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Electrical Potential in Plants Detached Stalks

Taiwo Adekolawole
School of Applied Sciences, Federal Polytechnic Ede, PMB 231, Ede, Osun State, Nigeria

Abstract
Some locally grown plants were selected at random for possible measurement of electrical potential, in the stalks and detached stalks, tip-wards. Using zinc and copper electrodes with Multimeter as clip and tap meter, electric potential was measured directly, under ambient conditions, at leaf nodal and inter-nodal points while for short stalks, at spacing of 2cm's tip wards, for 4 days in the peak tropical summer period of August 2016. The results showed the existence of measurable potential difference or electromotive force in plants stalks and detached stalks that varied towards the tip. It was also observed that the natural electric potential is peculiar to each plant and is independent on environmental temperature or ambient conditions. The results further showed that electric potential within the plant is naturally sustained in the stalk for days until wilting sets in.
Keywords: measurements, electric potential, plants stalks, detached plants stalks and leaves

1. Introduction

'Behold I have given you every herb bearing seed for …. meat'. This statement from the Bible (Genesis 1:29 KJV: Bongani Sithole) underscored the importance of plants to human life-sustenance. Naturally, plants manufactured food by the process of photosynthesis. Therefore, all information on the understanding of photosynthesis and other developmental processes in plants should be of immense interest to all, especially, those in agricultural business, biologists, botanists and plant physiologists.

Bose, J. C (1923) and others (Pickard, 1973; Davies, 1987a and b; Shepard. 1992,1999; Bilby and Shepard, 1999), have worked on electrical responses of growing plants to mechanical, and other stimuli which were found to vary with seasons, vigor, water status, temperature, age etc. Very recent works have shown that electrical signals are very important in physiological activities (Wang et al, 2007; Trabacz, 2006; Tromm et al, 2007; Koziolex et al, 2007).

These electrical signals have been shown to be involved in many processes of plants life. These include respiration, water uptake, leaf movement, and biotic stress responses (Davies et al, 1991; Pickard, 1975; Maffesi and Bossi, 2006). However, the ionic mechanism of electron flow / electrical signals has not been fully understood (Davies, 2006; Stahlberg et al, 2006). So far, as we know, it has not been reported that electrical potential exist nor sustained in detached plant stalks / leaves. The possible existence of this and its measurement formed the focus of this study.

2. Materials and Methods

Some locally grown plants were selected at random for electrical potential measurement. These include A. Spinach, *Spinacea oleracea;* B. Maize, *Zea mays*; C. Cassava, *Manihot esculenta* and; D. Garden Egg, *Solanum melongena*. Stalks of these were neatly detached from the main stem. Voltage measurements were made at leaf nodal and inter nodal points and in some at 2cm's spacing from the point of detachment to the stalk tip. Voltage readings were taken using Copper and Zinc electrodes and a Multimeter as a clip and tap meter. Readings were taken between 1500 and 1600 Hours daily. Also, a Multispectral Radiometer, developed in-house (Taiwo Adekolawole and Timothy Oke, 2015), for such purposes, was used for simultaneous readings of Moisture Content and Temperature at same points, amongst others. The observations made were as illustrated on the accompanied Figures using Microsoft Excel line charts.

