Asia-pacific Journal of Education Management Research
Vol.2, No.1 (2017), pp.25-30
http://dx.doi.org/10.21742/ajemr.2017.2.1.05

The Development of Teaching-Learning Programs based on the Relationship between the Biosphere and the Atmosphere in the Earth System

Jae-Hee Cho[1], Hak-Sung Kim[2*] and Yong-Pil Park[3]

[1,2*]*Department of Earth Science Education, Korea National University of Education, Chungbuk 28173, Korea*
[3]*Chungcheongbuk-do Office of Education, Chungbuk, 28635, Korea*
envir007@knue.ac.kr

Abstract

The relationship between the growth of licorice and meteorological elements was analyzed, and teaching-learning programs of seven sessions were developed for high school students through the analysis results of a relationship. The weather conditions of licorice seeding and harvesting time were derived and the growth of licorice was monitored. The teaching-learning programs were developed through the analysis results of the relationship between the growth of licorice and meteorological elements. The average for questions of the student satisfaction survey is 4.64, and students were satisfied in science knowledge, problem solving ability, and convergent attitudes. The content validity ratio is 0.8 or more, so the overall contents of the program are relevant. The teaching-learning programs can contribute to students' problem solving abilities and convergent attitudes towards understanding the interaction of the atmosphere and the biosphere among the components of the Earth.

Keywords: *Teaching-learning program, Atmosphere, Biosphere, Meteorological element, Growth of licorice*

1. Introduction

Natural phenomena have a property of a system that appear as a phenomenon of interaction of several factors [1]. From the perspective of earth as a system, efforts that approach natural phenomena are continuing [2]. Earth system education integrally approaches natural phenomena, and obtains scientific knowledge. In addition, the beauty of earth is appreciated, and a sense of curative responsibility towards the earth's environment is promoted [3][4]. There is an emphasis on develop earth literacy that understand interaction of subsystems such as lithosphere, hydrosphere, atmosphere, and biosphere.

When elements composed of a subsystem are changed, it affects other elements sequentially. Climate change is a typical case. It means long-term variations of temperature and precipitation in the atmosphere.

The programs in relation to climate change were developed and implemented based on an understanding of earth systems [5][6]. However, those only emphasize the development and implementation effect of the earth system educational program, and offer only cursory understanding subsystem interactions. In this study, we focus on understanding the

Article history:
Received (January 19, 2017), Review Result (March 28, 2017), Accepted (April 10, 2017)

Print ISSN: 2207-5380, eISSN: 2207-290X AJEMR
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interactions of subsystems based on natural phenomenon with the interaction between the atmosphere and the biosphere.

2. Method

2.1. Analysis of the relationship between the growth of licorice and meteorological elements

To analyze the interaction between the atmosphere and the biosphere, we focus on the growth of licorice in the Jecheon area. Licorice is a perennial plant used in medicinal herbs, and has been successfully cultivated in the Jecheon area for the first time in Korea. The root live-weight(g), diameter(cm), and length(cm) of licorice were measured in the Jecheon area from June to October in 2015. Furthermore, the relationship to growth of licorice was analyzed based on meteorological elements in the Jecheon area during that same period. In addition, changes of seeding and harvesting time of licorice were prospected based on an RCP scenario.

2.2. Process of the programs development and evaluation

The teaching-learning programs were designed as preparation, development, implementation and evaluation stages according to the PDIE procedure model with the theme of exploring the relationship between the growth of licorice and meteorological elements [7]. The teaching-learning programs can provide a self-directed learning experience consisting of situational presentation, creative design, and emotional experience [8]. The satisfaction survey consisted of 8 questions about science knowledge (1 question), convergence problem solving ability (3 questions), and convergent attitude (4 questions) for 10th grade (N=20), and responded to the 5-step Likert scale. Also, validity tests of the contents were asked to 10 subjects including 1 subject content expert, 2 subject education experts, and 7 earth science teachers.

