International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2024; 12(4): 49-53

Received: 28-05-2024
Accepted: 04-07-2024

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Evolution of the difference in potential between two points of a plant: Case of *Eucalyptus camaldulensis* and *Mangifera indica*

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Abstract
The objective of this work is to monitor the variation of energy in a plant based on the measurement of the potential difference (ddp) between 2 points on the plant. The ddp was monitored using a multimeter. Two plants were used: Eucalyptus *Camaldulensis and Mangifera indica*. The investigations focused on the influence of: sunshine; the distance between the two measurement points on the plant; the quantity of watering water or soil amendment. The main results obtained show that the highest values of the ddp are recorded around 3 p.m. in the study area. They also show an influence on the ddp between: the quantity of watering water, the soil amendment and the distance between the two points. The more the quantity of irrigation water increases, the more the distance between the two points increases or the more the amendment increases, the ddp also increases.

Keywords: Plants, potential difference; energy, sunshine, watering, amendment

1. Introduction
Over the past decade, global energy demands have experienced an exponential increase of 3.4%. This increase is partly covered by various energy resources, such as wind, hydro, solar and nuclear energy (IEA, 2023, Hannah *et al*, 2023) [2]. Fossil fuels (coal, oil and gas) represent approximately 82% of total energy supply (IEA, 2023) [2]. The use of these fossil fuels can harm the health of animals, the population or cause environmental problems (Strick *et al*, 2011) [4]. In Niger, in recent years the demand for electricity has experienced a meteoric rise reaching 30 to 35%, while the general electrification rate is 13% (Halid, 2019) [5]. To meet this national demand, it is therefore necessary for the State to strengthen its energy supply sources. Among the sources, the production of renewable energy is one of the greatest current challenges in the field of scientific research. This energy should be in the form of electricity produced from a renewable source from a clean and efficient conversion process. Studies have shown that living plants can generate energy by transforming sunlight into electrical energy. The potential difference being one of the most important concepts when talking about electricity. Because this potential difference measured between two points reflects the passage of a charge which circulates from one point to another (Rockwood *et al*, 2008) [6]. In order to increase the rate of electrification and reduce the consumption of fossil fuels, the use of plants for energy production is a way to investigate. The objective of the present study is to follow the evolution of the potential difference between two points of a plant in order to follow the influence of certain parameters (solar lighting, distance between two points of the plant, watering and amendment) on the potential difference between these points.

2. Materials and Methods
2.1 Study site
The potential difference measurements took place at two sites at ABDOU Moumouni University in Niamey (Niger). The first site is the Botanical Garden of the Faculty of Science and Technology with geographic coordinates (13°30'10'', 2°05'55'') and the second site is the Garden of the UNESCO Club with geographic coordinates (13°29'54'', 2°05'25'').

2.2 Materiel
As part of this study, the following plants were used for the study: Eucalyptus *Camaldulensis* and *Mangifera indica*.

Eucalyptus camaldulensis is a plant belonging to the *Myrtaceae* family. It has enjoyed success as an exotic tree thanks to their good capacity for rapid growth. They are tolerant of hostile environments and involve numerous effective adaptations: indeterminate growth, coppicing, drought, fire, insect resistance and tolerance to soil acidity and low fertility (Brancalion *et al*., 2020) [7].

Mangifera indica (Mango tree): is a plant of the *Anacardiaceae* family. It can reach 10 to 25 meters in height. They are a source of minerals (nitrogen; potassium; phosphorus; iron; sodium; calcium; magnesium) and vitamins B and C.

The equipment used for measuring the potential difference in the plant is a

DT-830D brand multimeter.

2.3 Methods

To measure the ddp values, the negative terminal of the multimeter is inserted into the root of the plant and the positive terminal at a point on the trunk.

To determine the influence of solar lighting on the ddp between the root and a point located on the trunk, ddp measurements were carried out from 6 a.m. to 11 p.m. and for 10 days. To determine the influence of the amount of watering and water stress on the ddp between the root and a point on the trunk, three *Mangifera indica* plants were watered at the same time with different amounts of water (5 liters, 10 liters and 15 liters) for 5 days. The potential differences were measured four hours after the last watering. The distance between the root and the point on the trunk was the same for all measurements and on all plants.

