



Centre for Atmospheric Research

2018

MONOGRAPH OF ATMOSPHERIC RESEARCH

Edited by A.B. Rabiou and O. E. Abiye

A Publication of
CENTRE FOR ATMOSPHERIC RESEARCH
National Space Research and Development Agency
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PREFACE

The Centre for Atmospheric Research was established in January 2013 with a compelling mission to improve our understanding of the behaviour of the entire spectrum of the Earth's atmosphere; promote capacity development in relevant atmospheric sciences as a way of facilitating international competitiveness in research being conducted by atmospheric scientists; and disseminate atmospheric data/products to users towards socio-economic development of the Nation. CAR's extant core research focus includes: space weather, tropospheric studies, atmospheric research software and instrumentation development, microgravity and human space technology, and atmospheric chemistry and environmental research.

Pursuant to the above, The *Monograph of Atmospheric Research* published by the Centre for Atmospheric Research (CAR), is a collection of peer-reviewed manuscripts in Atmospheric Sciences and closely related fields. This maiden edition comprises articles presented during two separate workshops; *1st National Workshop on Microgravity and Environmental Research* (26 - 29 November, 2017) and *1st National Workshop on Air Quality* (13 - 16 March, 2018). Such workshops are integral part of CAR's capacity building program and they were primarily aimed at advancing the course of atmospheric research in Nigeria towards sustainable development. The Microgravity workshop was geared towards introducing new research opportunities in space life science by simulating microgravity conditions here at the earth's surface as a means of investigation space biological environment. The Air Quality workshop was organized in collaboration with Ministry of Environment and Nigerian Meteorological Agency (NIMET). The workshop analysed current Air Quality scenario in Nigeria, explored new opportunities for collaborative research and offered novel means of improving the present quality of life of the populace without jeopardizing the chance of the future generation. Cumulatively 196 participants participated in these two workshops and about 52 articles were eventually submitted for publication consideration in this monograph. The twenty-one articles in this very monograph are the articles that eventually made it through the rigorous peer-review process. We remain grateful to the reviewers for doing thorough work on the articles.

Thus, we are very pleased to present the *2018 Monograph of Atmospheric Research* which contains twenty-one articles, including some review papers, to readers in all spheres of interest across Nigeria and beyond. It is our hope that this effort will continue and will serve as a reference to atmospheric researchers in Nigeria.

Prof. A. B. Rabi and **Dr. O. E. Abiye**,
Editors



Centre for Atmospheric Research

Investigation of watermelon seeds growth under simulated microgravity and its advantages to agriculture sector

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ABSTRACT

Microgravity simulating-equipment gives knowledge into gravitational-biology. Such equipment includes clinostats and random-positioning-machines used as ground-based instruments for microgravity-research. In this project two-dimensional clinostat was used. This project aimed to: understand the impact of gravity on watermelon (*Citrullus lanatus*) growth to determine what its orientation will be in space; conduct observational-experiments with respect to gravitropic-reactions with the roots grown under microgravity-environment and comparing them with those of control-experiments. Watermelon seeds were planted into petri-dishes using plant-substrate called agar-agar in a wet-chamber. The general experimental-variables were relative-humidity, temperature and light-conditions. After 4days of germination under normal-Earth-gravity, some of the petri-dishes were left under normal-Earth-gravity serving as controls for growth-rate and root-curvature analyses for the clinorotated-sample respectively. The clinorotated-sample was mounted on clinostat under specific: fast-rotation-speed, rotational-axis-angle and rotation-direction. The photos of the samples were taken at specific minutes for 2hours. After observations, the root-anatomy of the watermelon seeds were studied using specialized-software. The grand-average root-angles and root-lengths of all the seeds were calculated to give the root-curvatures and growth-rates respectively. The results showed the clinorotated-sample had reduced response to gravity per-hour. Roots-length increased in clinorotated-sample as compared to control-sample. Based on the results, several conclusions were deduced for benefits to the agriculture-sector.

