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Examination of STEM Education Program Using a Growth Test on Komatsuna

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Abstract This paper examines the Science, Technology, Engineering, and Mathematics (STEM) educational program using various growth tests on Komatsuna. An experiment was conducted to prove a hypothesis, and to determine the effectiveness and benefits of the most suitable soil to grow Komatsuna. The experiment included using 14 compartments with different components of soil mixing wood-based compost. As a result of the analysis and findings, it is proposed that growth tests could be part of the STEM education program. The research proved the hypothesis by conducting tests repeatedly to show the growth of Komatsuna.

Keywords: *STEM Education Program, growth test, Komatsuna, sustainable education*

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1. Introduction

In the United States, STEM comprises Science, Technology, Engineering, and Mathematics. STEM education has been important in expanding the market over the future. Furthermore, with regard to overall engineering education, STEM education includes various aspects of vocational and science education [1,2].

In this study, STEM education was interpreted as follows: "it is a kind of education in order to spread and improve science-technology literacy for all citizens." [3]. Furthermore, it had to be sustainable education from K–12. It was envisaged that STEM education would be promoted among young people and citizens to improve the workforce [4]. The President of the Science and Technology Advisory Committee of the United States submitted a proposal titled "Transformation and Opportunity: The Future of the U.S. Research Enterprise" to the President of the United States [5]. This committee proposed "overall effective towards STEM education were integrated, to develop teaching materials courses to cover."

In the following studies, it was established that STEM education was aimed at fostering scientific thinking in experiential learning. For example, Uchinokura, Ishizaki, Saito, Suwamura, Imamura, Kumano and Nagasu (2014) reviewed and analyzed a learning activity in Iowa, United States [6]. The intention of the learning activity was for children to create an effective filtration device to study the theme of water purification. In addition, they learned about the electrical circuit theory. In this case, it was required of the students to predict the results in order to turn on the light bulb of an electric circuit. In addition, Sumi, Takeno, Shirahama, Cardon and Rae (2016) introduced a practical case that was implemented in a junior high school in Michigan [1]. In this case, a Rube-Goldberg-machine was used as teaching material. In order to make their own Rube-Goldberg-machine, the students designed the machine and tested it repeatedly, to test their hypothesis. In Japan, the Ministry of Education, Culture, Sports, Science and Technology emphasized the importance of students' learning by doing learning activities such as planning, creating, and testing [7].

Though STEM had focused on the theme of protecting the environment, this study also looked at the problem of resource depletion, which is one of the serious environmental issues [8,9]. Chemical fertilizers that had been imported from abroad were used in Japan. It was necessary to, instead, use organic fertilizers for environmental protection because all fossil resources that are made with mineral resources are limited. Furthermore, using organic fertilizers was expected to prompt the circulation of resources. The Japanese Minister of Agriculture, Forestry and Fishes recommended optimizing the amount of fertilizer and recycling, and using biomass resources for conservation of the environment, to Japanese farmers. In addition, the Forestry Agency has promoted the use of woody biomass as a method for efficient resource use [10].

A study of wood-based compost has been conducted before [11,12]. For instance, Takeno (2008) proposed the generation process of composts as environmental teaching material [13]. In his study, composts were made with fallen leaves of Satoyama; there is a close synergy between nature and human beings. Furthermore, the MEXT emphasized the importance of learning spontaneously about conservation of the environment and environmental issues through various activities. Therefore, STEM education is researched by many researchers in Japan.

However, teaching material research in junior high school classes is not enough. From the above, this study focused on technology education in Japanese junior high schools. This is because junior high school Japanese students take technology as a subject. The theme of cultivation is included in this subject. This study examined the STEM educational program using the growth test of a vegetable.

2. Research Method

The purpose of this study is to develop two teaching materials related to STEM. One is a preparation of compost, and the other is a growth test on a vegetable that is used the compost.

2.1. Preparation of Compost

In this study, wood-based composts were made with self-made sawdust. Based on "making compost using fallen leaves", wood-based compost was made [14]. The wood-based composts consisted of sawdust (800g), fallen leaves (2400g), and rice bran (320g) [Table 1]. Making compost used some tools which are cardboard, packing tape, unicycle, saucer, Large scoop, Small scoop, Measuring instruments.

Table 2 shows the work progress of making wood-based composts.

Table 1. Wood-based compost material

Materials	Gram quantity	Tools	Quantity
Sawdust	800	Card-boards	2
Fallen leaves	2400	Packing tape	1
Rice bran	320	Unicycle	1
		Saucer	1
		Large scoop	1
		Small scoop	1
		Measuring instruments	2

Table 2. Work in progress

No.	Work in progress	Time (minutes)
1	Prepare the tools	20
2	Rake up Fallen leaves	30
3	Set up Card-board box	10
4	Mix the Sawdust and Fallen leaves	15
5	Mix the No.4 and Rice bran	10
6	Mix the No.5 and Water	5

Specifically, making compost process is as follows.