To determine the influence of soil amendment on the potential difference between the root and a point on the trunk, two *Mangifera indica* plants were used. One of the plants received manure and the other without manure. After two weeks, the ddp values of these two plants were recorded for seven days at the same time (11 a.m.) and at the same distance of fifteen centimeters between the root and a point located on the trunk.

3. Results and Discussion

3.1 Influence of solar lighting on the potential difference between the root and a point on the trunk

In order to demonstrate the influence of solar lighting on the potential difference between the root and a point located on the trunk, potential difference measurements were carried out on two plants (eucalyptus *Camaldulensis* and *Mangifera indica*) for ten days; from 6 a.m. to 11 p.m. The averages of the results obtained are shown in figure 1.

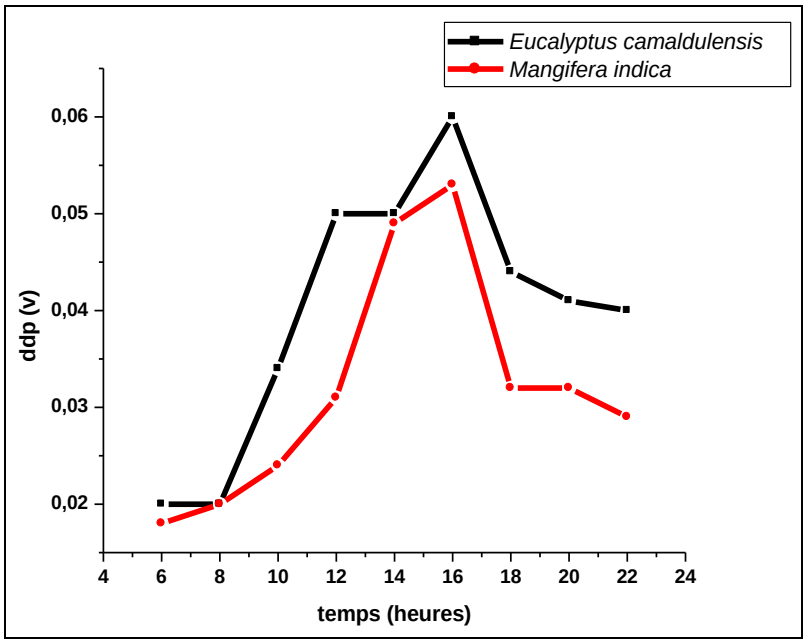

Fig 1: ddp between the root and a fixed point on the plant as a function of time

Figure 1 shows that, in the two plants (Eucalyptus *Camaldulensis* and *Mangifera indica*), from 6 hours to 8 hours, the potential difference is small and varies very little. It also shows that throughout the time the difference in potential is greater in Eucalyptus *Camaldulensis* than in *Mangifera indica*. It also indicates a strong increase in the potential difference in the two plants, from 8 a.m. to 3 p.m. The maximum values (0.06V for Eucalyptus *camaldulensis* and 0.05V for *Mangifera indica*) are reached around 3 p.m. From 3 p.m. to 6 p.m., we see a sharp drop in the potential difference. From 6 p.m. to 11 p.m. this potential difference varies little. According to Y.M. Azri *et al*., (2017) [9], Hubenova *et al*., (2012) [10], the energy of a plant depends on its CO_2 absorption capacity. Therefore, the higher potential differences recorded in Eucalyptus *Camaldulensis* may indicate that at the same time, Eucalyptus absorbs more CO_2 than *Mangifera indica*. According to Hubenova *et al*, (2012) [10], the highest potential difference values correspond to the moment when the light intensity is high. According to Boukmis, (2019) [12], Sylvain, (2012) [13] the light saturation point of the two plants is reached around 3 p.m., and photosynthesis in the two plants could be maximum at this time. These results indicate that the high light intensities at the study site are recorded around 3 p.m.

3.2 Influence of the distance between two points on the potential difference between the root and a point located on the trunk

To determine the influence of the distance between a point on the root and a point on the trunk on the potential difference, several points on the trunk at different heights were used. The measurements were made on the two plants (Eucalyptus *Camaldulensis* and *Mangifera indica*) for five days at the same time. The results obtained are shown in figure 2.

