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The Effects of Different Amino Acid Chelate Foliar Fertilizers on Yield, Fruit Quality, Shoot Growth and Fe, Zn, Cu, Mn Content of Leaves in Williams Pear Cultivar (*Pyrus communis* L.)

A. İlhami KÖKSAL, Hatice DUMANOĞLU, Nurdan Tuna GÜNEŞ
Ankara Univ., Faculty of Agriculture, Dept. of Horticulture 06110 Ankara-TURKEY

Mehmet AKTAŞ
Ankara Univ., Faculty of Agriculture, Dept. of Soil Science 06110 Ankara-TURKEY

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Abstract: In this study, utility opportunities of three different amino acid chelate foliar fertilizers in Williams pear trees (*Pyrus communis* L.) on seedling for reduction in yield, fruit quality and growth resulted from direct irregularities such as yellowing, browning and falling of leaves in early season were investigated. By this aim, the effects of fertilizers applied three times at 15 days of intervals on total yield, yield per trunk cross section unit area, fruits size, firmness, total soluble solids and titretable acidity, shoot length and Fe, Zn, Cu, Mn content of leaves were determined. Especially amino acid chelated–Fe increased total yield by 64% for the third year and 47% as mean, yield per trunk cross section unit area by 64% for the third year and 45%, extra fruit ratio by 75% for the third year and 11%, shoot length by 70% for the third year and 30%, Fe content of leaves by 112% for the third year and 120%, Zn content by 11% for the third year, Cu content by 22% as mean, but decreased Cu content by 4% for the third year, Mn content by 20% for the third year and 22% as mean when compared with control. Thus it was seemed that this fertilizer prevented yellowing, browning and falling of leaves. In the consideration means of three years, the highest Fe (325.5 ppm), Zn (82.9 ppm), Cu (28.4 ppm) and Mn (66.5 ppm) content of leaves was reached by amino acid chelated–Fe, Zn and multi mineral and control, respectively.

Amino Asit Kleyti Farklı Yaprak Gübrelerinin Williams Armudunda (*Pyrus communis* L.) Verim, Meyve Kalitesi, Sürgün Gelişimi ve Yaprakların Fe, Zn, Cu, Mn Kapsamı Üzerine Etkileri

Özet: Bu çalışmada, çöğür anaçlar üzerine aşılı Williams armudunda (*Pyrus communis* L.) erken dönemde yapraklarda sararma, kahverengileşme ve dökülme gibi rahatsızlıkların neden olduğu verim, meyve kalitesi ve gelişmede ortaya çıkan gerilemeye karşı amino asit kleyti üç farklı yaprak gübresinin kullanım olanakları araştırılmıştır. Bu amaçla, 15 gün aralıklarla üç kez uygulanan gübrelerin toplam verim, birim gövde kesit alanına düşen verim, meyve iriliği, meyve eti sertliği, suda eriyebilir toplam kuru madde, titre edilebilir asitlik, sürgün uzunluğu ve yaprakların Fe, Zn, Cu, Mn kapsamı üzerine etkileri belirlenmiştir. Özellikle amino asit kleyti–Fe, kontrol ile karşılaştırıldığında toplam verimi üçüncü yılda %64 ve ortalama %47, birim gövde kesit alanına düşen verimi üçüncü yılda %64 ve ortalama %45, ekstra meyve oranını üçüncü yılda %75 ve ortalama %11, sürgün uzunluğunu üçüncü yılda %70 ve ortalama %30, yaprakların Fe kapsamını üçüncü yılda %112 ve ortalama %120, Zn kapsamını üçüncü yılda %11, Cu kapsamını ortalama %22 artırmış, fakat Cu kapsamını üçüncü yılda %4, Mn kapsamını üçüncü yılda %20 ve ortalama %22 azaltmıştır. Ayrıca bu gübrenin yaprakların sararmasını, kahverengileşmesini ve dökülmesini önlediği gözlenmiştir. Üç yılın ortalaması dikkate alındığında, yapraklarda en yüksek Fe (325.5 ppm), Zn (82.9 ppm), Cu (28.4 ppm) ve Mn (66.5 ppm) kapsamına sırasıyla amino asit kleyti–Fe, –Zn, –multi mineral ve kontrolde ulaşılmıştır.

