Effects on Growth of Plants by the Soil Conditioner FFC-Ace©

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Since 1984, Akatsuka Garden Company has continued research on various solutions to not only accelerate plant growth, but also activate physiological functions of plants. We focused our attention on the behavior of certain ions, especially iron ion in water or interactions of water molecules with them. Based on this research, we have developed FFC materials such as FFC-Ceramics (a water improvement device), FFC-Ace (a soil conditioner), and FFC-Pico Power (a liquid plant energizer). In addition, many agricultural producers in Japan have been utilizing FFC materials to rejuvenate plants and increase profits. Those producers have also explored many other original methods for using FFC materials, and consequently found good ways to fit them into their actual production sites. As a result, they obtained many advantages over years of use, for instance, productivity enhancement, cost reduction, decreased amount of agricultural chemicals required, and so on. In addition to that, it is reported that FFC-Ace enhances the growth of plants under laboratory conditions, improves disease resistance, and drought and salt stress tolerance of plants (Fujita et al., 2010; Hasegawa et al., 2006; Konkol et al., 2012; Shiraishi et al., 2010; Toyoda et al., 2010). In this paper, we will report the effects of FFC-Ace on plant growth, acid tolerance of plants, and growth of soil microbes under laboratory and/or field conditions.

To investigate early plant growth of white turnip (*Brassica campestris* var. *glabra*), we cultivated white turnips in Andosol mixed with FFC-Ace (3% w/w) or in untreated Andosol for 7 days. Shoot length and shoot fresh weight of white turnip grown in FFC-Ace treated Andosol were approximately 1.27 times and 1.16 times respectively higher than in untreated Andosol (Fig. 1). Root length and root fresh weight of white turnip grown in FFC-Ace treated Andosol were approximately 1.21 times and 1.30 times, respectively, higher than in untreated Andosol.

Next, with regard to the examination of the effects of FFC-Ace on growth of plants under field conditions, we cultivated turnips (*Brassica rapa* L. var. *glabra*) in the experimental field plot mixed with FFC-Ace (FFC-Ace 121 $g \cdot m^{-2}$) or without FFC-Ace for 48 days (from late September to middle November). Taproot fresh weight of the FFC-Ace treated field plot was approximately 2.68 times higher than that of the untreated field plot (Fig. 2).

Development of acidic soil is a crop production problem of increasing concern worldwide (Matsuo, 2003). Focusing on the investigation of the effects of FFC-Ace on early plant growth in acidic soil, a cultivation study was conducted to evaluate the growth of field peas (*Pisum sativum* L.) after 10 days cultivation. Acidic Andosol was adjusted to pH 4.5 before being mixed with FFC-Ace (9% w/w), along with the same preparation of untreated acidic Andosol with no FFC-Ace. Shoot fresh weight and root fresh weight of field peas grown in FFC-Ace treated acidic Andosol were approximately 1.66 times and 1.50 times respectively higher than in untreated acidic Andosol (Fig. 3). These results indicate that FFC-Ace treated soil might stimulate plant growth and enhance the tolerance to acidic stress, and additionally confirms the evidence about the effects of FFC-Ace on increasing crop yields at fruit, rice, and vegetable farms in Japan.

Generally, it is known that soil microbes have important roles for control of soil-borne pathogens, formation of aggregated structure, and nutrient supply by decomposition of organic matter. Therefore, our attention has been turned to study of the effects of FFC-Ace on microbial growth in soil. To investigate this, we incubated field soil mixed with FFC-Ace (3% w/w) or without FFC-Ace at 25°C in the dark, and measured viable cell counts of three types of microbes (filamentous fungus, bacteria, and actinomycetes) in the soils by dilution plate technique over the course of 30 days. The maximum growth of all types of microbes was higher in the FFC-Ace treated soil than in untreated soil (Fig. 4). This result suggests that FFC-Ace causes microorganisms to flourish in the soil. Although further studies would be required to reveal all benefits of FFC-Ace, we consider that the FFC-Ace might contribute to growth of soil microbes, which leads to productivity enhancement, decrease of usual amount of agricultural chemicals required, and other effects.