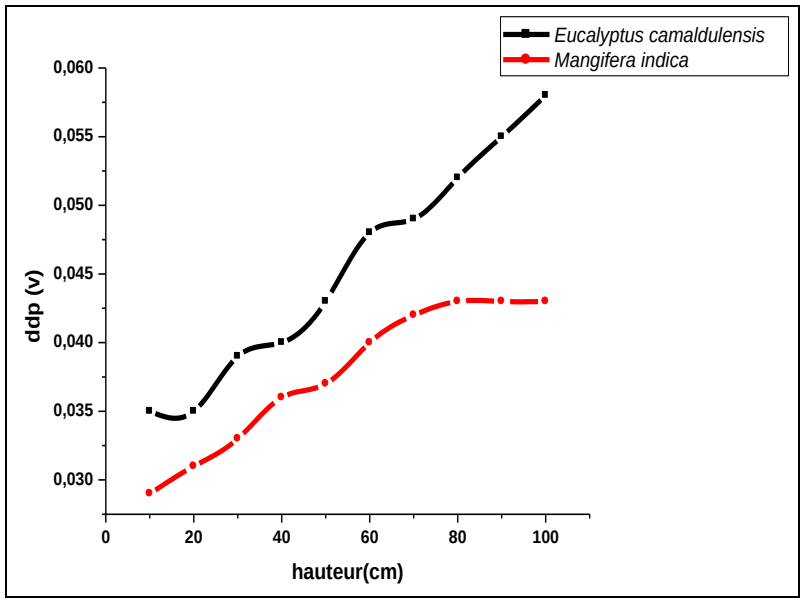

Fig 2: Influence of the distance between the root and a point on the trunk of plants on the ddp

Figure 2 shows that in both plants (Eucalyptus *Camaldulensis* and *Mangifera indica*), the more the distance between a point on the root and a point on the trunk increases, the more the potential difference between these two points increases. The figure also shows that at the same distance from the ground Eucalyptus *Camaldulensis* has a higher potential difference than *Mangifera indica*. According to Frédéric, (2013) [11], the potential of the soil where the root is located constitutes the anode potential and that on the trunk, the cathodic potential. During the measurement no modification was made to the ground level and therefore to its potential. Therefore, this increase in the potential difference with distance may indicate that the higher one goes up the trunk, the more the potential drops and, the potential difference increases.

3.3 Influence of the quantity of watering and water stress on the potential difference between the root and a point on the trunk of these two plants

In order to determine the influence of the quantity of watering water and water stress on the potential difference between a point on the root and a point on the trunk, three *Mangifera indica* plants were watered respectively with 5 liters, 10 liters and 15 liters of water for 5 days. The potential difference was noted just after the last watering and was monitored for 10 days. The distance between the point on the root and the point on the trunk was the same for all measurements and on all plants. The results obtained are shown in figure 3.

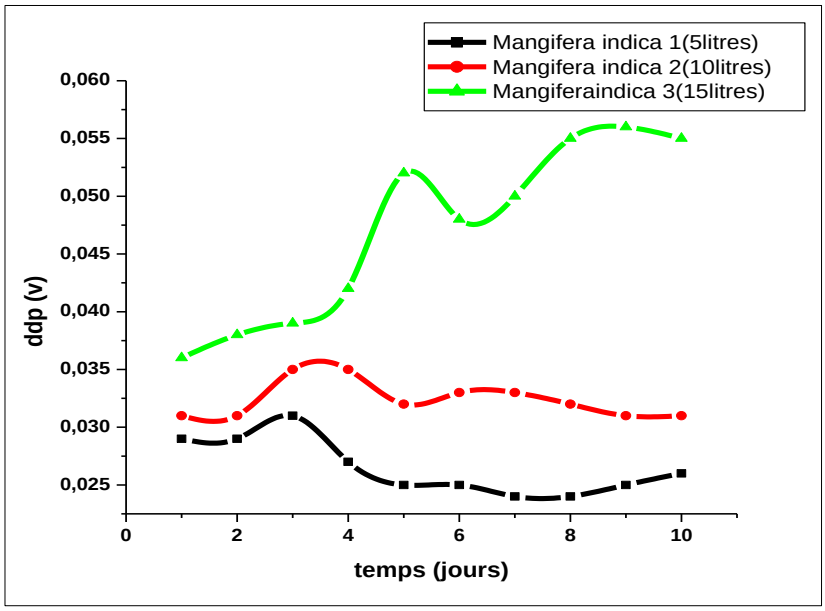

Fig 3: influence of the quantity of watering water and water stress on the ddp between the root and a fixed point on the trunk

Figure 3 indicates that the difference in potential between a point on the root and a point on the trunk is a function of: the quantity of watering water and water stress. The greater the quantity of irrigation water, the greater the potential difference. The figure also shows that with a small quantity of irrigation water of less than 10 liters, the potential difference varies little with water stress. With a larger quantity of water (15 liters) the potential difference increases with water stress. Indeed, Frédéric, (2013) [11] this increase in the quantity of water makes it possible to reach the roots, promoting the formation of the biofilm, and the production of the enzymes necessary for the transfer of electrons and ion exchange which

can explain the strong increase in the difference in potential with stress when the plant is watering with 15 liters of water.