No.1: In preparing the composts, other materials that were used were cardboard, packing tape, a unicycle, a saucer, a large scoop, a small scoop, and measuring instruments. The large scoop and unicycle were used in work progress No.2. The saucer, small scoop, and measuring instruments were used to make the wood-based composts.

No.2: During the raking of fallen leaves, a large scoop and unicycle were used to carry the fallen leaves to the workspace (Figure 1).

Figure 1. Rake up fallen leaves

No.3: A cardboard box was for storing the wood-based composts made using packing tape.

No.4: Sawdust (600g) and fallen leaves (1800g) were mixed in the saucer, after they were measured using measuring instruments (Figure 2, Figure 3). Some branches were removed from the composts when it was mixed sawdust and fallen leaves in the saucer.

No.5: Rice bran (240g) was added to the No.4 mixture. This was then added to the composts (2400g) to make No.5 (Figure 4).

No.6: Some water was added to the Mixture No.5 composts (2640g) to make No.6 (Figure 5).

Figure 2. Measure the materials

Figure 3. Rake fallen leaves

Figure 4. Mix No.4 and rice bran

Figure 5. Watering

Figure 6. Wood-based composts

Thereafter, the wood-based composts were stored in a woodworking room on campus at the university (Figure 6). The period of generating composts was 2 months. Wood-based composts were given, as appropriate, water and temperature, and they were stirred once every two weeks to control the condition of soil.

2.2. Growth Test

Purpose of growth test is evaluating the compost. The compost carried out a measure of the maximum leaf length and the maximum leaf width of the vegetable on test pots.

In this study, the growth test of Komatsuna was conducted three times. Komatsuna was defined as Japanese mustard spinach. Komatsuna was adopted because it is strong against for heat and cold, and growth Komatsuna is easier than other vegetables [15]. This study conducts a three-step growth test. The exam is as follows.

Figure 7. Komatsuna of First Growth Test

First test task: The compartment for the first growth test was established as Table.1. This was done to analyze the ratio of compost that was effective for growth. The first test showed that many test pots germinated; however, some test pots did not germinate (Figure 7).

It was concluded that the soil was very hard because it was watered too often. The variations in the growth of Komatsuna in each pot were noted; however, the data collected was not adequate to be statistically analyzed. Therefore, the first growth test did not indicate a better effect on the growth of Komatsuna.

Second test task: The second test was established as Table 2. In this test, many test pots germinated; however, many other test pots were damaged by pest insects (Figure 8). As Table 2 shows, the results of the second growth test task indicated that some compartments had not germinated. This meant that the data was not adequate for statistical analysis.

Third test task: In the third test, the designated compartment was Table 3. This was where a hypothesis were created. The hypothesis was that a well-balanced ratio of solids and composts encourages the growth of Komatsuna along with appropriate watering regimes and protection from insects (Figure 9).

The third growth test was conducted from May 23, 2016 in June 17, 2016. In the third test, soils from the campus field, culture soils, wood-based composts, and cow-dung composts were used. Thereafter, 14 compartments with 70 pots of the soils were divided. Table 3 shows the rates of the soils. In order to test the rate of germination of Komatsuna, 6 tablets of Komatsuna seed were put in each test pot, and in 10 days extra Komatsuna was thinned out. For 26 days, the maximum leaf length and width of Komatsuna in each pot were measured.

Figure 8. Komatsuna of Second Growth Test

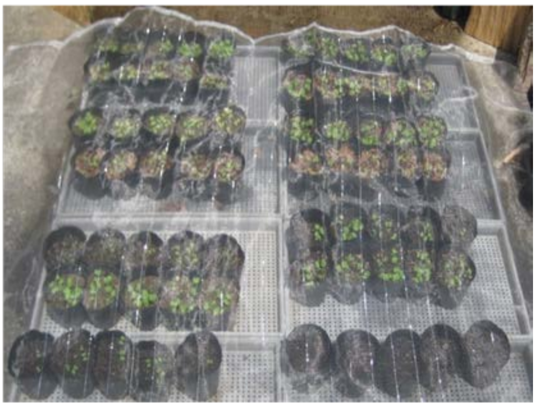

Figure 9. Komatsuna with nets for insects

Table 3. Result and Mixed the Contents of the First Growth Test

First Growth Test				
Compartment (No.)	Mixed	Volume ratio	Number of germination (Max=3)	Germination rate (%)
1	Soil of the campus field	1	3	100.0
2	Soil of the campus field: Wood-based compost	1:1	3	100.0
3	Soil of the campus field: Wood-based compost	9:1	2	66.7
4	Soil of the campus field: Coffee beans-based compost	1:1	3	100.0
5	Soil of the campus field: Coffee beans-based compost	9:1	3	100.0
6	Soil of the campus field: Chemical fertilizer	9:1	3	100.0
7	Vermiculite	1	3	100.0
8	Vermiculite: Wood-based compost	1:1	3	100.0
9	Vermiculite: Wood-based compost	9:1	0	0.0
10	Vermiculite: Coffee beans-based compost	1:1	3	100.0
11	Vermiculite: Coffee beans-based compost	9:1	3	100.0
12	Vermiculite: Chemical fertilizer	9:1	2	66.7