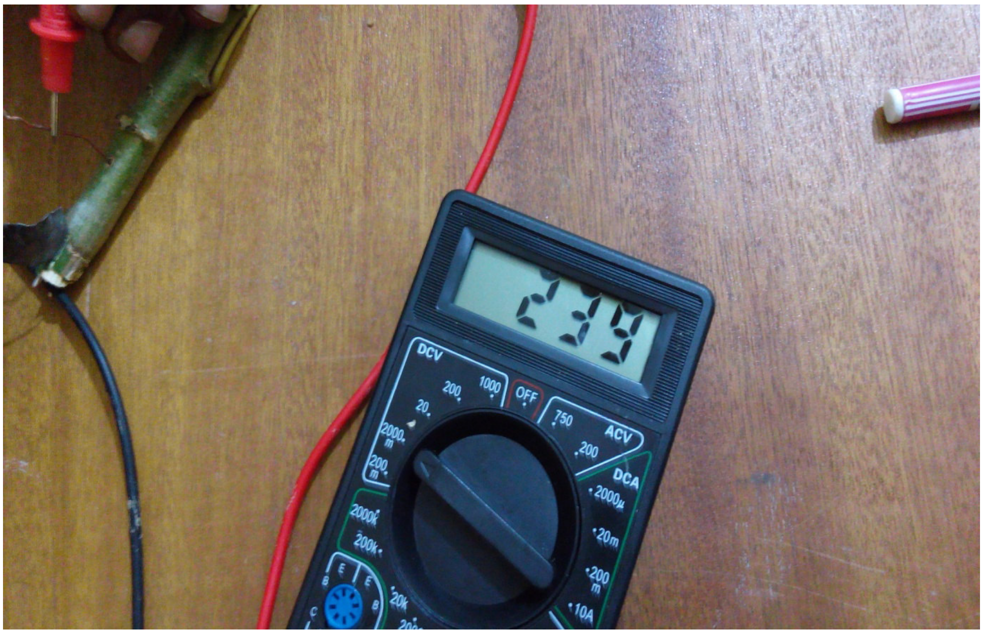


Plate 1: Measurement of Electric Potential in Plant Stalk

2.1 Observations

The observations made were as illustrated on the spectral responses shown on the accompanied Figures:

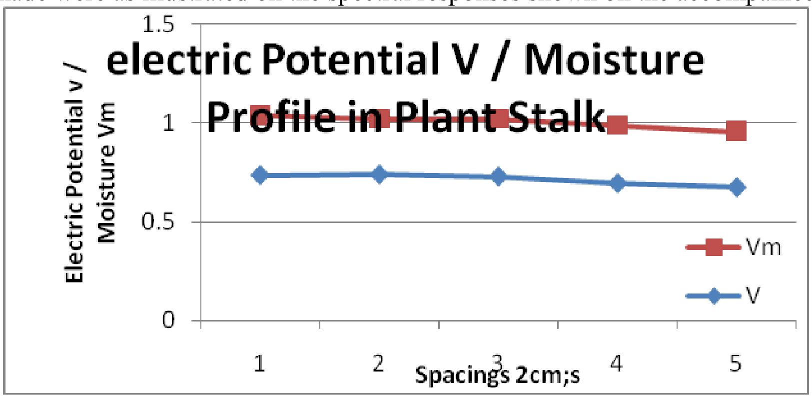


Figure 1.0 : Graph of Electric Potential V/ Moisture Content Vm vs Spacings(2cm's) tipwards: *Spinacea oleracea*

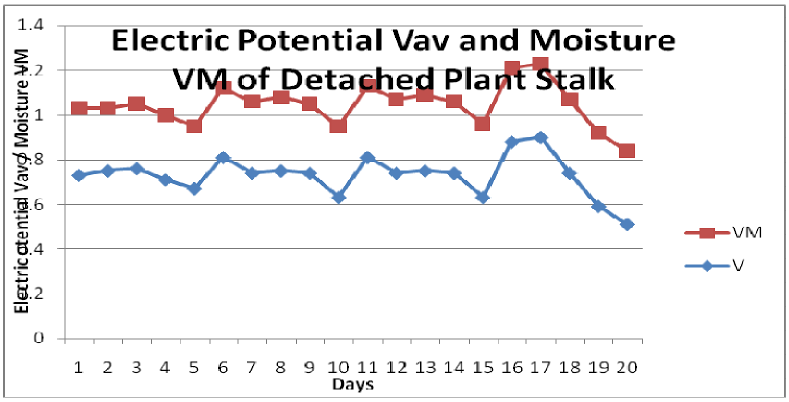


Figure 1.1: Graph of Electric Potential and Moisture of Detached Plant Stalk Vs Days: *Spinacea oleracea*

