Enhancing Space Education & Research in Microgravity among School Children in Africa: Lessons Learnt and Potential Improvements - ARCSSTE-E UN-ZGIP EXPERIENCE

Affiliated to
UNITED NATIONS
Office for Outer Space Affairs

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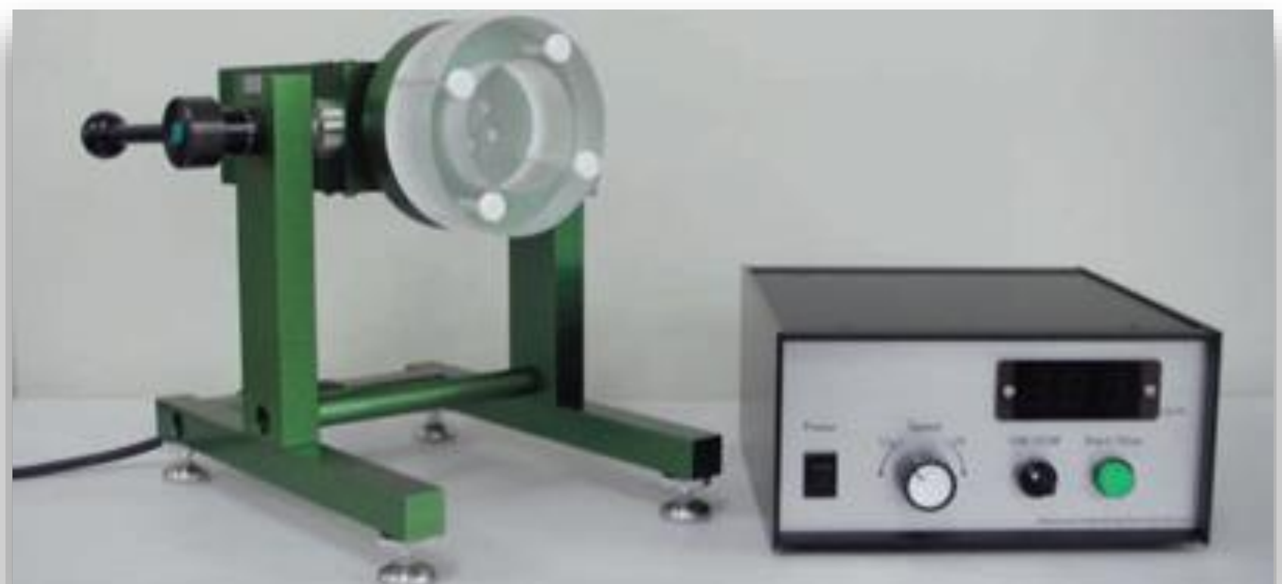


United Nations Expert Meeting on Human Space Technology
"Providing Access to Space"

Vienna International Centre, Vienna, Austria
4-6 December 2018

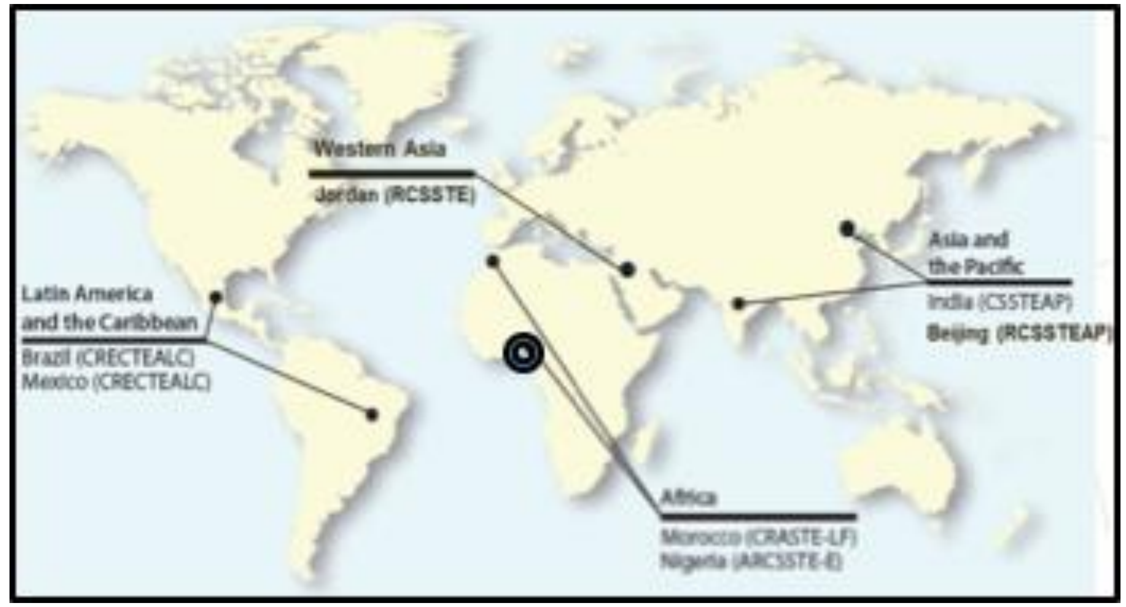
About ARCSSTE-E

African Centres

- ARCSSTE-E (Anglophone – NIGERIA
- CRASTE-LF (Francophone - MOROCCO)

Other Centres

- India (inaugurated 1995)
- Mexico/Brazil (inaugurated 2003)
- Jordan (inaugurated 2012
- China (inaugurated 2014)



Mandate: "Develop, through in-depth education, indigenous capability in the core areas of SST

Core Activities

1. Education
   - Post Graduate Diploma (PGD) programme
   - MTech programme
2. Space Education and Outreach Programme (SEOP)
3. Research & Short Term Training in SST

6 thematic areas of Space Science and Technology

- Remote Sensing/Geographic Information Systems (GIS)
- Satellite Communication
- Satellite Meteorology/Global Climate
- Basic Space Science/Atmospheric Physics
- Global Navigation Satellite Systems (GNSS)
- Space Law

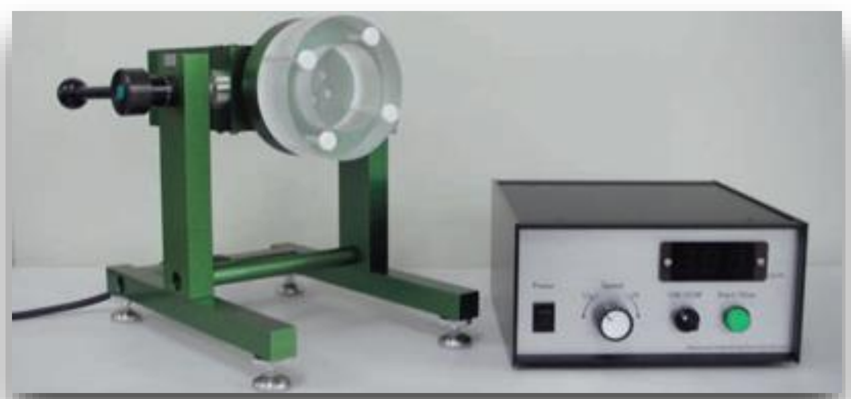
UNITED NATIONS
Office for Outer Space Affairs

Human Space Technology Initiative [HSTI]

Zero-Gravity Instrument Project (ZGIP)

Aim: Promotes Space Education and Research in Microgravity

Launched: 1st February 2013



1-Axis Clinostat

20 Clinostat distributed on Competitive basis to:

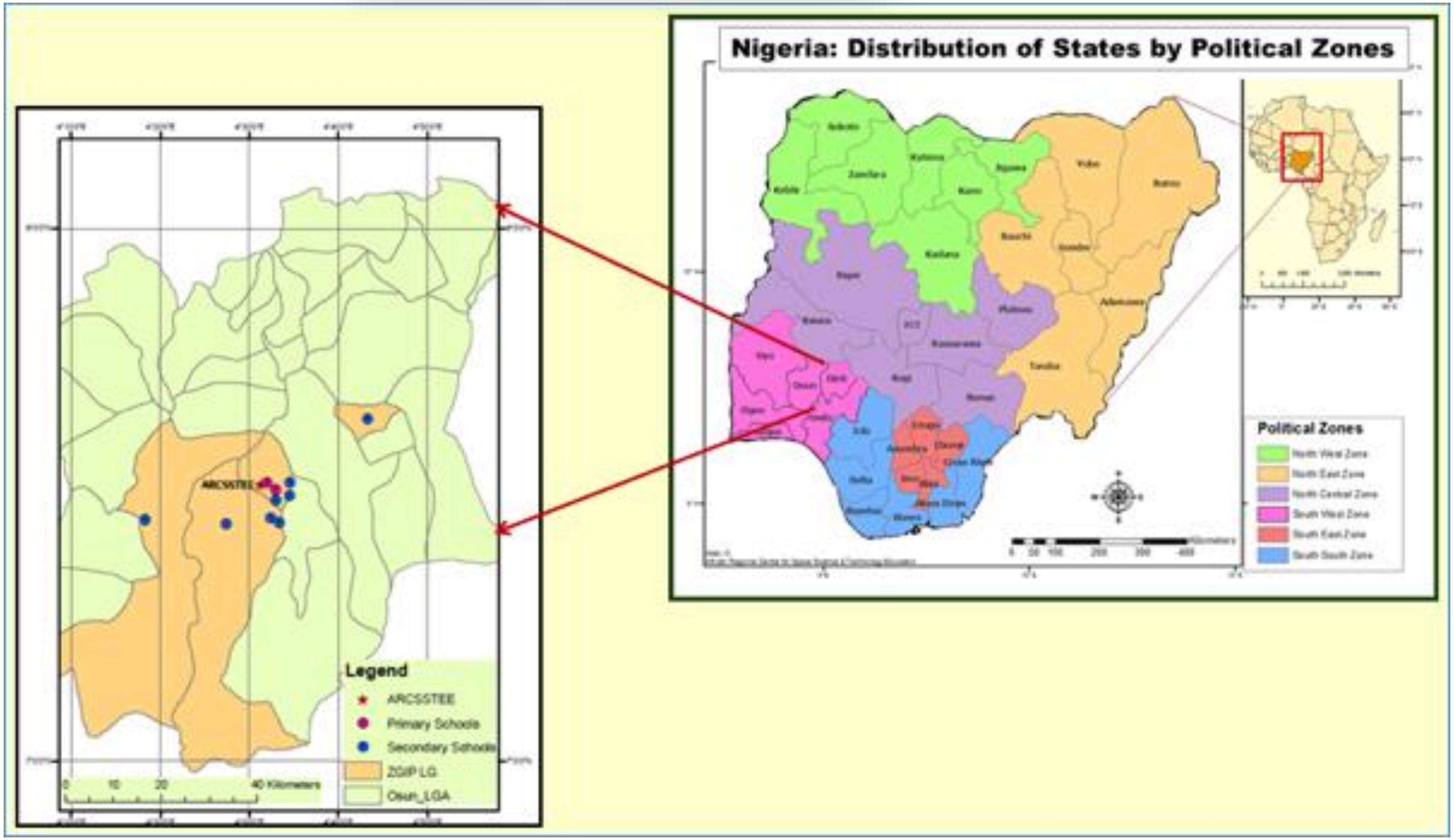
- Schools, Universities, Research Centres &Institutions