Table 4. Result and Mixed the Contents of the Second Growth Test

Second Growth Test				
Compartment (No.)	Mixed	Volume ratio	Number of germination (Max=5)	Germination rate (%)
1	Soil of the campus field	1	5	100.0
2	Soil of the campus field: Wood-based compost	1:1	5	100.0
3	Soil of the campus field: Wood-based compost	9:1	5	100.0
4	Soil of the campus field: Wood-based compost	1:9	5	100.0
5	Soil of the campus field: Cow dung compost	1:1	2	40.0
6	Soil of the campus field: Cow dung compost	9:1	5	100.0
7	Soil of the campus field: Cow dung compost	1:9	0	0.0
8	Vermiculite	1	5	100.0
9	Vermiculite: Wood-based compost	1:1	5	100.0
10	Vermiculite: Wood-based compost	9:1	5	100.0
11	Vermiculite: Wood-based compost	1:9	5	100.0
12	Vermiculite: Cow dung compost	1:1	5	100.0
13	Vermiculite: Cow dung compost	9:1	4	80.0
14	Vermiculite: Cow dung compost	1:9	0	0.0

Table 5. Mixed the Contents of the Third Growth Test

Second Growth Test						
Compartment (No.)	Mixed	Volume ratio	Number of germination (Max=6)	Germination rate (%)	Maximum leaf length (mm)	Maximum leaf width (mm)
1	Soil of the campus field	1	4.8	80.0	101.4	36.4
2	Soil of the campus field: Wood-based compost	1:1	5.8	96.7	46.8	10.0
3	Soil of the campus field: Wood-based compost	9:1	6.0	100.0	66.0	11.6
4	Soil of the campus field: Wood-based compost	1:9	5.8	96.7	31.0	12.6
5	Soil of the campus field: Cow dung compost	1:1	5.8	96.7	188.0	65.0
6	Soil of the campus field: Cow dung compost	9:1	6.0	100.0	150.4	61.4
7	Soil of the campus field: Cow dung compost	1:9	5.0	83.3	125.0	48.0
8	Culture soil	1	5.8	96.7	177.4	65.0
9	Culture soil : Wood-based compost	1:1	5.8	96.7	82.6	14.8
10	Culture soil: Wood-based compost	9:1	6.0	100.0	113.6	40.0
11	Culture soil: Wood-based compost	1:9	5.8	96.7	15.2	10.2
12	Culture soil: Cow dung compost	1:1	4.4	73.3	141.6	54.8
13	Culture soil: Cow dung compost	9:1	5.6	93.3	192.8	67.0
14	Culture soil: Cow dung compost	1:9	1.8	30.0	34.0	11.4

Figure 10. Komatsuna of Third Growth Test

The third test showed the growth of Komatsuna in all the test pots [Table 4]. These Komatsuna in these pots was prevented from being damaged by pests (Figure 10).

In addition, with regard to the maximum length and width of a leaf, the soil, which was made of 90% culture soil and 10% wood-based composts, had a better effect on growth as compared to the other wood-based composts. These results suggest that the third test could show an improvement in the growth of Komatsuna [Table 5]. It is considered that these results support the hypothesis. It can be concluded that a growth test may become a part of the STEM educational program, as environmental teaching material and wood-based composts were made with woody biomass. Furthermore, the process of the third test may also be used as teaching material in STEM and environmental education.

3. Results and Discussion

This study process consists of make the compost, growth test on Komatsuna, evaluating the compost. It can be concluded that a growth test may lead into becoming part of the STEM educational program, as a teaching material of technology education, and environmental education. According to curse of study, technology education in junior high schools has 4 Contents. One of the 4 contents has "Technology of nurturing living things" [16]. In addition, according to Commentary of "The Guide of the Course of Study for Junior High School Technology", it is significant to learn the problem solving with experiential learning [17]. Therefore, this study process is considered to be teaching material on technology education in Japanese junior high schools.

Also, this study process of the this test may also be used as a teaching material for STEM education that is considered foster scientific thinking through trial and error repeatedly, and environmental education that is used woody biomass of disposal plans as compost.

4. Conclusion

This study examined the STEM educational program that used a growth test of Komatsuna. The results indicate that the process of a growth test of Komatsuna may be used as part of the STEM educational program. The hypothesis about the best soil for the effective growth was proven with evidence. In addition, STEM can be used as environmental teaching material because wood-based compost was made with woody biomass. The process of this test has the potential to become teaching material in STEM and environmental education.

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