

Smart Tattoo Patch for Long-term Monitoring and Drug Delivery

[Characterized for Detection of Temperature and Relative Humidity on Live Plants]



Award No. 2138701



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Motivation

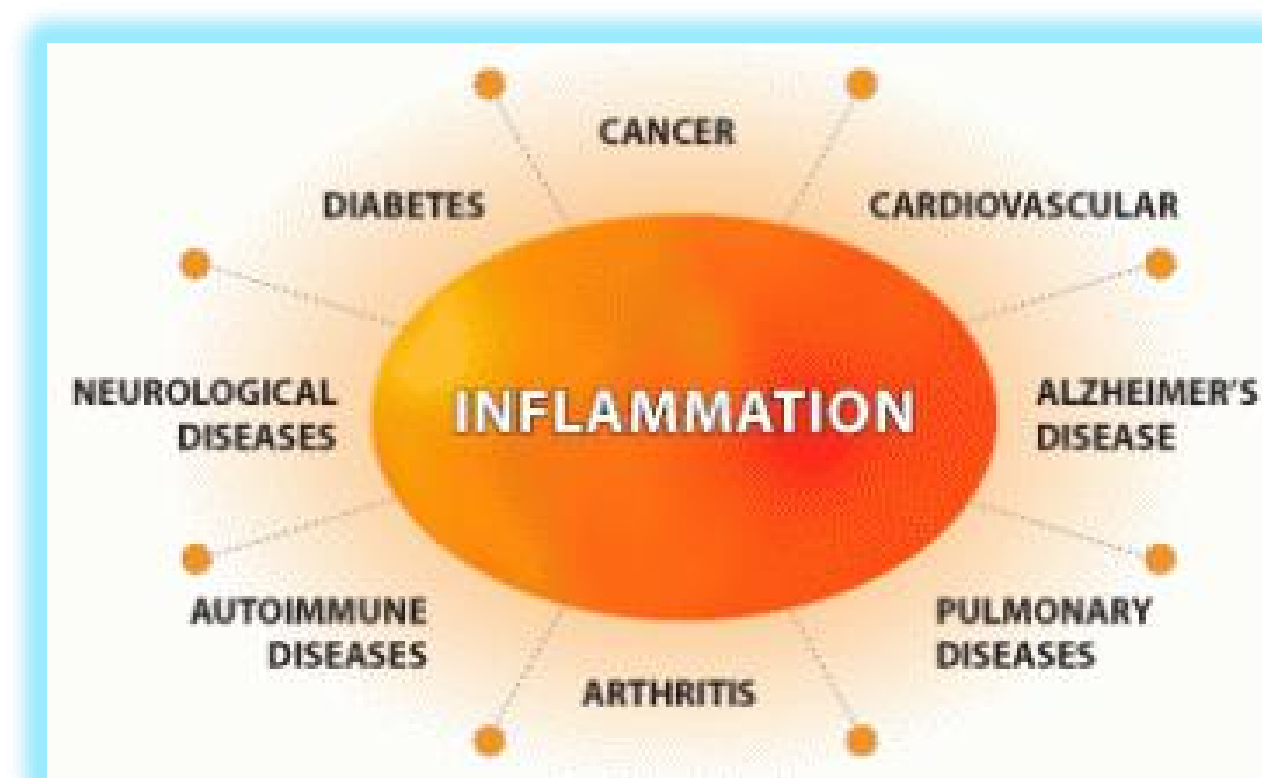
215 Million Americans are Infected with

Chronic
Disease

Cardiovascular
Disease

Infectious
Disease

- All these diseases are associated with inflammatory biomarkers
- Therefore, by detecting the level of the biomarkers, we can detect the severity of these inflammatory conditions
- Along with detection, real-time monitoring of the inflammatory biomarkers can open the scope of continuous treatment with on-demand drug delivery
- Transdermal drug delivery provides non-invasive therapeutics [1]



- We need fully skin conformal tattoo like sensor
- Strain-insensitive response requires functionalization with strain-insensitive active materials

Limitations

- Invasive sample collection
- Not suitable for children
- Large volume of sample required
- 2-3 Days to get test result
- Advanced laboratory setting and trained personnel
- Not an affordable solution for rural areas
- Difficult to differentiate among diseases with similar presentations such as COVID-19 and Flu
- Not fully skin conformal
- Drug delivery method is invasive, oral, and intravenous



Better Be Prepared, Not Regret Later

Value Proposition of Our Device

- Multiplexed, Strain-insensitive Detection and Real-time Monitoring of Inflammation-related diseases
- Fully Skin Conformal like Tattoo
- Non-invasive, rapid, and user-friendly process
- Cost-effective, cleanroom-free, and roll-to-roll production on flexible substrates
- Personalized healthcare with accurate data, high sensitivity and selectivity
- Non-invasive transdermal drug delivery
- Ensure Healthcare for All