ZGIP Specific Objectives

Teach primary and secondary school students how to:

- Collect scientific data in a laboratory environment
- Analyze the data with specialized software (Image J: http://rsbweb.nih.gov/ij/download.html)
- Make Posters and present the result of their study in a Poster Competition

ARCSSTE-E's ZGIP Location



Participants:

- About 100 school children, aged between 7 and 21 years,
- Drawn from ten public and private schools located in Osun State, Nigeria.
- Schools were located within 4 out of the 30 local government areas in Osun State

ZGIP Implementation Stages

Project was implemented in 5 stages:

1. 1-Day Introductory Workshop
2. Laboratory Session
3. Poster Making Session
4. Results Poster Competition
5. Project Evaluation

Introductory Workshop

10 Primary and Secondary schools participated

3 Sessions:

- The Theoretical Session
  - Understanding the Outer Space environment, with special emphasis on the concept of microgravity
- The Practical Session:
  - Introduction to the Clinostat
  - Demonstration on Seed Preparation
  - Demonstration on how to use the Data Analysis Software: “IMAGE J”
- The Quiz Competition to test knowledge in microgravity.

- Instructional Materials were distributed
- Each participating school designed a project that used the Clinostat to examine the growth of indigenous plant seeds, in simulated microgravity conditions in ARCSSTE-E’s laboratory

Introductory Workshop

1 Introducing participants to the environment of Outer Space

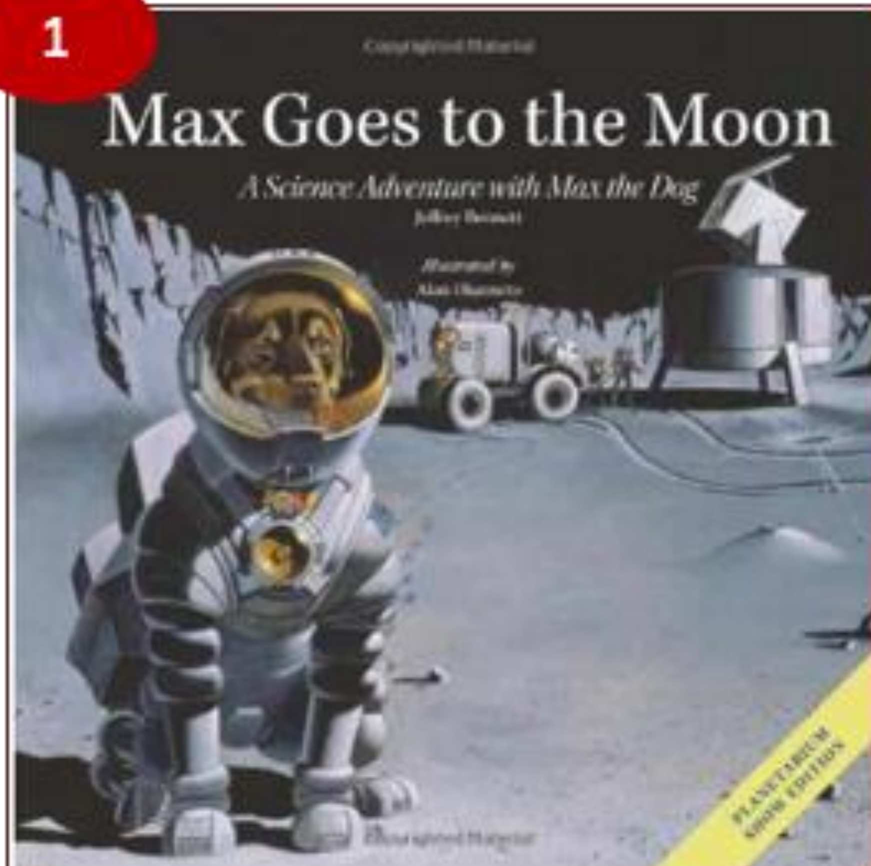
2 Introducing participants to the Clinostat: simulation of microgravity conditions in the laboratory

3 Introducing participants to the ImageJ software for data analysis

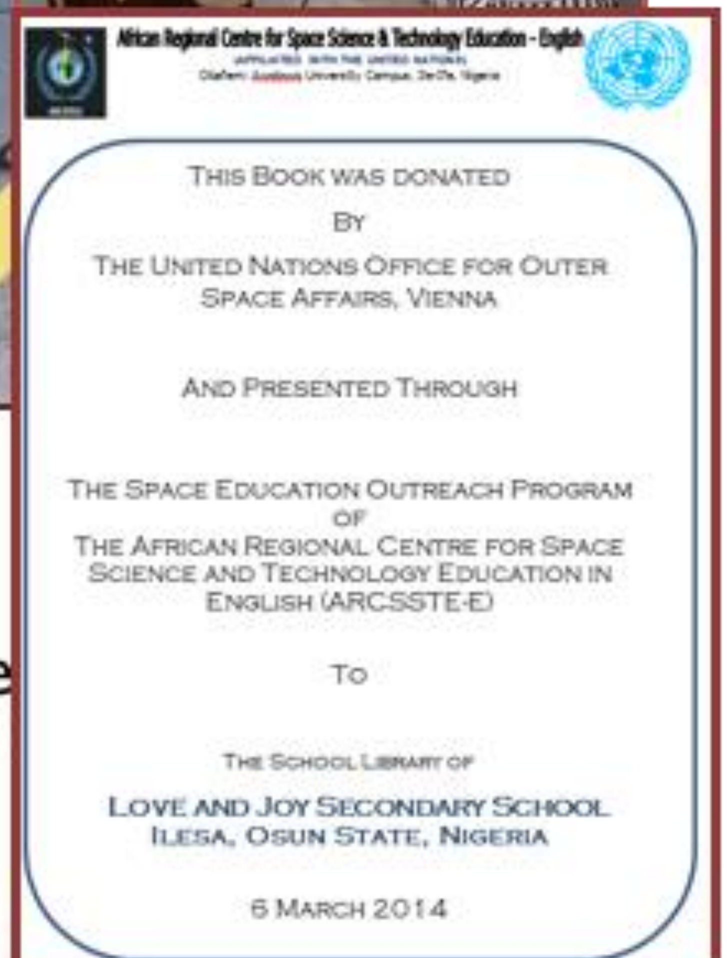
Introductory Workshop:

Distribution of Instructional Materials

1



- Written by astrophysicist Jeffrey Bennett.
- Winner of 2013 Science Communication Award by the American Institute of Physics
- An exciting and informative book for children to learn about outer space.



African Regional Centre for Space Science & Technology Education - English

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TO

THE SCHOOL LIBRARY OF

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6 MARCH 2014

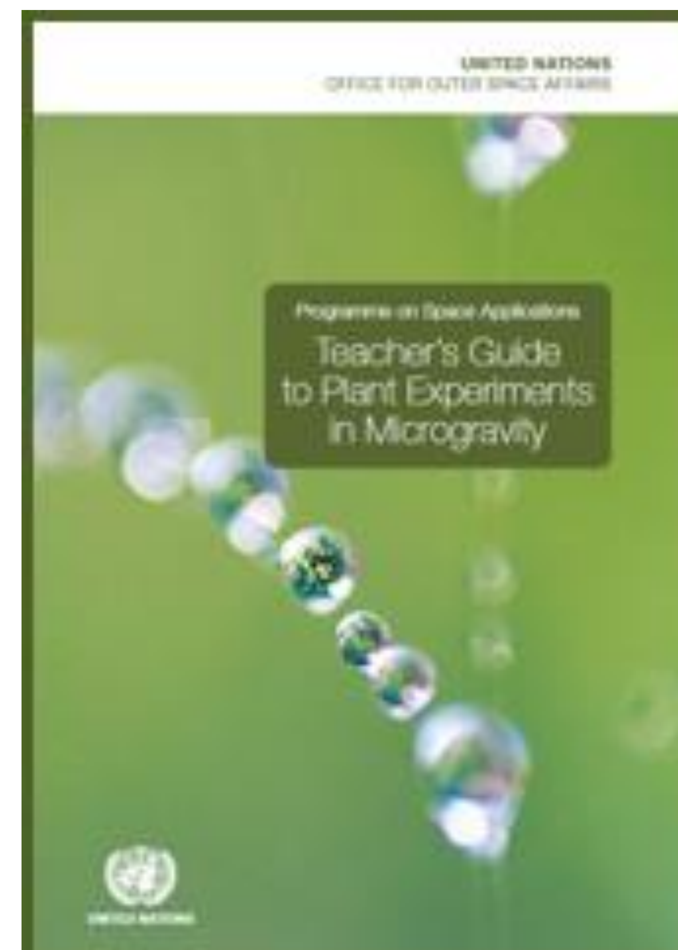
2

- Power-Point Presentation on the "Zero Gravity" Instrument Project
- UNOOSA Teacher's Guide to Plant Experiment in Microgravity
- ImageJ User's Guide

The Laboratory Session

- To observe the effect of microgravity on the seedlings of some indigenous plants cultivated for food in Nigeria - Black-eyed Pea, Cowpea, Guinea Corn, Maize, Millet, Okra, Rice and Wheat
- Each School had a period of one week, on a planned time-table to work in the ARCSSTE-E's Laboratory to execute their designed project
- "Teacher's Guide to Plant Experiments in Microgravity" published by UNOOSA was used.

