Effects of soil conditioner FFC-Ace© on inhibited plant growth under acidic soil conditions©

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INTRODUCTION

Since 1984, Akatsuka Garden Company has focused on the behavior of certain ions, especially the iron ions in water, and interactions of water molecules with them. We have continued research on various solutions to not only accelerate plant growth, but also activate physiological functions of plants. Based on this research, we have developed FFC materials such as "FFC-Ceramics" (for water improvement), "FFC-Ace©" (for soil improvement), and others.

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 possible methods of using FFC materials and consequently found good ways that benefit their actual production sites.

As a result, they have obtained many advantages over years of use, such as improved productivity, cost reduction, decreased dependence on agricultural chemicals, among others. Additionally, it has been reported that FFC-Ace enhances the growth of plants under laboratory conditions while improving disease resistance, drought resistance, and salt stress tolerance (Ichikawa and Fujimori, 2012, 2013; Ichikawa et al., 2014; Fujita et al., 2010; Hasegawa et al., 2006; Konkol et al., 2012; Shiraishi et al., 2010; Toyoda et al., 2010).

Andosol, which occupies half of field soil area in Japan, contains much organic matter and the soil easily forms an aggregate structure. However, andosol contains much alumina. As the soils acidify, soluble aluminum ions dissolve and inhibit root growth at micromolar concentrations. As a result, crop production decreases (Shoji, 1984; Yamamoto, 2002; Matsumoto, 2003).

In this study, we researched the effect of the soil conditioner FFC-Ace on both the inhibition of plant growth by artificially acidified andosol and on the inhibition of root growth by aluminum ions.

MATERIALS AND METHODS

Experiment 1: using acidified andosol

Sixty grams of andosol was mixed with 1.4 g of $FeSO_4.7H_2O$ to decrease pH value to 4.5 and then was moistened by addition of 10 ml distilled water for acidic andosol. FFC Ace treated andosol was made by addition of 6 g of FFC Ace to the acidic andosol. Sixteen seeds of komatsuna [*Brassica rapa* var. *pekinensis* 'Osaka-shirona' (Japanese mustard spinach)] were sown in FFC Ace treated andosol as well as the acidic andosol. After cultivating the komatsuna under fluorescent light for 11 days (12 h light-dark cycle for 11 days at 25°C, humidity 75%), the length of both shoots and roots were measured.

Experiments 2: water culture using solution containing aluminum ions

Three grams of FFC Ace were mixed with 100 mL of 10.5 mg L^{-1} (as Al) of aluminum chloride solution and was left overnight. The particles of FFC Ace were removed from the immersion water by filter paper and a cellulose syringe filter. The filtrate was diluted three times with distilled water. Distilled water was used as a control as well as 10.5 mg L^{-1} (as Al) aluminum chloride solution diluted three times with distilled water. Seeds of *Brassica rapa* var. *pekinensis* 'Osaka-shirona' (shirona) were sown in each solution, and after cultivating it

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for 4 days, the length of both shoots and roots were measured.

Experiment 3: re-elongation of roots by using water immersed with FFC Ace

Seeds of shirona were sown in about 350 mL of 3.5 mg L^{-1} (as Al) aluminum chloride solutions and were germinated. After 2 days, the seedlings were transferred to distilled water (control). FFC Ace treated water was prepared removing the FFC Ace from water immersed with FFC Ace that was left overnight. As with the control, the germinated seedlings were transferred to FFC Ace treated water for the measurement of shoot and root length after 4 days.

RESULTS AND DISCUSSIONS

In Experiment 1 using andosol which was acidified artificially by $FeSO_4.7H_2O$, the average shoot length of komatsuna grown in FFC Ace treated andosol was about 1.4 times as long as the control, and the average root length was about twice as long as the control. FFC Ace reduced inhibition of plant growth under acidic soil stress such as an acidified andosol.

In Experiment 2, the root elongation of shirona grown in aluminum chloride solution was inhibited. On the other hand, in FFC Ace treated aluminum chloride solution root elongation was not inhibited and we observed elongation to be more accelerated.

Generally, it is said that inhibition to root elongation by aluminum ions is irreversible (Clarkson, 1965; Morimura et al., 1978; Matsumoto and Morimura, 1980). Seedlings of shirona which germinated in aluminum chloride solution were transferred to distilled water or FFC Ace treated water. As shown in Figure 1 of the Experiment 3, further root elongations of seedlings in distilled water did not ever occur in any measurable amount. On the other hand, root elongations of seedlings in FFC Ace treated water restarted and some of the roots grew.

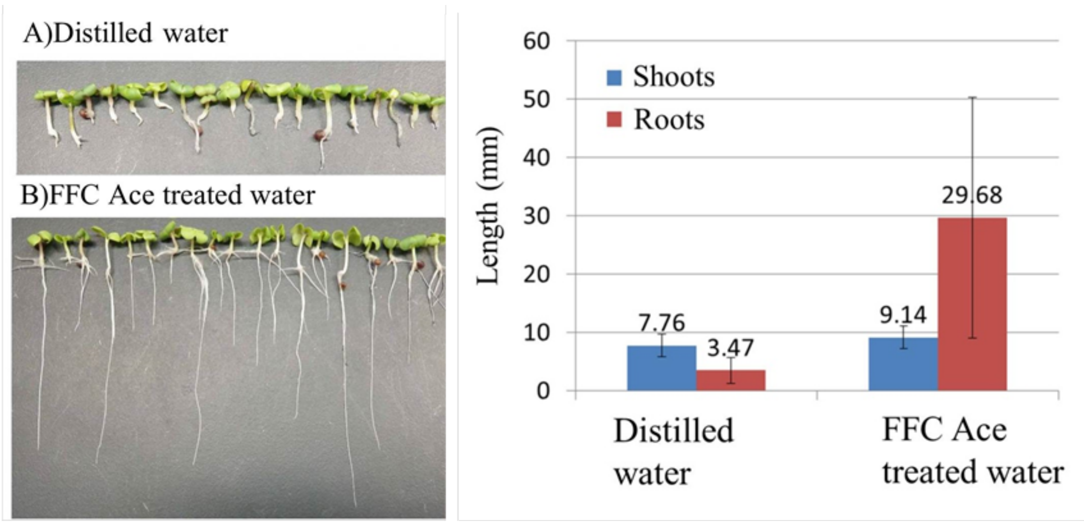

Figure 1. Re-elongation of roots *Brassica rapa* var. *pekinensis* 'Osaka-shirona' (shirona) using FFC® Ace treated water (Experiment 3): left shows seedlings and right shows graphical results.

The results suggest that FFC Ace treated water was effective in restarting the root elongation which had been stopped by aluminum ions. Based on the above results, FFC Ace was effective in reducing growth inhibition of plants under conditions of acidic andosol or existence of aluminum ions. In cultivated land where acidification of soil is accelerated, the application of FFC Ace should enable a noticeable increase in crop productivity.

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