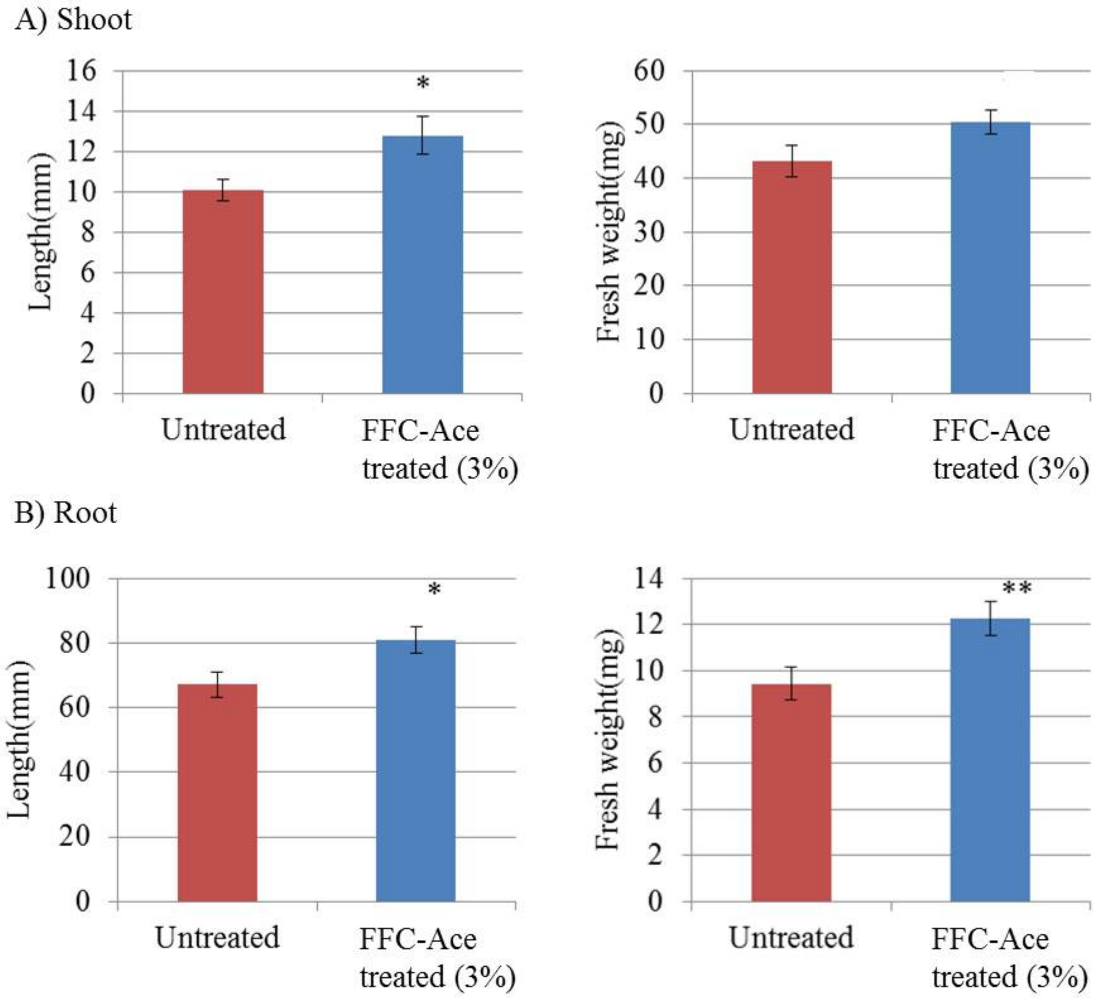

Fig. 1. Effects of FFC-Ace on early growth of white turnip in Andosol. Values are given as the mean ± standard error. Values with * and ** are significantly different (p<0.05 and p<0.01, respectively) in each frame.

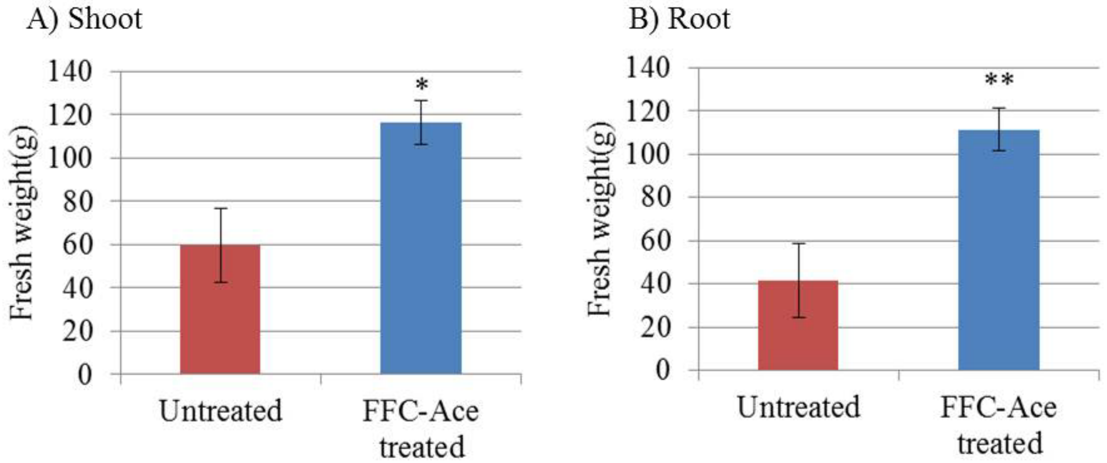

Fig. 2. Effects of FFC-Ace on growth of turnip under field conditions. Values are given as the mean ± standard error. Values with * and ** are significantly different (p<0.05 and p<0.01, respectively) in each frame.