Local Seeds Analyzed



The Laboratory Session

Preparing a fertile 'soil' (Agar-agar solution) for planting the seeds

Planting the seeds in the Agar-agar solution

Samples of seeds planted in the Agar-agar solution

Preparing the seeds for fast germination

The Laboratory Session

Mounting the sample on the Clinostat

Adjusting the speed of rotation of the Clinostat

Using a digital camera to collect periodic data from the rotating clinostat

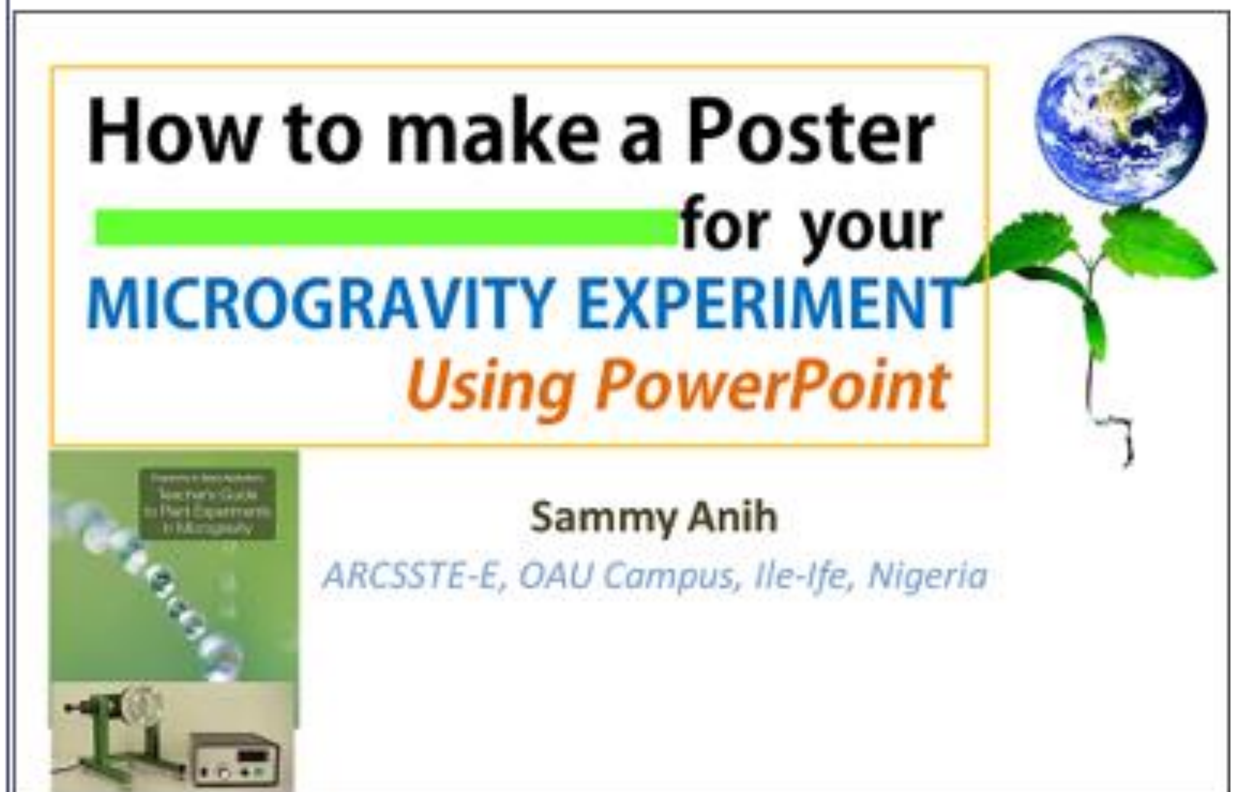
Germinating seeds: samples of data collected

Data analysis with ImageJ software

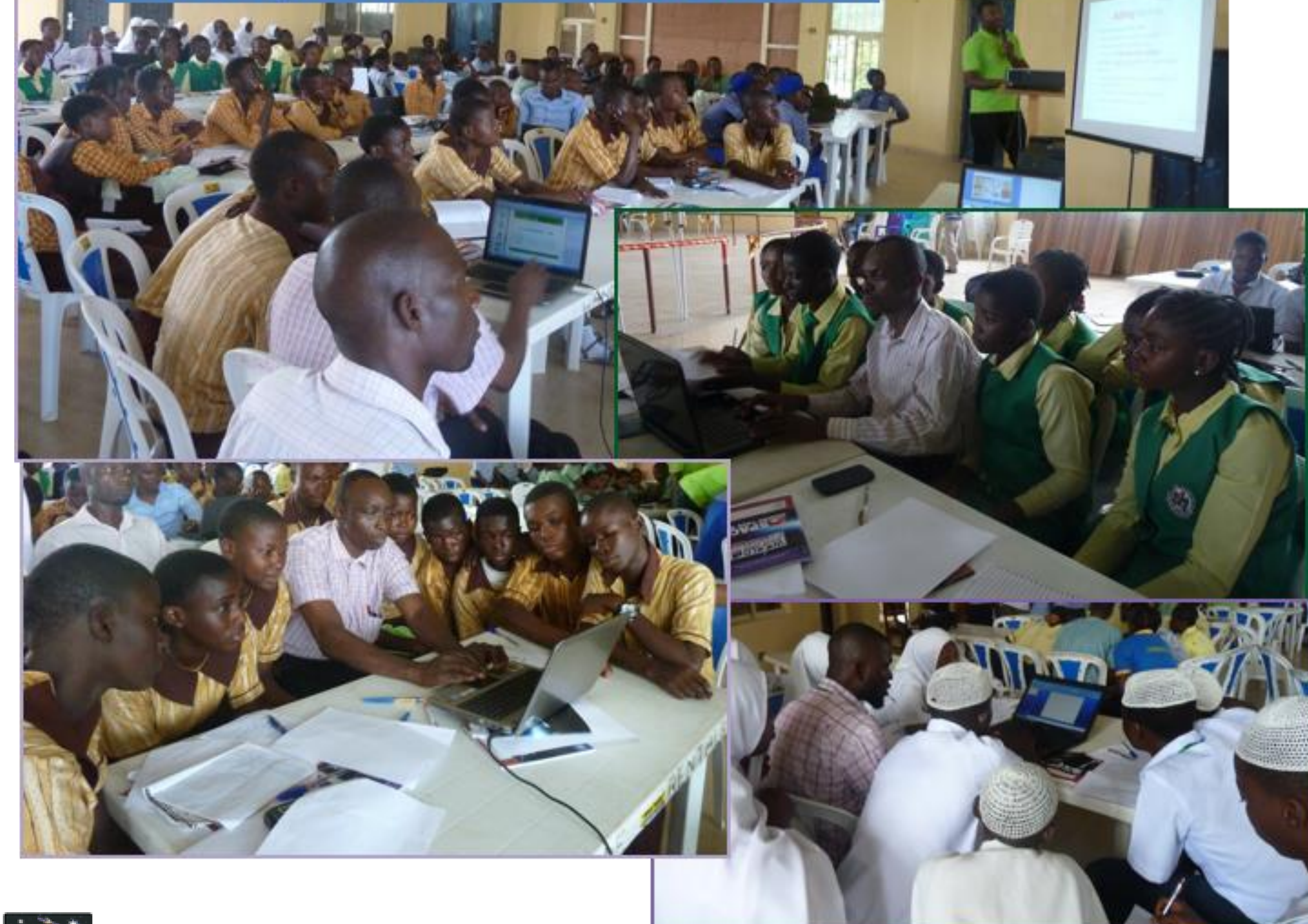
The Poster Making Session

A Poster Making Workshop was organized for the participating schools at the ARCSSTE-E Space Museum where the schools were introduced to the rudiments of poster production and discussed the following topics:

- What is Poster?
- Poster Contents
- Poster Layout
- Design [Techniques and aesthetics behind an effective poster presentation].
- Creating a poster using a PowerPoint.



Workshop: How to Make Research Poster



EFFECT OF MICRO–GRAVITY ON THE ROOT GROWTH OF MILLET AND OKRA SEEDS

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ABSTRACT

This experiment is to test if plant can grow in a micro-gravity environment. This, also examines whether the space can be commercialized or not in order to reduce the cost at which food items are transported into space.
This experiment also demonstrates how plant will grow in a micro-gravity environment. This can be achieved by planting seeds inside the petridish,placing the petridish inside humidifier and placing of the petridishes on the clinostat.

INTRODUCTON

Earlier on, observations made by the World Space Organization shows that there have been wastage of foods and agricultural products due to weightlessness. The Space scientists, therefore, design experiment to stop food wastage. This experiment has been carried out by the NASSA to inform young scientists. Therefore, we design our own method of performing this experiment on how to grow plant in space.

MATERIALS

This experiment is to be performed in a controlled environment(i.e. Micro-gravity environment.)
The device which produces the effect of microgravity. Agar-agar powder is the substrate used because of its fast rate of germination. Petri dishes are containers where the seeds are grown. Thermometer is used for checking temperature and hygrometer for checking relative humidity. Also, the heating element is used for heating Agar-agar solution.

PROCESS

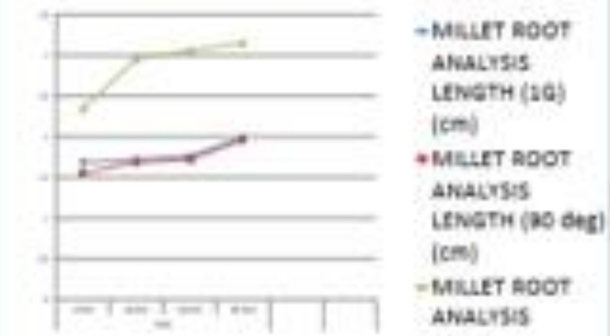
Firstly, 100ml of tap water is measured, and 1.5g of Agar- agar powder is added to it. The beaker containing the mixture is then placed on a heating device, the mixture is then heated to a range within 70 degree Celsius. The temperature is then checked on the heating device with thermal Crum.
A magnetic stirrer is then carefully drop into the mixture, to stir the mixture to prevent lumping of the solution. After heating the mixture to a certain degree, it is then poured into the marked petridishes. Then it is allowed to cool for 20 minutes and the seeds were be planted with the aid of twiser on the marked spot and covered with lid and allowed to solidify for about 20-30 minutes, after which the lid is cleaned with tissue paper and covered back. Then, the petridish is sealed with parafilm and little space is left to allow air penetration for fast germination . Thereafter, the petridish is placed in the petridish holder and transferred to the wet chamber to provide moist environment for the seed, then the thermal-hydrograph is placed inside the wet chamber to know the temperature and relative humidity in the cloud, and will be left there for about 20-30 hours.
After 20-30 hours, the petridishes will be removed from the cloud. 1G, clinostat, 90 degree and the backup will be sorted out accordingly. The 1G position will not be altered as it is placed in the wet chamber, the 90 degree turn will be turned vertically and the back up will be left unturned in case of error in the preparation of other petridish.
The one to be mounted on the clinostat will be done with the aid of double sided tape which can hold the petridish firmly on the clinostat. Then the revolution per minutes will be set within the range of 10- 20 revolution per minutes. Then, the device (clinostat) will be put on and pictured immediately.
After each 30 minute, the clinostat will be stopped and the picture of the petridishes mounted on the clinostat is then captured. The camera used to take the picture should be placed 30 cm away from the clinostat and the picture of the 1G , 90 degree turn and backup is also taken every 30 minutes for 4-5 times (2 – 2.5 hours).

