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The Effect of Gravity Variation on the Growth of Okra Root

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ABSTRACT

Space exploration is man's greatest means to subdue his environment and accelerate development. Many spinoff of the exploration has brought relief for mankind. If man is to survive in space, the gravitational effects on the root of indigenous plants became our concern. The project was carried out at the laboratory of African Regional Center for Space Science and Technology Obafemi Awolowo University, Ile-Ife. The indigenous seed used was okra. Image J application software and Microsoft excel was used for data analysis. Six readings were taking at 30 minutes interval to determine the growth rate. The research has shown the possible growth of plant under variation of gravitational force. There was decrease in the value of angle of Curvature comparing its value at each 30 minutes interval for clinostat sample and 90^0 turned sample. There are increases in the length per time with 90^0 turned with the largest value of 0.283cm followed by 1g sample (0.253) and clinostat experiencing the least growth of 0.218cm. This implies that the root of okra will grow faster in 90^0 turned position (while Gravitational force is acting on it) than micro gravity position (Clinostat sample). It was discovered that there are differences in the growth of the root of plants because of gravity influence. It has been practically established that the gravitational variation influences the growth of the root of plant. Plant under weak gravitational force (micro gravity) has stunted growth in comparison with others under full gravitational force (earth).

INTRODUCTION

Future missions to the Moon and Mars, involving long-term stays in space, rely on a life support system for food production and regeneration of resources. As identified through MELiSSA (Micro-Ecological life Support System Alternative), such Closed Regenerative Life Support Systems (CRLSS) need to include a compartment for the production of higher plants (Godia et al, 2002, Godia et al, 2004, Hendrickx et al., 2006, Paradiso et al, 2014, Kiss, 2014). Through CO_2 absorption and O_2 emission, water purification through transpiration, waste product recycling via mineral nutrition, and as a food source, plants play a key role in CRLSS (Paradiso et al, 2014, Wheeler et al, 2001, Ferl et al, 1993). On the earth, plants are known to adapt to extreme environments, and space experiment have demonstrated that plants are able to grow and reproduce in microgravity (Ivanova et al, 1993, Link et al, 2003, Musgrave et al, 1997, Sychev et al, 2007, Sychev et al, 2008). The first plant materials were materials brought into space in 1960, when seeds of wheat, pea, maize, and onion were flown on board of sputnik 4 (Stankovic, 2000). This was followed by photosynthetic measurements of Chlorella and the duckweed Spirodela (Ward et al, 1970) and with wheat seedlings and pepper plants on Biosatellite 11 (Johnson and TLbbitts, 1968). Since then, a number of experiments have been successfully performed in a spacecraft, and a full life cycle of Arabidopsis thailiana has been completed on Salyut-7 (Merkys et al, 1984). The extensive effort and resource allocated to plant cultivation in space have revealed many answers, and also raised new research questions, especially with regard to food plants. Knowledge about the long term effects of the space environment on plant growth and development is essential for the design of a dependable CRLSS for space exploration beyond low Earth Orbit (LEO).

A plant must be of the proper size and form to perform efficient physiological and biochemical process. The regulation of growth for size of and morphogenesis for form, thus, is very important for plant life. Because the form of the whole plant reflects the sum of the rates and directions of growth for different parts, the growth and morphogenesis are tightly associated with each other. Plant growth and morphogenesis are fundamentally regulated by a genetic program, as is the case in animals. However, plants are also surrounded by a great variety of environmental signals, such as light, gravity, temperature, and water, which strongly influence their process of growth and morphogenesis. Gravity is unique among these environmental signals, in that it is always present in a constant direction and magnitude on earth. Plants have utilized gravity as the most stable and reliable signal for their survival over the course of evolution (Takayuki, 2014).

The study of the universe and our solar system has shown that the earth is a very special planet- the only one we know to accommodate life. The earth is not only the habitat for plants, animals and human beings; it also offers space to many and different culture. The quest for man to fully subdue and expand his environment led him to space exploration which has brought a lot of spin off for mankind. These spin off has further motivated man to research into the possibilities of surviving in space as a second home apart from the earth. If man is then to survive in the outer-space, the gravitational variation on the root of an indigenous plant (okra) became our concern.

The gravitational force on the moon is about six times weaker than the one on Earth (Jeffrey, 2014).These variations necessitate the need to examine how the root of an indigenous plant will behave under a “weak” gravitational field stimulated by a clinostat device in a laboratory. A clinostat is a device used to minimize the effect of gravity by equalizing the gravitational vector around the horizontal axis.