Introduction

In Williams pear trees (*Pyrus communis* L.), first becoming yellowish in early season, later brownish and falling of leaves on some or all shoots in summer mid have occured due to mineral nutrient deficiency realized by absorption and translocation affairs in tree. Westwood (1) reported that minerals absorption of roots could be prevented by high pH, high calcerous and anaerobic growing conditions and translocation in tree by graft incompatibility and discontinuities in vascular tissue. As a result, healty leaf area on the trees is not enough for photosynthesis, so trees have become partially weaker at the begining, later completely died. For this reason, supplying of the plant with mineral nutrients effectively is the most important factor.

Micro elements are generally offered the plants by adding to medium or application to leaves. When they are applied as inorganic salts to the growing medium, above pH 6, Fe, and above pH 7 Mn, B, Cu and Zn have become insoluble forms, so their absorption by the plants has decrease. However chelates are obtained by the reaction of metalic salts with their synthetic or natural organic complexes has saved the metal cations from undesirable reactions such as precipitation. For this reason synthetic precursors which have the ability of making strong chelate is almost used in plant growing medium. EDTA (ethylene diaminetetra acetic acid) and EDDHA (ethylene diamin o–hydroxyphenylacetic acid) are well known as synthetic precursors. However because of the disadvantages mentioned above it has been suggested that micro elements as inorganic or organic complexes should be applied to the leaves instead of adding them to the growing medium in order to solve micro element requirements of the plants. The leaf fertilizers which an inorganic mineral structure hardly diffuse from the leaf surface into the plant because of high weight molecular structure. In order to eliminate these negative effects leaf fertilizers with organic structure as synthetic chelates were developed. But some difficulties such as releasing of metals from the chelating precursors and introducing into the plant cell has prevented absorption of micro elements from the plants. On the other hand, foliar fertilizers as chelate should be easily absorbed by the plants, rapidly transported and should be easily release their ions to affect the plant. Natural chelators as mid molecular weight compounds (like humic and fulvic acid, amino acids, polyflavanoids that have long organic chains) and low molecular weight compounds (like citric acid, ascorbic acid, tartaric acid that have short organic chains) diffuse easily to cell cytoplasm according to their chemical structure. These chelators are not phytotoxic to plants. They make complexes especially with heavy metals and prevent them to uptake by plants in higher ratio (1–5).

The aim of this research is to determine the effects of amino acid chelated–Fe, –Zn and –multi mineral foliar fertilizers on Fe, Zn, Cu and Mn content of leaves, shoot length, yield and fruit quality of Williams pear trees which have irregularities such as yellowing, browning and falling of leaves in early season.

Materials and Methods

This research was carried out between 1992–1994 on Williams pear trees (*Pyrus communis* L.) on seedling which are approximately 40 years old grown in Ankara conditions. Three different foliar fertilizers (Table 1), amino acid chelated–Fe, –Zn and – multi mineral (Kemito Inc.) were sprayed three times at 15 days intervals, first application was carried out a month after bud burst, during three year.

Table 1. Mineral content of amino acid chelated–Fe, –Zn and –multi mineral foliar fertilizers.

	Amino acid chelate foliar fertilizers and contents (g/kg)		
Micro Elements	Chelated–Fe	Chelated–Zn	Chelated–Multi Mineral
Fe	42.0	–	10.0
Zn	–	42.0	9.0
Mn	–	–	6.5
Cu	–	–	4.5
S	–	–	3.0
B	–	–	0.2
Co	–	–	0.05
Mo	–	–	0.01
Ni	–	–	0.005
Se	–	–	0.0005
Macro Elements			
N	80.0	80.0	80.0
Mg	–	–	7.5
Ca	–	–	1.0

In the first year while 0.2% concentration for the first and second applications, 0.4% concentration for the third application were used, 0.4% concentration was applied in the other years. Fertilizer solutions were sprayed as 10 liter per tree.

In this research Fe, Zn, Cu, Mn levels of leaves (ppm), total yield (kg), yield per trunk cross section unit area (kg/cm^2), distribution of fruit into the size classes (%), fruit firmness (lb), total soluble solids (%), titratable acidity (g/l) and shoot length (cm) parameters were investigated.