3. Results and discussion

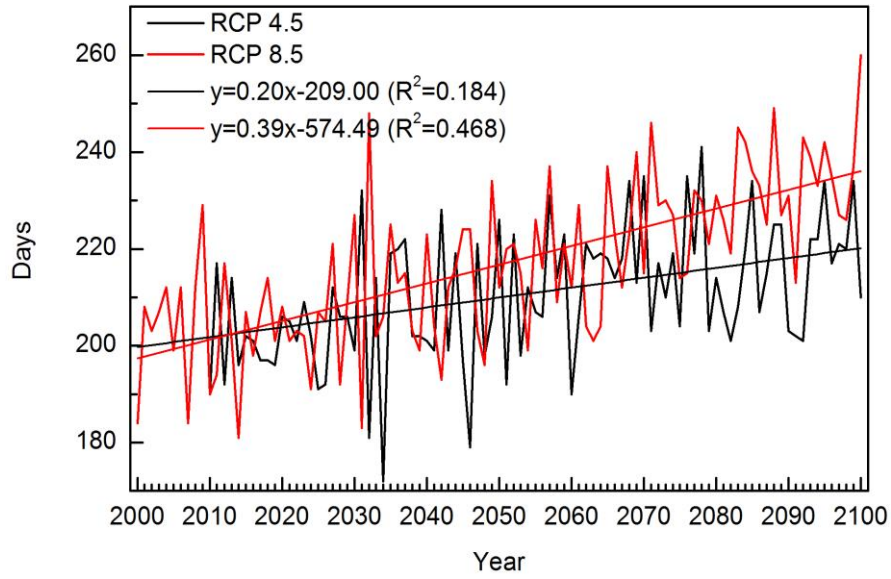
3.1. Relationship between the growth of licorice and meteorological elements

The correlation between monthly average weather elements and root live-weight, diameter, and length of licorice was analyzed between June-October 2015 [Table 1]. Root growth is negatively correlated with temperature and precipitation. The roots grow mainly in September-October rather than July-August when temperatures are relatively higher. It can be observed that the growth of licorice is active when the air temperature is cool and dry.

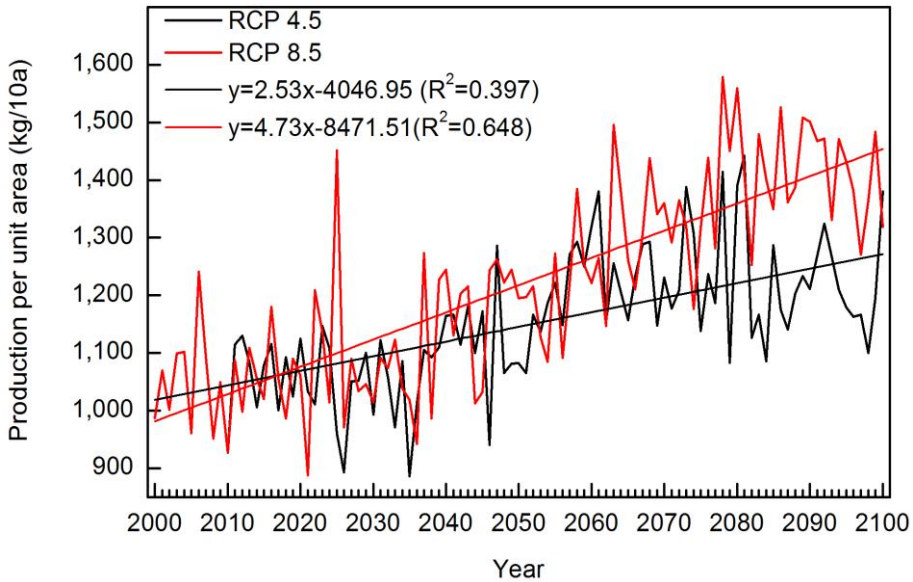
Table 1. Correlation factors between root growth and monthly meteorological elements in the Jecheon area from 2010 to 2015

Meteorological elements	Root live-weight	Root diameter	Root length
Mean Temp.	-0.839	-0.840	-0.785
Min. Temp.	-0.799	-0.799	-0.745
Max. Temp.	-0.879	-0.880	-0.817
Precip.	-0.582	-0.579	-0.570
Rel. Humid.	0.300	0.298	0.323
Total Sunshine	0.399	0.403	0.372

Because seeding and harvesting time of licorice affects the growth condition and production amount, timing is important. The growth and production of licorice were estimated for 2000-2100 by assigning weather conditions in Jecheon area based on an RCP scenario. The seeding time is moved up, and the harvesting time is delayed relative to the current period, so the growth period of licorice shows a tendency to increase. Also, the production per unit area of licorice is expected to increase in Jecheon area based on an RCP scenario.



