

# Ability of nitrogen and phosphorus assimilation of seven strawberry cultivars in a northern Atlantic coastal soil

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## Abstract

Optimizing plant nitrogen (N) and phosphorus (P) nutrition is required in healthy propagation of strawberry nursery plants for fruit production. Strawberry (*Fragaria x ananassa* Duch.) nursery plant ability for N and P acquisition was examined in a northern Atlantic coastal soil for providing field-based information for optimizing strawberry nursery plant nutrition. The study was conducted in a Cornwallis loamy soil in Nova Scotia, Canada in 2008. The treatments consisted of seven strawberry cultivars: 'Darselect', 'Mesabi', 'V151', 'Seneca', 'Serenity', 'K93-20' and 'Jewel', all highly hardy cultivars. Nutrient NPK supply was respectively at the rates of 105, 145 and 165 kg/ha, based on soil testing and regional recommendation. Results showed that strawberry nursery plant propagation and productivity expressed using runner and daughter-plant variables were significantly different among the seven cultivars ( $P < 0.05$ ). Total nitrogen uptake (mean $\pm$ SD) varied between 2.96 $\pm$ 0.91 g/plant and total P uptake was 0.29 $\pm$ 0.06 g/plant among the seven cultivars. The cultivar 'Seneca' and 'Jewel' showed a significantly higher ability of N and P acquisition ( $P < 0.05$ ). However, only higher N and P acquisition in 'Seneca' was corresponding to significantly higher runner numbers (23 runners/mother-plant) and daughter plants (42 daughters/mother-plant). Significantly lower productivity was associated with lower N and P uptake in the cultivars 'Darselect', 'Mesabi' and 'V151'. Whole plant P accumulation increased with increasing of N accumulation (up to 4.7 g/plant,  $R^2 = 0.76$ ,  $P < 0.01$ ). It was suggested that strawberry nursery plant propagation could be enhanced with nutrition accumulation ranges of 2.47-3.26 g N/plant and 0.25-0.34 g P/plant. Runner thinning would be an option for regulating strawberry plant N and P nutrition and nursery plant productivity.

## Key Words

Plant nitrogen, phosphorus nutrition, plant propagation, strawberry nursery plants.

## Introduction

Northern Atlantic climate (warm summer and cool fall) of Canada is favourable for growing cold-stored, disease-free strawberry (*Fragaria x ananassa* Duch.) nursery plants. Strawberry mother plants are transplanted in early spring for propagating in Nova Scotia and the nursery plants are harvested then shipped to many states for strawberry fruit production across North American. Strawberry plant is a rapid top-growth crop (Li *et al.* 2009a). The growth of crown, leaves, runners and daughter plants can occur in a short time (e.g. 2-3 months), depending on nutrient, light, temperature, salinity or water conditions (Kenlgen and Pawelzik 2009; Li *et al.* 2010). It is reported that strawberry plants require a high acquisition of N and P nutrition for the need of photosynthesis and rapid top growth (Li *et al.* 2009a). Nitrogen (N) is recognized as the most limiting nutrient to plant development and N nutrition determines crop yield and quality (Lea and Azevedo 2006; Li *et al.* 2006), and more than 50% of leaf-N is in components associated with plant photosynthesis (Gastal and Lemaire 2002). 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 *et al.* 1998; Schachtman 1998).

Knowledge of crop N and P requirements is essential in developing profitable nutrient management planning to meet plant needs for producing high quality crops (Gastal and Lemaire 2002; Li *et al.* 2006; 2009a). Selecting cultivars efficient in nutrient use could be an option for producing high quality crops (Li *et al.* 2009b). The objectives of this study were to understand the N and P acquisition ability of seven strawberry cultivars and to examine the co-limitation of N and P nutrition in strawberry plant nursery propagation.

## Methods

### *Filed experimental treatments*

The study was conducted in a deep, moderately-drained Cornwallis sandy loam in Annapolis Valley, Nova Scotia. The soil was classified as an Orthic Humo-Ferric Podzol. The soil was acidic, pH (soil:water/1:1) 5.9 and had a medium soil fertility level (P, K, Ca, Mg and Fe concentrations at 69, 98, 1,858, 247 and 32 mg/kg, respectively). The previous crop was a 2-year perennial ryegrass (*Lolium perenne* L.) that was chemically killed and incorporated into the soil in the spring.

The experimental treatments consisted of seven strawberry cultivars: 'Darselect', 'Mesabi', 'V151', 'Seneca', 'Serenity', 'K93-20' and 'Jewel', all highly hardy cultivars. The fertilizer NPK was applied at a constant rate of 105 kg N, 145 kg P<sub>2</sub>O<sub>5</sub> and 165 kg K<sub>2</sub>O per ha, based on the soil test performed in the spring and regional recommendations. The NPK fertilizers were split applied with an equal rate at transplanting and at runner stage, using ammonium-nitrate (NH<sub>4</sub>NO<sub>3</sub>, 27.5-0-0), monocalcium phosphate Ca(PO<sub>4</sub>)<sub>2</sub> (0-46-0) and potassium chloride (KCl, 0-0-60).