The study focused on the growth of an indigenous plant (okra) under various gravity conditions with reference to the microgravity environment of outer space. The biological material used for the study was okra seed. Okra seed was selected for the study because of the nutritional benefit (i.e. it is a good source of vitamin A). Furthermore, the size of seed and the short germination period were considered for the selection. The rationale for this experiment is to see how this plant will behave under microgravity environment if man is to successfully live in space, since man and plant will need to cohabit for survival.

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MATERIALS AND METHODS

The selected okra seeds were soaked for a period of 23 hours in order to hasten the process of germination. Thereafter, 36 healthy seeds were handpicked into four Petri-dishes. 1.5g of agar-agar phosphate was added to 100ml of boiled tap water to make solution and serve as substrate for the planting. After planting, the Petri-dishes were covered and sealed with parafilm at 2/3 of the surface along its circumference such that they can extract water from the outer environment as well as oxygen. They were then arranged vertically in the direction of gravity in the Petri-dish holder.

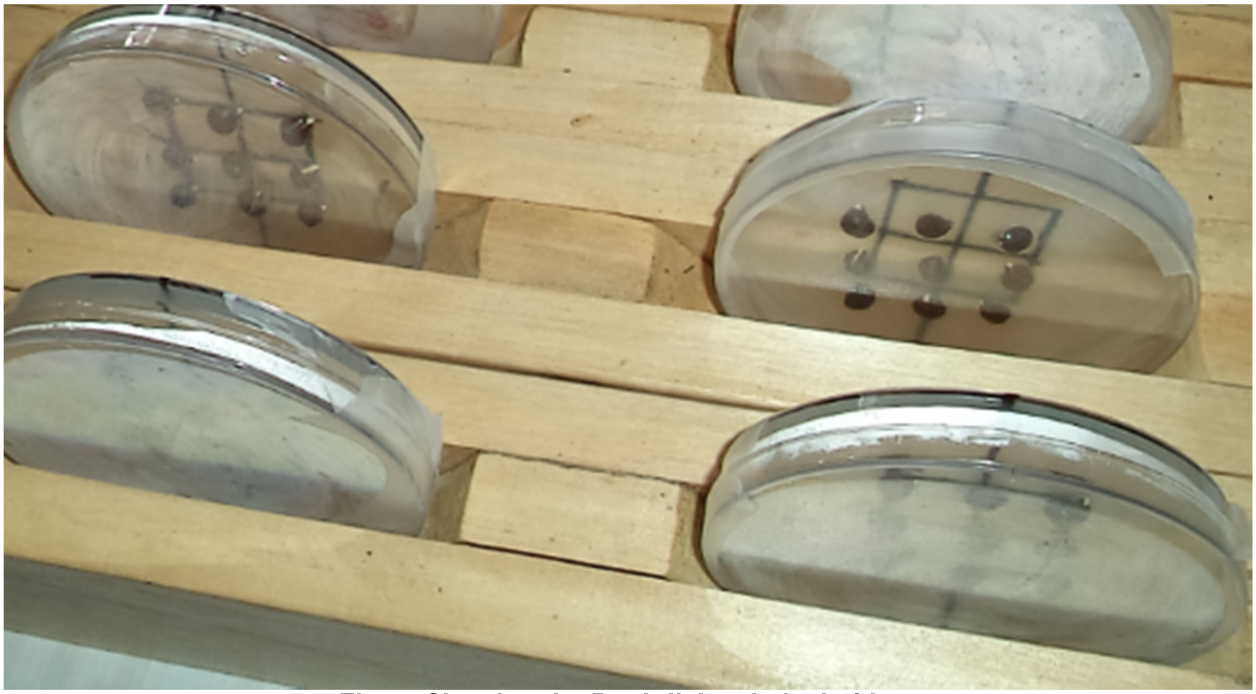


Fig. 1: Showing the Petri-dishes in its holders

Afterward, the Petri-dish holders were placed in the wet chamber at initial room temperature of 27.9^0C and a relative humidity of 66%. After a period of 23hours, the room temperature increases to 28^0C and a relative humidity increases to 73%. Immediately after removal from the wet chamber, the dishes were arranged as follows for observation:

- Clinostat sample was mounted on the clinostat with double sided cerotype.
- 90^0 turned sample was turned perpendicular to the gravity vector.
- 1g sample was made parallel to gravity vector.
- Back up sample was kept on the Petri-dish holder.

