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Automated okra (*Abelmoschus esculentus*) seed germinator using Arduino Uno R3

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Abstract

This study was carried out with the aim of utilizing the Arduino UNO R3 in seed germination. Seed germination is the process by which seeds emerge from their dormant state. Germination is the first stage of a plant's life cycle, and it is also the most difficult to maintain and care for. The researchers aimed to develop an automated okra seed germinator that could reduce the following factors: soil moisture, temperature, humidity, and light, all of which affect seed germination, concentrating on soil moisture, which has a significant impact on seed performance. The main materials required for this study are an Arduino UNO R3, a soil moisture sensor, a servo motor, an LCD, and okra seeds. For the other components to function properly, code was uploaded to the Arduino UNO R3. Two setups were observed: setup A received treatment, while Setup B did not receive any treatment. Within 15 days, the experiment was conducted entirely through observation. Based on the findings, using an Arduino UNO R3 to germinate okra seeds yielded no significant difference between the germination duration of the seeds germinated by the prototype and the manual method. However, the experiment showed 55% and 35% germination percentages respectively. Further, the germination percentage of the okra seeds grown by the prototype is higher than the germination percentage of the okra seeds grown manually Thus, the researchers recommend experimenting with different vegetable seeds if varying environmental needs. to widen the use of the automated okra seed germinator thereby upgrading it into an automated vegetable seed germinator.

Keywords: seed germination, Arduino UNO R3, automated okra seed germinator, germination percentage, germination duration

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1. Introduction

Prior to COVID-19, backyard gardening was a thriving activity. People of all ages find joy and fulfillment in it as a hobby and a source of income. According to Ossola (2022), there has been a global increase in the appearance of plants, such as vegetables, flowers, and herbs, in neighborhoods and on balconies during the pandemic's onslaught when the flow of income is at its lowest. People have grown to appreciate the value of self-sustaining activities, and vegetable gardening is no exception. When it comes to cultivating vegetables, starting from seeds is preferable. Seeds provide adaptability over the plant's growth as well as being less costly than purchasing mature plants. A person can opt to raise them organically or experiment with different varieties. Starting from seeds, on the other hand, necessitates their effective germination. This is the stage that most gardeners, especially novices, struggle with.

It is challenging for seeds to start sprouting when they are germinating due to several variables. The temperature and soil moisture have an inversely proportional relationship; as the temperature rises, soil moisture falls. A warmer environment may cause more evaporation and less moisture, which would be detrimental to seed germination (Dove, 2010). This is why it is preferable to germinate seeds at a specific time of year so that the environment is favorable for them to sprout and flourish. However, using the seed germinator, concerns such as the weather will be lessened since the device will maintain the soil's optimum moisture content. The optimal circumstances for growth are sought after by seeds by keeping an eye on their surroundings; each type of seed needs a certain habitat to develop. Furthermore, Stivers (2017) asserts that the seed will begin to germinate when it determines that the soil's moisture level satisfies its requirements. Overly humid or moist soil will cause the seed to decay and prevent it from developing. Soil with a low moisture percentage, on the other hand, may cause the seed to dry up, interfering with its natural function and growth. In addition to moisture, oxygen also plays a significant role in the development of seeds. If the soil gets sodden with water, whereby oxygen is unable to penetrate the soil, both the percentage of germination and the duration of the procedure will be affected (Yasin & Andreasen, 2016). The amount of sunshine that seeds receive has an impact on them as well because some seeds require a specific amount of light. "The light requirement of such seed operates as a mechanism that governs where and when germination takes place and is crucial for the survival of the plant species in question because it prevents stored seed stores from being depleted," says Smith (Motsa et al., 2015). Some seeds sprout equally well in light and darkness, while others grow better in only light or darkness (Chanyenga et al., 2012).