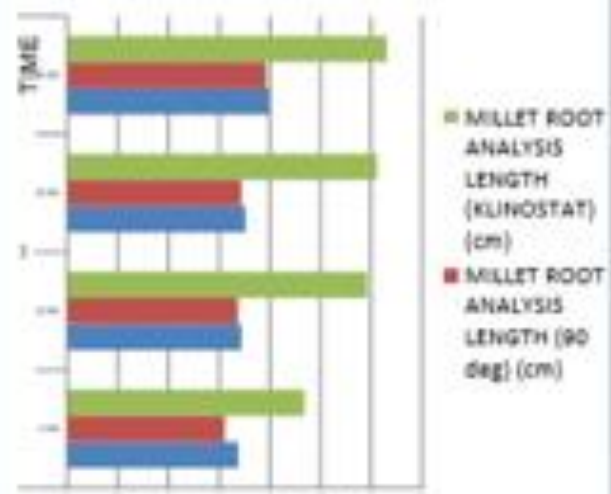
RESULTS

After all these processes, there came in the results of the whole experiment.
When weighing the Agar-agar powder, the initial weight of the petridish was 7.2g and the final weight was 8.7g because 1.5g of Agar-agar powder was used for **OKRA.** The initial temperature before heating the Agar-agar solution on the heating device was 26.2ºc and the final temperature was 71.4 . When the petridish was in the wet chamber the thermal hydrograph reads the initial temperature to be 27.5ºc and the initial humidity was 60%, the final temperature and final relative humidity was 28.2ºc and 86% respectively. It was observed that the relative humidity in the wet chamber is within the appropriate range i.e (70%-100%)
When it was exactly 9:36 am the clinorotated petridish has been mounted on the clinostat and the revolutions per minute is set to 15 revolutions per minute and the direction was set to counter clockwise When it was 9:37 am, the clinostat was powered on. Thereafter, the picture of the root was taken and analysis is done with the aid of IMAGE J
The tables and graphs below illustrate the root growth of Okra and Millet roots

MILLET ROOT ANALYSIS

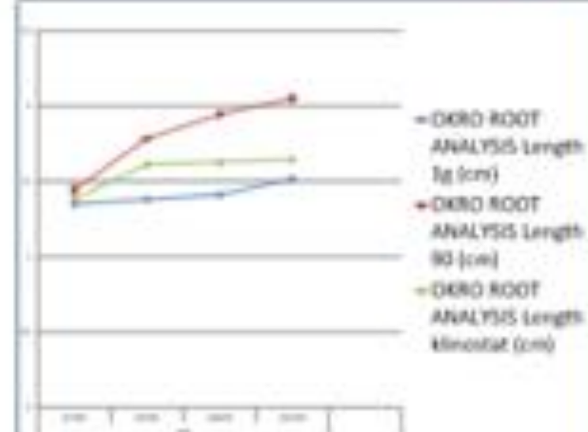
TIME MIN	AT (1G) LENGHT [CM]	AT (90⁰) LENGHT [CM]	ON THE (KLINOSTART) LENGHT [CM]
0	1.687	1.554	2.342
30	1.72	1.684	2.959
60	1.76	1.718	3.058
90	1.959	1.965	3.154

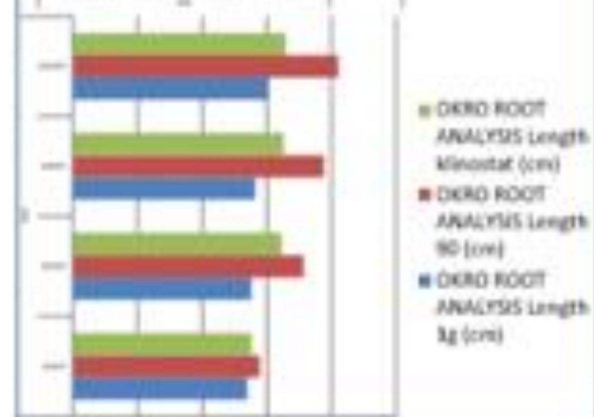




OKRA ROOT ANALYSIS

MIN	AT [1G] LENGHT [CM]	AT (90⁰) LENGHT [CM]	ON THE (KLINOSTART) LENGHT [CM]
30	1.348	1.445	1.383
60	1.38	1.785	1.615
90	1.41	1.944	1.628
120	1.516	2.052	1.646





REFERENCES

➤Teacher's guide of the 2GIP practical
➤http.www.google.com
➤image –J software

ACKNOWLEDGEMENT

We like to acknowledge the effort and support of the ARCSSTE-E . Also our profound gratitude goes to our great citadel of learning Islamic College Osogbo and the school's management who gave us the opportunity to partake in this programme and to made it come to reality. Lastly, we will like to appreciate the effort of the United Nation (UN).

CONCLUSION

In conclusion, after carrying out the experiment and after analyzing our results, we discovered that plants can grow in a micro-gravity environment with absence of gravity or with very low gravity.
Also, it was discovered that gravity tends to pull the plant's roots towards the direction of gravity while the shoot tends to move in the opposite direction of gravity. Therefore, "plants' roots are positive to gravity while the shoot is negative to gravity".
Furthermore, there was the presence of oxygen and high humidity that aided the plant's growth.
In addition to this, we noticed that the plants in micro-gravity environment grow faster than the plants grown in a gravity environment.

EFFECT OF MICRO-GRAVITY ON THE GROWTH RATE AND THE CURVATURE ANGLE OF RICE ROOT

Participants: ABE Favour, OMONITAN Daniel, OMITIRAN Isaac, FAROMO Olalade, OMONITAN Samuel, TAIWO Oluwaseun, ADEBISI Dare, OMITIRAN Adesola, FAFIYEBI Alaba, ADEOBA Phebe, OMONITAN F.A (Mrs.);
Love and Joy Secondary School, Ilaje-Ile, Ilesa, Osun State, Nigeria.

Abstract

❖Can rice be cultivated in space?
❖Does rice roots have effect in a micro-gravity environment?
❖What is the effect of micro-gravity on the angle of curvature of rice roots?
❖Will micro-gravity affect the growth of rice adversely?

Since the beginning of human space flight, the feeding of astronauts has being a major problem. This is so because astronauts are not able to feed on fresh food in space. That is why it is important to study the behaviors of plant in a micro-gravity environment and know whether plants can be cultivated in space or not.
It is said that the force of gravity determines the movement, growth, and direction of living things especially green plants. And growth and direction of plants affects how a plant will yield/produce. Therefore, is it possible for plants to survive in space where the effect of gravity is being cancelled out?

So, in order to achieve a micro-gravity environment here on earth, a clinostat was used to stimulate a micro-gravity environment for the plants to check the influence of gravity on them. Seeds were planted in agar-agar substrate in a Petri-dish which serve as soil for the seeds to germinate. The seeds were studied for two hours and readings were taken.

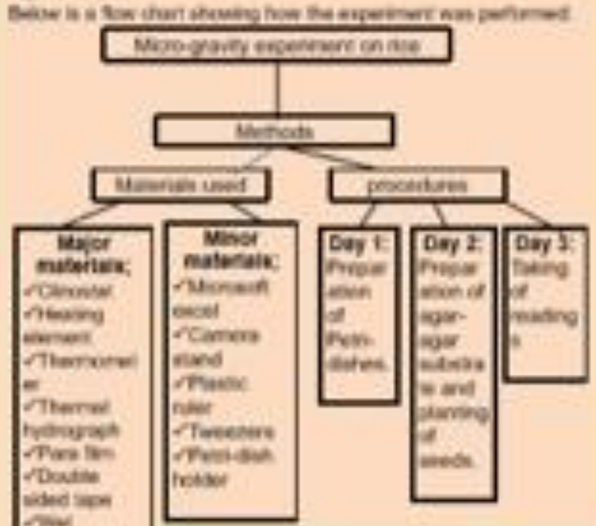
Introduction

Rice is a very popular food. It is eaten all over the world. Rice was used for the experiment because:
❖It **feeds about two million of the world's population**
❖It serves as raw materials for the production of some other food materials e.g. beer.
❖Rice seeds are not too big neither are they too small to be handled
❖The germination of rice seeds is within 2-5 days
The above reasons are why rice was chosen for the experiment.

So far, micro-gravity researches have been conducted on rice seeds to understand the effect of gravity on it, and to check weather or not it can be cultivated in space.
The following micro-gravity researches have been conducted on rice so far:
❖Effect of micro-gravity on ferulic acid production in rice cell wall
❖Effect of gravity on the activity of rice shoot cell walls
❖Effect of gravity on the wavering of rice shoot
❖Effect of gravity on the growth rate of rice shoots
It is observed that researches have not been conducted on the effect of gravity on the growth rate and angle of curvature of rice roots. That is why we have chosen to research on the effect of micro-gravity on the behaviour of rice roots.
As students, the clinostat experiment is the best because it is faster, safer, easy to manipulate and can be easily understood.

Methods

We are interested in knowing the effect of micro-gravity on the growth rate and angle of curvature of plant. Rice was chosen for the experiment.
Below is a flow chart showing how the experiment was performed:



•Four Petri-dishes were prepared: 1G, clinorotated, 90° turned and backup.
•Readings were taken by taking pictures of seeds at 30mins interval for 2hrs.
•The clinostat was switched off every 30mins and pictures were taken as fast as possible. This is to prevent gravity from acting on the seeds.

