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Differences in Mineral Contents of Apple Leaves Associated with Fruiting and Non-Fruiting of Biennial Bearing Trees

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The relationships between differences of mineral content and biennial bearing in 'Amasya' apple cv was determined. The 'Amasya' apple cultivar was grafted on the M.9, MM.106 and MM.111 clones and on the seedling rootstocks were planted in 2 × 2, 4 × 4, 6 × 6 and 6 × 6 m densities, respectively. The contents of leaf N, Ca, Mg, Fe, (Ca + Mg)/K, N/K and Ca/K were found higher in fruiting trees than in non-fruiting trees. Ca and Mg contents of leaves of grafted trees on M.9 were higher than MM.106, MM.111 and seedling rootstocks. Significant differences ($P < 0.01$) were found for K, Cu, Zn content, and N/K, (Ca + Mg)/K and Ca/K ratio of mature leaves according to used rootstocks. It is generally agreed that an increase in bearing results in an increase in leaf N, Ca and Mg. The results for P and K for fruiting and non-fruiting trees are inconclusive.

Key Words: Apple, Fruiting, Non-fruiting, Macro-micro nutrients.

INTRODUCTION

Alternate bearing is one of the most important problems in apple production. Fruit buds are produced on two years old branches in apple cultivars. Heavy flowering-fruiting in 'on year' trees causes alternate bearing in apple cultivars. The ratio of carbohydrate/nitrate, some macro- and micro-nutrients and some internal hormonal contents were varied in fruiting 'on year' trees and non-fruiting 'off year' trees as reported by Marino and Greene[1].

The heavy bearing generally increases the water consumption per unit leaf area and results in higher concentrations of N, Ca and Mg of leaf blades. On the contrary, potassium concentrations of leaves decrease by fruit load as reported by many research workers. As a consequence of strong inhibition of the vegetative growth by fruit load, the total amount of mineral elements in fruit bearing trees was lower than in the non-bearing ones[2].

The main objective of our study is to investigate the nutrient contents of 'Amasya' apple cultivar during fruiting and non-fruiting years.

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EXPERIMENTAL

'Amasya' apple cultivar shows alternate bearing characteristics. 'Amasya' apple cultivars grafted on M.9, MM.106 and MM.111 clone apple rootstocks and on seedling rootstocks were used in the study. The plantation was established in 1985. The apple trees grafted on the M.9, MM.106 and MM.111 clones and on the seedling rootstocks were planted in 2 × 2, 4 × 4, 6 × 6 and 6 × 6 m densities, respectively. This research was conducted under Tokat-Turkey ecological conditions.

Matured leaves were sampled on July 15. The representative plant samples were analyzed to determine the plant nutrition level. The dry matter yield of leaves was determined after getting constant weight in an oven at 65°C. Total nitrogen was determined by Kjeldahl method as suggested by Bremner[3]. K, Ca, Mg, Fe, Cu and Zn contents were determined by atomic absorption spectrophotometer after dry ashing at 550°C and the ash was dissolved in 10% hydrochloric acid[4]. Phosphorus was determined by vanadate molybdate yellow colorimetric method[5].

Optimum macro- and micronutrient contents of leaves as suggested by other workers[6] are given as follows: N, 1.80–2.20%; P, 0.12–0.19%; K, 1.20–1.80%; Ca, 0.99–1.52%; Mg, 0.24–0.36%; Cu, 5 ppm; Fe, 100–400 ppm and Zn, 35–60 ppm.

RESULTS AND DISCUSSION

The macro- and micronutrient content of leaf is given Fig. 1. There are important differences ($P < 0.01$) in between the rootstocks according to K, Cu content and N/K, (Ca + Mg)/K and Ca/K ratio of mature leaves. N, P, K, Cu and Zn contents in the mature leaves of 'Amasya' grafted on the M.9, MM.106 and MM.111 clones and on the seedling rootstocks were found to be at optimum level. However, the levels of Ca, Mg and Fe content in the leaves were observed low in all rootstocks.