Given the challenges of germination, the researchers intend to use an Arduino UNO to construct a vegetable seed germinator that can regulate the amount of light and moisture it needs to grow. Furthermore, the researchers intend to incorporate a sensor that keeps track of the environmental conditions and surrounding temperature. This is primarily to reduce concern about the factors of germination that vegetable gardeners must deal with, particularly soil moisture percentage and soil temperature.

Statement of the Problem - This study aims to produce an automated seed germinator using Arduino Uno. Specifically, it sought to answer the following questions: (1) How efficient is Arduino Uno R3 in producing a prototype automated okra seed germinator? (2) What is the germination percentage of the seeds grown by the prototype compared to the germination percentage of the seeds grown manually? (3) Does the intervention of the prototype within a limited time affect the following aspects in terms of germination percentage, and germination duration? (4) Is there a significant difference between the seedlings grown by the prototype and seedlings grown manually in terms of germination duration?

Significance of the Study - Through this study, the researchers were able to produce a device that could aid in vegetable production specifically in its early stage, germination. This study provides importance to the following: Community Germinating the seeds is the first phase of most vegetable production. There are a lot of factors that could affect germination mainly, water, temperature, planting depth, nutrients, and pests. As such, individuals who are not familiar with farming are much more prone to failure and may feel overwhelmed to start especially those who want to garden at home. This device automatically regulates the soil's moisture making planting much simpler and less cornering. To vegetable farmers, there are routines vegetable farmers have to undergo daily to ensure that their crops are growing healthy. This includes cultivating the oil, irrigating, fertilizing the crops, monitoring, and occasionally, performing tasks that prevent pests and insects from invading the produce. On a small scale, the workload might still be manageable but in a larger case, it can prove to be exhausting. Additionally, farmers also need to monitor the seedlings they have to sow for the next cropping. This device hopes to lessen the labor farmers need to expend. This study would assist future researchers that aim to explore a similar topic and serve as a reference in conducting their study. Fellow researchers can use this study as a basis to innovate and improve products that will help the agricultural industry.

Scope and Delimitation of the Study **-** This study focused on producing an automated vegetable seed germinator using Arduino as an aid in the early stage of vegetable production, and germination. The priority of this project is to help farmers and beginners in vegetable gardening to manage soil moisture. This study does not look at other factors such as fertilizers, planting depth, or pests. The researcher will test the effectiveness of the device through experimentation. The researchers selected the okra seeds out of all the vegetable seeds due to local farmer recommendations and advice since they proliferate and thrive in warm climates. The experiment was completed in only 15 days. The okra seeds purchased by the researchers' provided instructions and information on proper spacing, sowing depth, and even fertilizer functions. This investigatory project was conducted with limited funds for resources and within the time frame of October 2022 until April 2023.

2. Methodology

Research Design **-** This study used applied experimental research that aims to develop an effective device that will help farmers facilitate vegetable production, particularly in its initial stage, germination. A true experimental research design was employed in this study, wherein subjects are assigned randomly and were divided into two groups. In contrast to the control group, which received no intervention, the experimental group was given the variable or treatment. According to Sirisilla (2023), statistical analysis is significant in true experimental research designs because it depends on statistical analysis whether to confirm or refute a researcher's hypothesis. A cause-and-effect relationship between several variables may also only be established via a true experimental design, as opposed to all other types. This design was used by the researchers to accumulate data from a variety of observations and experiments to measure the efficacy of the seed germinator in regulating the percentage of moisture in the soil and monitoring the temperature. It was also used to assess the differences between seedlings grown manually and those grown using a seed germinator.

Data Gathering Procedure **-** Direct observation was used for this experiment. The researchers collected data by experimenting firsthand. Since this was experimental research, the researchers conducted an experiment to see the effect of an automated seed germinator on seed germination and compared it to traditional planting methods. Experimentation and personal observation provided the data used to analyze and interpret the result of the study. The experiment was conducted within 15 days after the seed was sown and intervention was given. The researchers gathered, organized, and analyzed the presented results in order to compare and contrast the two different methods for growing a seed in order to determine the effectiveness of the automated device.