Keywords: *Microgravity; Clinostat; Watermelon; Biotechnology; Agriculture-sector.*

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INTRODUCTION

Space exploration is man's greatest means to subdue his environment and accelerate development. There are some factors that differentiate the environment on Earth and the environment in outer space. These factors include pressure, temperature and gravity. Gravity is very important among these environmental factors, in that it is always present in a constant direction and magnitude on earth. It is also indispensable for all life on Earth because it is needed for direction of the growth of plants. The impact of gravity on orientation and growth can be examined during the developmental stages of the plant. Microgravity environment (μg) is defined as an environment where some of the effects of gravity are reduced compared to what is experienced at Earth's surface (Oluwafemi, 2014). Microgravity is one of the most essential features of orbital flight in space. With the clinostat as microgravity simulation equipment, it is quite effective giving more knowledge into gravitational biology. Inclusive of these microgravity simulating equipment are the random-positioning machines used as ground based instruments for microgravity research. There have been several studies carried out regarding the effects of microgravity conditions on plant growth using spacecrafts and ground base equipment. Plants experiments in microgravity using the clinostat have opened up an exciting new world of discoveries which are beneficial to mankind ranging from food-security, new medical-cures etc (United Nations, 2013). In this project two-dimensional clinostat was used. This project aimed

to: understand the impact of gravity on watermelon (*Citrullus lanatus*) growth to determine what its orientation will be in space; conduct observational-experiments with respect to gravitropic-reactions with the roots grown under microgravity-environment and comparing them with those of control-experiments. The root curvature and growth rates of watermelon under gravity and microgravity influence were determined using specialized software called ImageJ (Oluwafemi, 2016). Following results from the experiments done, deduction for Earth future plant farming was done.

Watermelon is a fruit and it's an excellent source of antioxidants, including vitamin C. It can help combat the formation of free radicals known to cause cancer. It also have other health benefits such as prevention of kidney disorders, high blood pressure, diabetes, heart disease, heat stroke, macular degeneration, and impotence (Organic Facts, 2016).

MATERIALS AND METHODS

The properties that make watermelon seeds suitable for this experiment are that: it is small, easy to handle and fast-growing with germination period of 4 days. The Clinostat that was used for this research is a One-Axis Clinostat (Desk-top type). Being a one axis clinostat means it is a two-dimensional (2D) clinostat with a single rotational axis, which runs perpendicular to the direction of the gravity vector. It operates with respect to speed and direction of the rotation. A rotation on a clinostat is called "clinorotation".

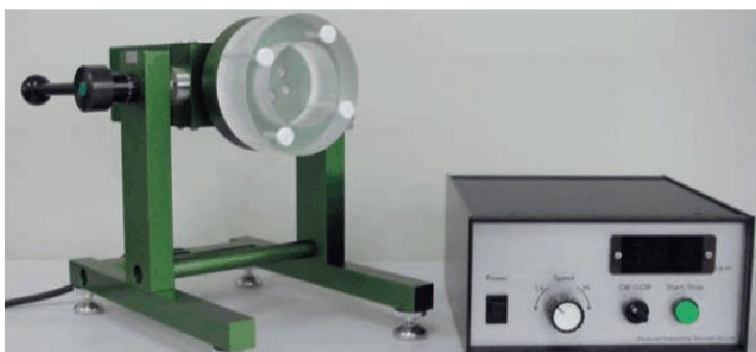


Figure 1. Uniaxial Clinostat and its Control Box, with Rotation Position Horizontal (i.e. rotational axis angle of 90°)

The substrate of seeds called plant agar-agar was prepared into 3 petri-dishes following the standard preparation method in the Teacher's Guide to Plant Experiments by United Nations Office for Outer Space Affairs (UNOOSA) of the Programme on Space Applications (2013), then the seeds were planted in the substrate and it was cultivated inside a wet chamber in vertical positions. After 4 days, germination of the seeds with short roots was observed. The 3 petri-dishes were then taken and labeled "1g-control", "90°-turned" and "Clinorotated". The 1g-control sample was remained in the vertical position. The 90°-turned sample was rotated by 90° and the Clinorotated sample was then placed at the centre of the clinostat using double-sided tape. The photos of the 3 petri-dishes were taken every 30 minutes (with very short stopping time of the clinorotated in order to avoid the effect of gravity) for 2 hours. This observation was done under the following conditions. Humidity between 60% to 100%, temperature of 23°C and light of 50lx. In addition to these, the Clinorotated sample had the following conditions, rotation speed of 80rpm, rotational-axis angle (horizontal) and the direction of rotation was clockwise. At the end of observation, the analysis of root curvature and growth rate were carried out.

RESULTS AND DISCUSSION

Results

Data Analysis 1: Root Curvature

The data obtained were the three sets of photos of the roots which show the "1g-control", "90°-turned" and "Clinorotated" roots. An image-processing application soft-ware called ImageJ was used to analyse these photos. Analysis 1 focuses on the curvature of the roots which are photos of the 90°-turned and the Clinorotated samples. All the curvature angles of the roots were measured using the angle measurement tool. The average angular rate of the root bending in degrees per hour was then calculated.