Leaves collected just before the first, second and the third applications from the trees were wet ashed with $HNO_3 \pm HClO_4$ solution and micro element compositions were determined by atomic absorption spectrofotometer (6). Total yield was determined by weighting all fruits of each tree. Trunk cross section unit area was calculated by measuring of trunk circumference of tree at 15 cm above of grafting point and yield per trunk cross section unit area was determined by dividing of yield to trunk cross section area. All harvested fruits were sized based on their diameters into four classes such as extra (>6.0 cm), class I. (5.5–6.0 cm), class II. (5.4–5.0 cm) and discard (<5.0 cm) and calculated in total fruit amount and percentage of each class. Fruit firmness were measured by pressure tester had a plunger with 7.8 mm in diameter on ten fruit sample for three replicate. Total soluble solids were determined with hand refractometer as three times for each replicate and ten milliliters of fruit juice was titrated with 0.1 N NaOH to a malic acid endpoint of pH 8.2 for titratable acidity measurements. The lengths of ten shoots of each replication were measured and mean shoot length was calculated as arithmetical.

In this research, a randomized plots experiment design was used with five replications. 'Treatment x year' interaction was controlled by analysis of variance by means SAS and Minitab and mean comparisons were performed by Duncan's multiple range test at $P<0.05$ where appropriate.

Results and Discussion

Yield and Fruit Quality

Total yield was found higher in amino acid chelated–Fe and in other applications as compared to the control in all years (Table 2). But differences were not found statistically significant. In the first year, total yield was found as 136.4 kg in amino acid chelated–Fe and as 136.3 kg in amino acid chelated–multi mineral foliar fertilizer. These values are 35% higher than control. The highest total yield as 79.0 kg was also obtained amino acid chelated–Fe in the second year. This value is 45% higher than control. Total yield was determined as 60.3 and 62.2 kg in amino acid chelated–Zn and –multi mineral, respectively. In the third year, amino acid chelated–Fe, –multi mineral and –Zn being 128.0, 105.0 and 83.8 kg increased total yield at 64, 34 and 7%, respectively, as compared to the control (Table 2).

Table 2. The effect of amino acid chelate foliar fertilizers on the yield.

	Total Yield (kg/tree)							
Treatments	1992	%	1993	%	1994	%	Mean	%
Control	100.7	100	54.4	100	78.1	100	77.7	100
Chelated–Fe	136.4	135	79.0	145	128.0	164	114.5	147
Chelated–Zn	115.2	114	60.3	111	83.8	107	86.4	111
Chelated–Multi Mineral	136.3	135	62.2	114	105.0	134	101.1	130
Mean	122.1a	121	64.0c	118	98.7b	126		
LSD (P<0.05)				15.9				
	Yield per Trunk Cross Section Unit Area (kg/cm^2)							
Control	0.25	100	0.14	100	0.19	100	0.19	100
Chelated–Fe	0.33	134	0.19	141	0.31	164	0.28	145
Chelated–Zn	0.35	140	0.18	131	0.25	135	0.26	136
Chelated–Multi Mineral	0.34	136	0.15	113	0.25	134	0.25	130
Mean	0.32a	128	0.16c	114	0.23b	121		
LSD (P<0.05)				0.04				

Pehlivan (7) reported that 0.4% amino acid chelated–multi mineral foliar fertilizer increased the yield 39% in Starkspur Golden Delicious apple. But increase was not found statistically significant. Shazly (8) reported that Rakbeh et al. found amino acid chelated–multi mineral and Zn metalosote increased the yield 54% more than control in orange and mandarins. Shazly (8) determined that Zn metalosote and multimineral metalosote increased the yields 79 and 18%, respectively. According to Table 2, in consideration of mean values of three years, amino acid chelated–Fe resulted 47%, –multi mineral 30% and –Zn 11% higher yields than control, being 114.5, 101.1 and 86.4 kg, respectively. But statistically significant differences were not found among these means. Statistically important differences realized among means of years. Total yield in the first year was higher than others as 122.1 kg (Table 2).

