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Effect of Shading on Seasonal Variation of Some Macro-nutrients in Camarosa Strawberry†

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This study is aimed to determine the effects of shading on variation of mineral elements as seasonal. The treatments included greenhouse check, no shade and constant shading (CS). Nitrogen, phosphorus, potassium and calcium in root, crown and leaf of strawberry camarosa were determined. In the study, N and P contents in the plant parts were generally lower, the plants in greenhouse check having more crown size and leaf area and a greater root volume, probably as a result of dilution. Potassium content in crown and root generally reduced prior to spring while it increased with starting of growth period. Calcium content increased in spring and summer with increasing temperature. Phosphorus and calcium content were more than that of root and crown. In addition, it was shown that shading does not affect the K and Ca content in leaf and crown.

Key Words : Strawberry, Light, Mineral elements, Yield, Growth.

INTRODUCTION

Strawberry has been widely grown worldwide because of adapting to various climate and soil conditions. Prerequisites for a successful strawberry growing are climate and soil. Specific nutrient management practices are required for individual cultivars grown under these widely different environmental conditions to ensure large yields of quality fruit[1].

Nitrogen, P, K and Ca are very important mineral elements in strawberry growing[1, 2]. Nitrogen is used for producing proteins, nucleic acids and various coenzymes. Phosphorus is effective in energy transfer process in plants. Potassium influences uptake of carbon dioxide, photosynthesis and regulates opening of stomata[1]. Calcium provides maintenance of membrane integrity and wall structure and acts as a secondary messenger in metabolic regulation[1, 2].

A good nutrition program for strawberry is important in terms of yield, fruit quality and preventing environmental pollution and wasteful expenditure. For this reason, it is important to know the factors affecting nutrient availability and uptake. Over the range of climates, soil physicochemical conditions, genotypes

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and cultural practices affect nutrient uptake from soil[3]. To develop sound nutritional programs for optimal strawberry production, cultural, climatic and plant growth media factors must be considered together with an understanding of the physiological role each element plays in the growth and development of plant[1].

Flower initiation and runner formation in strawberry are controlled by photo-period[4–7]. There is a relationship between light requirement of plant and soil fertility. Leaves of plants growing on fertile soil contain more chlorophyll, so these bring about more photosynthesis. Light causes opening of stomata and more transpiration. Thus, the plant uptakes more water and minerals[8]. Although many studies investigating the relationships between plant growth and lighting have been carried out, studies showing the relationships between nutrient contents and shading or reducing light levels are rare. This study aims at determining the effects of shading on variation of nutrient contents (N, P, K and Ca) in different parts including root, crown and leaf of strawberry during vegetation period in greenhouse condition.

EXPERIMENTAL

Plots were established on peat, manure and garden soil mixture (1 : 1 : 1). Conventional fertilizers were applied with ammonium sulfate (3 g/plant). Chemical properties of plant growth media are presented in Table-1. Plant growth media was slightly alkaline, no salt (< 0.98 dS m^{-1}). It was of low $CaCO_3$ (< 5%) and high organic matter content (> 3%). Also, it consisted of adequate nutrient levels such as N, P, K and Ca. Temperature and soil temperature were measured by a digital thermograph and light intensity by a Delta-T Devices SS1 Sun Scan Canopy Analyzer (Fig. 1). First flower, fruit set and harvest dates and yield of Camarosa strawberry are given in Table-2.

TABLE-1
CHEMICAL PROPERTIES OF PLANT GROWTH MEDIA

pH	Total N (%)	$CaCO_3$ (%)	$EC_{25°C}$ (dS m^{-1})	Available P (mg/kg)	Exchangable K (mg/kg)	Exchangable Ca (meq/100)	Organic matter (%)
7.35	0.302	2.77	0.36	162.9	776.86	21.26	6.03

TABLE-2
FIRST FLOWERING, FRUIT SET AND HARVEST DATES IN THE DIFFERENT SHADING TREATMENTS[9]

Treatments	First flowering	Fruit set	First harvest	Yield (g/plant)
Greenhouse check (GC)	30 March	06 April	29 April	1014.8 a^z
Constant shading (CS)	05 April	20 April	06 May	710.9 b^z

Mean separation by Duncan's multiple test, 5% level.

