USE OF IOT DEVICE TO MEASURE THE ACIDITY OF DEW AND ITS IMPACT ON CROP

Raju Marotrao Pole
Department of Computer science Adarsh college hingoli
rpole441@gmail.com

Abstract
Dew deposition on crops plays a non-negligible role in the micro-environmental moisture and can act as a vector of acidic deposition (via atmospheric pollutants, acid rain, etc.). Monitoring the acidity (pH) of dew can provide insight into potential stress on crops or soil systems. This paper proposes and discusses an IoT-enabled device to measure dew acidity in the field, outlines its design, deployment strategy, data acquisition and analytics, and links dew acidity to plant stress and crop productivity through review of literature on acidity impacts. The ultimate aim is to suggest how such measurements can inform precision agriculture practices and mitigate adverse effects of acidic deposition on crops.
Keywords: *IoT, dew acidity, pH sensor, precision agriculture, crop stress, acidic deposition*

1. Introduction

The microclimate around crop surfaces (leaves, stems) is influenced by dew formation, relative humidity, ambient temperature, and atmospheric deposition. While much attention has been given to soil pH and acid rain, less attention has been paid to the acidity of dew that deposits on plant leaves or near-soil surfaces. Dew may pick up acidic ions (e.g., from sulphur and nitrogen compounds in atmosphere) and contribute to micro-acidification of leaf surfaces or near-soil layers, which may affect nutrient uptake, foliar health, stomatal function, or soil-leaf interfaces.

Meanwhile, the growing adoption of the Internet of Things (IoT) in agriculture has enabled real-time monitoring of many environmental and soil parameters (soil moisture, humidity, pH, temperature, etc.). [7] Integrating an IoT device to monitor dew acidity would thus offer a novel data stream to better understand crop micro-environment.

This paper proposes a device and monitoring methodology, explores the relationship of dew acidity to crop health, summarises relevant literature on acidity effects in soil/plant systems, and discusses how the results might be utilised in the field to improve crop management.

2. Background and Literature Review

2.1 Dew formation and its relevance

Dew forms when surface temperatures drop below the dew-point of ambient air, leading to condensation of water vapor on leaves, soil, and other surfaces. Dew can act as a medium for deposition of atmospheric ions, dust particles, and dissolved gases. For instance, a study found that dew collected on farmland showed higher ion concentrations (e.g., K^+, Cl^-) compared to more natural marsh areas, possibly due to agricultural-spraying disturbances and particulate matter accumulation. [9] Such deposition means that dew might carry acidity or ionic loads that could interact with plants or soils.

2.2 Acidity in precipitation, soil and plants

Acid rain (precipitation with low pH) has well-documented negative impacts on crops and soils: it can accelerate soil acidification, leach essential cations (Ca^{2+}, Mg^{2+}, K^+), increase solubility of toxic metals (Al^{3+}, Mn^{2+}), impair nutrient uptake and reduce crop yields. [5] Soil acidification affects nutrient availability and crop performance globally; for example, about 30-40% of agricultural land is affected by acidity. [2] Studies on crop response: for example, in rice seedlings, acidic conditions caused root length reduction by up to 31% for one variety. [1] Thus, acidity near the root/soil interface is harmful. However, less is reported on acidity deposited via dew onto foliar or near-soil surfaces, which may initiate localised stress.

2.3 IoT in agriculture and acidity/soil pH monitoring

IoT systems have been deployed in agriculture to monitor soil moisture, pH, temperature, humidity, and automate irrigation. For instance, a system integrated pH and moisture sensors via IoT for rice farming, giving remote alerts. [6] Another example: IoT-based monitoring of water pH in fish ponds (though different domain) demonstrates sensor + connectivity feasibility. [8] These show that deploying pH sensors in the field in a connected manner is feasible. Extending this to measure dew acidity is conceptually similar, though dew poses technical challenges (e.g., collecting condensate, ensuring reliability, calibration).

3. Proposed Methodology

3.1 Device design and sensor configuration

The proposed IoT device consists of:

- A microcontroller (e.g., ESP8266 or ESP32) with WiFi connectivity for data transmission.
- A pH sensor module capable of measuring acidity in small volumes (e.g., condensate).

- A dew collector/condensation plate or leaf-mimicking surface where dew forms and is then channelled to the pH sensor measurement cell.
- Temperature and humidity sensor to record ambient conditions.
- Optional conductivity/ion sensor to assess ionic load of dew.
- Power supply (solar + battery or mains) for field deployment.
- Data transmission to cloud server, linked to dashboard/mobile interface.

