a CAN bus system also allowed to collect real-time data on the growing environment of a specific crop. This data could be used to optimize growth and yield in greenhouses with hydroponic systems.

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