Title
Strawberry Nursery Plant Propagation in Relation to Soil Phosphorus and Water Variation

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Publication Date
2009-08-07

Peer reviewed

1. Introduction

Strawberry, a popular small fruit in the *Rosaceae* family, is a rapid-top growth, chilling required crop. Strawberry nursery plants are grown from spring through early fall in Nova Scotia and are exported to Florida, California and other southern states for fruit production in the winter.

Soil phosphorus (P) concentrations are highly variable in the northern Atlantic coastal areas. Growers continue to apply high rates of P fertilizers to try to keep up the nutrient needs for the nursery plants. Phosphorus, an important nutrient for propagation, vigor and general health of all plants, is often referred to as the 'energizer' because it helps store and transfer energy within plants during photosynthesis process (Busman al., 1998; Schachtman, 1998). Soluble P ions can be fixed by cations Fe, Ca, Mg and Al in the adsorption process, the most remarkable P reaction in the soil (Busman al., 1998).

Loading soils with very high levels of phosphate will generally not hurt plants but it can build up soil phosphorus levels (Busman et al., 1998). Soil P concentrations vary with soil water content (SWC) and pH levels in tree orchards (Li et al., 2007). Available SWC had a significant effect on strawberry fruit yields in the Atlantic coastal soils (Li et al., 2009). The objectives of this study were to examine the relationships of strawberry plant propagation, plant P acquisition and P accumulation within nursery plants in relation to different soil P, SWC and pH levels.

2. Materials and Methods

A study of strawberry plant and soil P relations was conducted in two commercial fields (Field A and Field B) in the coastal areas of Annapolis Valley, Nova Scotia. The two fields, 1.2 km apart, presented a similar topographical feature and the soils were a loose, deep, water-worked Somerset sandy loam in both fields. However, the soil water holding, pH and mineral nutrient characteristics were highly different in the two fields (Table 1).

The new cultivar 'Strawberry Festival', a recently certified nursery variety by University of Florida, was used in the study. The planting in both fields, with a 1.5-m row spacing and 0.25 m between plants on the row, was done in the first week of May 2008. The chemical fertilizer inputs for the two sites were equally, based on soil testing, at the rates of 105 N, 165 P and 185 K kg ha^{-1} using mixing granular ammonium nitrate (NH_4NO_3), di-ammonium phosphate ($(NH_4)_2HPO_4$) and chloride potassium (KCl). The fertilizers were applied at planting by broadcast and at runner emerging stage by side dress with 50% of the total rates each time.

For strengthening runners and daughter plants, flowering stems on the plants were consistently removed as they appeared in the summer. Irrigation was supplied on a rainfall compensation basis using sprinkler system with pipes installed 24 m apart across the field. A transect across the greatest features in topography in each field was setup for plant, soil and water measurements. A total of 20 GPS measurement points, 6 m apart along transects, were taken for the measurements.

In strawberry nursery production, each plant was essentially a clone. Runners developed from mother crown then became 'daughter' plants when runners grew leaves and roots (Fig. 2). Whole plants and soils (0-0.15 m) were sampled at runner and daughter development stages at each GPS point. Soil water content was determined using a TDR300 probe (Spectrum Tech., IL). At harvest (22 Sept.) soil pH was measured using m/v 1:1 ratio and the Mehlich III-extracted soil P concentrations were determined using molybdate solution by spectrophotometer at 880 nm.

Data statistics were done using SAS PROC UNIVARIATE and PROC GLM. Comparison of the means was done using Honestly Significant Difference (HSD) test (SAS Institute, 1990).

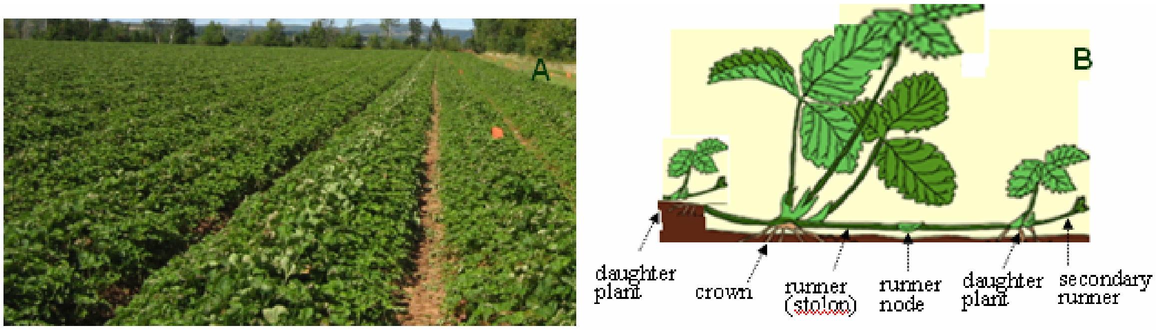

Fig. 1. Strawberry nursery plantings (A) and strawberry plant physiological development (B).