Rice seeds on clinostat

Team picture

Results

After the seeds were analyzed, the followings were observed:

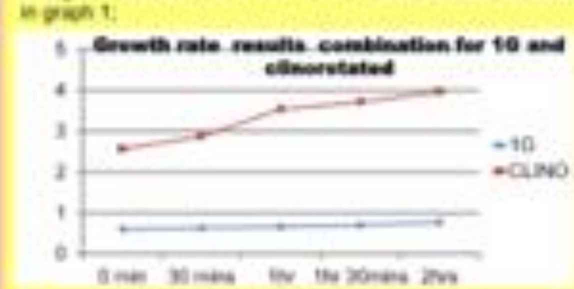
Growth rate

For growth rate, 1G and clinorotated seeds were analyzed. The data obtained are summarized below:

	Time	0min	30mins	1hr	1hr30mins	2hrs
Average length of roots (cm)	1G	0.60	0.63	0.66	0.70	0.77
	Clinorotated	2.57	2.87	3.54	3.71	3.97

Table I: the growth rate of 1G and clinorotated seeds;

The growth rate of 1G and clinorotated seeds for rice as shown in graph 1;

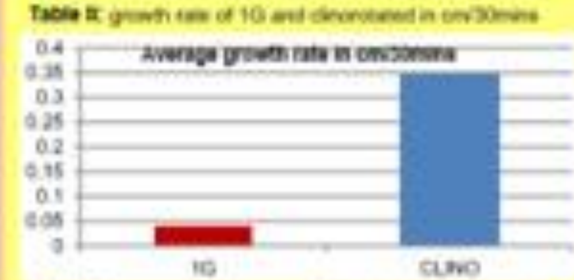


Graph I: the growth rate of 1G and clinorotated seeds

Average growth for both 1G and clinorotated rice seeds as shown in table ii:

Time	0min-30mins	30min-1hr	1hr-1hr30mins	1hr30mins-2hrs	Average
1G(cm)	0.02	0.03	0.04	0.07	0.04cm/30mins
Clinorotated (cm)	0.03	0.67	0.17	0.26	0.36cm/30mins

Table II: growth rate of 1G and clinorotated in cm/30mins



Graph II: average growth rate of 1G and clinorotated seeds in cm/30mins

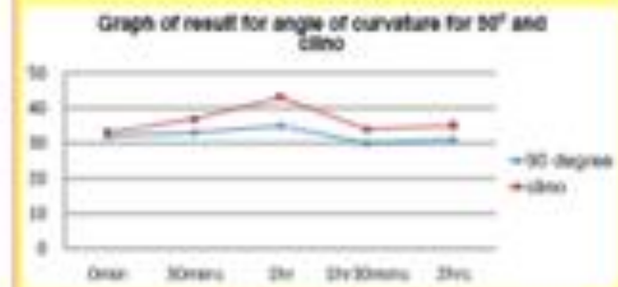
Angle of curvature

For angle of curvature, clinorotated and 90° turned were analysed and the following were observed.

Average angle of curvature of clinorotated and 90° as shown in table iii:

Average angle of curvature in degree	time	0min	30mins	1hr	1hr30mins	2hrs
	90 degree	32	33	35	30	31
	clinorotated	33	37	43	34	35

Table III: the average angle of curvature rate of clinorotated and 90° seeds;



Graph III: the average angle of curvature rate of clinorotated and 90° seeds.

Conclusion

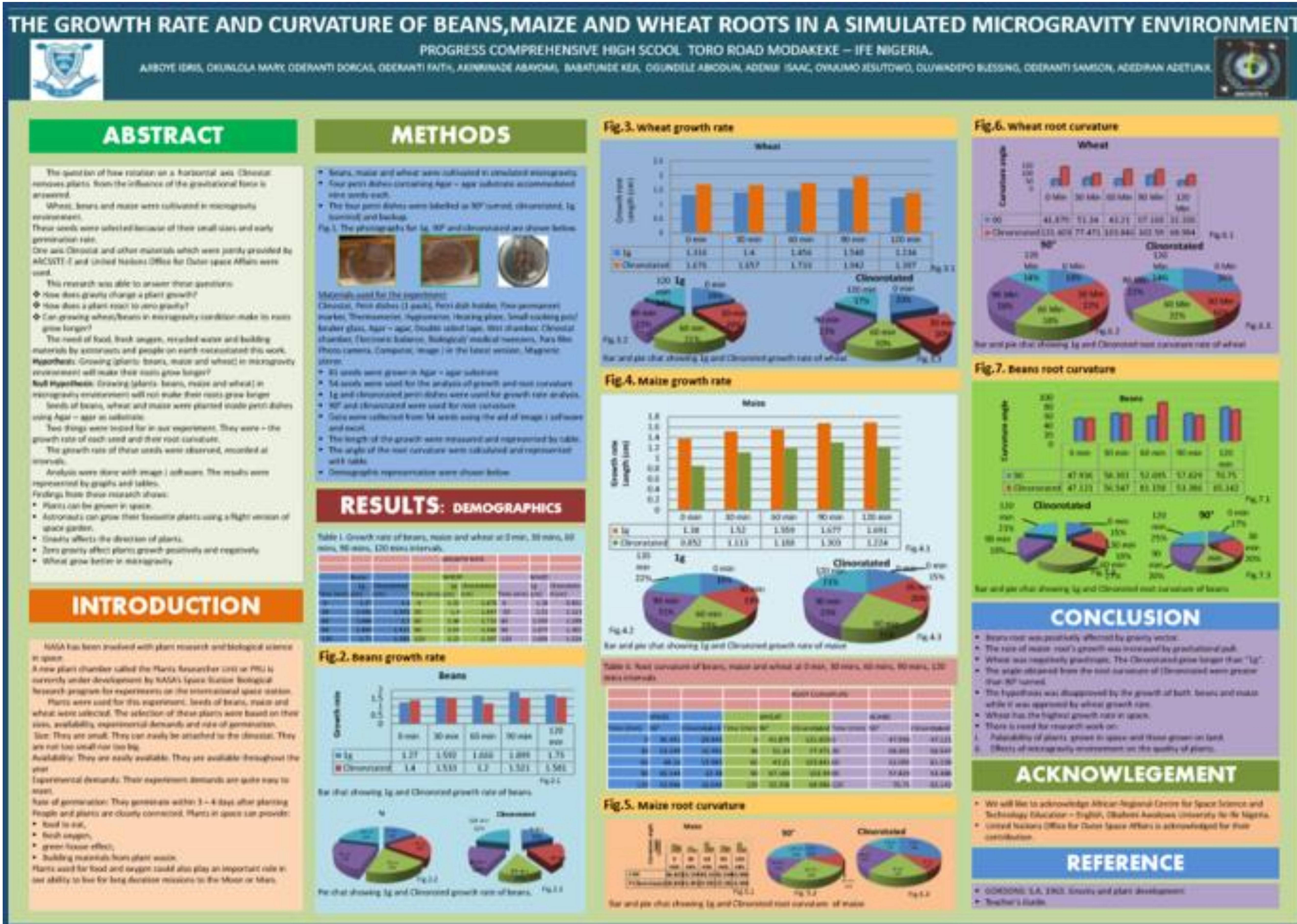
From the experiment so far, it was observed that clinorotated rice roots has a faster growth rate and a higher angle of curvature compared to that of 1G. Therefore, it was concluded that rice can successfully be cultivated in space.

Acknowledgement

For the success of this project, we hereby acknowledge the following bodies who contributed to the success of the research:
❖The United Nations
❖African Regional Centre for Space Science and Technology Education in English
❖Love and Joy Secondary School team

References

❖Kazuyuki Wakabayashi, PhD. Osaka university. September 2010
❖Japan Aerospace exploration. 2007
❖Bennett coleman & co. 2014


THE GROWTH RATE AND CURVATURE OF BEANS,MAIZE AND WHEAT ROOTS IN A SIMULATED MICROGRAVITY ENVIRONMENT
PROGRESS COMPREHENSIVE HIGH SCOOL TORO ROAD MODAKEKE – IFE NIGERIA.
ABSTRACT
METHODS
RESULTS: DEMOGRAPHICS
INTRODUCTION
Fig.2. Beans growth rate
Fig.3. Wheat growth rate
Fig.4. Maize growth rate
Fig.5. Maize root curvature
Fig.6. Wheat root curvature
Fig.7. Beans root curvature
CONCLUSION
ACKNOWLEGEMENT
REFERENCE

EFFECT OF MICROGRAVITY ON WHEAT AND GUINEA CORN SEEDLING PLANTS

Saliu K., Adeyemi T., Ajayi M., Oladapo M., Bakare R., Akinwumi V., Ijimade B., Adefiwitan F., Olasode O., Oladele O. and M. K. Onabowale
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ABSTRACT

Quantitative information on the effect of microgravity on wheat and guinea corn seedling plants were provided. Length and root curvature of the plants were determined using imageJ method.
The minimum and maximum root lengths of the wheat for clinorotated and non-clinorated (1g) were 2.63 cm and 4.2 cm; 3.03 cm and 3.23 cm while that of guinea corn are 2.17 cm and 2.58 cm ; 3.03 cm and 3.23 cm respectively.
The growth rate of clinorotated wheat is 1.88 times that of guinea corn at 90 minutes while that of 1g was not affected. The higher value of angle indicates a more pronounced curvature of the root. It was observed that clinorotated plants germinated faster than non-clinorotated plants in a micro-gravity environment.

INTRODUCTION

Microgravity is a unique environment in outer space where the effects of gravitational force are minimized. It is also lead to understand how organisms and matter react to gravity, and may also lead to new applications benefiting humankind. Clinostat has been utilized for nearly 100 years to negate gravity and thus provide information on the significance of gravity to the growth of plants, utilized to simulate or duplicate the weightless environment of space flight to provide understanding of possible growth effects upon plants in space stations and provide insights into how plants seed react to an environment with simulated microgravity during germination and early growth.

MATERIALS AND METHODS

The experiment was performed with two seeds-wheat (Triticum aestivum) and guinea corn (Sorghum bicolor). The size of the seed selected must neither big nor small but MODERATE, for the agar-agar solution-a fertile land to hold for germination.
The substrate, agar-agar solution prepared was evenly distributed into the petri dish where nine seeds each of wheat and guinea corn was planted on 5 petri dishes. The seeds were covered for about 20-30 minutes and sealed two-third of the petri dishes with parafilm and leaving the remaining part of the petri dishes for air to the planted seeds inside the wet chamber. The petri dish holder position the seeds in the right position of wheat and guinea corn was placed into the wet chamber, a moist environment for the plants one after the other for about 20 - 30 hours with thermal hydrograph measuring both temperature and relative humidity.
Data on plants growth were collected from photographs taken during the course of the experiments between 28th July and 1st August 2014 and analyzed using imageJ to analyzed the root length and curvature.

