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# Evaluating the Effect of Jellyfish Chips on the Survival and Growth of *Pinus thunbergii* Seedlings Planted in a Coastal Area of Ehime Prefecture, Japan

Suk-Woo Kim[1], Tsugio Ezaki[2], Youn-Tae Lee[1], Yukiyoshi Teramoto[3] and Kun-Woo Chun[1,*]
[1]*Divison of Forest Sciences, College of Forest & Environmental Sciences, Kangwon National University, Chuncheon 24341, Republic of Korea*
[2]*Faculty of Agriculture, Ehime University, Matsuyama 790-8566, Japan*
[3]*Faculty of Agriculture, Kagoshima University, Kagoshima 890-0065, Japan*

## Abstract

This study aimed to evaluate the effectiveness of jellyfish chips in promoting the survival and growth of *Pinus thunbergii* seedlings in a coastal area based on a five-year field investigation from 2012 to 2016. Seedling survival rate was significantly higher in the treatment (96%) than in the control (75%) group in 2012. Furthermore, the height of five-year-old seedlings after plantation in 2012 was significantly greater in the treatment (3.41 m) than in the control (2.32 m) group ($t$=10.151; p-value<0.01). These results revealed that jellyfish chips can improve soil condition by enhancing moisture retention during the early growth stages and supplying nutrients to the seedlings over time. Our findings indicated that jellyfish chips could be used effectively as an organic fertilizer for growing coastal disaster prevention forests.

**Key Words:** *Pinus thunbergii* seedlings, survival, growth, jellyfish chips, coastal disaster prevention forests

## Introduction

In Japan, the importance of the construction of costal disaster prevention forest has been consistently emphasized for reducing tsunami damage since the Tohoku earthquake in 2011 (Sakamoto et al. 2012; Nakamura 2014). The Setouchi Region, which is located on the seaward side of Matsuyama City in Ehime Prefecture, Japan, is potentially vulnerable to a substantial tsunami that could be induced by an earthquake in Nankai in the future. To reduce the potential damage from such a tsunami and assure time for evacuation, local residents have constructed coastal disaster prevention forests along the coast in cooperation with members of Matsuyama rotary club since 2012.

To establish these forests, *Pinus thunbergii* seedlings were planted and jellyfish (*Nemopilema nomurai*, *Aurelia surita*, etc.) chips were applied as a fertilizer. Several previous studies have demonstrated that jellyfish fertilizer can contribute to the enhancement of initial growth of tree seedlings by retaining soil moisture and providing nutrients for hillside reforestation works in mountainous areas (Kim et al. 2012; Damdinsuren 2013; Seo et al. 2014). However, few case studies have been reported about the effect of jellyfish fertilizer on the vegetation growth in a coastal sandy area.

In the present study, we investigated the effects of jellyfish chips on the survival and growth of *P. thunbergii* seed-

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**Corresponding author: Kun-Woo Chun**
Divison of Forest Sciences, College of Forest & Environmental Sciences, Kangwon National University, Chuncheon 24341, Republic of Korea
Tel: 82-33-250-8313, Fax: 82-33-259-5617, E-mail: kwchun@kangwon.ac.kr

lings planted for establishing coastal disaster prevention forests based on field monitoring for five years.

## Materials and Methods

Field monitoring was carried out on the sandy beach of Awaikawara in Matsuyama city, Ehime Prefecture, Japan (Fig. 1). According to the Matsuyama Local Meteorological Office's weather report for 2012-2016, the mean annual precipitation was 1,536 mm as well as the mean monthly temperature was 6.1°C to 28.2°C. The area of the study site is 1.0 ha and entirely covered with cogongrass (*Imperata cylindrica*). At the study site, two-year-old *P. thunbergii* seedlings with a height of approximately 30 cm and root-collar diameter of 6 cm were planted for establishing coastal disaster prevention forests in March 2012. A total of 100 seedlings of *P. thunbergii* were planted simultaneously into each hole having a diameter of 50 cm and a depth of 40 cm in rows at intervals of 1.5 m on both sides in either direction. Among those seedlings, 80 seedlings were planted with the jellyfish fertilizer at the rate of 100 g per one seedling as treatment groups, and the remaining 20 seedlings were planted without any treatment as control groups. After planting, the survival of *P. thunbergii* seedlings was investigated on April, May, June, August, and November in the first year. The height of *P. thunbergii* seedlings was measured annually in November corresponding to the dormant period from 2012 to 2016.