A



B

Figure. 1. Variations in days of growth and production of licorice in the Jecheon area between 2000-2100 based on the RCP scenario: A, days of growth; B, production amount per 10a.

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3.2. The development of teaching-learning programs

The relationship between the growth of licorice and meteorological elements was analyzed, and teaching-learning programs of seven sessions were developed for high school students through the analysis results of a relationship. The aims of the program are in Table 2. Exploring concepts and phenomena in science can promote interest in the surrounding natural phenomena [9].

Table 2. The aims of programs in STEAM education

Classification	aims
Ultimate goal	Students learn the STEAM elements that can explore the relationship between the weather and the growth of licorice through creative design and emotional touch. And the students can try new challenges. Through these STEAM education programs, we intend to develop fusion thinking and problem solving abilities.
The aims of the session	Students learn to explain that various natural phenomena are the result of the Earth system cycle as examples of interactions between the atmosphere and the biosphere. Students observe licorice in several ways and can explain the effect of weather on the growth of licorice. Students discover the weather conditions to consider when seeding licorice. Students measure the growth of licorice and can draw graph measured results. Students discover the weather conditions to consider when harvesting licorice. Students learn to predict the growth of a plant caused by climate change. Students become aware of climate change phenomena and can practice response strategies.

3.2.1. Situation presentation (1-2 sessions)

In the Situation Presentation, students should be curious and motivated to explore the characteristics of the earth system focus on the interaction of the atmosphere and the biosphere by understanding the characteristics of the earth system from a systematic point of view. Furthermore, students learn to observe by observing licorice in several ways, and understand the relationship between plants and weather through the change in licorice growth caused by weather.

3.2.2. Creative design (3-5 sessions)

In the Creative Design stage, students understand the relationship between the growth of licorice and meteorological elements through examples of changes in growth due to the influence of meteorological elements. Students experience the process of deriving the timing of seeding. They observe licorice growing, and measure the length and thickness of roots expressed as a graph. Additionally, students find meteorological conditions of frost, consider the time of frost and find the harvesting time compared with actual harvesting time of licorice in the Jecheon area.

3.2.3. Emotional touch (6-7 sessions)

In the Emotional Touch stage, students should think about how the seeding and harvesting time of licorice will change in the future according to climate change. As a result, students gain an understanding of the impacts of climate change in the earth ecosystem and forecast the future in several ways.

4. Conclusion

The growth of plants in the biosphere and meteorological elements in the atmosphere affect each other through interaction among the components of the Earth. Temperature and precipitation are important meteorological elements affecting the growth of licorice. The weather conditions of licorice seeding and harvesting time were derived and the growth of licorice was monitored. According to climate change based on an RCP scenario, seeding time will accelerate and harvesting time will be delayed, so the entire cultivation period will increase in the future.

The relationship between the growth of licorice and meteorological elements were analyzed, and teaching-learning programs of seven sessions were developed for high school students through the analysis results of a relationship. The program was developed in the order of preparation, development, application, and evaluation, and it consisted of three stages of Situation Presentation in 1-2 sessions, Creative Design in 3-5 sessions, and Emotional Touch in 6-7 sessions based on the three STEAM educational learning criteria. The average for questions of the student satisfaction survey is 4.64, and students were satisfied in science knowledge, problem solving ability, and convergent attitudes. The content validity ratio is 0.8 or more, so the overall contents of the program are relevant. The teaching-learning programs can contribute to students' problem solving abilities and convergent attitudes understanding the interaction of the atmosphere and the biosphere among the components of the Earth.

Acknowledgements

This research is partially based on the dissertation submitted to the graduate school committee of Korea National University of Education in the February of 2017.

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