RESULTS AND DISCUSSION

Table 1 shows the summary of the descriptive statistics of the growth rates for clinorotated and non-clinorotated (controls) wheat (Triticum aestivum) and guinea corn (Sorghum bicolor). The minimum and maximum root lengths of the wheat for clinorotated and non-clinorated (1g) were 2.63 cm and 4.2 cm; 3.03 cm and 3.23 cm while that of guinea corn are 2.17 cm and 2.58 cm ; 3.03 cm and 3.25 cm respectively. The overall mean lengths of clinorotated wheat and Guinea-corn in the microgravity environments were 3.05 cm and 2.35 cm respectively. It was observed that the wheat has the longest root of about 4.2 cm at 90 minutes and Guinea corn 2.58 cm at 120 minutes. The mean lengths of 1g for both wheat and guinea corn was 3.14 cm. The average growth rate of wheat and guinea corn for clinorotated root and 1g are 1.55 cm h^{-1}, 1.18 cm $h^{-1}$and 1.57 cm h^{-1} respectively. Also the growth ratio of wheat to guinea corn is 1.3. Figs 1 and 2 show the histogram of the distributions. The charts show that the growth rate of clinorotated wheat is 1.88 times that of guinea corn at 90 minutes while that of 1g remained the same. The speed of clinorotation did not affect growth of clinorotated wheat and guinea corn but growth rate of guinea corn was about 23% lower than wheat.

Table 1: Summary of the results obtained for Clinorotated Wheat and Guinea corn and Non-clinorotated (1g control)

	WHEAT LENGTH (cm)		GUINEA CORN LENGTH (cm)	
Time(min)	Clinorotated	Non-clinorotate(1g)	Clinorotated	Non-clinorotate(1g)
0	2.63	3.03	2.17	3.03
30	3.07	3.19	2.41	3.19
60	2.73	3.14	[illegible]	3.14
90	4.2	3.11	2.23	3.11
120	2.63	3.23	[illegible]	3.23

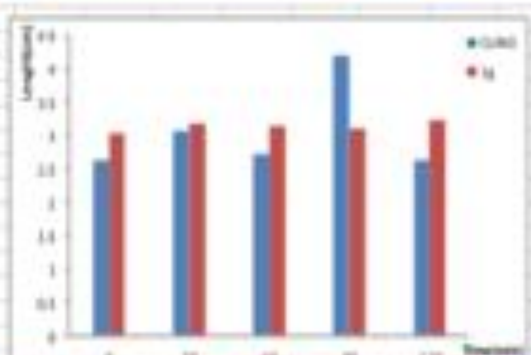

Fig 1: The Variation of Clinorotated Wheat and Non-clinorotated (1g control)

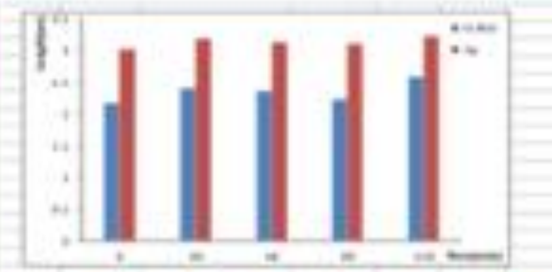

Fig 2: The Variation of Clinorotated Guinea corn and Non-clinorotated (1g control)

Table 2 shows the mean root curvature for both clinorotated wheat and guinea corn. The overall mean for wheat and guinea corn was 108.2° and 65.52° respectively. The least root curvature (44.7°) was observed in guinea corn while the highest 112.94° was observed in wheat in the gravitational response. The line graph of root curvatures for both wheat and guinea corn was showed in figure 3. The higher value of angle indicates a more pronounced curvature of the root therefore, wheat germinated faster than guinea corn in a micro-gravity environments.

Table 2: Summary of the results obtained for Root Curvature of Wheat and Guinea corn

Time (min)	Wheat α^{o}	G-Corn β^{o}
0	108.35	93.37
30	109.53	50.79
60	105.66	44.7
90	104.41	75.41
120	112.94	83.35

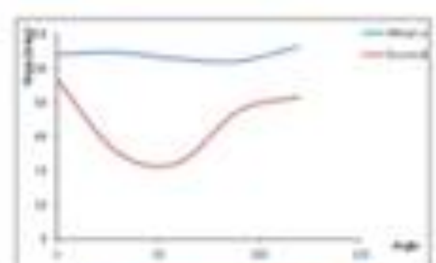

Fig 3: Curvature Chart

CONCLUSION

The results of this study have shown that total mean lengths of clinorotated wheat and Guinea-corn in the microgravity environments were 3.05 cm and 2.35 cm respectively. It was observed that the wheat has the longest root of about 4.2 cm at 90 minutes and Guinea corn 2.58 cm at 120 minutes. The mean lengths of 1g for both wheat and guinea corn was 3.14 cm. The average growth rate of wheat and guinea corn for clinorotated root and 1g are 1.55 cm h-1, 1.18 cm h-1and 1.57 cm h-1 respectively. Also the growth ratio of wheat to guinea corn is 1.3The average growth rate of wheat and guinea corn for clinorotated root and 1g are 1.55 cm h-1, 1.18 cm h-1and 1.57 cm h-1 respectively. The growth rate of clinorotated wheat is 1.88 times that of guinea corn at 90 minutes while that of 1g remained the same. The speed of clinorotation did not affect growth of clinorotated wheat and guinea corn but growth rate of guinea corn was about 23% lower than wheat. The higher value of angle indicates a more pronounced curvature of the root therefore, wheat germinated faster than guinea corn in microgravity environment.

ACKNOWLEDGEMENT

We are extremely grateful to African Regional Centre for Space Science and Technology Education in English Obafemi Awolowo University Campus, Ile-Ife, Nigeria (ARCSSTE-E). The authors gratefully appreciate ARCSSTE-E, USA supply the 1-D-Clinostat and the authority of St. David's High School, Ile-Ife.
We are also thankful to Dr. Wumi Alabi, the Head of ARCSSTE-E, O. A. U., Ile-Ife Space Education Outreach Program.

EFFECT OF MICROGRAVITY ON THE GROWTH RATE OF OKRA SEEDLING ROOTS

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Abstract

The experiment is aimed at investigating the effect of microgravity on the growth rate and curvature of growing okra seedling using a simulated microgravity environment which is a clinostat.
Some attempts have been made by various space scientists and the results showed that some plants could successfully grow in microgravity. However there will be variations: notably, there were reduction in yields and delayed development.
Could this be replicated using a clinostat and will there be a significant effect on the growth of the plants compared to those in 1g?
To find out we used a clinostat to stimulate microgravity condition. Okra seeds were used during the investigation and necessary conditions for quick germination of seeds were fulfilled.
The result shows clinostat triggers the same changes that occur when plants are in microgravity of Earth orbit, and would occur during transit to the Moon, Mars and any other first four planets in the Solar System.

Introduction

In the nearest future, space travel would require astronauts to grow their own food due to long time duration of their missions, there will also be the need to supplement food consumed by people on earth due to increase in population. Research in improving plants growth rate and yield as well as their behaviour when under different gravitational conditions will be of great interest to the scientists.
The experiment is aimed at providing space researchers with the opportunity to grow okra in space. The experiment was performed under stimulated microgravity conditions. However, similar experiments have been performed in real microgravity in space using various plants: the results came out with variations in the duration of growth and yield. It takes longer time to grow and reduction in yield when one grows in space. This experiment is to provide additional information and a way of discovering improved method in microgravity.

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Procedure

The okra seeds were soaked in tap water on the first day and taken out for planting after 24 hours. Four petri dishes were prepared to contain the substrate on which the seeds will be planted. The substrate used is Agar-agar and nine seeds were planted in each petri dish. Each petri dish was closed up to 75% with parafilm to allow air passage. We arranged the petri dishes in in the petri dish holder and put them in the wet chamber. The temperature and the relative humidity of thea wet chamber were recorded.
After 24 hours, we opened the wet chamber, recorded the temperature, the relative humidity and brought out the seeds to carry out the investigation.
We took three comparable petri dishes : the first at 1g control, the second at 90 degrees turned and the third mounted on the clinostat with double-sided tape. For each of the samples snapshots were taken at 0 minutes, 30 minutes, 1 hour, 1hour 30 minutes and 2 hours. Measurement of root lengths and angles were done using Image J while analysis was done with Microsoft Excel.

Results

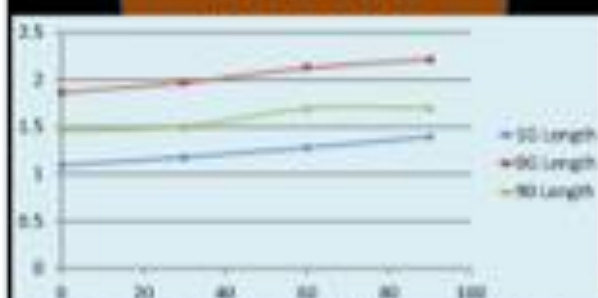


Figure 1: Growth rate okra root at various conditions

Figure 2: the length of okra root at 30 min interval.

Results

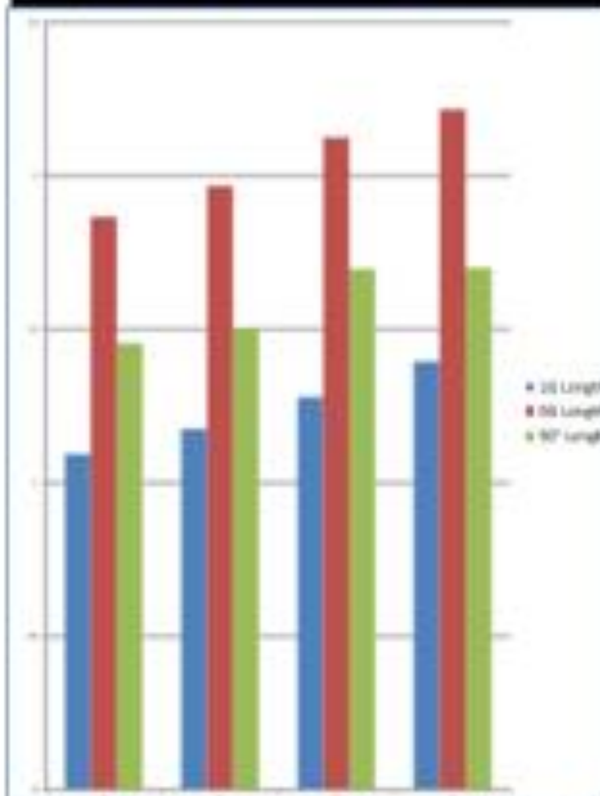


Figure 3: Relative growth rates of Okra roots at different conditions.

