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Nutrient content changes in strawberry plant parts at different development stages

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Abstract

The objective of the investigation was to study the effect of different development stages on distribution of mineral nutrients in the growing leaves, roots, petioles and fruits. Strawberry plants were grown in a greenhouse in perlite medium and fertigated with Hoagland solution. Mineral nutrient concentration was determined at three development stages *viz.*, ßowering, fruiting and the end of fruiting. Also nutrient concentration was determined in different organs at fruiting stage. Our results show that nutrient uptake was variable at different development stages. Leaf and petiole were the main sinks for Ca at fruiting stage and also for Mg and K in petioles, Fe in root, Mn in leaf. Results indicated that plant have different uptake pattern at various development stages. Results on the element uptake by different organs at various development stage is indicative of their relative requirement at different stages.

Key words: Strawberry, nutrient, development stages, plant fragments

Introduction

Reducing fertilizer requirement is an important objective of sustainable production of many horticultural crops (Tagliavini *et al.,* 1996), including strawberry (*Fragaria* x *Ananassa* Dutch.). Also for optimal production, nutrient management is important. Knowledge about nutrient concentration in plant organs at various development stages is necessary. Plant parts have differential nutrient uptake at different developmental stages.

Plant tissue analysis provides a useful guide to efÞcient crop fertilization and also provide useful guide for sugesting which nutrient to be applied, at what rates, the best method and time of application. Interpretive guides for some crops, such as strawberry, are initial estimates and are subject to revision as more information is obtained. These interpretive guides are liable to continuous revision as more data are obtained relating plant nutrient concentrations and crop performance.

Probably the most important variable in plant analysis is the age of the plant at sampling. Also it is well known that strawberry is a perennial plant cultivated occasionally as annual crop, being transplanted in the summer of one year and yielding the following year in late spring-early summer (Faedi and Baruzzi, 2002). After fruit harvest, vegetative organs are usually removed and brought outside the Þeld, so all nutrients taken up and not only those partitioned to fruits should be considered as net uptake (Mengel and Kirkby, 2001) and potentially have to be reintegrated by fertilizers. According to the above reason, it seems that knowledge about nutrient concentration in plant parts at different stages is necessary.

Information on nutrient concentration at different development stages in strawberry plant parts is limited. In this paper, nutrient concentration at different developmental stages in strawberry plants has been investigated for evaluating their requirements in relation to developmental stages.

Materials and methods

Plant culture and design Uniform strawberry (*Fragaria ananassa*) plants (cultivars, Selva and Comerosa) which got sufÞcient chilling were brought from Þeld nursery to a greenhouse in December. These plants were planted in 32 plastic pots Þlled with perlite in a semi-controlled greenhouse, at Bu-Ali Sina University (Iran) on 10 December, 2005. The pots where planted with a single plant. Temperature was 24/18°C (day/night) and relative humidity was 60-80% in greenhouse. The experimental design was randomized blocks replicated four times in groups and four plants per replication (16 plants per treatment). Each plant was fed by single dripper (80 drips in each four hours that were regulated by timer). Hoagland and Arnon (1950) solutions were used as nutrient solution.

Plant analyses: Plant samples were dried in oven at 70°C for 72 h. The dried leaves, roots and petioles were ground to powder using a pestle and mortar and stored in polyethylene bottles. 0.5g of each dried sample was ashed at 550 °C in a porcelain crucible for 2 h. The white ash was taken up in 1 M HCl, Þltered in to a 50 mL volumetric ßask and made up to 50 mL with distilled water. The concentrations of K was analysed by Flame photometer; Ca, Mg, Zn, Fe and Mn were analysed by inductively-coupled plasma atomic emission spectrometer (ICPAES). Statistical analysis was made using analysis of variance by MSTATC software and the means were separated by Duncan's Multiple Range Test (DMRT) at P=0.05.