Ca and Mg contents of leaves of grafted trees on M.9 were higher than MM.106, MM.111 and seedling rootstocks. However, similar results were found by other workers[7, 8].

The rootstocks with different abilities on nutrient absorption are possibly the reason of the variation of nutrient contents in rootstocks used[8]. In our research, the rootstock has significant effect on the contents of K, Zn and Cu. There is no significant difference for N, P, Ca, Mg and Fe content of leaves among rootstocks.

The micro and macro nutrients of leaves were determined in 1998 'off year', 1999 'on year', 1998 'on year' and 1999 'off year' to investigate the relationship between biennial bearing and mineral nutrients.

N, Ca, Mg, Fe, N/K, (Ca + Mg)/K and Ca/K were found higher in 'on year' trees than 'off year' trees. We also found an important difference ($P < 0.01$) between 'off year' and 'on year' according to contents of N and Ca/K.

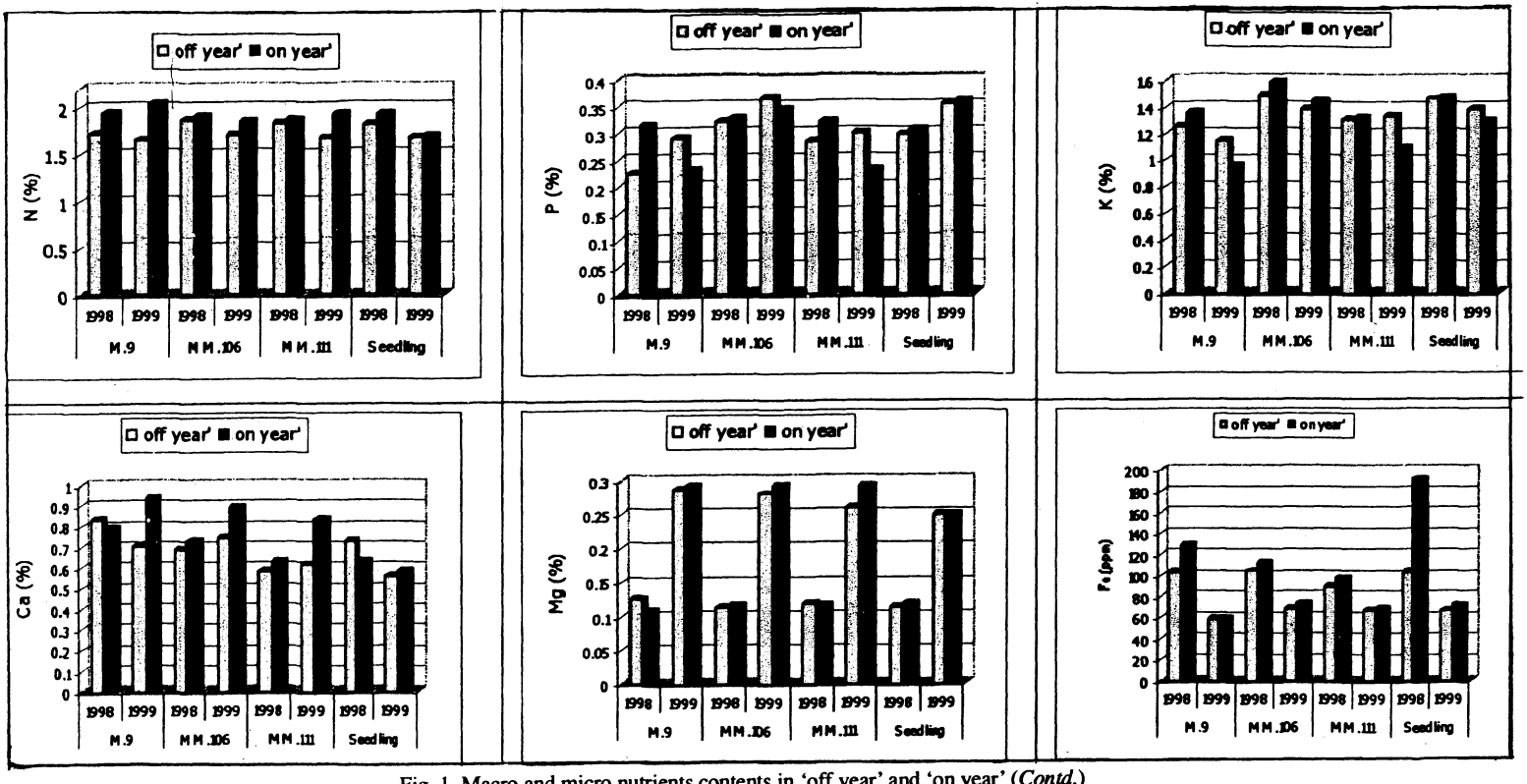

Fig. 1. Macro and micro nutrients contents in 'off year' and 'on year' (*Contd.*)