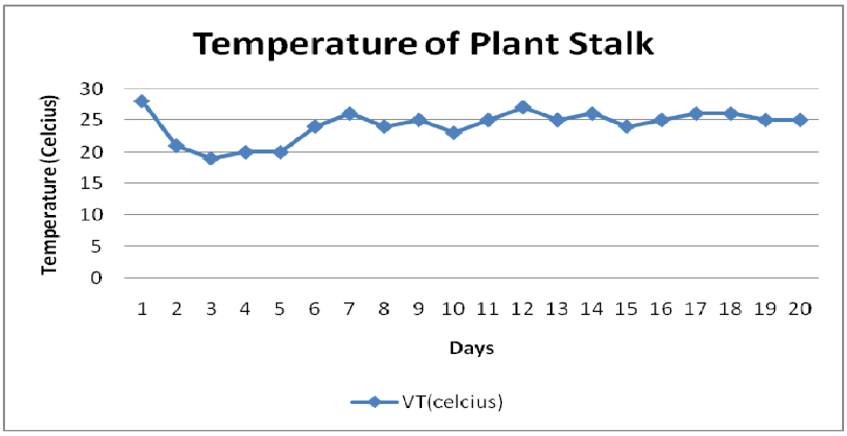


Figure 1.2: Graph of Plant Stalk Temperature vs Days: *Spinacea oleracea*

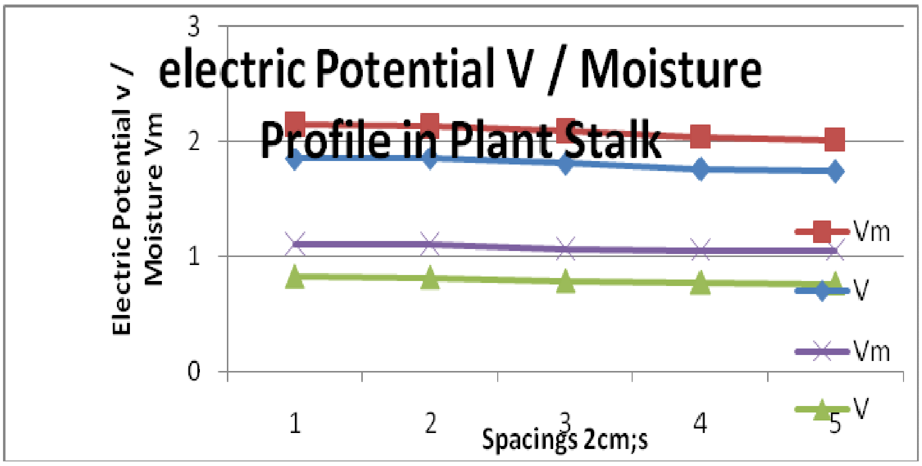


Figure 2.0: Electric Potential V / Moisture Content Vm vs Spacings (2cm's) tipwards: *Zea mays*