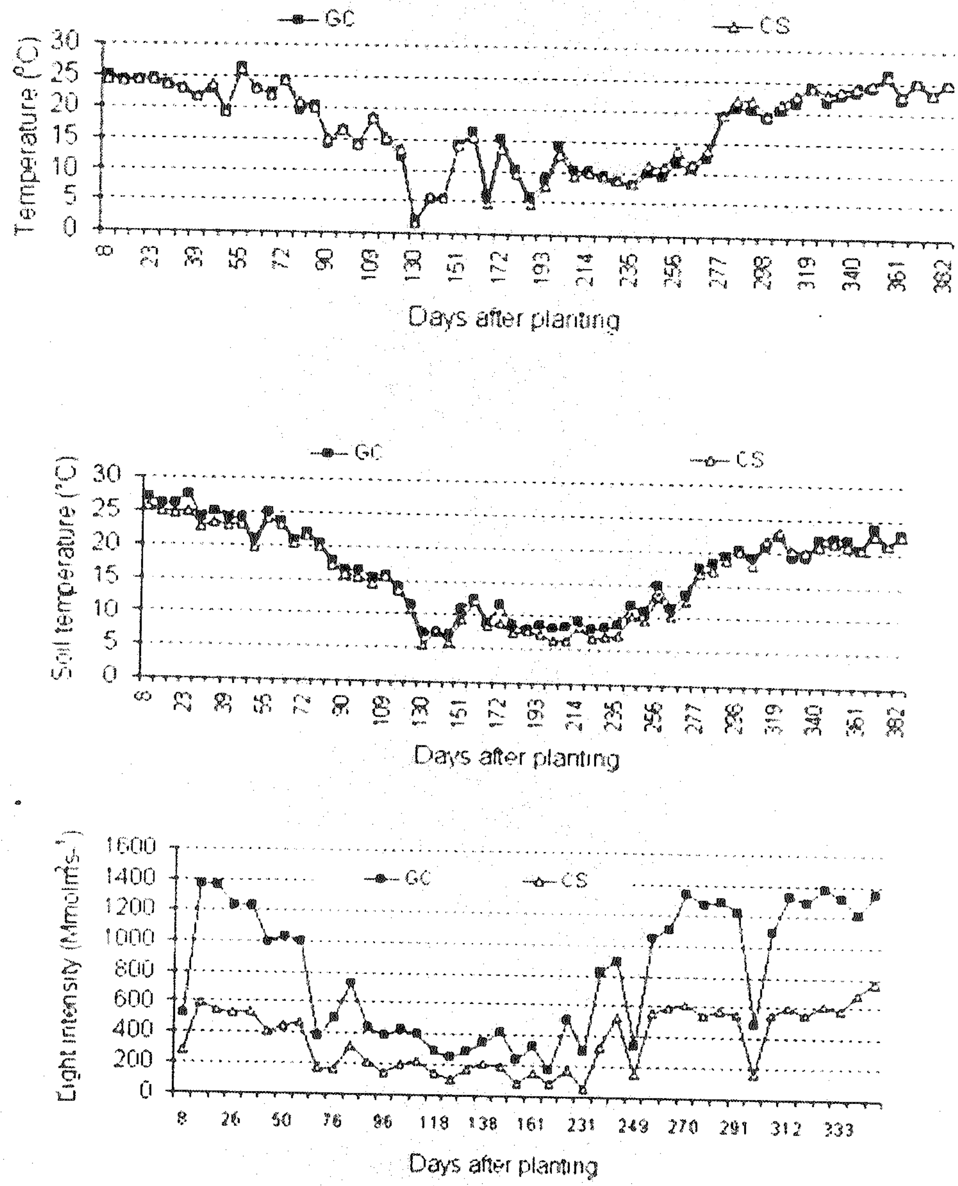


Fig. 1. Temperature, soil temperature and light intensity of experiment sites (GC: greenhouse control, CS: constant shading)

Experimental design: On 1 August 2002, frigo seedlings of camarosa cultivar were planted in double-row plots at 30 × 30 cm spacing in a triangle planting system in a plastic greenhouse. The experiment was arranged in a randomized complete block design with five treatments and four blocks per treatment giving a total of 30 plants per block. A total of 120 plants per treatment were used. The treatments included : greenhouse check (GC), no shade and constant shading (CS). Commercial shade material (50%) was used to enclose the sides, top and ends of the treatments during each of treatment periods. The plants were watered by dripping system and mulched with straw.