In Figure 1 the graph shows the growth of the okra roots at various conditions. That is, when the seedling is under gravity, at 90 degrees turn and microgravity. Looking at the 1G and 0G lengths, the lines joining the graph plots are almost linear. This shows increase in the lengths of the roots as the time increases.
In Figure 2, the composite bar chat shows the length of the okra roots at thirty minutes interval for each of the three conditions represented by the three colours. As indicated by the red portions of the bars, there seem to be high rate of growth at micro gravity compared to those of gravity and 90 degrees turn.
In figure 3, the multiple bar chart shows the relative growth rates of okra roots at different conditions as shown by the colours. It can again be seen that the red bars representing the root lengths at microgravity are the longest as opposed to those under gravity which the shortest root lengths.

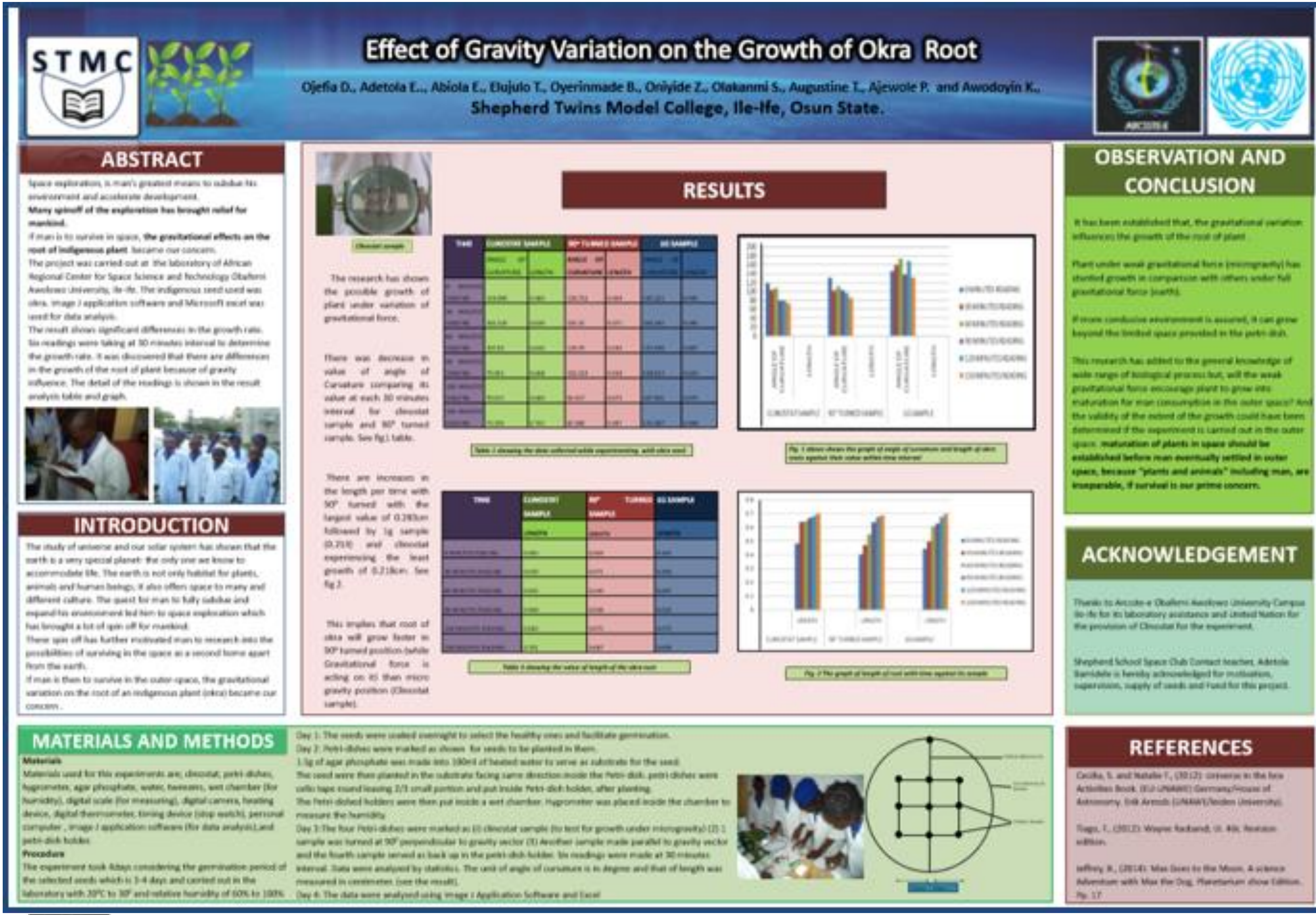
Conclusion

The growth of okra seed roots were noted at various conditions and their responses were noted. At 1G, the okra roots grew on a straight line in the direction of gravity thereby making it positively gravitropic.
At 90 degrees turns, the roots responded to gravity by curving in the direction of gravity and even curved the more as the time increased.
Normally, roots grow in the direction of gravity but at microgravity where the influence of gravity is very low, the roots did not grow in the direction of gravity. Hence, okra seeds can grow in microgravity.
As shown by the results in this experiment, the okra seed roots grew longer at microgravity than those under gravity. This means that there is really no hindrance to growing roots in microgravity.
The findings of this experiment further boosts the possibility and chances of cultivating food plants in space and even on other planets like Mars and Venus.

For further research works, the following questions need to be asked:
i. What are the factors that influence the direction of root growth in microgravity?
ii. Will the roots later skew and curve like those growing under gravity?

Acknowledgement

1. We would like to acknowledge the support from the **ARCSSTE-E, OAU Campus, Ile-Ife, Nigeria**.
2. In addition, this project would not have been successful without the support from **The United Nations Office for Outerspace Affairs**



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THE EFFECT OF MICRO GRAVITY ON THE GERMINATION OF MILLET SEED

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ABSTRACT

Zero gravity instrument project is to promote space education and research in microgravity. It helps students especially geographers in studying the world beyond outer space.

The question that first came to mind in the course of the project is that "can microgravity be stimulated in the laboratory on earth?" Other question that follows include: can researchers solve the problem of feeding for the Astronauts and other inhabitants of the outer space? The project helps to gather and solve the presumption hypothesis stated above.

The image j was used for the analysis of the growth rate and root curvature of the millet seeds. Bar chart was used to interpret the result. From the chart, the clinorotated was increasing as the 90° turned sample was decreasing for the growth rate while both clinorotated and 1g control sample were increasing for root curvature.

The project recommends that plant should be grown in space to provide food for the inhabitants of the space.

INTRODUCTION

This project gives insight to what people thought will never happen in years to come, things like: how can microgravity be simulated on earth, how can the problem of feeding be solved for those living in space, can plants be grown in space? These things have never been thought possible.

Clinostat is a device used to simulate microgravity on earth and can be used to grow plant/ crop under microgravity in the laboratory by following some basic principles and protocols. The clinostat cancel out the effect of gravity in all direction. The plant under normal condition will respond to light, temperature, gravity, pressure and water.

PROCEDURE

The apparatus or instruments used during the experiment includes, Clinostat, petri dishes, Parafilm tape, double-sided sticky tape, beaker, weighing balance, hygrometer, wet chamber, agar-agar substrate, heating source, magnetic stirrer. The reference line was drawn on the petri dish which indicates the gravity-vector line, the petri dish mass was measured, then it was used to measure 1.5g of Agar-Agar substrate and was poured into 100ml of water, the solution was heated on the heating source. A magnetic stirrer was dropped into the solution to avoid lumps, after which the solution was poured equally into the petri dishes and was allowed to cool for sometime.

The millet seeds were then planted with their micropyle facing one direction, after the vapour had been tapped out, petri dishes were covered and sealed with parafilm tape.

Note: The seed must not be too big or too small. The petri dishes were arranged in the petri dish holder and were placed into the wet chamber with an hygrometer and left for 30 – 40hours. The petri dish holders were removed from the chamber. The petri dish for the clinorotated sample was mounted on the clinostat. The speed was set into 10rpm. Pictures were taken at interval of 30 minutes.

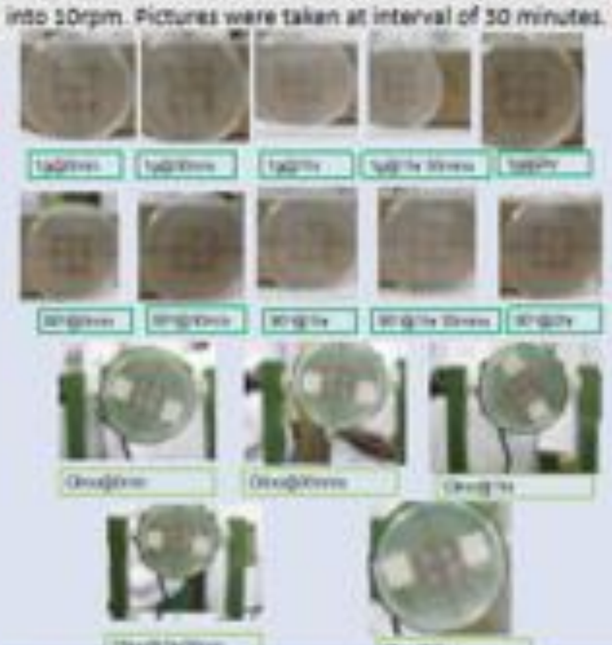

Fig1.0 IMAGES OF THE OBSERVATIONS OF 1G AND 90° TURNED SAMPLES

Table 1: Root Growth Observation

Petridishes	Time	Root Curvature	Growth Rate
Clinorotated	0 min	126.830	1.550
	30 min	132.480	1.953
	1 hour	135.215	2.199
	1hr 30 min	138.440	2.224
	2hrs	150.470	2.275
90° turned	0 min	126.830	
	30 min	124.830	
	1 hour	123.796	
	1 hr 30 min	121.873	
	2 hrs	118.327	
1g	0 min		1.550
	30 min		1.640
	1 hour		1.664
	1 hr 30 mins		1.708
	2 hrs		1.718