The device is installed at crop canopy height or just above soil surface in the field. Each morning (or at predetermined intervals), the dew-collector surface accumulates dew; after a set time or condition (e.g., via temperature/humidity threshold), the dew is channelled to a small measurement cell where the pH sensor records the dew acidity. The sensor reading is timestamped and logged along with ambient conditions. The microcontroller then sends the data via WiFi (or other LPWAN) to a cloud database.

3.2 Data acquisition and deployment

Deploy multiple units across different locations in a field (e.g., at varying soil types, canopy covers, proximities to edges) to capture spatial variability. Collect continuous readings over a growing season to examine changes in dew acidity over time, correlate with weather events, crop stage, canopy condition, and soil pH. Data intervals might be hourly or daily (morning reading). Additionally, integrate crop health monitoring (leaf chlorophyll, growth metrics, yield) or soil pH sampling to correlate with dew-acidity readings.

3.3 Data analytics and hypothesis

Hypotheses to test:

- H1: Dew pH varies significantly with ambient conditions (e.g., humidity, temperature, particulate deposition, proximity to emission sources).
- H2: Sites with more acidic dew (lower pH) show higher crop stress indicators (e.g., reduced growth, lower chlorophyll content, root damage) compared to sites with neutral dew pH.
- H3: Dew acidity shows correlation with soil acidification processes or deposition of acidic ions (e.g., sulphate/nitrate) and thus might serve as an early indicator of acid deposition stress.

Analyses: time-series of dew pH vs ambient conditions; cross-site comparisons; correlation/regression of dew pH vs crop-growth/yield metrics; spatial mapping. Use caution: correlation is not causation — controlling for other variables (soil pH, nutrient status, irrigation) is important.

3.4 Challenges and calibration

Challenges include:

- Ensuring the dew collector surface is representative and consistent across deployments.
- Calibrating the pH sensor for small volumes and low ionic strength (dew may have low buffering capacity) – sensor drift, contamination, and temperature compensation are concerns.
- Preventing evaporation or contamination of dew prior to measurement.
- Powering, weather-proofing and data connectivity in field.
- Data noise from external events (rainfall, spray drift).

  Proper calibration, maintenance and validation (e.g., cross-check with lab-measured dew samples) will be necessary.

4. Impact of Dew Acidity on Crops: Implications

Although direct literature on dew acidity is limited, related research on acid deposition, soil acidity and plant responses offers insights.

4.1 Plant/soil stress from acidity

Acidic environments harm crops by multiple mechanisms: lowering nutrient availability (especially Ca, Mg, K), increasing aluminium and manganese toxicity, damaging root systems, impairing water and nutrient uptake, reducing photosynthesis, and increasing susceptibility to pathogens. ([3]) For example, in rice seedlings under acidic rhizospheric conditions, root length reductions of up to ~31% were reported. (1) Soil acidification is also associated with increased incidence of bacterial wilt in potato fields when pH falls <5.0. ([9])

While these pertain to soil/plant root zones primarily, one can anticipate that acidic dew deposits might affect plants via foliar surface interactions: altering stomatal function, leaf cuticle integrity, increasing ingress of harmful ions, or localized micro-acidification at leaf surface altering nutrient exchange. If dew drips into soil or onto near-soil surfaces, it may contribute to local acid loading, especially in soils with low buffering capacity.

4.2 Crop productivity and yield implications

Large-scale meta-analyses show that increasing soil pH (i.e., reducing acidity) via liming or other amendments yielded significant crop productivity gains (e.g., 29-57% increase depending on amendment) in acidic soils. (research.wur.nl) This underscores that acidity is a major limiter of crop yield. Thus, monitoring acidity—even via dew—

may provide an early warning of acid stress before larger soil-based effects manifest.

4.3 Integration with precision agriculture

By measuring dew acidity via IoT devices, farmers or agronomists can gain a new parameter in their environmental monitoring toolkit. For instance:

- Identify zones within a field that receive higher acidic deposition (e.g., edge vs interior, proximity to pollution sources) and adjust liming, fertilisation, or foliar treatments accordingly.
- Time interventions (e.g., foliar sprays, irrigation) at points when dew acidity is low, thus reducing stress.
- Use trending dew-pH data to assess long-term acid-deposition risk and implement mitigation (e.g., soil amendments, buffer plantings, use of acid-tolerant cultivars). Thus, dew acidity monitoring complements soil and weather sensors for a more holistic microclimate/crop-health system.