All data were analyzed using SPSS 11.0 statistical software (SPSS Inc.). Analysis of variance (2-way ANOVA) was performed to compare differences;

where significant F-values were obtained; differences between individual means were tested using the Duncan's multiple comparison tests. All the figures presented include standard error of the data and F-values.

Nutrient contents : Three plants were pulled up from each treatment on the following dates: (1) 90 days after planting (30th October 2002), (2) 131 days after planting (10th December 2002), (3) 158 days after planting (6th January 2003), (4) 228 days after planting (17th March 2003), (5) 292 days after planting (20th May 2003), (6) 338 days after planting (5th July2003). The plants were separated into roots, crowns and leaf with petioles and washed. Plant materials were oven-dried at 70°C. Total nitrogen was determined by Kjeldahl method. Dried and homogenized plant materials were wet-digested with $HNO_3 : HClO_4$ (4 : 1, v/v) and then P concentration in the solutions was determined by ammonium heptamolybdate-ammonium vanadate in nitric acid method with a spectrophotometer (Consort P903). Potassium and calcium concentration of plant materials were determined after wet-digestion using AAS (Perkin-Elmer 2280) with flame[10].

RESULTS AND DISCUSSION

Nitrogen: Nitrogen content in leaves significantly decreased from late autumn through winter while it increased forward prior to flowering in camarosa strawberry (Fig. 2). Human and Kotze[11] reported that nutrient uptake was not very active during the late autumn and winter in cv. Selekta. Chunghong *et al.*[12] found that most N was absorbed during vegetative growth in strawberry. Foliar N significantly decreased during fruiting (Table-2), especially the fruit expansion stage and harvest stage as informed by Chunghong *et al.*[12] We also thought that N in leaves in fruiting period moved from leaves to fruit. In addition, it may be thought that foliar N decreases because of dilution in leaves with increasing crown size and leaf area. N content in leaves varied from 1.36–2.49% during the experiment. May and Pritts[1] showed that foliar N levels of between 2.0 and 2.8% were considered sufficient for strawberries. Unlike leaves, N content in crown significantly increased from 30th October 2002 to 6th January 2003 while it tended to fall during the following period, significantly (Fig. 2). Guilin *et al.*[13] found that the content of N in stems declined with development of strawberry plants. It was the highest in winter period (158th day after planting). In the experiment, N content in crown varied from 0.82–1.98%. Stanisavljevic *et al.*[14] also reported that crown N was 0.92% in strawberry. Nitrogen content in root generally showed a similar trend to crown. N content in root during the experiment varied from 1.13–2.24%.

Nitrogen content in all the parts (leaf, crown and root) decreased from prior to fruiting period through the end of growth period. Likewise, many researchers[11, 14–16] informed that N content in different plants parts decreased from beginning of fruiting period to end of harvest.

There were significant differences between GC and CS in terms of N content in leaf and root in cv. camarosa. Nitrogen content in plant parts including leaf, crown and root was generally lower, the plants in GC having more crown size and root volume and leaf area because of higher light intensity and temperature