**Save Time
to Save Lives**
 Efficient Response
in the Time of Crises

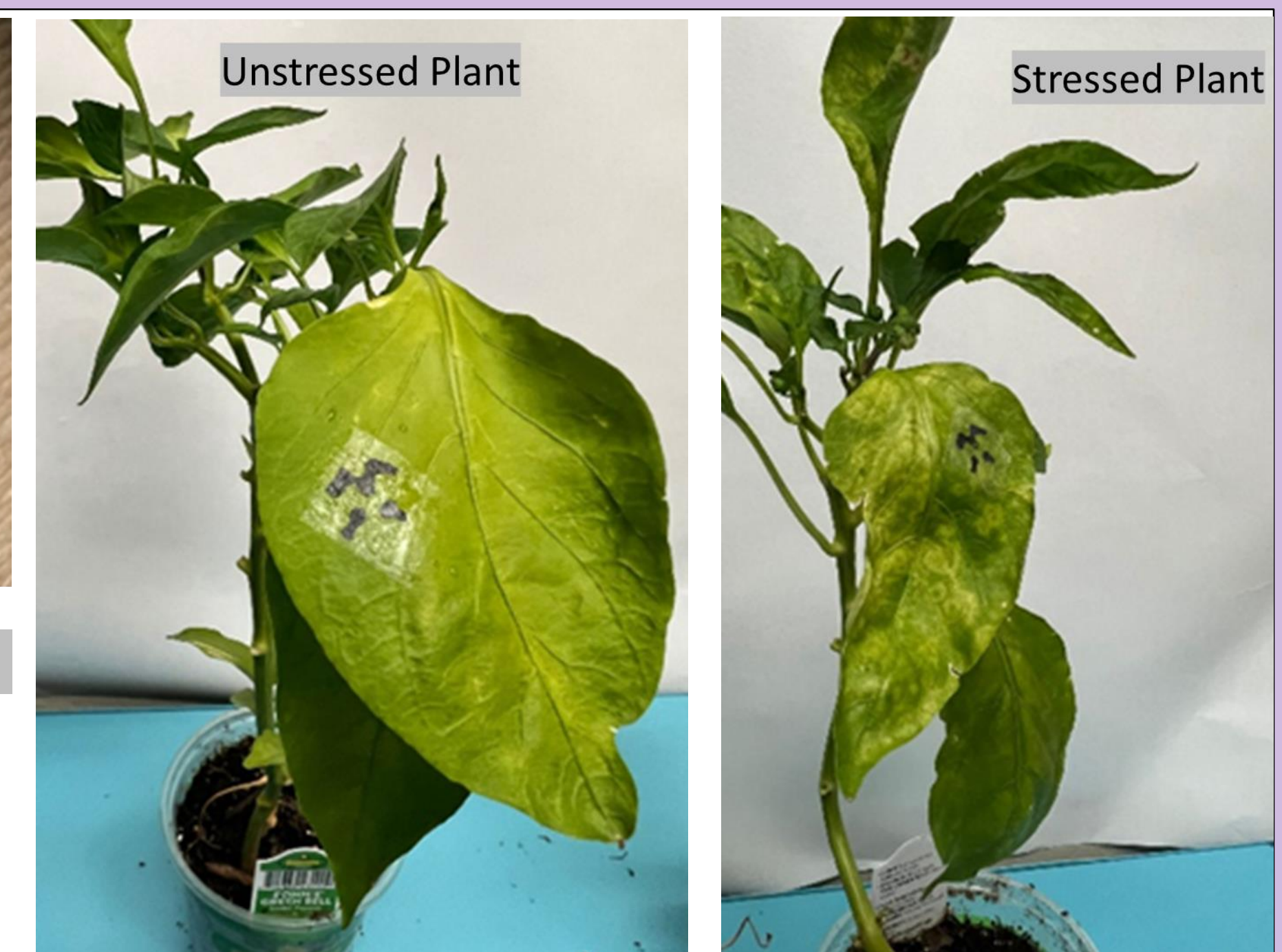


Tattoo Sensor



Fig: Tattoo sensor attached to the skin at ankle:
 (a) relaxed state (b) flexion state of ankle

- Vapor-pressure deficit (VPD) in plants works as the driving force for transpiration in plants
- VPD measurement requires on-leaf temperature (T) and relative humidity (RH) values
- Higher VPD indicates water stress in plants
- Therefore, by continuous monitoring of VPD will aid in managing plant growth environment and the farmers can take actions earlier to ensure optimum water and nutrient supply, apply disease control measures and reduce yield decline from stress.