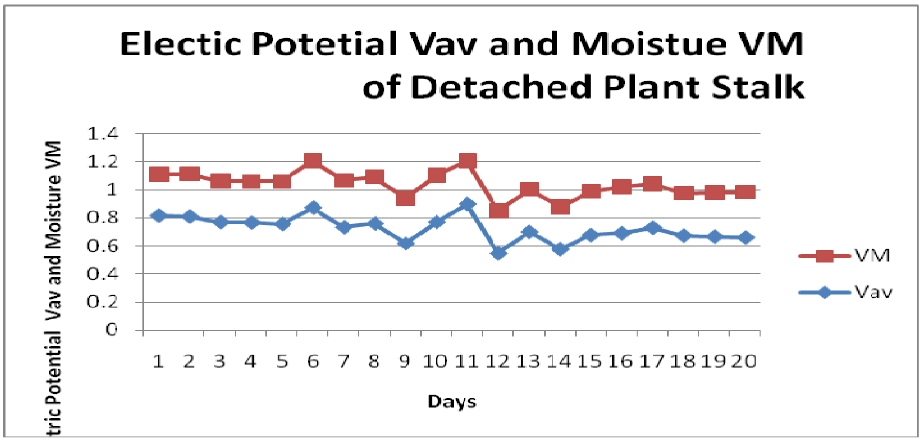


Figure 2.1: Graph of Electric Potential in Plant Stalk vs Days : *Zea mays*

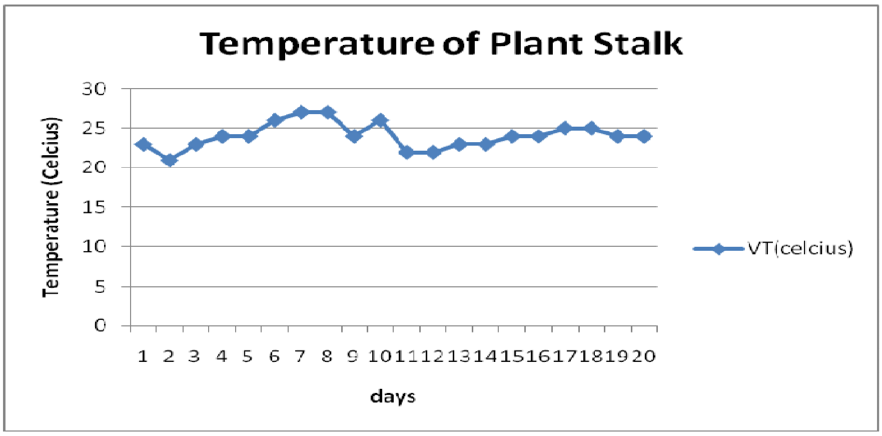


Figure 2.2: Graph of Temperature of Plant Stalk vs Days: *Zea mays*

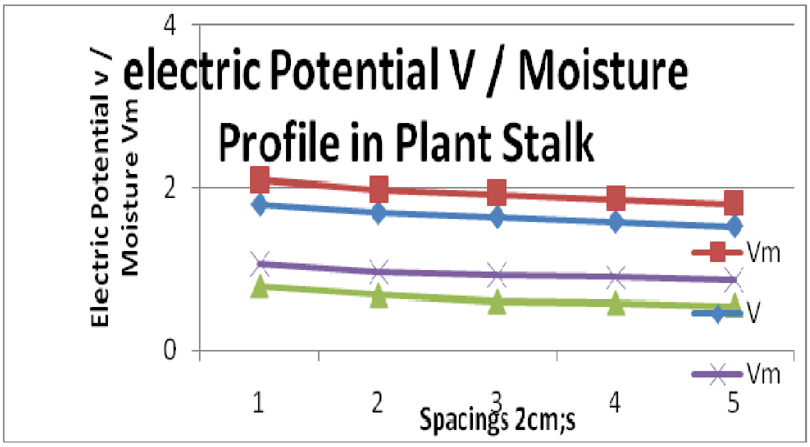


Figure 3.0: Electric Potential V / Moisture Content Vm vs Spacings (2cm's) : *Maanihot esculental*

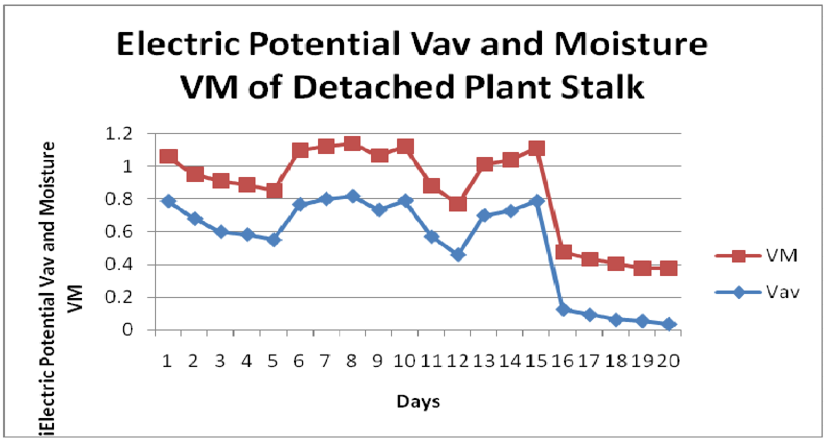


Figure 3.1: Graph of Electric Potential in Plant Stalk vs Days: *Manihot esculenta*

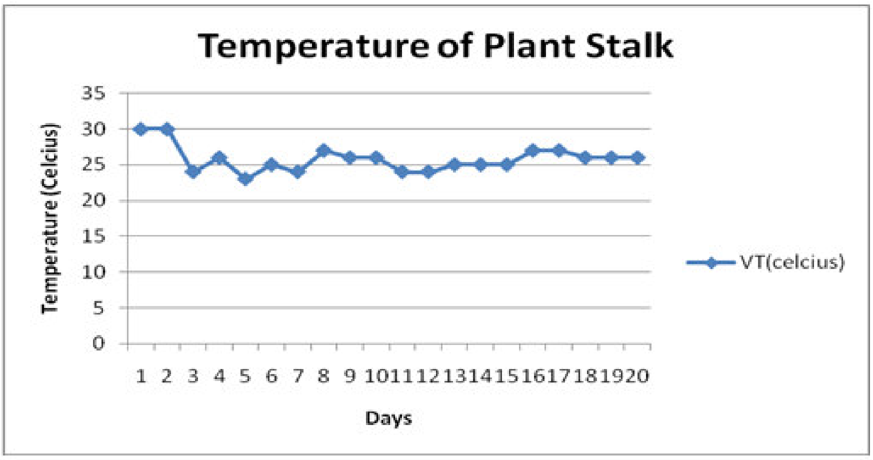


Figure 3.2: Graph of Temperature of Plant Stalk vs Days: *Manihot esculenta*

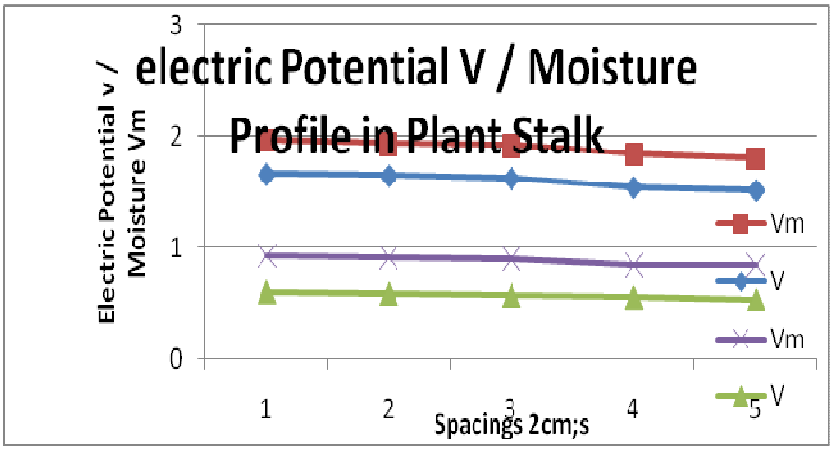


Figure 4.0: Graph of Electric Potential V/ Moisture Content Vm vs Spacings (2cm's)tipwards:*Solanum melongena*