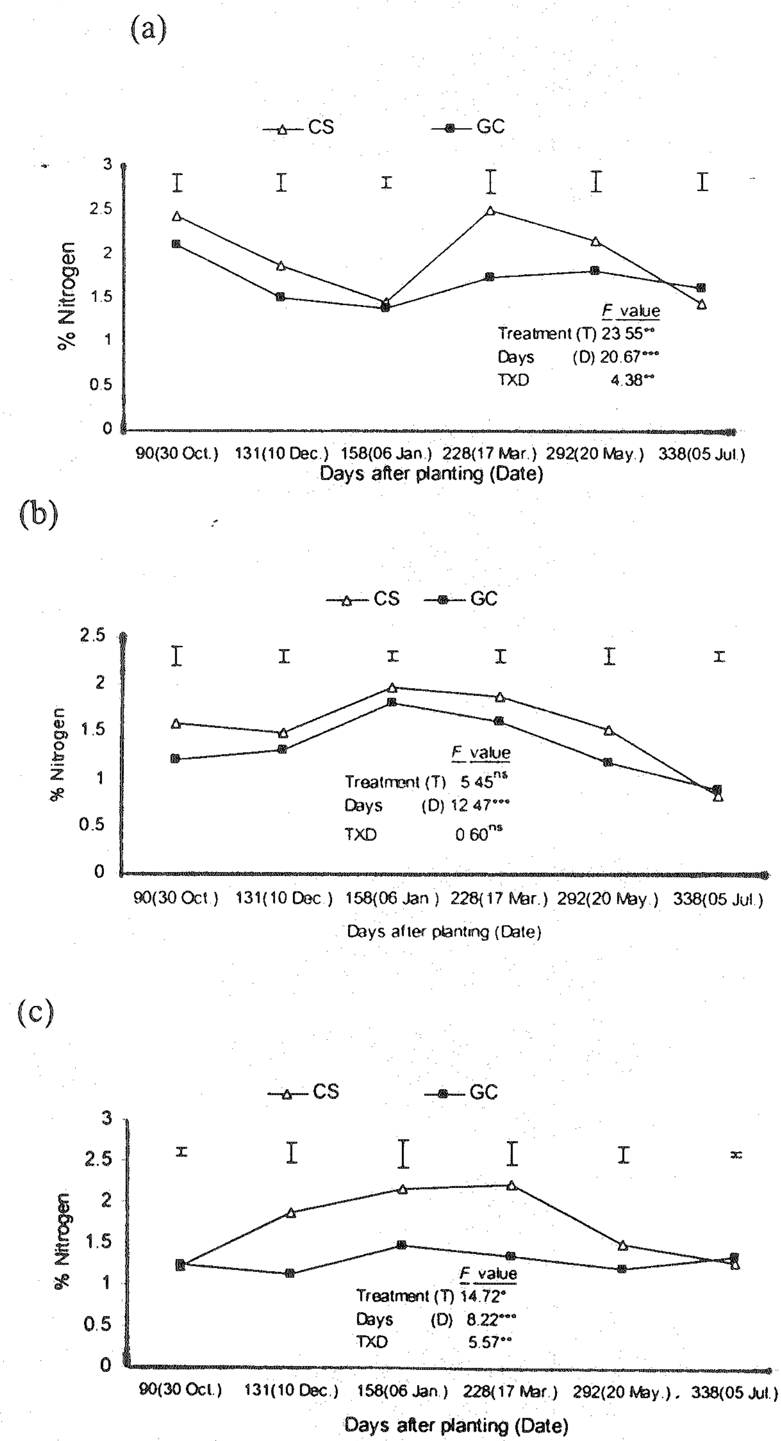
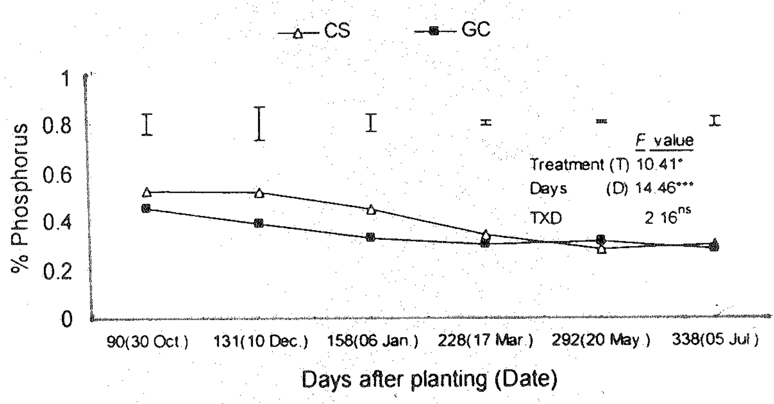


Fig. 2. Effect of shading on N variation in leaf (a), crown (b) and root (c) in camarosa strawberry. Vertical bars on graph represent the standard error of the difference for each dissection.

compared to CS (Fig. 1) as determined in the same plants by Ozturk and Demirsoy[9] and also as a result of, probably, dilution.