Differences in yield per trunk cross section unit area for all treatments were not statistically significant. Furthermore, yield was higher in all treatments than control. In the first year, amino acid chelated–Zn gave better result as 0.35 kg/cm^2 than –multi mineral (0.34 kg/cm^2), –Fe (0.33 kg/cm^2) and control (0.25 kg/cm^2).

Table 3. The effect of amino acid chelate foliar fertilizers on fruit ratio in size classes.

		Fruit Ratio (%)			
Treatments	Years	Extra	Class I.	Class II.	Discard
Control	1992	44.9a* ab**	33.9	14.2b ab	7.0a
	1993	52.5a a	36.9	7.9a b	2.7a b
	1994	29.6bc b	36.8	22.4ab a	11.2a a
	Mean	42.3	35.9	14.8	7.0
Chelated–Fe	1992	32.5ab b	37.2	20.7ab a	9.6a a
	1993	57.0a a	36.4	5.9a b	0.7a b
	1994	51.8a ab	34.2	11.9b ab	2.1b b
	Mean	47.1	35.9	12.8	4.1
Chelated–Zn	1992	24.2ab b	45.6	22.5ab a	7.7a a
	1993	50.7a a	41.6	5.9a b	1.8a b
	1994	44.6ab ab	34.8	12.7b ab	7.9a a
	Mean	39.8	40.7	13.7	5.8
Chelated–Multi Mineral	1992	19.4b b	39.0	30.9a a	10.7a a
	1993	61.5a a	32.4	5.5a b	0.6a b
	1994	20.3c b	39.1	27.9a a	12.7a a
	Mean	33.7	36.8	21.4	8.0
LSD (P<0.05)		12.8	NS	12.8	12.8

* Differences in treatments for each year.

** Differences in years for each treatment.

Otherwise, amino acid chelated–Fe gave higher results than others as 0.19 and 0.31 kg/cm^2, in the second and third year, respectively. When the means of three years were compared, yield per trunk cross section unit area were 45, 36 and 30% higher in amino acid chelated–Fe, –Zn and –multi mineral, respectively, than the control. The mean as 0.32 kg/cm^2 in the first year was statistically differ than that of other years (Table 2).

Differences in extra fruit rates were statistically significant. In the first year, the highest extra fruit rate was obtained in control (44.9%), amino acid chelated–Fe (32.5%) and –Zn (24.2%). Amino acid chelated–multi mineral provided the lowest extra fruit ratio as 19.4% (Table 3).

On the other hand Pehlivan (7) found that amino acid chelated–multi mineral treated in two times at 0.2% concentration without basal fertilizer not significantly increased the extra fruits as 74.5%, and single treatment

Table 4. The effect of amino acid chelate foliar fertilizers on the fruit firmness, total soluble solids and titratable acidity.

Treatments	Firmness (lb)			
	1992	1993	1994	Mean
Control	15.9	14.0	14.9	14.9
Chelated–Fe	16.0	15.5	15.0	15.5
Chelated–Zn	15.7	14.8	14.6	15.0
Chelated–Multi Mineral	16.3	14.9	15.1	15.4
Mean	16.0a*	14.8b	14.9b	
LSD (P<0.05)	0.7			
	Total Soluble Solids (%)			
Control	11.5	12.2	11.8	11.8
Chelated–Fe	10.8	12.4	11.6	11.6
Chelated–Zn	12.1	12.0	12.0	12.0
Chelated–Multi Mineral	11.2	12.0	11.8	11.7
Mean	11.4b	12.1a	11.8ab	
LSD (P<0.05)	0.5			
	Titratable Acidity (g/l)			
Control	3.6	2.7	3.2	3.2
Chelated–Fe	3.5	3.0	3.2	3.2
Chelated–Zn	3.8	2.9	3.5	3.4
Chelated–Multi Mineral	4.0	3.0	3.3	3.4
Mean	3.7a	2.9c	3.3b	
LSD (P<0.05)	0.2			

* Differences among the years.

at 0.4% concentration caused 68.3% increases when compared with control in Strakspur Golden Delicious apple at the result of one year treatment. In current research, in the second year extra fruit ratio was high in all treatments. However in the third year, effects of amino acid chelated–Fe (51.8%) and –Zn (44.6%) on the extra fruit ratio were statistically important (Table 3).