$$VPD = VP_{sat} - VP_{air}$$

VP_{sat} = saturated vapor pressure in plant leaf

VP_{air} = air vapor pressure

$VP_{sat} = 0.6107 \times 10^{7.5 T_l / (273.3 + T_l)}$

T_l = temperature on the leaf in Celsius,

$VP_{air} = 0.6107 \times 10^{7.5 T_a / (273.3 + T_a)} \times RH/100$

T_a = air temperature in Celsius

RH = relative humidity on the leaf surface [2]



Real-time Measurements on Live Plant Leaves

Measured Data

- On-leaf Plant Temperature (T)
- On-leaf Plant Relative Humidity

Future Body Parameters To Be Measured

- Multiplexed Inflammatory Biomarkers
- Sweat pH
- Skin Temperature
- Transdermal Electrically-controlled Drug Delivery

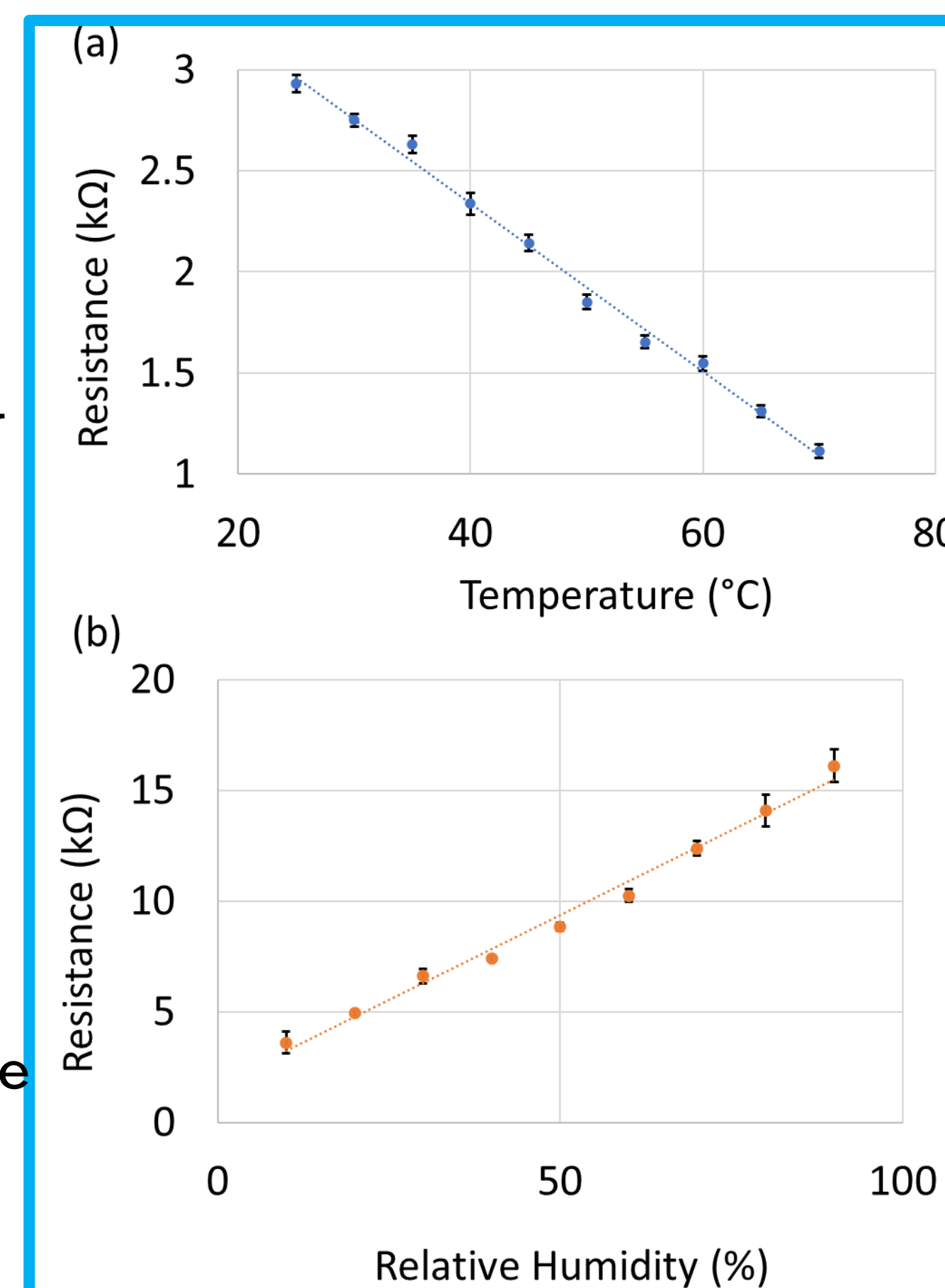


Fig: (a) Calibration of temperature sensor
 (b) Calibration of humidity sensor