Phosphorus: Foliar P in the experiment significantly decreased from 30th October through prior to flowering (Fig. 3) as a result of lower soil temperature



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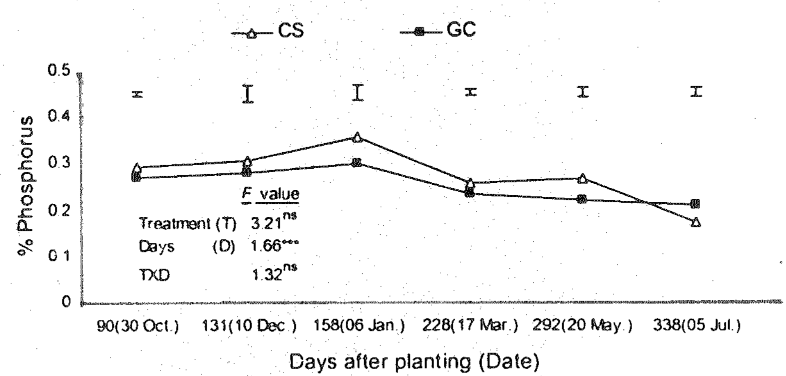

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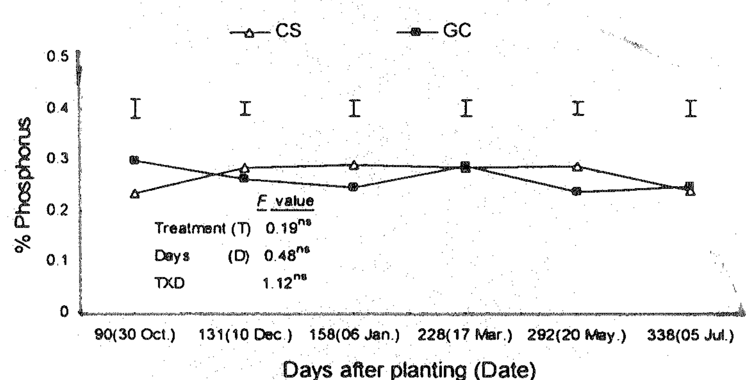


Fig. 3. Effect of shading on P variation in leaf (a), crown (b) and root (c) in Camarosa strawberry. Vertical bars on graph represent the standard error of the difference for each dissection.

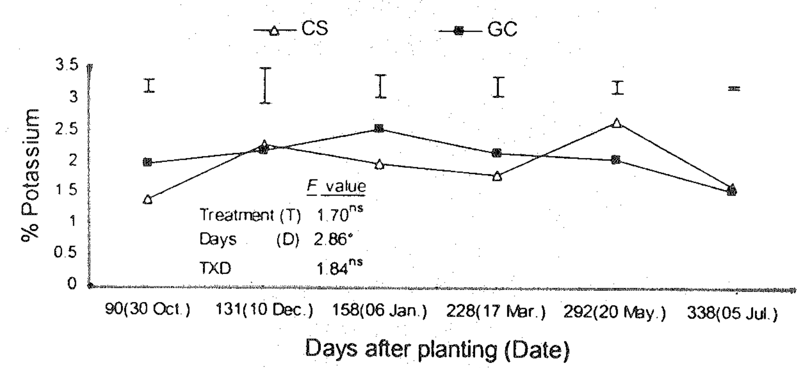
(Fig. 1) just as May and Pritts[1] reported that leaf P content was greatest at the soil temperature of 65°F (18°C). In addition, P in the period may have been excessively used for flowering and then moved to fruit as determined by John *et al.*[17] and May *et al.*[18] Afterward, ,foliar P in both treatments was generally stable by the end of summer growth period. Foliar P varied from 0.28–0.52% in the experiment. May and Pritts[19] found that foliar P varied from 0.40–0.25% in strawberries.

Phosphorus content in crown significantly increased from 90th day after planting through 158th day while it decreased from 158th day after planting through end of summer growth period (Fig. 3). This case could result from the fact that P moved to fruit as reported by Kacar[20]. P content varied from 0.21–0.35% in crown. Ferree and Stang[21] found that crown P varied from 0.40–0.25% at the end of harvest in Earliglow strawberry. In another study, it was 0.14% in strawberry (cv. Senga Fructarina)[14]. P content in root in both treatments did not show clear variation (Fig. 3) and varied from 0.24–0.30%.

There was a significant difference between GC and CS in terms of P content in leaf of camarosa strawberry (Fig. 3). Phosphorus content was generally also lower the plants in GC because of, probably, reasons which affected N variation as above. P accumulated more in leaves than in crown and roots. Albregts and Howard[15] found that accumulation of P was more in leaves in 3 strawberry cvs.

