MASTER'S THESIS

Effects of agronomic practices on aluminium and fluoride concentrations in soil and tea plants

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Effects of Agronomic Practices on Aluminium and Fluoride Concentrations in Soil and Tea Plants

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Abstract

Tea is one of the most popular beverages in the world and it is well-known accumulator of Al and F. The present study aims to investigate the effects of different agronomic practices on Al and F uptake by tea plants, and to find ways to reduce the concentration of these elements within the plants. A reduction is desirable as Al and F absorbed will leach into the tea liquor through infusion thus posing a serious threat to the health of the consumers of tea.

The soil pH of the tea plantation (4-4.52) was lower than that in the normal soil obtained near the tea plantation on Lantau Island, Hong Kong. The soil extractable Al and F concentration ranged from 168-193 Al mg/kg and 1.41- 2.61 F mg/kg, and were found to be inversely proportional to the soil pH ($p<0.001$). Extractable of both species decreased ($p<0.05$) gently along the soil profile. The ecological survey indicated that the extractable amount of Al and F and their concentrations within the plants were directly proportional to the age of the plantation. Al accumulated in old leaves and roots were quantified to be 15,268 mg/kg and 10,101 mg/kg in average, and F accumulated in old tea leaves was 2072 mg/kg. The average amount of Al and F in young leaves, which makes up of the bulk of commercial tea products, were, 7017 mg/kg and 310 mg/kg respectively. Among the various species tested, "small leafed variety" had the highest ($p<0.05$) Al and F concentration, followed by "large leafed variety" and Assam variety. Aluminium and F contents in black tea were higher than those in green tea, and both elements' concentrations in tea liquor under repeated infusion was slightly higher than in continuous infusion.

Acidifying materials and lime are commonly applied on tea plantations. All acidifying materials included in this studies ($Al_2(SO_4)_3$, H_2SO_4, $(NH_4)2SO_4$ and NH_4NO_3) increased extractable Al and F concentration but decrease available nutrient contents (such as P and K) in soil while calcium-containing materials ($CaCO_3$, $CaCl_2$ and $CaSO_4$) reduced extractable Al and F but maintained the normal nutrient level. Therefore, Ca-containing materials were chosen for the purpose of Al and F uptake reduction by tea seedlings.

Extractable Al, F, Fe, Mn and Zn concentrations decreased whereas extractable Ca, Cu, K, Mg, Na and P concentration increased when the soil pH was raised from 3 to 6. The three growth measurement, relative dry weight gain (RDW), relative leaf number gain (RLN) and relative leaf area gain (RLA), decreased when the soil pH increased which resulted in a decrease in soil extractable Al and F. Tea seedlings grown in soils of pH 3.0 and 3.5 were the tallest and the healthiest in both varieties while those in pH 6.0 died after 3 months of cultivation. "Large leafed variety" was noted to display higher growth rates than "small leafed variety". The highest ($p<0.05$) amount of Al and F, 4225 mg/kg and 430 mg/kg, were found in seedlings under treatment of pH 3.5, and they were observed to be directly proportional to the plant growth rate. When Al and F contents increased in the seedlings, nutrient contents such as Ca, Mg, Mn, Na and Zn gently decreased ($p<0.05$) whereas P and Fe concentrations increased. Potassium and Cu were not

influenced by varying the amount Al and F. It has been suggested high pH values (> 4) can reduce the Al and F concentrations in tea plants.

All true lime material ($CaCO_3$, $Ca(OH)_2$ and CaO) increase the soil pH and decrease soil extractable Al and F concentrations. There are no ($p<0.05$) change of pH when $CaCl_2$ was added, and a slight decrease in Al and F concentrations was observed in the treatments with $CaSO_4$. Tea seedlings under the addition of $CaSO_4$. were the tallest and the healthiest, followed by $CaCl_2$, $CaCO_3$, $Ca(OH)_2$ and CaO. The treatment with 4,000 mg $CaSO_4$ /kg yield the tallest seedlings and the height decreased subsequently ($p<0.05$). Seedlings under large doses of $Ca(OH)_2$ and CaO, there were dead seedlings. RDW, RLN and RLA decreased significantly with increasing calcium compounds added except in the treatment with $CaSO_4$. The highest Al concentration was also found in the treatment with 4,000 mg $CaSO_4$ /kg, it then decreased gently from 3364 to 933 mg Al/kg in leaves. For all treatments in both varieties, F concentrations in leaves were lower than the control (374 mg/kg). Therefore, $CaSO_4$ is a material capable of accelerating growth of tea seedlings, without reducing the uptake of Al and F. The growth rate, as well as Al and F concentrations, were greatly reduced in the true lime treatments. Calcium chloride was a suitable agent reduction of Al and F uptake by Al and F while maintaining a high growth rate of the seedlings.

The present experiment indicated that there was a decrease in Al and F concentrations in soil and tea plants with the addition of organic amendments applied to soil. the amount of organic Al concentration in soil was directly proportional to ($p<0.001$) the values of CEC and TOC in the soil. Tea plants exhibited poorer growth when the application rates of the organic amendments were increased, and death was observed at higher doses. The highest growth rate (RDW, RLN and RLA values) was found in the treatments of 1% peat moss (361-398% in average). Peanut cake was not a suitable amendment for tea plantation as it reduced Al and F concentrations in both soil and plants, and resulted in death of the plants. Although the leaves of seedlings did not grow so healthily, pig manure compost could still be one of the organic amendments for reducing Al and F availability to tea plants. Peat moss, when adjusted to a suitable pH (e.g. pH 4.5), could be another suitable organic amendment, for it was effective in reducing Al and F availability while promoting healthy plant growth.

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