Extra fruit ratios in amino acid chelated–Fe and –Zn were significantly higher in the last two years than the first. Differences among treatments were not statistically significant in class I. Amino acid chelated–Fe and –Zn caused decreasing in fruit ratio in the class II in the third year. Discard fruit ratio was decreased by especially amino acid chelated–Fe in the last year (Table 3).

Differences in fruit firmness were not statistically significant among treatments for each year. Differences among means of years were significant (Table 4).

The mean in 1992 as 16.0 lb was significantly higher than in 1993 as 14.8 lb and 1994 as 14.9 lb. In the total soluble solid, statistical differences were occurred only among the years. It was higher in 1993 as 12.1% and 1994 as 11.8% than 1992. Similarly differences in titratable acidity were significant only among years and titratable acidity was higher in the first year than others (Table 4).

Shoot Length

Amino acid chelated–Fe significantly increased mean shoot length as 32.71 cm for means of three years. The mean shoot length at 30% higher than control (25.15 cm) and amino acid chelated–Zn 25.09 cm and 27% higher than amino acid chelated–multi mineral (Table 5).

Pehlivan (7) reported that amino acid chelated–multi mineral at 0.2% concentration without the basal fertilizer did not increased shoot length with respect to control. In current research, shoot length was significantly lowest in the third year (Table 5).

Fe, Zn, Cu, Mn Content of Leaves

Differences in Fe content were statistically significant among treatments for each year and among years for each treatment. Fe content was significantly higher in amino acid chelated–Fe in the first as 301.8 ppm and the second year as 335.8 ppm. In the third year, foliar fertilizers significantly increased Fe content in leaves (Table 6).

According to means of years, the highest Fe content as 325.5 ppm was provided by amino acid chelated–Fe. Differences among years for each treatment were not statistically significant with the exception of amino acid chelated–Zn. Amino acid chelated–Zn significantly increased Zn content of leaves in all years. Differences among years was found statistically significant with the exception of control and the highest values were reached by the third year (Table 6).

Differences among treatments were not statistically significant. Cu content was significantly higher in the third year with 35.5 ppm than other years (Table 7).

Table 5. The effect of amino acid chelate foliar fertilizers on the shoot length.

	Shoot Length (cm)							
Treatments	1992	%	1993	%	1994	%	Mean	%
Control	29.74	100	33.28	100	12.42	100	25.15b*	100
Chelated–Fe	39.02	133	37.96	114	21.16	170	32.71a	130
Chelated–Zn	28.46	96	28.34	85	18.46	149	25.09b	100
Chelated–Multi Mineral	25.60	87	34.52	104	17.22	139	25.78b	103
Mean	30.70a**	103	33.53a	101	17.32b	139		
LSD (P<0.05)				6.20**				
LSD (P<0.05)				6.13**				

* Differences among the treatments based on means in years.

** Differences among the years based on means in treatments.

In the first year, Mn content of leaves was between 41.4 and 61.8 ppm, but differences in means were not found significantly. In the second year, Mn content was significantly higher in amino acid chelated–multi mineral as 66.4 ppm, in control as 48.6 ppm and amino acid chelated–Zn as 47.0 ppm than amino acid chelated–Fe as 42.4 ppm.

In the third year, Mn content of all treatments increased and control as 89.0 ppm, amino acid chelated–Fe as 71.6 ppm and amino acid chelated–multi mineral as 69.2 ppm were significantly higher than amino acid chelated–Zn as 62.2 ppm. Differences among the years were statistically significant with the exception of amino acid chelated–Zn and Mn content highly increased in control, amino acid chelated–Fe in the last year (Table 7).

As a result of this research, firstly Fe content of leaves and shoot length followed by yield and fruit quality were improved in amino acid chelated–Fe and so irregularities such as yellowing, browning and falling of leaves in early season were seemed to highly correct. The use of amino acid chelated–Fe is worthy of further consideration because of its beneficial effect on especially Fe nutrition.

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Table 6. The effect of amino acid chelate foliar fertilizers on Fe and Zn content of leaves before the third application.