Potassium: There were no significant differences between treatments in terms of foliar K on 30th October, 6th January and 20th May (Fig. 4). Foliar K in the plants in CS was slightly lower by 17th March because of low soil temperature in CS (Fig. 1). Roberts and Kenworthy[22] reported that leaf K increased as root temperature was increased. Foliar K in the experiment significantly increased by 6th January while it significantly decreased from 20th May onwards (Fig. 4). Foliar K was slightly lower in the plants in GC during optimum harvest period (20th May) because of higher yield (Table-2), thus, transporting more to fruit. Albregts *et al.*[23] reported that foliar K reduced toward harvest in strawberry. John *et al.*[24] found that foliar K reduced after harvest. Foliar K varied from 1.38–2.64%. May and Pritts[1] also reported that adequate foliar K varied from 2.5–1.5%. In general, K content in crown in both treatments significantly reduced by spring while there was no more variation from this period through the end of the experiment (Fig. 4). Unlike in CS, K content in crown in GC having higher soil temperature and light intensity resulting in more vegetative growth in autumn (Fig. 1) showed a slight increase by 10th December. Brohi *et al.*[8] also found that there was a positive correlation between K uptake speed and growth. K content in crown varied from 0.98–2.20%. Stanislavljevic *et al.*[14] reported that the variation in crown K was 0.45%. There was no difference among days of planting in terms of K content in root. However, K content in root relatively decreased toward winter while it increased prior to flowering and fruiting period (Fig. 4). K content in root slightly decreased from 20th May through 5th July with increasing soil temperature (Fig. 1). Likewise, May and Pritts[1] reported that K content decreased with increasing soil temperature. In the experiment, K content in root varied from 0.53–1.24%. However, Stanislavljevic *et al.*[14] reported that root K was 0.37%.

Potassium content in crown and root generally reduced prior to spring while it increased with starting of growth period. Brohi *et al.*[8] also found that most of K was absorbed at the vegetative growth period. Lieten and Missoten[25] found that uptake of K had risen during flowering and ripening period in strawberry (cv. Elsenta) in our study. There was no difference between CS and GC in terms



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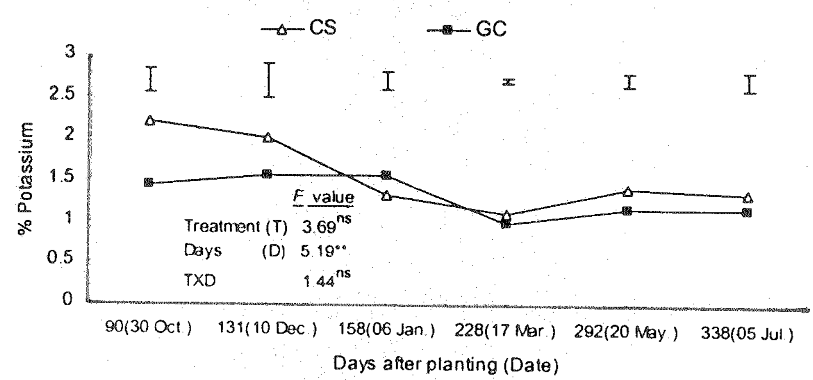

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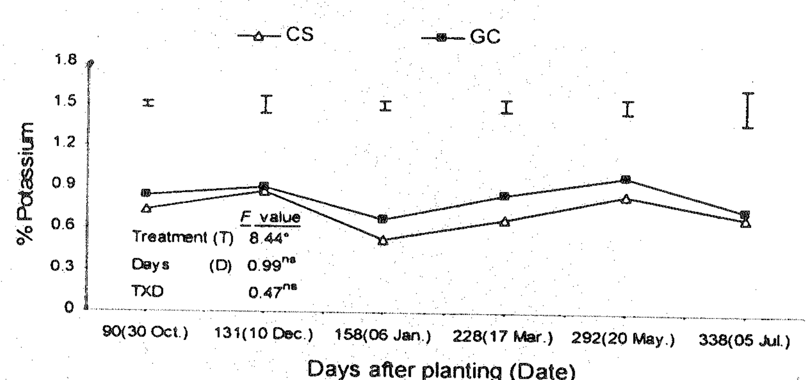
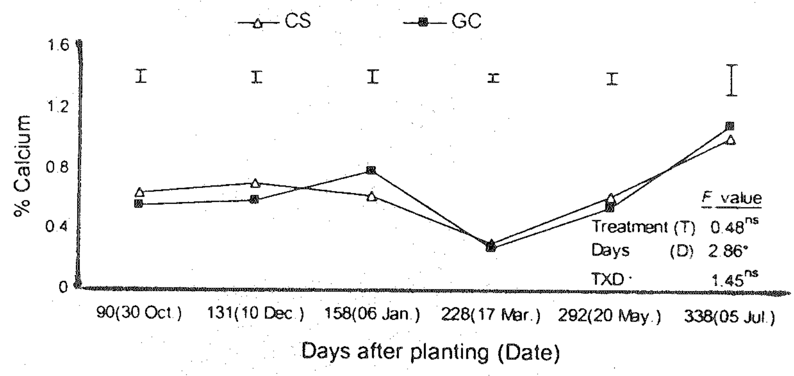