2.1 Research Process; Stage 1 Preparation and Gathering of Materials

The materials required in this experiment were purchased in electrical stores, hardware stores, and online shopping. In order to complete the product, the researchers gathered the most effective materials that allowed the device to operate ideally. These are the following materials that were used in creating an Automated Seed Germinator Using Arduino R3:

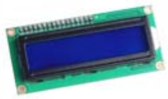
Figure 1: Arduino Uno R3

https://store.fut-electronics.com/products/arduino-uno-r3-latest-revision-clone

Figure 2: Moisture Sensor

https://www.indiamart.com/proddetail/okra-seeds-13675448262.html

Figure 3: LCD



https://circuit.rocks/lcd-i2c-1602-display-module-blue-backlight.html

Figure 4: Breadboard

https://ph.element14.com/twin-industries/tw-e40-510/breadboard-solderless-400-tie/dp/1994456

Figure 5: Jumper wires

https://store.arduino.cc/collections/cables-wires-Lock.html

Figure 6: Servo Motor

https://www.packware.com.au/products/rectangle-plastic-storage-containers-natural-500ml-genfac

Figure 7: 1 kΩ resistor

https://img.dxcdn.com/productimages/sku_426887_3.jpg

Figure 8: Seed tray

https://cdn.greenhousepeople.co.uk/images/products/original/seed-tray.jpg

Figure 9: Okra seeds

https://www.indiamart.com/proddetail/okra-seeds-13675448262.html

Figure 10: Water container

https://indoplasphil.com/wp-content/uploads/2020/12/2f96fc9399c164bbe48b8450a44fe1f0.jpg

Figure 11: Aluminum Pan

https://dovsbythecase.com/wp-content/uploads/2013/12/74kugel.jpg

Figure 12. Power bank

https://www.amazon.com/Portable-36800mAh-Tri-Outport-External-Compatible/dp/B0936GZ7H3?th=1

Figure 13. Tube/Hose

https://www.n30.com.sg/others/937-up-aqua-black-silicon-air-tube-a618b-per-meter.html#.ZGCYg3ZBzcc

Figure 14. Soil

https://d2gg9evh47fn9z.cloudfront.net/800px_COLOURBOX4360743.jpg

The materials above were purchased by the researchers online at a cost of approximately P2,000.

2.2 Stage 2: Construction and Development of the Project

For the main body of the prototype, jumper wires were connected to the Arduino components and inserted into their designated pins in a breadboard that is connected to the motherboard. The Initial code that to operate the prototype was programmed in an IDE. Combine the device with the seed tray of the experimental setup. The moisture sensor was placed in the middle of the tray approximately 2.5 cm deep into the soil. After multiple trials, it was determined that the ideal moisture value of the soil to ensure germination was between 290 – 330, values lower than 290 are observed to be too moist for growth while values greater than 310 do not provide enough moisture for the seed to trigger germination. Once all necessary data has been obtained, the coding of the program was completed in the Arduino IDE and uploaded to the motherboard. The Arduino motherboard was then connected to a 5V outlet of a power bank as a power source. Trials were conducted to observe whether the prototype functions according to its program. If not, check the inputted code for errors.

Figure 15. Actual Product of Automated Okra (Abelmoschus esculentus) seed germinator using Arduino Uno R3

2.3 Stage 3: Experimental Stage, Observation and Data Recording

Twenty samples of seeds were chosen for each setup. Each container is filled with approximately the same amount of soil from the same source. No fertilizers were added to the soil to avoid interference with the data. Furthermore, since seeds only require water and light in their early stage of germination, the presence of fertilizers before the seeds have sprouted is not recommended and may reduce the rate of germination. Once, a sprout has emerged from the soil can a fertilizer only be added to avoid lanky and tall stems however this will not be implanted in this experiment. The seeds are then sown directly into each container. One container is given treatment through the implementation of the prototype and is labeled setup A. The other is not given treatment and is labeled setup B. Data was gathered through observation of the two groups. The researchers conducted a 15-day observation to record the device's performance in germinating vegetable seeds and compare the results of seedlings grown with the device to those grown traditionally. Direct observation was used to collect data firsthand. Progress of germination on each setup was recorded daily. All relevant data such as the number of days setup A was subjected to the prototype and seeds that germinated each day as well as germination percentage at the end of the experimentation was collected. The device and each of its components were monitored to check for malfunction.