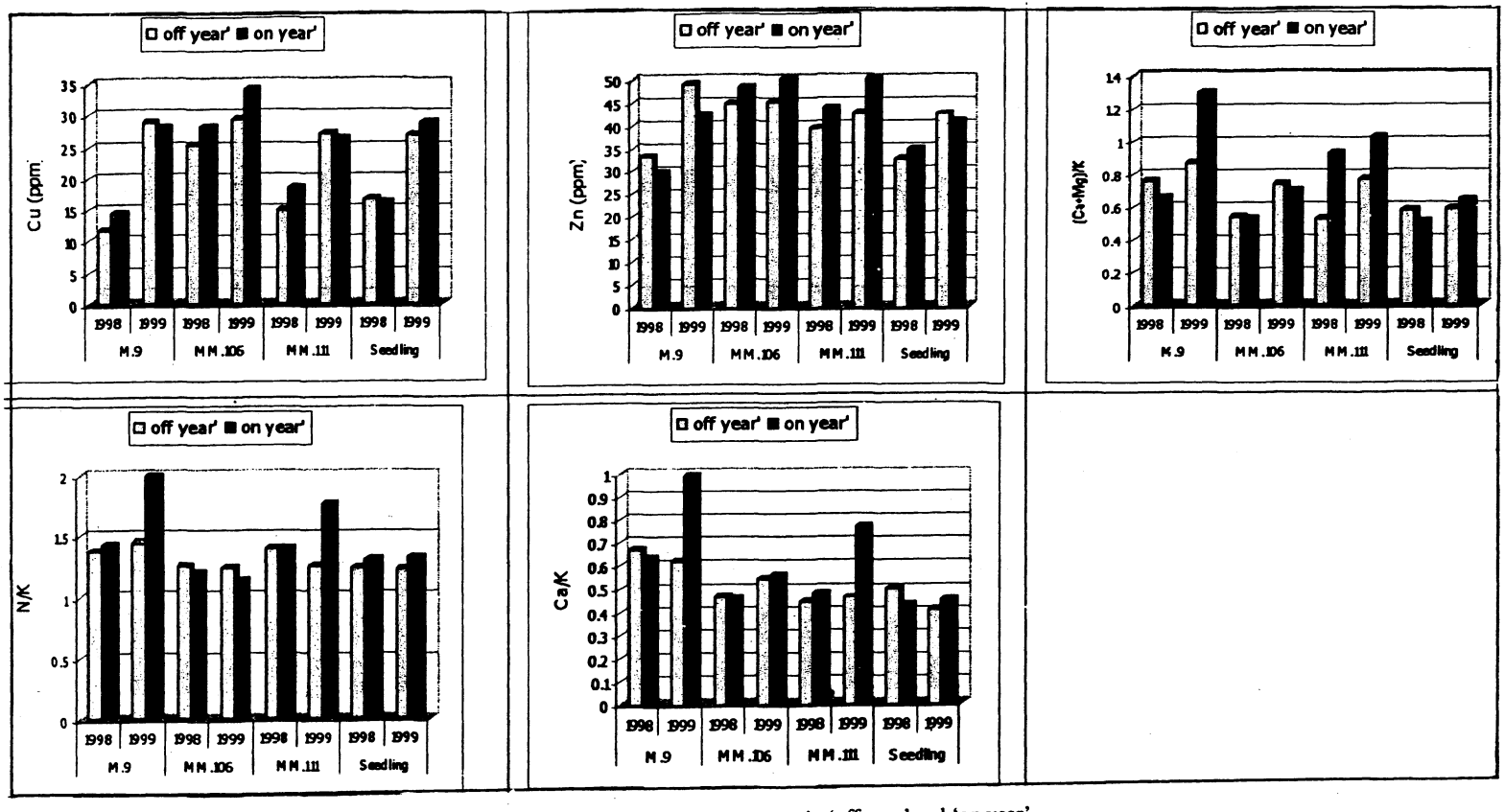

Fig. 1. Macro and micro nutrients contents in 'off year' and 'on year'

The content of leaf Ca and Mg increased in fruiting trees[9]. The contents of leaf N, P, Mg, Ca and Mn levels were found higher in fruiting trees than in non-fruiting trees[10]. There was no significant difference in the between the levels of K or Fe in 'on' and 'off' years. But, there are significant differences in N, P, Mg, Ca and Mn in 'on' and 'off' years. Lamb *et al.*[11] found that the mid-shoot leaves from fruiting trees had higher percentages of N, Ca and Mg. However, lower percentages of P and K were found for non-fruiting trees. It is generally agreed that an increase in fruiting results in an increase in leaf N, Ca and Mg. The results for P and K are inconclusive (Table-1).

TABLE-1
COMPRESSIONS ON EFFECT OF NUTRIENTS ON ALTERNATE BEARING OF APPLES STUDIED BY MANY RESEARCHERS

References	Concentration changes of nutrients associated with 'on year'[a]											
	N	P	K	Ca	Mg	Mn	Fe	Cu	Zn	N/K	Ca/K	Ca + Mg/K
Cain *et al.*[9]	+	–	–	+	+							
Boynton *et al.*[16]	+	+	–	+								
Emmert[18]	+	–	–	+	+							
Roach[25]	+		–	+	+							
Mason[10]	+	+	N	+	+	+	N					
Lamb *et al.*[11]	+	–	–	+	+							
Forshey[21]	+		–		N							
Ljones[23]			–	+								
This work	+	–	–	+	+		+	–	–	+	+	+

[a] + increase; – decrease; N= no significant change.

The experiment carried out with olive cultivars has shown that the olive trees could use more nitrate and potassium in 'on year' season. Gonzales *et al.*[12] reported that higher amount of potassium and nitrate and lèss amount of calcium are needed to obtain a good yield. In another research, Mg and Ca contents of leaves of 'on year' trees were found higher than those of 'off year' trees in olives. The results showed close relationship between N/K, Ca/K, (Ca + Mg)/K and alternate bearing. The ratios of N/K, Ca/K and (Ca+Mg)/K were also found higher in 'on year' than those of 'off year'[13–15]. Similar relationship was found in the present study. The correlation between N, Ca, Mg, Fe and alternate bearing was strengthened due to the higher N, Ca, Mg and Fe content in 'on year' than those in 'off year' trees. On the other hand, it is a normal physiological procedure of a tree to consume higher amounts of N, Ca, Mg and Fe during fruiting years. Therefore, it is really a case that needs to be clarified for determining the reason of higher amounts of N, Ca, Mg and Fe contents in the 'on year' trees. The present study showed a close relationship between biennial bearing, N, Ca, Mg, Fe contents and Ca/K, N/K, (Ca + Mg)/K ratio.

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