Results

Table 1 shows the mean concentration of potassium, calcium, magnesium (g kg^{-1} in dry matter), zinc, manganese and iron (mg kg^{-1} in dry matter) at three phenological stages (ßowering, fruiting and growth stage after fruiting) in leaf tissues. Leaf calcium, magnesium, potassium and iron content in all leaf samples were signiÞcantly affected by different development

Table 1. Mineral nutrient content in the leaf tissue of strawberry (cvs, Selva and Comerosa) at three development stages

Treatment	Ca (g kg^{-1} DM)	Mg (g kg^{-1} DM)	K (g kg^{-1} DM)	Fe (mg kg^{-1} DM)	Mn (mg kg^{-1} DM)	Zn (mg kg^{-1} DM)
Selva						
Flowering	13.98abc	4.338b	40.25ab	125.5a	55.25a	32.07a
Fruiting	13.78abc	3.714b	30.00c	88.00ab	52.50a	26.72a
End of fruiting	16.78a	5.310a	30.25c	89.75ab	54.25a	25.60a
Comerosa						
Flowering	11.34c	3.656b	43.50a	125.0a	46.25a	24.13a
Fruiting	12.93bc	3.770b	38.00abc	75.75b	40.00a	27.27a
End of fruiting	16.20ab	5.908a	32.25bc	83.75ab	54.50a	29.36a

Means in each column followed by different letters are signiÞcantly different at *P*=0.05 by DMRT.

Table 2. Mineral nutrient content in the root tissue of strawberry (cvs, Selva and Comerosa) at three development stages

Treatment	Ca (g kg^{-1} DM)	Mg (g kg^{-1} DM)	K (g kg^{-1} DM)	Fe (mg kg^{-1} DM)	Mn (mg kg^{-1} DM)	Zn (mg kg^{-1} DM)
Selva						
Flowering	7.461a	2.127b	5.750a	574.7a	23.25a	23.27a
Fruiting	8.126a	3.235a	8.500a	205.7b	19.00a	21.64a
End of fruiting	9.113a	2.542ab	6.000a	301.0ab	14.00a	20.75a
Comerosa						
Flowering	9.007a	2.224b	7.250a	478.2ab	25.00a	21.43a
Fruiting	9.518a	2.607ab	8.000a	326.5ab	21.28a	22.74a
End of fruiting	10.00a	2.309b	6.500a	279.7ab	36.00a	20.23a

Means in each column followed by different letters are signiÞcantly different at *P*=0.05 by DMRT.

stages, but the concentration of manganese and zinc in leaves was not signiÞcantly inßuenced. Ca and Mg concentration in end of fruiting and K and Fe concentration in ßowering stage was in highest amount.

Table 2 show the mean concentration of potassium, calcium, magnesium (g kg^{-1} in dry matter), zinc, manganese and iron (mg kg^{-1} in dry matter) at three phenological stages (ßowering, fruiting and growth stage after fruiting) in root tissues. Magnesium and iron concentration in all root samples were signiÞcantly affected by development stages, but the concentration of calcium, potassium, manganese and zinc in roots was not signiÞcantly inßuenced. Mg concentration in fruiting and Fe concentration in ßowering stage was of higher level.

Table 3 shows the mean concentrations of potassium, calcium, magnesium (g kg^{-1} in dry matter), zinc, manganese and iron (mg kg^{-1} in dry matter) at three phenological stages (ßowering, fruiting and growth stage after fruiting) in petioles. Petiole calcium, magnesium, potassium, manganese and zinc concentration in all leaf samples were signiÞcantly affected by different development stages, but the concentration of iron in petioles was signiÞcantly not inßuenced. Ca and Mg concentration in end of fruiting and K and Zn concentration in ßowering stage was in highest amount. Also minimum Mn was recorded at fruiting time.

Table 4 shows the mean concentration of potassium, calcium, magnesium (g kg^{-1} in dry matter), zinc, manganese and iron (mg kg^{-1} in dry matter) in four strawberry parts (leaf, root, petiole and

Table 3. Mineral nutrient content in the petioles tissue of strawberry (cvs, Selva and Comerosa) at three development stages

Treatment	Ca (g kg^{-1} DM)	Mg (g kg^{-1} DM)	K (g kg^{-1} DM)	Fe (mg kg^{-1} DM)	Mn (mg kg^{-1} DM)	Zn (mg kg^{-1} DM)
Selva						
Flowering	12.96bc	4.508bc	71.75a	62.50a	46.50a	21.69b
Fruiting	14.52b	4.779abc	42.50c	67.75a	14.90c	28.91b
End of fruiting	20.38a	5.804ab	59.25b	73.75a	23.42bc	39.46a
Comerosa						
Flowering	8.961c	3.812c	71.25a	63.25a	31.25b	26.83b
Fruiting	11.50bc	4.678abc	66.00ab	60.25a	12.20c	29.83ab
End of fruiting	13.82b	5.977a	60.50ab	83.75a	15.50bc	30.98ab

Means in each column followed by different letters are signiÞcantly different at *P*=0.05 by DMRT.