Result 1: Photo of the 90°-turned sample showed that the roots started bending in the direction of gravity after the petri-dish was turned by 90° as evident from Figure 1. The average angular rate of the root bending for the 90°-turned was 33.13°/hr while that of the Clinorotated was 17.18 °/hr.



Figure 2. Haphazard Roots of the Watermelon Seeds Under Simulated Microgravity Effect of Clinostat

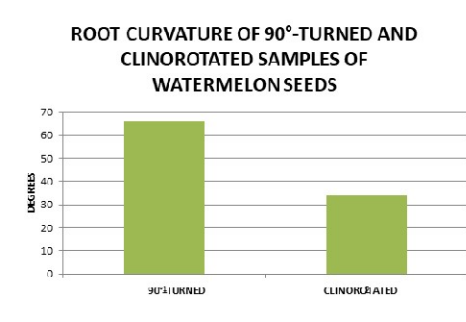


Figure 3. Histogram of the Root Curvatures in Degrees of 90°-turned and Clinorotated Samples

Data Analysis 2: Growth Rate of the Root

The pictures of the 1g-control and the Clinorotated roots were used for analysis 2. The difference between the two cases was analyzed by measuring the length of the roots, which thereby allowed their growth rate to be determined. For the analysis of the length of the roots, the length of the roots was measured

with a ruler or drawing a line which is exactly 10mm long on each petri-dish and the growth rate analysis was done using the ImageJ software. This was done by using the length measurement tool and measuring a fixed length in the photo. Figure 2 shows lengths of the 1g-control sample roots and Clinorotated sample roots versus the time after germination. The average growth rate was calculated (*millimetres/hour*) for the 1g-control and the Clinorotated roots.

Result 2: The average growth rate of the roots for the 1g-control sample was 4.94mm/hr while that of the Clinorotated sample was 6.58 mm/hr.

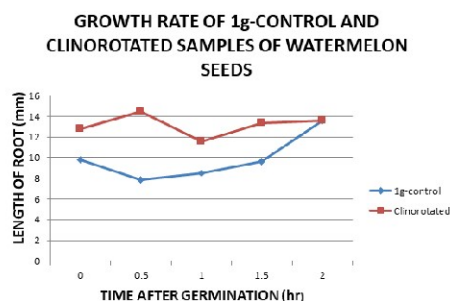


Figure 4. This shows an experimental result with the length of the 1g-control sample roots and the Clinorotated sample roots versus the time after germination.

Discussion

The photos of the 1g-control showed that the roots continuously grew vertically as stimulated by the Earth's gravity. For the Clinorotated roots, however, nothing stimulates their growth in any direction (random). The photo of the 90°-turned sample showed that the roots started bending in the direction of gravity after the petri-dish was turned by 90°. This was evidence of gravitropism of the roots. The average angular rate of the root bending for the 90°-turned sample was 33.13°/hr while that of the Clinorotated sample was 17.18°/hr, which means that the Clinorotated sample had its roots curvature diminished by 48.14% of the 90°-turned sample. This indicates a positive response to simulated microgravity. The average growth rate of the roots for the 1g-control sample was 4.94mm/hr while that of the clinorotated sample was 6.58 mm/hr which means there was an increased growth rate of watermelon under microgravity by 24.92%. Note that these results are analytical and what was gotten in the laboratory are reported.

CONCLUSION

Based on the results, the following conclusions can be deduced for future plant farming in the agriculture sector, that clinostat rotation can affect the plant tissues positively because of increase in growth rate, and this technique can be used to enhance plant germination, growth and ultimately, productivity in the agriculture sector through biotechnology. A second deduction is that the use of simulated microgravity environs for planting purposes provides solution to land scarcity and deforestation

caused by agricultural purposes. Lastly, the result observed in this clinostat study is only on the roots-length, therefore further investigations on the shoot length and possibly the weight needs to be done in spaceflight experiments.

Acknowledgement

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Our Mandates

The Center for Atmospheric Research, CAR, is a research and development center of NASRDA committed to research and capacity building in the atmospheric and related sciences. CAR shall be dedicated to understanding the atmosphere—the air around us—and the interconnected processes that make up the Earth system, from the ocean floor through the ionosphere to the Sun's core. The Center for Atmospheric Research provides research facilities, and services for the atmospheric and Earth sciences community.

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