Draft – A more detailed instruction manual with photos will be added later

Parts List:

- Cardboard box (approx 30 x 24 x 9.5 cm)
- Raspberry Pi 4 (1 GB RAM or more)
- Raspberry Pi Camera 3 NoIR (76°)
- Waveshare 7 inch Display Capacitive Touchscreen HDMI LCD (H)
- Raspberry Pi USB-C power supply (5.1V / 3.0A)
- Case for Display and Raspberry Pi
- microSD card
- USB stick
- Iduino ST1168 transistor module
- 12x Kingbright Infrared LED 880 nm L-7104SF4BT
- 2x 13 Ohm resistors
- Strip board (10 cm)
- 6x Dupont connector cables
- 3D printed case and mounts

Tools

- Cutting tools (scissors, knife)
- Ruler
- Small slotted screwdriver
- Soldering iron + solder
- Glue

1. Chamber Construction

1.1   Material Selection:

1.1.1   Choose a sturdy, light-blocking cardboard box. The dimensions of the box we used were 30 x 24 x 9.5 cm, so a box of a similar size should be for optimal seedling growth and camera placement.

1.1.2   Optional: Consider using black foam board or paint for improved insulation and to minimize light reflections.

1.2   Chamber Assembly:

1.1.2   Cut a slit with a length of 20 mm in one side of the box as a pass-through for the cable connecting the camera module and the Raspberri Pi single board computer.

1.2.2 Cut an opening of 130mm x 20mm in the lid to allow rhizobox insertion. The opening should be at around 220 mm distance of the side of the box.

2. 3D Printing of mounting parts

Download the 3D model files which include:
- case for Raspberry Pi and the 7 inch Display
- camera mount
- **car**LED mount

- reinforcement for lid slit
- water tray

Use a 3D printer to print those files. PLA and standard printing settings should be fine. For improved sturdiness it is recommended to print the display stand with a higher infill, also PETG will improve strength for this part.

3. Camera and Specimen Placement

3.1 Camera Mounting:

3.1.1 Glue the camera mount into the box. Maintain a distance of approximately 20 cm between the camera lens and the rhizobox to capture the entire root growth area. This has already been considered in step 1.2.2.

3.1.2 Rhizobox Preparation:

Design the rhizobox to fit within the chamber. We use square Petri plates with dimensions of 120 x 120 x 17 mm. To create an opening for the shoots to grow we remove the plastic on the lid on one side. Fill the rhizobox with moistened soil and plant the seeds as required on the top of the soil. If necessary use tape on the side of the Petri plates to secure them

4. Electronics Setup

4.1 Computer Module Configuration

4.1.1 Install Raspberry Pi OS (64-bit with desktop) on a microSD card for touchscreen compatibility and user-friendly interface.

4.1.2 Secure the Raspberry Pi and the monitor into the 3D- printed case

4.1.3 Connect the camera cable to the camera module and the Raspberry Pi

4.1.4 Connect the Raspberry Pi to the monitor using the USB and HDMI cables. Also connect the Raspeberry Pi to the power supply

5. LED Lighting System

5.1 LED Placement:

5.1.1 Solder 6 LEDs and the resistor onto a perforated grid plate of 8 x 1.5 cm

5.1.2 Glue the LED mounts into the box. They should be in a distance of around 10 cm from the rhizobox, positioned at a 45-degree angle towards the rhizobox to ensure even illumination. Maintain a distance of approximately 10 cm between the LEDs and the rhizobox to avoid excessive light intensity and reflections.

5.2 LED Circuitry:

5.2.1 Connect the LEDs in parallel using a 13 Ohm resistor to limit current flow and prevent overheating.

5.2.2 Utilize a transistor module to control the LED power supply based on the Raspberry Pi's GPIO signals. This is necessary as the GPIO pins are not designed for a high power output and thus the Rasperry Pi could be damaged if attempting to power the LEDs directly.

5.2.3 Connect the transistor module to the 5V power output of the Raspberry Pi