Let's Be Prepared to Fight the Next Pandemic

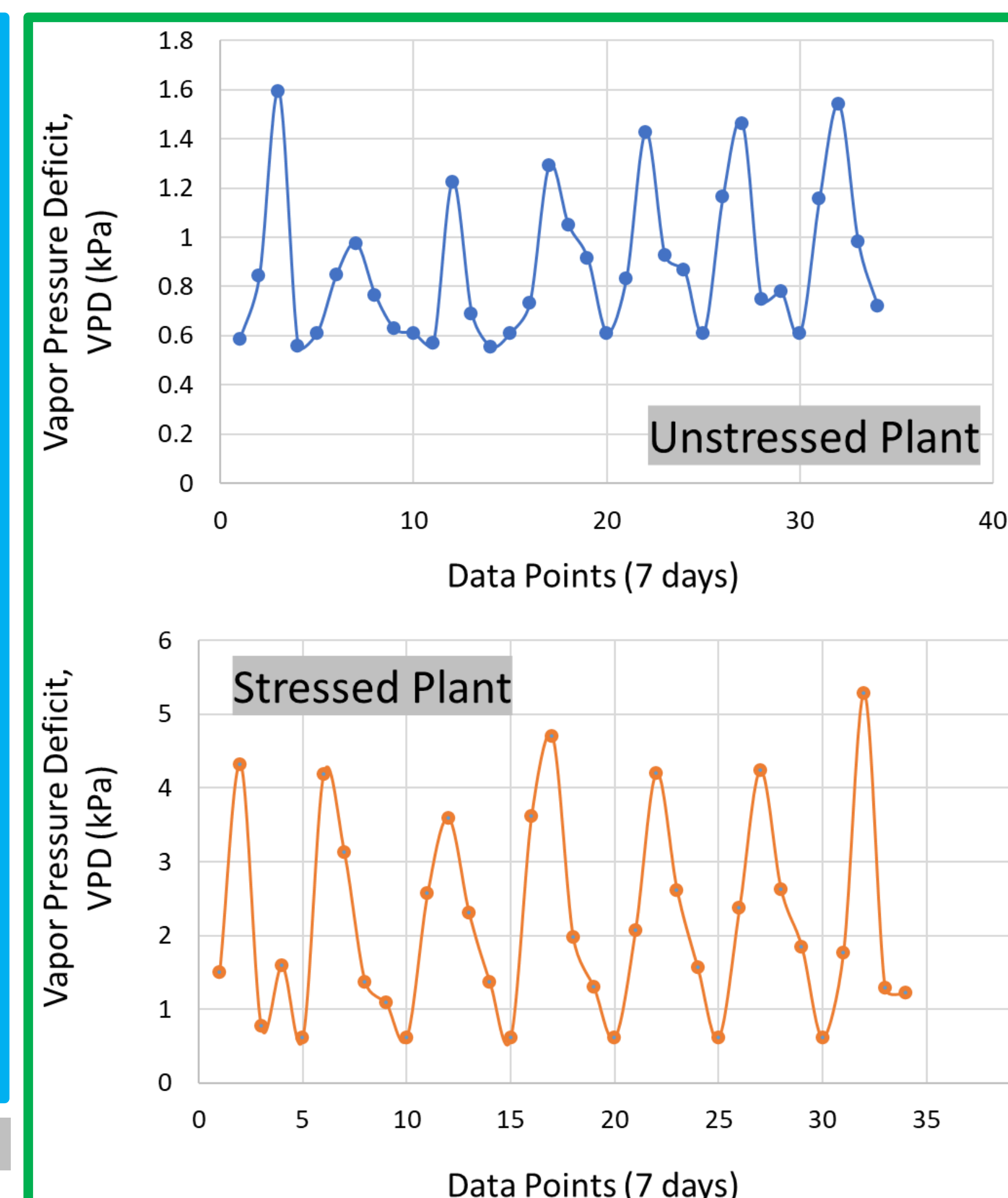


Fig: Vapor Pressure deficit (VPD) in (a) unstressed and (b) stressed plants over 7 days
 (Data was recorded 4 times a day)

References

- [1] Chansai P, Sirivat A, Niamlang S, Chotpattananont D, Viravaidya-Pasuwat K. Controlled transdermal iontophoresis of sulfosalicylic acid from polypyrrole/poly(acrylic acid) hydrogel. Int J Pharm. 2009 Oct 20;381(1):25-33. doi: 10.1016/j.ijpharm.2009.07.019. Epub 2009 Jul 28. PMID: 19643172
- [2] Shihao Yin, Hussam Ibrahim, Patrick S. Schnable, Michael J. Castellano, and Liang Dong, "A Field-Deployable, Wearable Leaf Sensor for Continuous Monitoring of Vapor-Pressure Deficit," Advanced Materials Technologies, vol. 6, no. 6, 2021