Statistical Treatment of the Data - This study used a t-test analysis of variance to compare the difference between the germination percentage and germination duration of the experimental and control group. A t-test is a statistical tool that was used to compare the means of two groups. It is often used in hypothesis testing to determine whether a process or treatment actually has an effect on the population of interest, or whether two groups are different from one another. Additionally, regression correlation was used to determine the relationship between the duration of intervention and the germination percentage and duration of the experimental group. Regression was a statistical method that attempts to determine the strength and character of the relationship between one dependent variable (usually denoted by Y) and a series of other variables (known as independent variables).

3. Results and Discussions

Table 1

Distribution of the germination percentage of setup A and setup B.

	No. of seeds planted	No. of seeds germinated	Percentage
Setup A	20	11	55%
Setup B	20	7	35%

Table 1 shows the result after 15 days of experimentation, 55% and 35% of the seeds in setup A and setup B respectively succeeded in germination. That is, with intervention from the prototype, for every two seeds sown, one is guaranteed successful germination. While, without intervention, for every two seeds, there is a chance one seed germinates successfully. It is evident that the germination percentage of seeds grown by the prototype is greater than the seeds grown manually. Thus, the germination percentage of the seeds grown by the prototype is greater than the seeds grown manually. In germinating seeds, a 70 % germination percentage is considered substantial as 100% success is not expected as a germination percentage greater than 50% is acceptable (Hendry, 2019). However, these rates are yielded when seeds are sown in nutrient-rich soil such as those treated with fertilizers. Considering, the experiment was done with only untreated soil, the germination percentage of 55 % is more likely to increase in an on-field application.

Table 2

The summary output of the regression statistics for germination percentage of setup A.

	df	SS	MS	F	Significance F (P-value)	Multiple R
Regression	1	0.5989375	0.5989375	49.89146976	8.49989E-06	0.8906709
Residual	13	0.1560625	0.012004808			
Total	14	0.755				

Legend: P-value < 0.05, reject H0.

Table 2 contains the summary output of the regression statistics between the number of days of intervention of the prototype on setup A and the germination percentage of the seeds. The correlation coefficient r is 0.891 which is greater than 0.70 but less than 0.90 indicates a positive strong relationship. This means that as the duration of the intervention increases, there is a rise in the germination percentage. The computed p-value of the regression is 8.50×10^{-6}. Since the p-value is lower than the significance level of 0.05, the researchers reject the null hypothesis. Therefore, the intervention of the prototype within a limited time does affect the germination percentage of the okra seeds in setup A. In a study conducted by Tania et al. (2020), where four different priming sources were evaluated to determine their effect on okra seed germination, hydro-primming (hot water and normal water) and halopriming suggest better germination and production.

Table 3

The summary output of the regression statistics for germination duration of setup A.

	df	SS	MS	F	Significance F (P-value)	Multiple R
Regression	1	239.575	239.575	49.89146976	8.49989E-06	0.890670928
Residual	13	62.425	4.801923077			
Total	14	302				

Legend: P-value < 0.05, reject H0.