	Fe (ppm)							
Treatments	1992	%	1993	%	1994	%	Mean	%
Control	132.0b* a**	100	152.0b a	100	160.0b a	100	148.0	100
Chelated–Fe	301.8a a	229	335.8a a	221	338.8a a	212	325.5	220
Chelated–Zn	125.4b b	95	136.8b b	90	346.6a a	217	202.9	137
Chelated–Multi Mineral	167.0b a	126	187.6b a	123	248.4ab a	155	201.0	136
Mean	181.5	137	203.0	133	273.4	171		
LSD (P<0.05)	95.7							
	Zn (ppm)							
Control	31.8b* a**	100	32.4b a	100	43.2c a	100	35.8	100
Chelated–Fe	32.6b b	102	27.0b b	83	48.0bc a	111	35.9	100
Chelated–Zn	61.2a c	192	78.2a b	241	109.2a a	253	82.9	232
Chelated–Multi Mineral	42.8b b	135	40.4b b	125	59.6b a	138	47.6	133
Mean	42.1	132	44.5	137	65.0	150		
LSD (P<0.05)	15.3							

* Differences among treatments for each year.
** Differences among years for each treatment.

Table 7. The effect of amino acid chelate foliar fertilizers on the Cu and Mn content of leaves before the third application.

	Cu (ppm)							
Treatments	1992	%	1993	%	1994	%	Mean	%
Control	14.8	100	14.8	100	35.6	100	21.7	100
Chelated–Fe	20.4	138	24.8	168	34.2	96	26.5	122
Chelated–Zn	12.0	81	14.0	95	28.4	80	18.1	83
Chelated–Multi Mineral	22.0	149	19.4	131	43.8	123	28.4	131
Mean	17.3b	117	18.2b	123	35.5a	100		
LSD (P<0.05)	13.3							
	Mn (ppm)							
Control	61.8a* b**	100	48.6ab c	100	89.0a a	100	66.5	100
Chelated–Fe	41.4a b	67	42.4b b	87	71.6ab a	80	51.8	78
Chelated–Zn	52.4a a	85	47.0ab a	97	62.2b a	70	53.9	81
Chelated–Multi Mineral	47.4a b	77	66.4a ab	137	69.2ab a	78	61.0	92
Mean	50.7	82	51.1	105	73.0	82		
LSD (P<0.05)	19.1							

* Differences among treatments for each year.
** Differences among years for each treatment.

References

1. Westwood, M.N., Temperate–Zone Pomology Physiology and Culture. Third Edition. Timber Press Portland, Oregon, p. 523, 1993.
2. Ashmead, H., World Nutritional Crisis in Agriculture, Foliar Feeding of Plants with Amino Acid Chelates. Albion Laboratories Inc., Clearfield, Utah, p. 1–9, 1986.
3. Graff, D.J., Radioactive Isotope Studies in Plants. Weber College, 1986.
4. Hsu, H.H., Nutrient Balance and Crop Yield, Foliar Feeding of Plants with Amino Acid Chelates. Albion Laboratories Inc., Clearfield, Utah, p. 183–198, 1986a.
5. Hsu, H.H., Chelates in Plant Nutrition, Foliar Feeding of Plants with Amino Acid Chelates. Albion Laboratories Inc., Clearfield, Utah, p. 209–217, 1986b.
6. Chapman, H.D. and Praff, P.F., Methods of Analyses for Soils, Plants and Waters. Univ. of California, Division of Agricultural Series, California, 1961.
7. Pehlivan, G., Yaprak Gübresi Uygulamalarının Elmada (*Malus domestica* Borch. cv. Starkspur Golden Delicious) Meyve Verim ve Kalitesi ile Sürgün Gelişimi Üzerine Etkileri. Ankara Üniversitesi, Fen Bilimleri Enstitüsü Yüksek Lisans Tezi (Basılmamış), Ankara, p. 53, 1994.
8. Shalazy, S.A., The Effects of Amino Acid Chelated Mineral Deficiencies and Increasing Fruit Production in Trees in Egypt, Foliar Feeding of Plants with Amino Acid Chelates. Albion Laboratories Inc., Clearfield, Utah, p. 289–299, 1986.