Fig. 4. Effect of shading on K variation in leaf (a), crown (b) and root (c) in camarosa strawberry. Vertical bars on graph represent the standard error of the difference for each dissection.

of K content in root. However, root K in GC was slightly higher compared to CS because of more vegetative growth of the plants in GC.

Calcium: Foliar Ca in the experiment significantly reduced towards spring while it significantly increased from this time through the end of the experiment (Fig. 5). The increase likely resulted from increase of uptake of Ca at warm periods (Fig. 1) because of increasing transpiration as informed by May and



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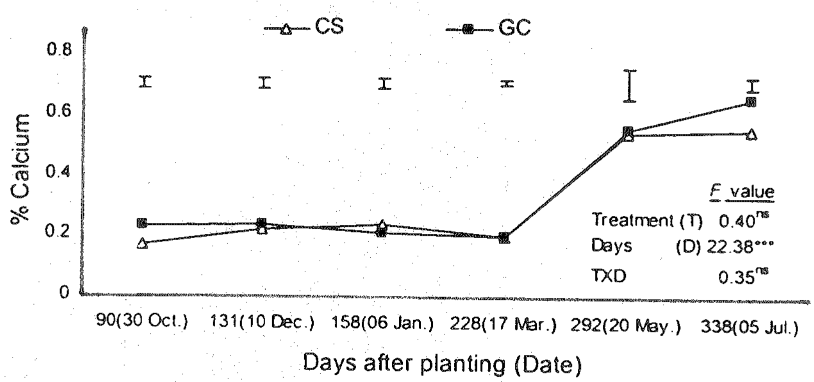

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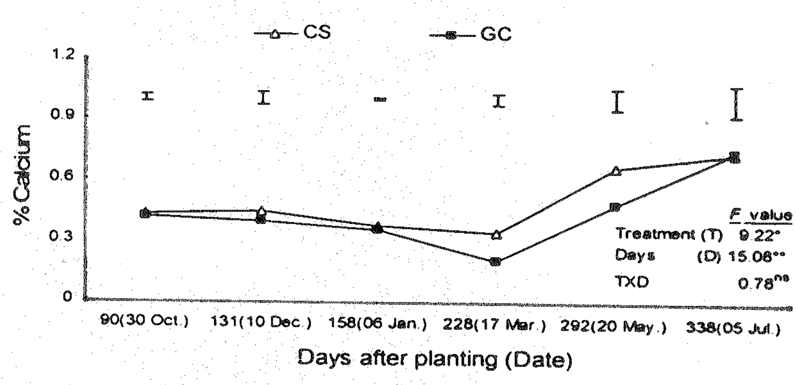

Fig. 5. Effect of shading on Ca variation in leaf (a), crown (b) and root (c) in Camarosa strawberry. Vertical bars on graph represent the standard error of the difference for each dissection.

Pritts[1]. And also, May *et al.*[18] reported that foliar Ca, Mg and Mn increased from mid-April through late June. Foliar Ca varied from 0.28–1.09%. May and Pritts[1] also reported that adequate foliar Ca varied from 1.7–0.7%. Also, Cline[26] found that adequate foliar Ca was 0.5–1.5% in strawberry.