The strawberry mother plants were transplanted in strip in the field in early May 2008. The spacing was 1.5 m between rows and 0.25 m apart between plants on the row. Irrigation was done on a rainfall compensation basis using sprinkler system with pipes installed 24 m apart across the field. The strawberry nursery plants were maintained using regional recommendations of insecticides, fungicides and herbicides. Flowering stems on the plants were consistently removed as they appeared. The flower thinning strengthened the mother plants and runner plants.

### *Strawberry plant propagation and N and P acquisition measurements*

During the growing season, we assessed the strawberry plant propagation status at runner development stage, daughter plant growth stage and at harvest (2 well-rooting daughter plants per early runner). Strawberry whole plants including roots, runners, daughter plants and leaves were sampled individually at 10 geo-referenced points (Garmin International, Olathe, KS) in a 15 x 5 sampling grid for each cultivar. Strawberry plant heights, total leaves, runners, runner tip lengths, daughter plants, root length, leaf spots, biomass, dry matters, spot leaves and dead runner of whole plant samples were determined in the laboratory. Soil samples (0-0.15 m) were taken simultaneously at each geo-referenced point at each plant sampling time. Gravimetric soil water content and soil pH (1:1 soil/water) were determined for each sample.

Strawberry whole plant tissues were ground into 0.5-mm size and concentrated H<sub>2</sub>SO<sub>4</sub> solution and 30% H<sub>2</sub>O<sub>2</sub> solution were used for plant tissue digestion. Plant total N was analysed using Kjeldahl steam distillation analysis (Labconco, Kansas City, MO). Plant total P was determined using Libra spectrophotometer (Biochrom, Cambridge, UK) using ascorbic method by reading at 880 nm (Jones 2001).

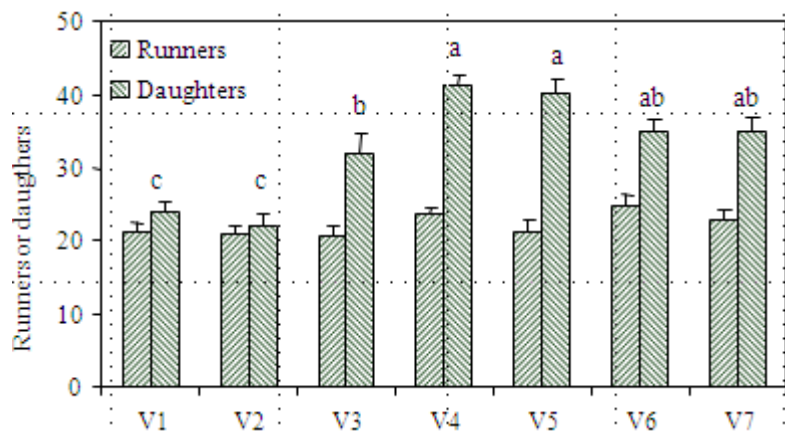
Descriptive statistics, correlation and regression analysis of plant and soil data were done using PROC UNIVARIATE, PROC CORR and PROC GLM (SAS Institute 1990). Homogeneity of datasets was verified using the Bartlett test, normality and residual distribution of data sets were confirmed using PROC UNIVARIATE, and comparison of the means was done using the Honestly Significant Difference (HSD) test (SAS Institute 1990).

## Results

There was a significant difference in strawberry nursery plant development among the seven cultivars, V1='Darselect', V2='Mesabi', V3='V151', V4='Seneca', V5='Serenity', V6='K93-20' and V7='Jewel', in this Cornwallis loam (Figure 1). The highest nursery productivity expressed in well-rooting daughter plants was 42 daughters, determined in the cultivar 'Seneca'. The highest runner number was 25 runners per mother plant, measured in the cultivar 'K93-20' (Figure 1). The optimum daughter/runner ratio was 1.7-1.8, determined in the cultivars 'Seneca' and 'Serenity', which had the significant higher runners and daughter plants than the other varieties ( $P < 0.05$ ). The cultivar 'Mesabi' had the significantly higher spot leaves (8 tri-leaves per mother plant) and dead runners (4 dead runner/mother plants) than the other cultivars, which might be the reason for its lowest daughter plant numbers (Figure 1).

Total plant N uptake varied between 1.66-3.63 g/plant and the mean and standard deviation (SD) were  $2.96 \pm 0.91$  g/plant (or  $78.9 \pm 5.9$  kg/ha). The cultivars 'Serenity' and 'Jewel' had the highest N uptake ability among the seven cultivars (Figure 2). Total P uptake ranged between 0.17-0.42 g/plant with a mean and SE

value of  $0.29 \pm 0.06$  g/plant (or  $7.73 \pm 0.26$  kg/ha) among the seven cultivars. The cultivar ‘Serenity’ and ‘Jewel’ showed a significantly higher ability of P acquisition than other cultivars (Figure 2). The significantly lower nursery productivity was associated with lower N/P uptake in the cultivars ‘Darselect’, ‘Mesabi’ and ‘V151’ (Figure 1-2).