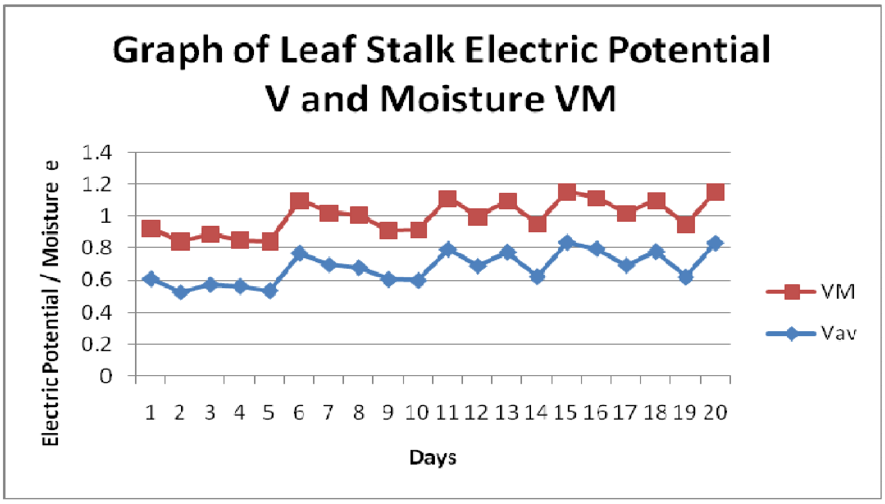


Figure 4.1: Graph of Electric Potential Plant Stalk vs Days : *Solanum melongena*

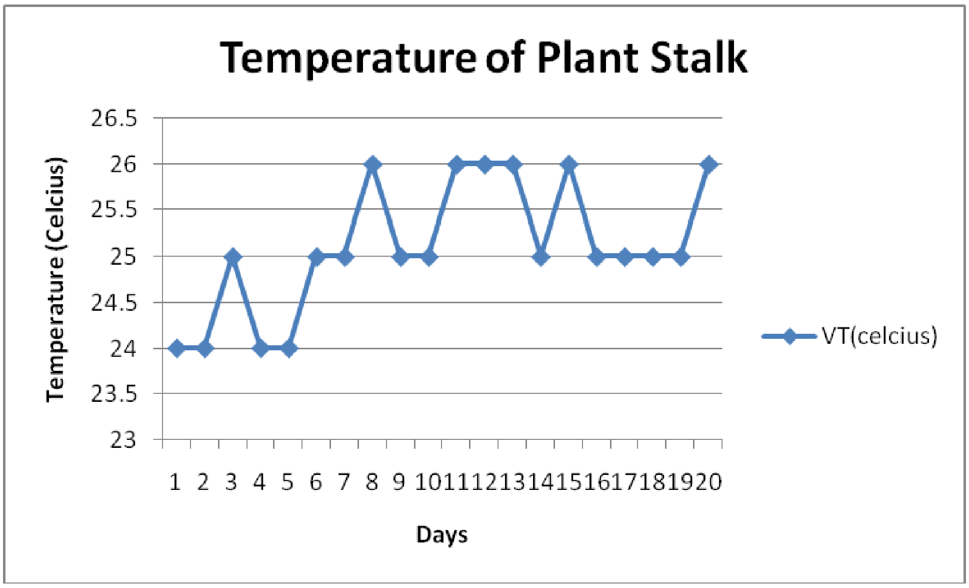
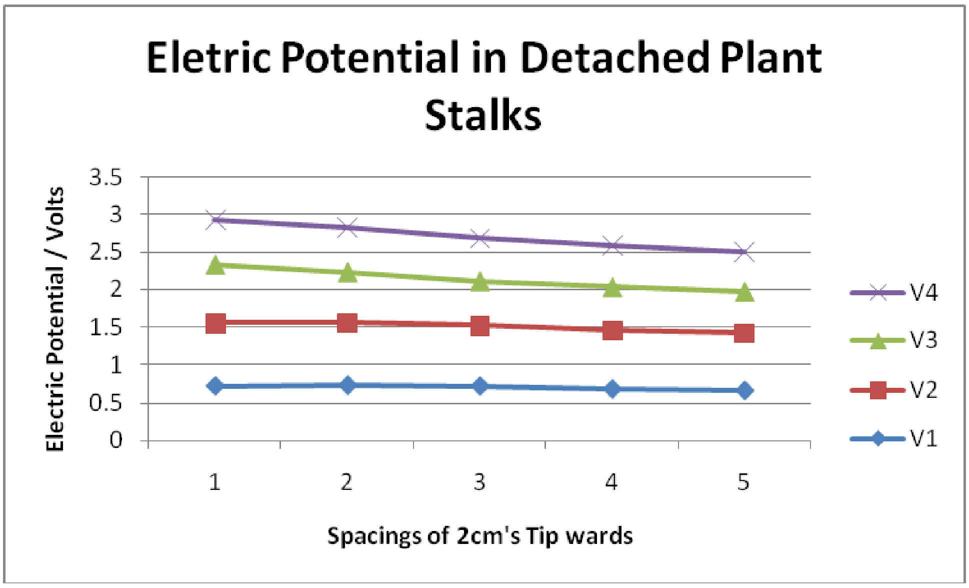