Table 3 contains the summary output of the regression statistics between the number of days of intervention of the prototype on setup A and the duration of the germination of the seeds. The correlation coefficient r is 0.891which is greater than 0.70 but less than 0.90 indicating a positive strong relationship. This means that as the duration of the intervention increases, there is a rise in the germination duration. The computed p-value of the regression shown in Table 5 is 8.50 x 10-6. Since the p-value is lower than the significance level of 0.05, the researchers reject the null hypothesis. Therefore, the intervention of the prototype under a limited time does affect the germination duration of the okra seeds in setup A. The longer duration of germination may be caused by the absence of fertilizer. In a study conducted by Jammu et al. (2017), where they investigate the effect of different types of fertilizer on the germination and seedling growth of sunflowers, a significant difference was shown between the time of germination across four experimental setups; a) urea b) DAP c) manure d) control. The control setup was observed to be the slowest to germinate among all four. Considering the experiment was done without any intervention of fertilizer, the result may not reflect on the field application of the prototype.

Table 4

Distribution of scores between setup A and setup B.

Group	Mean Score	Standard Deviation	Mean Difference	T-value	Critical Value
Setup A	3.55	3.70596958	0	0.9141	2.021
Setup B	3.55	5.124502543			

Table 4 shows the computed t-value for the difference in germination duration between setup A and setup B is 0.9141. The critical value for comparison with df = n – 2, 38, is 2.021. Since the t-value is less than the critical value, the study failed to reject the null hypothesis. Thus, there is no significant difference between grown by the prototype and seedlings grown manually in terms of germination duration. Though the length at which both setups completed germination differs little, the germination percentage of setup A and setup B, as seen in Figure 3, indicates better crop yield when treated with the prototype than manual sowing. The overall results of this study prove that the implementation of technology, especially of Arduino UNO R3, has a great impact on the agricultural sector. Patel and Iliyas (2014) assert that the role and potential agriculture benefits of information technology (IT) are a tool for direct agricultural productivity contribution and an intangible tool for empowering farmers to make accurate and excellent choices that will ultimately have a beneficial influence on how agriculture and related operations are carried out.

In addition, based on the experiment of the researchers, the implantation of Arduino Uno R3 as its main component allows for easier programming, and its affiliated IDE provided a simple and friendly interface that made navigation and completion of the prototype less time-consuming. Pre-experimental trials were conducted to monitor the performance of the prototype before subjecting it to the experiment. The prototype showed no problem in executing the programmed response of rotating the servo that allows the flow of water into the aluminum pan thus increasing moisture of the soil in setup A. Successful display of intended characters in the LCD was also exhibited during the trials. Thus, Arduino Uno R3 is efficient in producing a prototype automated seed germinator. This is further supported by Singla et al. (2019), who proved Arduino UNO R3 is effective in enhancing smart irrigation systems to preserve water resources and optimize agricultural production.

4. Conclusions and Recommendation

Based on the experiment and data gathered by the researchers the following conclusions were drawn: Arduino Uno R3 is efficient in producing a prototype automated okra seed germinator. The germination percentage of the okra seeds grown by the prototype is higher than the germination percentage of the okra seeds grown manually. The intervention of the prototype within a limited time does affect the germination percentage and germination duration of okra seeds. There is no significant difference between the seeds grown by the prototype and seedlings grown manually when it comes to germination duration.

Based on the result of the experiments, the researchers recommend the following: The researchers recommend using other features that can control the temperature and setting parameters in the desired moisture and temperature levels by experimenting with different types of Arduino products that would be useful in formulating a control for the influencing factors which would lead to agricultural improvement and an increasing rate of germination success. The researchers recommend comparing the seeds grown using the prototype with other planting methods. The seed germinator prototype can be given greater value if it grows more efficiently compared to other types of cultivation. The researchers recommend having a longer observational period until each sample has completely germinated rather than a limited observation period. It is also recommended to increase the sample of seeds in each setup to increase the accuracy of the result. The researchers also recommend experimenting with different vegetable seeds if varying environmental needs. to widen the use of the automated okra seed germinator thereby upgrading it into an automated vegetable seed germinator. The researchers recommend that future researchers conduct two or more test runs in order to analyze and differentiate two setups accurately while distinguishing significant differences between seedlings grown by the prototype and seedlings grown manually.

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