Calcium content in crown was stable prior to flowering (Fig. 5). It significantly increased from this date together with increasing temperature (Fig. 1). It was at the highest level on 5th July at GC treatment as foliar. As explained above, increasing of Ca uptake was related to increasing transpiration with high temperature as informed by Vardar and Guven[27]. In the experiment, Ca content in crown varied from 0.17–0.65%. Stanislavljevic *et al.*[14] reported that crown Ca was 1.33%.

Root Ca in both treatments showed similar tendency (Fig. 5). It significantly increased towards summer as foliar and crown. Ca content in root varied from 0.20–0.74%. The data harmonized with the result of Stanislavljevic *et al.*[14] There was a significant difference between CS and GC in terms of K content in root. Root Ca in GC was slightly lower despite more root development of the plants in GC, probably as a result of dilution (Fig. 5).

Foliar Ca was more than that of root and crown. Uptake of Ca increased in spring and summer because of increasing temperature. Likewise, according to Brohi *et al.*[8] transpiration controlled the moving speed of Ca to upper part.

Although N, P, K and Ca content of plant growth media was at an adequate level at the beginning (Table-1), those of leaves sampled during the experiment were rather variable. Their nitrogen and Ca contents were low or inadequate while P and K concentrations of leaf samples were at adequate level[17]. This case for N likely may have resulted from mobility of N in soil. Mobility of N in soil is higher than the other nutrients and it may leave the soil by some processes such as leaching, denitrification and losing of NH_3[28]. In the experiment, it was determined that N being at an adequate level at the beginning was not uptaken by plants and the N content of plant leaf samples was below the adequate level. Like N, Ca content of the media was at an adequate level at the beginning while that of plant leaves was at an inadequate level. Basic resource of Ca in soil is $CaCO_3$. In addition, Bolt and Bruggentwert[29] reported that manure and peat material in plant growth media includes low lime content. In the experiment, $CaCO_3$ level was determined as low in the media (Table-1). Exchangeable Ca content being at an adequate level at the beginning of the experiment may not have responded to the requirements of the plant during vegetation and there was low level in the leaves. The plants were not able to uptake them at adequate level despite an adequate level of Ca and N content in the media. For this reason, Ca and N sources with high solubility and availability should be added to the media. In addition, P and K being adequate at the beginning were adequate in plant leaves during the vegetation period. This may result from the fact that P and K having low mobility are more stable than N.

Conclusion

In the study, it has been shown that the contents of N and P are related to vegetative growth; P is excessively used by the plant in autumn; Ca content is related to transpiration with increasing temperature; K is continuously being accumulated in the plants and stable during the year and higher light intensity and temperature, increasing photosynthesis and transpiration may increase nutrient uptake, especially of Ca.

In the experiment, N and P contents in the plant parts were generally lower, the plants in GC having more crown size and leaf area and a greater root volume, probably as a result of dilution. Nitrogen content in leaves decreased in autumn and winter while that in root and crown increased, depending on root and crown growth and production of additional runner plants. Potassium content in crown and root generally reduced prior to spring while it increased with starting of growth period. Ca content increased in spring and summer with increasing temperature. Potassium and Ca content was more than that of root and crown. In addition, it was shown that shading did not affect K and Ca contents in leaf and crown.

As a result, although nutrients in plant growth media at the beginning are adequate in strawberry growing in greenhouse, the level of these nutrients in plants may be inadequate or low during vegetation. Nutrient concentration of plants must be followed by plant analysis and nutrients reducing or lacking should be added to the media. In addition, it should be considered that plant nutrient contents may change with growth media, cultivar, environmental condition etc. We think that there is need for further study about these.

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ERRATUM

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Iridium(III) Catalyzed Oxidation of Propane-1,2-diol by Hexacyanoferrate(III) in Aqueous Alkaline Medium: A Kinetic and Mechanistic Study

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Figs. 1 and 2:
Please read [HCF(III)] × 1000 M and [PDL-1,2] × 100 M respectively along x-axis.

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Synthesis, Biological and Pharmacological Activities of 2(-Hydroxy-4′5′-Dimethyl Substituted Chalcones and Flavones

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Asian Journal of Chemistry Vol. 18, No. 2 (2006), 1455–1461

Antimicrobial Activities of Some Thyme (Thymus, Staureja, Origanum and Thymbra) Species against Important Plant Pathogens

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Please read **Staureja** as **Satureja** in the title.