3.4 Influence of manure use on the potential difference between the root and a point on the trunk

To determine the influence of soil amendment on the potential difference between a point on the root and a point on the trunk of the plants in the study. Two *Mangifera indica* plants were used, one of which was amended with five kilograms of organic fertilizer (animal manure) and the other without manure. After two weeks, the potential difference values of these two plants were recorded for seven days at the same time (11 a.m.) and at the same distance of fifteen centimeters between the root and a point located on the trunk. The results obtained are shown in figure 4.

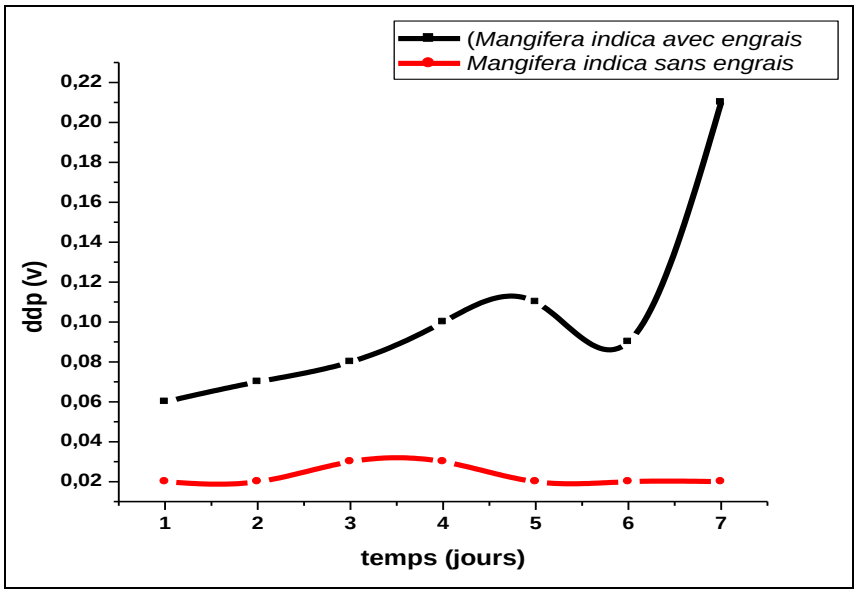

Fig 4: Influence of fertilizer use on the potential difference between the root and a point on the trunk

Figure 4 shows that the potential difference is lower and varies very little with time in *Mangifera indica* without manure. On the other hand, in *Mangifera indica* with manure the difference in potential is higher compared to that without fertilizer and increases significantly over time. These observed phenomena can be explained by the following reasons: in *Mangifera indica* without fertilizer, the weakness of the potential difference and its low variation over time can be due to the absence of bacteria, the main factor for the redox of the material organic and the formation of biofilms. According to Kaku *et al*., 2008 [15], in *Mangifera indica* almond, the addition of fertilizer promotes the formation of microorganisms (bacteria, fungi), biofilms which oxidize the organic matter and causes a significant release of electrons (increase in the difference of potential) between the root and point on the trunk.

4. Conclusion

The objective of the study is to follow the evolution of the potential difference between two points of a plant, in order to study the influence of certain parameters (solar lighting, distance between two points of the plant, watering and amendment) on the potential difference between two points on the plant. The results obtained indicate that the potential difference depends on the lighting, and that it is maximum around 3 p.m. on Eucalyptus *Camaldulensis* and *Mangifera indica* in the study area. These results also show that, the higher one climbs on the trunk, the more the potential drops and the ddp increases. They also show that, the potential at a point on the trunk is a function of the quantity of water received. With large quantities of water, this potential increases. When the plant receives large quantities of water, the longer the stress, the more the ddp increases. The amendment with organic matter increases the potential at a point on the plant.

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