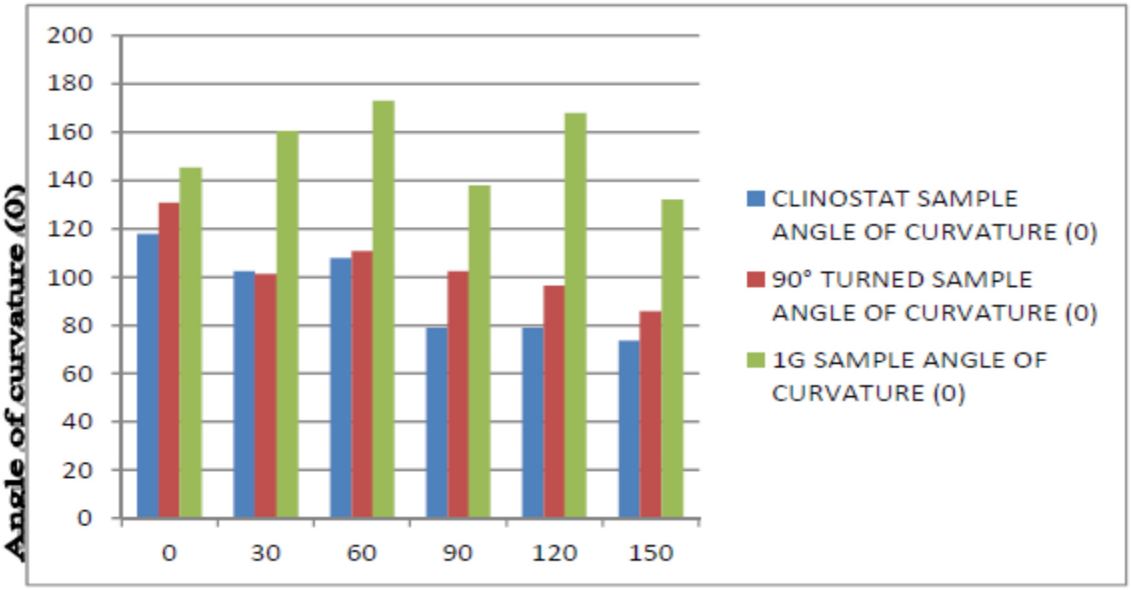
Readings were collected on the three samples respectively (clinostat, 90^0 turned and 1g sample). The initial reading was tagged 0 minute; four consecutive readings were then made at 30 minutes interval with the clinostat revolving at 20 revolutions per minute.

RESULTS

Table 1: Showing the angle of curvature of the data collected

TIME (MINUTE)	CLINOSTAT SAMPLE	90° TURNED SAMPLE	1G SAMPLE
	ANGLE OF CURVATURE (^{0})	ANGLE OF CURVATURE (^{0})	ANGLE OF CURVATURE (^{0})
0	118.009	130.732	145.321
30	102.529	101.31	160.345
60	107.83	110.76	172.948
90	79.061	102.529	138.013
120	79.011	96.417	167.905
150	73.596	85.988	131.987

NB: The real readings were generated as follows:
Angle: The computer generated angle of curvature was deducted from 180^0 to have our real angle of curvature



V
Time (Minutes)

Fig 2: Shows the graph of angle of curvature of okra root against their value within time interval.

Table 2: Showing the value of length, change in length and growth rate of the okra root

TIME(MINUTES)	CLINOSTAT SAMPLE			90° TURNED SAMPLE			1G SAMPLE		
	L (cm)	L△(cm)	GR	L (cm)	△L (cm)	GR	L (cm)	△L (cm)	GR
0	0.483			0.404			0.445		
30	0.639	0.156	0.0052	0.471	0.067	0.0022	0.496	0.051	0.0017
60	0.645	0.006	0.0002	0.549	0.068	0.0022	0.607	0.111	0.0037
90	0.668	0.021	0.0001	0.638	0.089	0.0029	0.629	0.022	0.0007
120	0.683	0.015	0.0005	0.675	0.037	0.0012	0.675	0.046	0.0015
150	0.701	0.018	0.0006	0.687	0.012	0.0004	0.698	0.023	0.0007

NOTE:

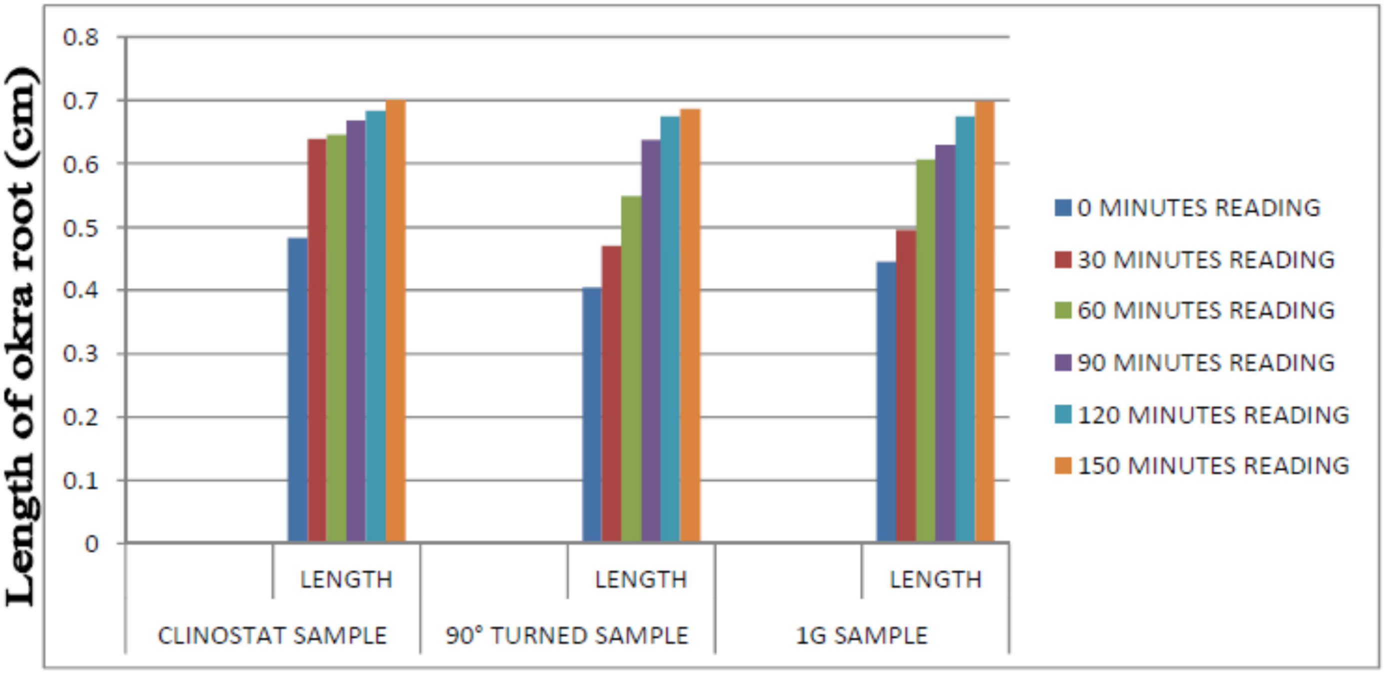
L (cm) – Length (The same length as our computer generated value is our real length)
△ L (cm) – Change in length

$$\text{GR – Growth Rate} = \frac{\text{Change in Length}}{\text{30 minutes interval}}$$

Table 3: Showing the value of Average growth rate of the three samples taken

CLINOSTAT SAMPLE	90^0 TURNED SAMPLE	1G SAMPLE
0.0014	0.0017	0.0016

$$\text{Average Growth Rate} = \frac{\text{Total sum Growth Rate}}{5}$$



The three samples
Fig 3: The Graph of Length of Root with Value against time.

DISCUSSION AND CONCLUSION

The result had shown the increase in the length per time with 90^0 turned sample experiencing the largest average growth rate(0.0017), followed by 1g sample experiencing average growth rate of 0.0016 while clinostat sample, the least average growth rate of 0.0014. This implies that okra seed will grow faster in 90^0 turned position (while gravitational force is acting on it) than in microgravity position (clinostat sample).

It has been practically established that the gravitational variation influences the growth of the root of plants. Plants under weak gravitational force (micro gravity) have stunted growth in comparison with others under full gravitational force (earth). (See table 2).

Although, this research has added to the general knowledge of a wide range of biological process but, can weak gravitational force environment encourage plant to grow into fruit bearing stage?

The project had been an interesting exposure of pupils to data collection and analysis using an open application software image J application software (Teachers Guide, 2012). With our first time of using clinostat device, the pupils interest in science has been motivated the more than before they had the opportunity of handling this instrument.

The extent of the growth could have been determined supposing the experiment was carried out in the outer space directly. Since plants and animals are inseparable from coexisting, maturation of plants in outer space should be established if man is to fully survive there. For future zero-gravity projects, the clinostat device should be provided to individual schools participating in the project.

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