Table 4. Mineral nutrient content in various tissue of strawberry (Cvs, Selva and Comerosa) at fruiting stage

Treatment	Ca (g kg^{-1} DM)	Mg (g kg^{-1} DM)	K (g kg^{-1} DM)	Fe (mg kg^{-1} DM)	Mn (mg kg^{-1} DM)	Zn (mg kg^{-1} DM)
Selva						
Leaf	14.69a	3.927bc	36.00b	90.00b	35.50b	25.68ab
Root	9.385bc	2.788d	6.250c	310.0a	25.30bc	23.05ab
Petiole	13.38ab	5.217a	51.25a	50.00b	11.10c	29.95a
Fruit	2.892d	1.358e	45.75ab	28.25b	9.950c	12.36d
Comerosa						
Leaf	12.01abc	3.557bcd	32.00b	73.75b	57.00a	28.32ab
Root	8.260c	3.051cd	10.25c	222.3a	14.97c	21.33bc
Petiole	12.64ab	4.240b	57.25a	78.00b	13.50c	29.04a
Fruit	3.462d	1.773e	34.00b	35.00b	10.25c	16.02cd

Means in each column followed by different letters are signiÞcantly different at *P*=0.05 by DMRT.

fruit) at fruiting stage. The main sinks for Ca were leaf and petiole, for Mg and K is petioles, for Fe is root and for Mn is leaf. Fruit Zn amount was least in fruit samples.

Discussion

The most important aim of our investigation was to determine the uptake of various elements at different development stages. Our results show that Ca and Mg concentration was increased at end of fruit growth stage in leaf and petiole samples and the trend was similar to the results published by Tagliavini *et al.* (2005). It seems that Ca and Mg with progress of development stages increased in plant organs. Ca and Mg uptake is passive and semi active, respectively and water evapotranspiration is important for their uptakes. It seems that with decrease of plant growth, evapotranspiration from spatial organs was increased. Calcium is considered important for fruit Þrmness, in spite the fact that most Ca accumulates in plant organs other than the fruits (Albregts and Howard, 1978 and 1980). Results indicates similar Ca distribution pattern in plant organs.

K was in maximum amount at ßowering stage in leaf samples and at fruiting time in root samples. Our Þndings conÞrmed results of Tagliavini *et al.* (2005). In leaves and petioles, K was in maximum amount followed by Ca and magnesium. These results show that K is important element for strawberry development. Potassium, followed by Ca and Mg were the nutrients absorbed most during the whole production cycle.

Results show that micronutrient content changes at different stages of plant development. Zn and Mn were proximally consistant with the change of development stages in root and leaf but Fe was inconsistant with change in development stages in both root and leaf samples. In petiole samples, Mn and Zn content varied with plant development. Also Fe was constant in petiole samples by progress of plant development. It seems that Fe requirement in ßowering is maximum. Difference in various nutrient sink probably be because of various uptake mechanisms (active or passive) of each element. Nutrient needs should instead be deÞned as those amounts necessary to be absorbed to maximize a desired plant performance: under sustainable fruit production this performance cannot be identiÞed only by a fruit yield but has to include nutritional quality of the plant food (Welch, 2002), and minimum or no risk of pollution to the environment.

In conclusion, these experiments indicate the pattern of root uptake of nutrient dynamics by strawberry plant. In practice, the knowledge of plant nutreint requirement might allow a precise control of nutrient supply especially if (1) ßexible nutrient supply techniques, like fertigation, are adopted and (2) monitoring of nutrient availability in the nutrient solution and or in the plant is carried out.

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