5. Case Study (Hypothetical)

To illustrate, imagine deploying the IoT dew-acidity sensor network in a 5-hectare wheat field in Nagpur region (Maharashtra, India). Five sensor units are installed: one at field centre, four at edges near roads, one near an irrigation canal (possible source of dust/chemical drift). Over a cropping season the following might be observed:

- Morning dew pH values: centre units average 6.2-6.5, edge units near road average 5.8-6.1, canal-side unit average 5.5-5.9.
- Ambient humidity, temperature, and particulate deposition measured concurrently show higher particulate load near road.
- Soil pH sampling shows subtle drop at edge zones (pH 5.4 vs 5.7 centre).
- Crop health metrics: edge zones show slightly reduced chlorophyll index and ~3% yield reduction vs centre.

From these data, agronomists might decide to apply additional liming or calcium foliar treatment at the edge zones, schedule irrigation to flush potential acid loading, or introduce buffer rows to reduce deposition.

Though hypothetical, this demonstrates how dew-acidity monitoring could prompt actionable interventions.

6. Discussion

6.1 Strengths and potential

The approach offers a novel measurement: dew acidity—often overlooked—could act as an early indicator of atmospheric acid loading and its crop-microenvironment consequences. IoT deployment allows real-time, spatially distributed monitoring that can integrate into precision agriculture systems. The technology is an extension of existing IoT sensor frameworks (soil moisture, pH, temperature) and therefore feasible.

6.2 Limitations and considerations

- Scientific literature explicitly linking dew acidity to crop yield or foliar health is sparse; thus, empirical data will need to validate assumed links.
- Dew volume and composition vary widely with meteorology; small volumes may challenge sensor reliability.
- Dew acidity might be masked by other factors (e.g., foliar spray residues, irrigation splash, dust).
- Cost and maintenance of multiple sensors (calibration, cleaning, connectivity) may limit adoption in smaller farms.
- Distinguishing causation (acidic dew causing stress) from correlation (areas subject to acid deposition are also soils of lower buffering) will require careful experimental design.

6.3 Future research directions

- Field experiments correlating dew pH with foliar physiological metrics (chlorophyll fluorescence, stomatal conductance) and yield outcomes.
- Longitudinal studies assessing whether sites with persistently acidic dew show progressive soil acidification.
- Development of low-cost, robust dew-collector & pH sensor modules optimized for agricultural field use.
- Integration of machine learning to predict dew acidity trends based on weather, particulate deposition, canopy cover, and then generate alerts for management.
- Economic assessments of whether dew-acidity monitoring leads to improved yield or cost savings via targeted interventions.

7. Conclusion

This paper has proposed the use of an IoT-enabled device to measure the acidity of dew in crop fields, argued why such a measurement is relevant (given links between acidity and crop stress), and outlined how it could be deployed, analysed, and used in precision agriculture. While direct literature on dew acidity and crop impact is limited, the broader evidence on acidity effects in soil and plant systems supports the value of early-warning monitoring. With robust deployment and proper calibration, dew-acidity monitoring could become a valuable component of smart-farming systems, helping to protect crops from acid-deposition stress and optimise management responses. Further field work is required to validate the conceptual model and determine cost-effectiveness.

References

1. Awasthi J. P., Saha B., Chowdhara B., et al. (Year). Differential response to acidic pH in rice seedlings. *Sains Tanah – Journal of Soil Science and Agroclimatology*.
2. Enesi R. O., et al. (2023). Liming remediates soil acidity and improves crop yield and profitability – a meta-analysis. *Frontiers in Agronomy*.
3. "Soil Acidification and its Impact on Plants". (2020). Springer Nature.
4. Warke A. T., Wakgari T. (2024). A review on the impact of soil acidification on plant nutrient availability, crop prod uctivity, and management options. *Agriculture, Forestry and Fisheries*.
5. "The Impact of Acid Rain on Crops and Countermeasures". (n.d.).
6. "Utilizing IoT Technology for Soil Moisture Management through Integration of pH and Moisture Sensors in an Android Application for Rice Farming". Budi Sutomo et al. (2025).
7. "IoT Based Smart Agriculture Monitoring System". Chavan M. D., Solankar A., Mulla I., etc. (2025).
8. "The IoT-based pH sensor's performance in detecting the acidity level of catfish pond water in the Cadek area of Aceh Besar Regency." (2024).
9. "Does Marsh Restoration Have an Impact on Dew?" (2024). *Water*.