Figure 4.2: Graph of Temperature vs Days : *Solanum melongena*



V1-*Pinacea oleracea* V2-*Zea mays* V3-*Manihot esculenta* V4-*Solanum melongena*

Figure 5.0: Graph of Electric Potential in the Detached Plants Stalks vs Spacing (2m's) Tip wards

Tables showing raw data of Electric Potential Measurement (Volts) in Plant Stalk amongst others:

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Table 1. Datasheet of Electric Potential in detached *Spinacea oleracea* Plant's stalk

X(cm)	V			RF1	RF2	RF3	RF4	FL	CLM	VM	VT(celcius)
2	0.77	0.71	0.73	0.54	0.51	0.64	0.61	0.48	0.49	0.3	28
4	0.74	0.73	0.75	0.51	0.55	0.55	0.62	0.48	0.45	0.28	21
6	0.68	0.75	0.76	0.52	0.56	0.54	0.63	0.47	0.45	0.29	19
8	0.7	0.68	0.71	0.54	0.58	0.57	0.66	0.47	0.5	0.29	20
10	0.69	0.67	0.67	0.49	0.52	0.57	0.62	0.5	0.52	0.28	20
2	0.81	0.82	0.81	0.55	0.55	0.6	0.62	0.5	0.49	0.31	24
4	0.79	0.76	0.74	0.55	0.54	0.6	0.64	0.52	0.53	0.32	26
6	0.76	0.76	0.75	0.55	0.55	0.6	0.62	0.52	0.53	0.33	24
8	0.65	0.39	0.74	0.55	0.53	0.6	0.62	0.52	0.51	0.31	25
10	0.6	0.64	0.63	0.55	0.54	0.6	0.63	0.52	0.52	0.32	23
2	0.81	0.82	0.81	0.55	0.55	0.61	0.63	0.5	0.49	0.32	25
4	0.79	0.76	0.74	0.54	0.54	0.61	0.65	0.52	0.54	0.33	27
6	0.76	0.76	0.75	0.55	0.55	0.61	0.63	0.52	0.54	0.34	25
8	0.65	0.69	0.74	0.54	0.53	0.61	0.63	0.52	0.52	0.32	26
10	0.6	0.64	0.63	0.53	0.54	0.61	0.64	0.5	0.53	0.33	24
2	0.94	0.82	0.88	0.71	0.7	0.76	0.62	0.68	0.68	0.33	25
4	0.9	0.72	0.9	0.71	0.71	0.75	0.63	0.68	0.68	0.33	26
6	0.7	0.69	0.74	0.71	0.7	0.75	0.64	0.68	0.68	0.33	26
8	0.5	0.61	0.59	0.71	0.7	0.76	0.64	0.68	0.67	0.33	25
10	0.3	0.51	0.51	0.71	0.69	0.75	0.64	0.65	0.67	0.33	25