## Results

### *Seedling survival*

*P. thunbergii* seedlings begun to die after two and three months for control and treatment groups, respectively (Fig. 2).

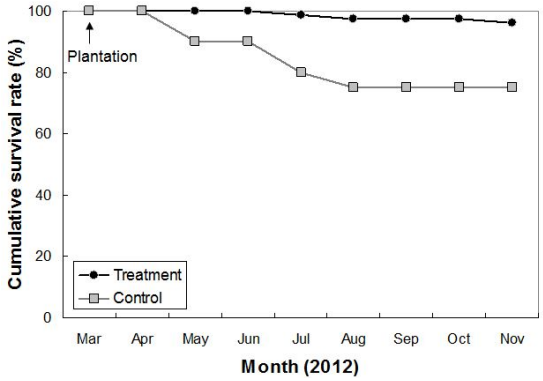


**Fig. 2.** Changes in cumulative survival rate of *P. thunbergii* seedlings for treatment and control groups from March to November 2012.


**Fig. 1.** Location of the study site.

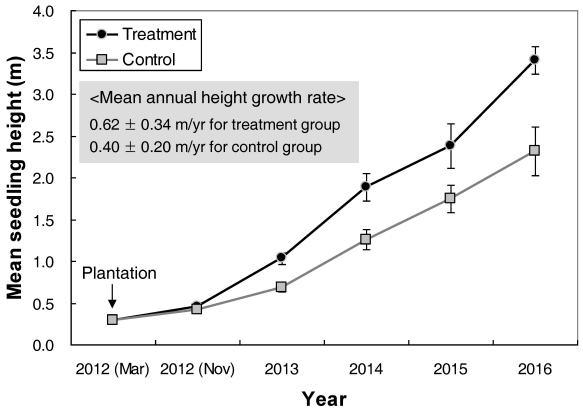


**Fig. 3.** Changes in mean height of *P. thunbergii* seedlings for treatment and control groups from 2012 to 2016 (error bars represent standard deviation).

Cumulative survival rate of *P. thunbergii* seedlings was lower in the control group (75%) than in the treatment group (96%), showing a drastic decrease in the former between May and August (Fig. 2). After November 2012, it was observed that *P. thunbergii* seedlings showed no additional mortality in either of the two groups.

### *Seedling growth*

The height growth of *P. thunbergii* seedlings was faster in the treatment group than in control group, and the difference between the two groups gradually increased with time since plantation in 2012 (Fig. 3). In November 2016, i.e., five years after the seedlings were planted, mean height of *P. thunbergii* seedlings was 3.41 and 2.32 m for the treatment and control groups, respectively, indicating a significant statistical difference at the 99% confidence level ($t=10.151$; p-value $< 0.01$).

## Discussion and Conclusions

The positive contribution of jellyfish chips to seedling survival and growth could be explained by soil amendment effects, particularly retention of moisture and supply of nutrients, as noted by Kim et al. (2012) and Seo et al. (2014). It is known that jellyfish chips can absorb water up to seven times of their own weight, and that they contain nutrients, such as nitrogen (N), phosphorus pentoxide ($P_2O_5$), and potassium oxide ($K_2O$) (Ezaki et al. 2008). These nutrients promote seedling survival, particularly under dry summer conditions. Seedling survival was relatively higher owing to higher moisture retention in the initial growth stages (Fig. 2). In addition, the increase in height was promoted by the higher supply of nutrients due to decomposition of jellyfish chips over time than that in the control group (Fig. 3).

Our findings suggest that jellyfish chips can be used effectively as an organic fertilizer to promote the early survival and growth of *P. thunbergii* seedlings for the establishment of coastal disaster prevention forests.

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