3. Results and Discussion

The soils in the Field A had a significantly lower P level but significantly higher Ca, Mg and Fe concentrations than in the Field B (Table 1). Correspondingly, soil pH in the Field A was significantly lower (mean 5.7) than in the Field B (Table 1). In the Field B, soil pH value (mean 6.5) was in the optimal range for strawberry and soil P was significantly higher than in the Field A (Table 1). The low concentration in P but high in Ca, Mg and Fe concentrations in the Field A suggested that P ions might have been fixed by the Ca, Mg and Fe cations in this acidic soil.

Table 1. Comparison of soil properties in two strawberry nursery plant fields (HSD, $\alpha = 0.05$).

Field	Soil water content†	pH	P†	K†	Ca†	Mg†	Fe†
A	0.09 b	5.7 b	70 b	130 a	3492 a	396 a	45 a
B	0.12a	6.5 a	244 a	116 a	2497 b	228 b	29 b

†: Soil water content in g g^{-1} and nutrient P, K, Ca, Mg and Fe concentrations in g kg^{-1}.

The low P and pH but high Ca, Mg and Fe levels in Field A resulted in significantly lower runners and daughter plants ($P < 0.01$), compared to the soil with high P, optimal pH but moderate Ca, Mg and Fe concentrations in the Field B (Fig. 2). High P concentration and adequate soil pH were likely more useful for strawberry plant growth.

High soil Fe concentration was related to low soil pH and fruit tree decline (Li et al., 2007). It was reported that mineral P can be adsorbed by cations Ca, Mg, Al and Fe in the soil, resulting the decrease in P availability in the soil over time (Busman et al., 1998). Also, P adsorption process is soil-pH dependent because cation Ca, Mg and Fe concentrations change with soil pH (Busman et al., 1998). When soil is acidic (e.g. pH = 5.7 in Field B), cations Ca and Fe can be dominant ions reacting with soil P to form amorphous Ca and Fe phosphates that are generally not available to plants. It is needed to verify whether high Ca and Fe concentrations in the Field A have led to low P concentration through the adsorption process.

The strawberry nursery plant development was positively associated also with soil water content (SWC) ($Straw_{Daughter} = 3.96$ SWC - 23.1, $R^2 = 0.50$, $P < 0.05$, n = 40), and with soil pH $Straw_{Daughter} = 3.96$ SpH - 65.6, $R^2 = 0.61$, $P < 0.01$, n = 40) in the two loamy soils. Liming to bring up the soil pH should be an option to increase strawberry productivity for the Field A.

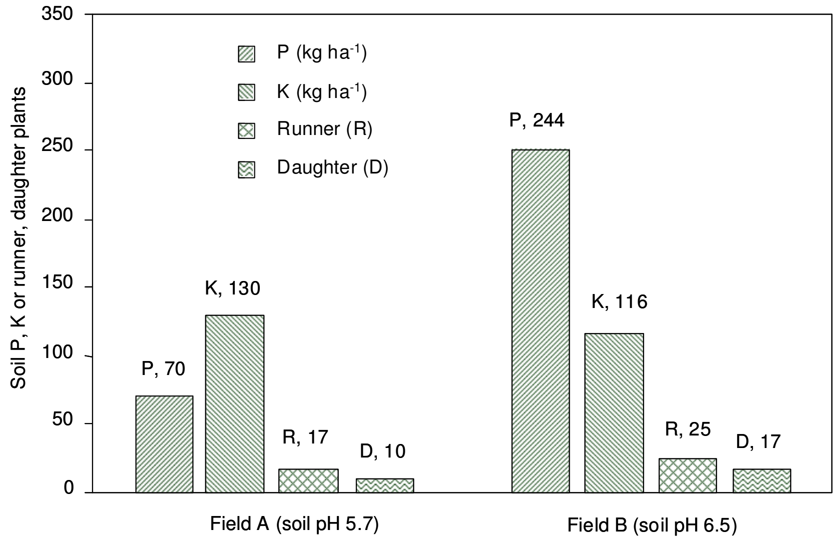

Fig. 2. Comparison of mean values of soil P and K concentrations and strawberry plant runner numbers (R) and daughter plants (D), measured in Field A and Field B.

4. Conclusions

Strawberry nursery plant propagation and productivity were significantly related to soil P availability, SWC and pH levels. High soil P nutrition at the pH 6.2 level would promote strawberry nursery plant propagation. High soil Ca and Fe concentrations might have resulted in low P concentration in the soil but further verification of P adsorption process is needed.

Acknowledgements

We thank NSDA-Agriculture-Technology Development Program, North American Strawberry Growers Association and Charles Keddy Nursery for support for this study.

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