Table2:*Zea.mays*

X(cm)	V			RF1	RF2	RF3	RF4	FL	CLM	VM	VT(ºC)	Vav	VM
2	0.87	0.75	0.83	0.56	0.53	0.54	0.61	0.54	0.53	0.29	23	0.816667	0.29
4	0.8	0.84	0.79	0.55	0.54	0.6	0.61	0.51	0.54	0.3	21	0.81	0.3
6	0.75	0.78	0.78	0.55	0.55	0.6	0.61	0.54	0.54	0.29	23	0.77	0.29
8	0.76	0.77	0.77	0.57	0.56	0.63	0.61	0.54	0.54	0.29	24	0.766667	0.29
10	0.75	0.76	0.76	0.56	0.56	0.61	0.61	0.54	0.55	0.3	24	0.756667	0.3
2	0.87	0.88	0.87	0.57	0.55	0.6	0.63	0.52	0.52	0.33	26	0.873333	0.33
4	0.71	0.74	0.75	0.56	0.57	0.61	0.64	0.53	0.54	0.33	27	0.733333	0.33
6	0.79	0.65	0.84	0.58	0.57	0.62	0.63	0.53	0.54	0.33	27	0.76	0.33
8	0.57	0.54	0.74	0.53	0.53	0.58	0.63	0.51	0.51	0.32	24	0.616667	0.32
10	0.79	0.8	0.72	0.58	0.56	0.63	0.63	0.54	0.55	0.33	26	0.77	0.33
2	0.9	0.91	0.89	0.55	0.54	0.6	0.62	0.51	0.52	0.3	22	0.9	0.3
4	0.51	0.59	0.54	0.59	0.51	0.64	0.62	0.55	0.56	0.3	22	0.546667	0.3
6	0.84	0.64	0.62	0.57	0.57	0.62	0.61	0.55	0.57	0.3	23	0.7	0.3
8	0.64	0.48	0.61	0.58	0.6	0.65	0.61	0.55	0.57	0.3	23	0.576667	0.3
10	0.71	0.72	0.6	0.58	0.58	0.63	0.61	0.55	0.56	0.31	24	0.676667	0.31
2	0.69	0.68	0.7	0.68	0.67	0.71	0.62	0.64	0.63	0.33	24	0.69	0.33
4	0.73	0.74	0.72	0.58	0.58	0.63	0.61	0.56	0.58	0.31	25	0.73	0.31
6	0.67	0.69	0.66	0.68	0.65	0.59	0.62	0.58	0.58	0.3	25	0.673333	0.3
8	0.69	0.65	0.66	0.6	0.6	0.65	0.63	0.58	0.59	0.31	24	0.666667	0.31
10	0.7	0.59	0.69	0.63	0.63	0.69	0.62	0.59	0.6	0.32	24	0.66	0.32

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Table 3: *Manihot esculenta*

X(cm)	V			RF1	RF2	RF3	RF4	FL	CLM	VM	VT(celcius)
2	0.79	0.78	0.79	0.54	0.55	0.54	0.6	0.53	0.47	0.27	30
4	0.7	0.67	0.67	0.54	0.52	0.6	0.6	0.5	0.47	0.27	30
6	0.6	0.6	0.6	0.6	0.61	0.64	0.64	0.61	0.53	0.31	24
8	0.59	0.58	0.58	0.57	0.55	0.6	0.6	0.55	0.53	0.3	26
10	0.55	0.55	0.55	0.58	0.58	0.57	0.63	0.57	0.5	0.3	23
2	0.8	0.81	0.69	0.55	0.54	0.59	0.62	0.53	0.52	0.33	25
4	0.76	0.79	0.85	0.51	0.49	0.54	0.61	0.47	0.48	0.32	24
6	0.81	0.82	0.82	0.55	0.5	0.59	0.63	0.51	0.51	0.32	27
8	0.72	0.75	0.73	0.58	0.55	0.62	0.64	0.53	0.53	0.33	26
10	0.7	0.89	0.78	0.6	0.51	0.62	0.62	0.55	0.55	0.33	26
2	0.34	0.9	0.47	0.61	0.61	0.64	0.61	0.58	0.58	0.31	24
4	0.49	0.44	0.45	0.62	0.61	0.66	0.63	0.58	0.59	0.31	24
6	0.81	0.62	0.67	0.63	0.6	0.67	0.62	0.5	0.59	0.31	25
8	0.71	0.7	0.77	0.63	0.63	0.68	0.62	0.59	0.6	0.31	25
10	0.79	0.8	0.77	0.64	0.62	0.61	0.64	0.61	0.6	0.32	25
2	0.13	0.12	0.13	0.68	0.7	0.75	0.62	0.65	0.7	0.35	0.27
4	0.09	0.11	0.08	0.69	0.68	0.72	0.64	0.68	0.68	0.34	27
6	0.06	0.06	0.07	0.69	0.69	0.74	0.63	0.65	0.66	0.34	26
8	0.05	0.05	0.07	0.69	0.69	0.74	0.64	0.66	0.67	0.32	0.26
10	0.04	0.03	0.04	0.7	0.67	0.74	0.65	0.65	0.66	0.34	26