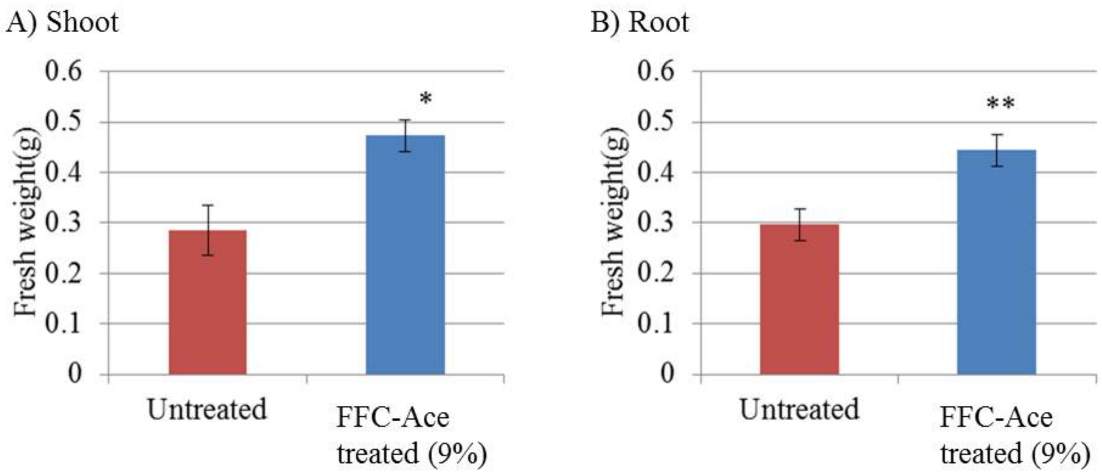

Fig. 3. Effects of FFC-Ace on early growth of field peas in acidic soil. Values are given as the mean ± standard error. Values with * and ** are significantly different (p<0.05 and p<0.01, respectively) in each frame.

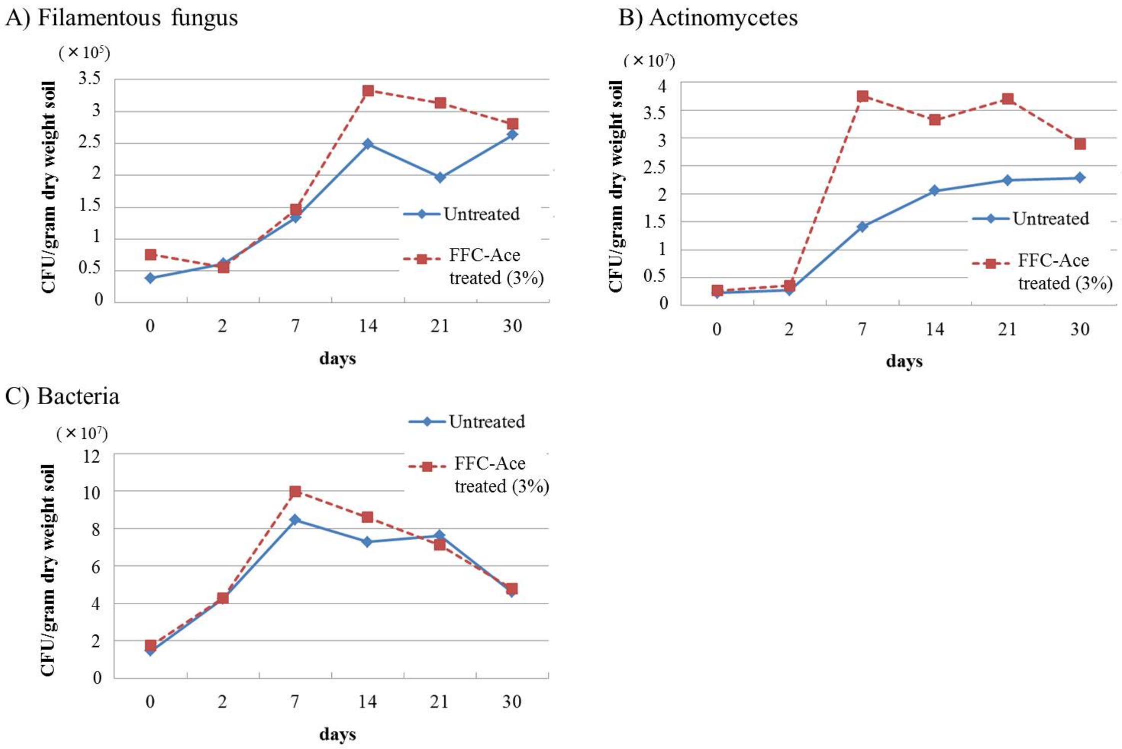

Fig. 4. Changes of viable cell counts of three types of microbes in FFC-Ace treated soil and in untreated soil. A) Filamentous fungus, B) Actinomycetes, C) Bacteria.

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