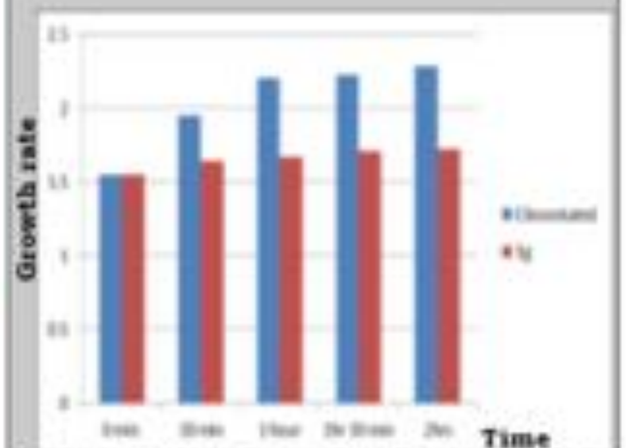

Fig 1.1The Bar chart Showing Growth Rate against Time

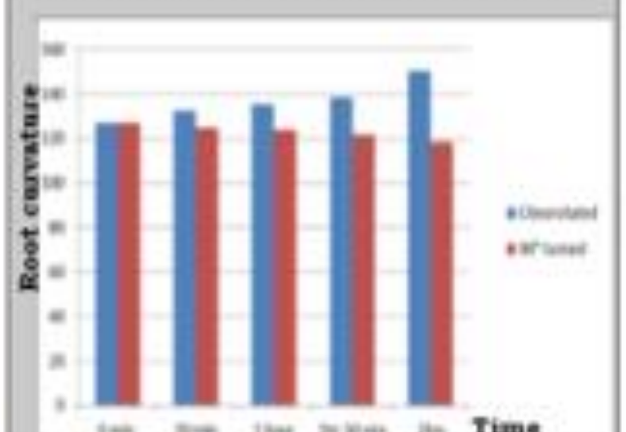

Fig 1.2. Bar Chart Showing Root Curvature Against Time

OBSERVATION

In fig 1.2, it was observed that angle of curvature formed in 90° turned samples decreased with time while angle of curvature formed in the clinorotated sample increased with change in time. For the growth rate, fig 1.1 showed that 1g and clinorotated samples increased with change in time.

RECOMMENDATION

Since the result was positive i.e plants grow in microgravity simulating environment, it can be recommended that plants/crops should be grown in the space.

ACKNOWLEDGEMENT

We thank God Almighty for making it possible for the completion of this project.

We appreciate the principal of our school for granting us the opportunity to partake in this competition.

We also thank our teachers who has participated in one way or the other for the success of this project, The Zero Gravity Instrument Project Management for allowing us to partake in the competition and for the help rendered during the course of the project.

We also extend our profound gratitude to the African Regional Centre for Space Science Technology Education in English (ARCSSTE-E), United Nation and the international cooperation in human space flight.

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- Sammy Anih, (2014) Microgravity Experiment Using PowerPoint *ARCSSTE-E, OAU Campus, Ile-Ife, Nigeria*.

Poster Competition

- The students presented their study in a Poster Competition in November 2014.
- The poster competition was evaluated by university professors and other eminent scientists. These role models encouraged the young aspiring scientists by their presence as they assessed their work and provided valuable feedbacks to the youngsters during the Poster Competition.
- Winners of the competition were awarded prizes.

Grading of Poster Competition

African Regional Centre for Space Science & Technology Education-English
(AFFILIATED WITH THE UNITED NATIONS)
Obafemi Awolowo University Campus, Ile-Ife, Nigeria

UN- Zero Gravity Instrument Project
Promoting Space Education and Research in Microgravity

Result for the Poster Competition

Instructions: Please rank the schools according to the grading criteria indicated on the following pages and indicate the total scores in the table below. Thank you

Position	Name of School	Total Score
7th	Islamic College, Osogbo	74.37%
2nd	Love and Joy Secondary School, Ilesa	77.70%
5th	Progress Comprehensive High School, Modakeke-Ife	76.06%
4th	Shepherd Twins Model College, Ile-Ife	76.74%
3rd	St David's High School, Ile-Ife	77.47%
6th	Sunshine Nursery and Primary School, Ile-Ife	75.36%
1st	Unique Minds International College, Ile-Ife	78.17%

African Regional Centre for Space Science & Technology Education-English
(AFFILIATED WITH THE UNITED NATIONS)
Obafemi Awolowo University Campus, Ile-Ife, Nigeria

UN- Zero Gravity Instrument Project
Promoting Space Education and Research in Microgravity

Award Rubric for Poster Competition

Sunshine Nursery and Primary School, Ile-Ife

S/N	Grading Criteria	Total Mark Obtainable	Mark Obtained	Total Score
1.	**Appearance:**			
	➢ Station Keeping	5	4	
	➢ Dressing	2	1½	
	➢ Organization	3	3	8½
2.	**Poster Content:**			
	➢ Originality	2	2	
	➢ Title	2	2	
	➢ Abstract	8	6	
	➢ Introduction	3	2	
	➢ Method/Procedure	5	3	
	➢ Result	10	8	
	➢ Discussion	5	4	
	➢ Conclusion	3	2	
	➢ References	2	1	30
3.	**Presentation**			
	➢ Knowledge	10	8	
	➢ Logical Flow	4	3	
	➢ Team Work	2	1½	
	➢ Confidence	2	1½	
	➢ Grammar	2	1½	15½
4.	**Poster Design**			
	➢ Layout	2	2	
	➢ Demonstration of Clarity and Organization	2	2	
	➢ Fonts	2	2	
	➢ Color Scheme	2	1½	
	➢ Aesthetics	2	1½	9
	Total Score			63

Analysis of the Results

- The scientific accuracy of the results of the laboratory activities cannot be guaranteed.
- It was observed that 71% of the local seeds analyzed germinated faster under microgravity conditions

➢ Most of the Seeds analyzed germinated faster under microgravity conditions

SN	Local Seed	Normal Gravity Condition Growth Rate (cm/hour)	Micro Gravity Condition Growth Rate (cm/hour)
1	Beans	0.230	0.091
2	Guinea Corn/ Sorghum	0.100	0.530
3	Maize	0.198	0.301
4	Millet	0.201	0.541
5	Okra	**0.101** | 0.111 | **0.202**	**0.087** | 0.175 | **0.287**
6	Rice	0.085	0.700
7	Wheat	0.153	0.172

Winners of the Poster Competition

1st Unique Minds International College
2nd Love and Joy Secondary School, Ilesa
3rd St David's High School, Ile-Ife

Gift item: Each participant received a branded Backpack (School Bag with Inscription)

Contents lists available at

Journal of Environmental Management and Safety

Journal homepage: www.cepajournal.com

A STUDY OF THE EFFECT OF MICROGRAVITY ON GERMINATION OF MILLET SEED(PENNISETUM GLAUCAM)
(Zero Gravity Instrument Project- ZGIP)

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ABSTRACT

This paper focused at studying the world beyond the outer space. Thus, plants grow through light stimulus and effect of gravity had been neutralized by clinostat in order to create microgravity environment. Microgravity environment will make plant respond to light stimulus, through this plant will grow faster. These are the reasons for faster germination in microgravity environment. It is on this note that this study therefore aims to empirically examine, (i.e. main aim) using the clinostat, how plant seeds, small organisms or small samples from material sciences react to simulated microgravity conditions with a view to promote space education and research in microgravity.

ZGIP Project Evaluation

An evaluation of the ZGIP through an oral interview session with the students and teachers was conducted on July 7, 2015

- An evaluation was via oral interview session with the students and teachers
- The project promoted the interest of the participants in the sciences especially in Plant Science, Biology, and Space Science
- This innovative scheme improved their interactive skills and ability to work together as a team
- The interactive mode of instruction employed in the laboratory sessions inspired some teachers to change their method of teaching
- The ZGIP provided a positive educational exposure to a space laboratory environment that many of the students would never have experienced.
- Created the spirit of research in some students, and motivated some to decide to study courses related to space science and exploration

Recommended Potential Improvements in the Implementation of the Project can be Achieved through:

1. Design and Development of Homemade Clinostats for microgravity studies;
2. This would provide opportunities for more students and teachers in Africa to conduct experiments in the different strata of gravity (from low-gravity to microgravity), and in different geographic regions
3. Collaboration between ARCSSTEE and the international community can facilitate the provision of blueprints and built instructions for ‘home-made’ Clinostats
4. Internet-based user platform where educators can share and discuss operational, educational and engineering/technical information.

Conclusion

- Enthusiasm displayed by the students
- Favourable responses recorded during oral interview
- The informal Education & Catch-them-Young approach can be used to:
  - Cultivate Scientific skills among school children
  - Motivate them to develop interest in Space Science & Technology
- Collaboration to design and develop ‘Home-made” Clinostats

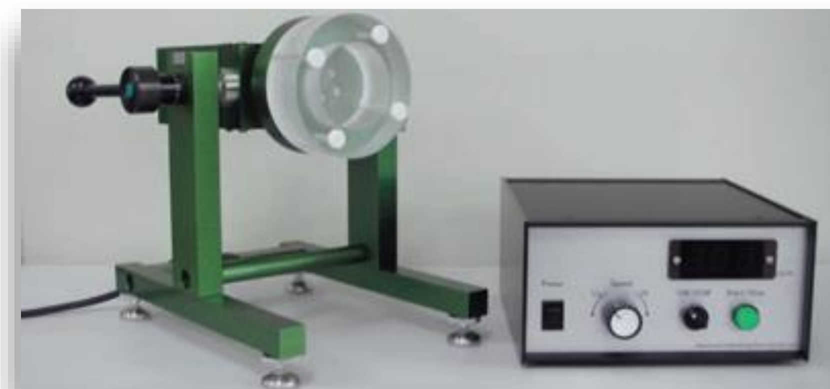
  for microgravity studies.

  will lead to increase participation across Africa.

Acknowledgements

- UN-OOSA, for making the Clinostat available for the project
- ZGIP team of ARCSSTEE; students and teachers from all the participating schools; and university professors and other eminent scientists who evaluated the poster presentation.

ZGIP Team of ARCSSTE-E



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