Table 4: *Solanum melongena*

	X(cm)x	V			RF1	RF2	RF3	RF4	FL	CM	VM	VT(° C)	Vav	VM
	2	0.6	0.61	0.61	0.53	0.54	0.59	0.6	0.3	0.51	0.32	24	0.606667	0.32
DAY 1	4	0.59	0.6	0.38	0.54	0.53	0.59	0.6	0.5	0.5	0.32	24	0.523333	0.32
	6	0.57	0.57	0.57	0.54	0.53	0.6	0.61	0.52	0.53	0.32	25	0.57	0.32
	8	0.56	0.55	0.57	0.54	0.53	0.61	0.61	0.53	0.53	0.29	24	0.56	0.29
	10	0.54	0.53	0.53	0.5	0.52	0.6	0.62	0.54	0.55	0.31	24	0.533333	0.31
DAY 2	2	0.8	0.81	0.69	0.55	0.54	0.59	0.62	0.53	0.52	0.33	25	0.766667	0.33
	4	0.7	0.69	0.69	0.54	0.54	0.59	0.61	0.51	0.51	0.33	25	0.693333	0.33
	6	0.67	0.68	0.68	0.56	0.56	0.6	0.63	0.53	0.52	0.33	26	0.676667	0.33
	8	0.61	0.61	0.59	0.57	0.55	0.61	0.63	0.54	0.52	0.31	25	0.603333	0.31
	10	0.6	0.6	0.59	0.55	0.55	0.6	0.62	0.53	0.53	0.32	25	0.596667	0.32
DAY 3	2	0.85	0.8	0.72	0.7	0.69	0.73	0.61	0.65	0.65	0.32	26	0.79	0.32
	4	0.69	0.66	0.71	0.7	0.69	0.73	0.62	0.66	0.66	0.31	26	0.686667	0.31
	6	0.84	0.79	0.69	0.7	0.69	0.74	0.63	0.66	0.66	0.32	26	0.773333	0.32
	8	0.32	0.7	0.84	0.71	0.7	0.73	0.62	0.67	0.67	0.33	25	0.62	0.33
	10	0.96	0.66	0.88	0.71	0.7	0.74	0.64	0.67	0.67	0.32	26	0.833333	0.32
DAY 4	2	0.85	0.81	0.72	0.69	0.68	0.73	0.62	0.65	0.65	0.32	25	0.793333	0.32
	4	0.69	0.67	0.71	0.69	0.68	0.73	0.63	0.66	0.66	0.33	25	0.69	0.33
	6	0.84	0.8	0.69	0.69	0.68	0.74	0.64	0.66	0.66	0.32	25	0.776667	0.32
	8	0.32	0.69	0.84	0.7	0.69	0.73	0.63	0.66	0.67	0.33	25	0.616667	0.33
	10	0.96	0.67	0.86	0.7	0.69	0.74	0.64	0.66	0.67	0.32	26	0.83	0.32

3. Results and Discussion

From the raw data obtained, Tables 1, 2, 3 and4, it was seen that Electric Potential naturally exists in detached plant stalk and is measurable. This was readily noted on Figures 1.0, 2.0, 3.0, 4.0 and 1.1, 2.1, 3.1, 4.1. It was also noted that a moisture profile exist alongside the noted electric potential.

From the Figures, it was observed that the electric potential response is *followed* by the moisture profile responses. This suggests very strongly that the electric potential *drives* the moisture profile in the detached plant stalk. This is quite novel in the sense that the process of osmosis had been held as been responsible for upward movement of water or moisture in plants.

Also, it had been held, that temperature played significant role in the osmotic process. However, from the responses of the temperature profiles on Figures 1.2, 2.2, 3.2, and 4.2, respectively, the plants stalks assumed the room temperatures and were independent on the electric potential responses. This observation was also peculiar to this study and was observed in all the plants stalks examined.

Another important observation made was that each electric potential response was peculiar to each plant and could be used to identify the plant as shown on Figure 5.0.

Of course, this author is not unaware of previous works on electrical signals especially in mimosa and other plants that responded to changes in external stimuli as stated in the literature, but no cogent explanation had been made as to the origin of either this electrical signals or its presence in detached plants stalks or parts. This work most probably explained the origin of these electrical signals as due to the presence of natural electrical potential in the plant system that is actually responsible for the upward movement of water and other nutrients in plants.

In other words, nature has put in place measurable electrical potential to *drive* the movement of water and other nutrients including waste products in plants. And this electric potential is sustained in detached plants stalks. This could lead to a revolution in research efforts on plant physiology and plants responses to physiological parameters, amongst others.

5. Conclusion

Using simple principles in physics, electric potential has been *discovered* to exist in plants and detached plants stalks and is responsible for uptake of water and nutrients including wastes in plants. This electric potential has been measured directly using very simple, low-powered technique of clip and tapped meter, using a common Multimeter with zinc and copper electrodes.

It has also been seen in this study, that the natural electric potential is peculiar to each plant and drives the movement of water/ moisture / nutrients/ waste in plants and detached plants stalk. The electrical potential has also been observed to be independent on the environmental temperatures and ambient conditions.

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