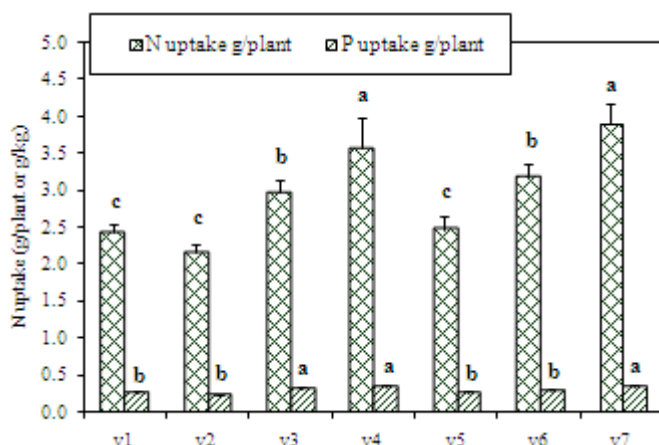


**Figure 1.** The productivity of strawberry nursery plants expressed as living runners and daughter plants. There were: V1=‘Darselect’, V2=‘Mesabi’, V3=‘V151’, V4=‘Seneca’, V5=‘Serenity’, V6=‘K93-20’ and V7=‘Jewel’. Each bar was the mean and SE value of 30 measurements. The means with the same letter was not significantly different at the probability  $P < 5\%$ .

The significantly higher ability of N and P acquisition in the cultivar ‘Serenity’ was corresponding to their significantly higher runner numbers (23 runners/mother plant) and daughter plants (42 daughters/mother plant). For the cultivar ‘Jewel’, the higher N and P uptake did not enhance plant propagation (low daughter plant numbers).

Whole plant P accumulation increased with increasing of N accumulation (up to 4.7 g/plant). The plant P accumulation ( $P_{\text{accu}}$ ) and plant N accumulation ( $N_{\text{accu}}$ ) can be described by the quadratic equation as follows:  $P_{\text{accu}} \text{ (g/plant)} = -0.0745 + 0.1808N_{\text{accu}} - 0.0181N_{\text{accu}}^2$  ( $R^2 = 0.76$ ,  $P < 0.01$ ,  $n = 70$ ).

Significantly higher strawberry runner and well-rooting daughter plants were in the nutrition accumulation ranges of 2.47-3.26 g N/plant and 0.25-0.34 g P/plant. Further determination of effects of runner thinning on plant N and P acquisition ability might possibly help understand if thinning can help regulate strawberry plant N and P uptake and nursery propagation.



**Figure 2.** The ability of N and P acquisition of seven strawberry cultivars measured at harvest. There were: V1=‘Darselect’, V2=‘Mesabi’, V3=‘V151’, V4=‘Seneca’, V5=‘Serenity’, V6=‘K93-20’ and V7=‘Jewel’. Each bar was the mean and SE value of 10 measurements. The means with the same letter was not significantly different at the probability  $P < 5\%$ .

The data showed also that the runner and daughter numbers of the seven strawberry cultivars were related to soil water content (SWC) and pH values ( $0.63 < R^2 < 0.91$ ). Soil water and pH levels might have also affected strawberry N and P acquisition ability among the different cultivars. The regression relationships of strawberry nursery plant performance and soil water and soil pH were significant, as shown by the equations as follows:

Strawberry variety	Regression equations	$R^2$
V5='Serenity'	Runner = 4.62 SWC – 20.54	0.82**
V7= 'Jewel'	Runner = 4.58 SWC – 19.18	0.81**
V5='Serenity'	Daughter = 11.9 pH – 26.59	0.91**
V7= 'Jewel'	Daughter = 13.4 pH – 40.56	0.89**

## Conclusion

The ability of plant N and P assimilation was significantly different among the seven strawberry cultivars. The cultivar 'Seneca' and 'Jewel' had a significantly higher ability of N and P uptake but only higher N and P acquisition in the cultivar 'Seneca' has related to significantly higher productivity expressed by daughter plant numbers. Significantly lower nursery productivity was associated with lower N and P uptake in the cultivars 'Darselect', 'Mesabi' and 'V151'. Strawberry propagation could be affected by its ability of acquisition of N and P nutrition but other factors such as runner numbers, soil water and soil pH might also influence plant N and P uptake and strawberry development. It is needed to further examine the relationships between strawberry plant N and P acquisition with runner thinning and these soil physical factors for regulating N and P nutrition in strawberry nursery plants.

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