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Changes of Elements Concentration in Onion Set Plants (*Allium cepa* L.) Traditionally Cultivated Under Different Soil Types in Greece

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ABSTRACT

The objective of this study was to record the traditional knowledge of the native variety, Chalcidos of onion set (*Allium cepa* L.) in Achaia Prefecture, Greece. The plants were grown in soil types [Sandy Clay Loam (SCL), Silty Loam (SL) and Clay Loam (CL)] in two cropping seasons. Field preparation and sowing was performed according to the traditional in the region farming practices. The seeds were produced by farmers in region during the former cropping season. Seeds of onion set were used at a density of 12 kg ha^{-1}. The N, P, K, Ca, Mg and B content in onion set plants was lower when the plants were grown in CL field, compared to the respective values in SCL and SL, in either cropping seasons. No differences were recorded in Ca, Zn and Fe content in plants. Differences in Mn content were observed in the plants and the best value was noticed when the plants were grown in the CL field. The Cu content in plants was higher in CL field compared to the respective values in SCL and SL. Content variation of plants in P, K, Ca and Na and in Mn, Cu and Fe micro-elements exhibits a diminishable trend in either cropping seasons. The macroelements concentrations in onion set for all soil types and cropping seasons were lower (N:1,62%, K:2,09%, P:0,20%, Mg:0,19%) than those referred in literature and this record of the documentation of traditional practices in this study can be used for verification of traditional culture authenticity.

Key words: Onion set, soil types, traditional cultivation, elements concentration, total soluble solids, bulb weight

INTRODUCTION

During the past 40 years, agriculture has greatly evolved, giving rise to significant changes in traditional agricultural systems. Mechanization of farming, introduction of modern crop varieties and new management systems like irrigation scheduling (Orta and Sener, 2001), are now a common practice. However, it is still possible to find small pockets of land where traditional agriculture still survives. Indigenous knowledge and practices hold the key to successful crop cultivation in these small pockets. In the case of onion (*Allium cepa* L.), a very old crop in Greece, many processes that exist in indigenous farming practices are complex and obscure poor requiring an innovative approach of research to be fully understood. These are marginal areas, generally in mountainous areas where ancient crops are still cultivated. Amongst these the onion set (*Allium cepa* L.) is still cultivated.

Onion (*Allium cepa* L.) belongs to the family Alliaceae, is a bulb crop and one of the most important vegetable spices of the world (Islam *et al.*, 2007; Thompson and Kelley, 1957). Onions, although grown on a wide range of soil types, i.e., from sandy, heavy clay soils to volcanic, heavy and rocky soils, prefer uniform and fine-grained texture of the soil surface layer (Bosch-Serra and Currah, 2002). However, the soil type could not necessarily be the most important parameter in the plants' uptake of all nutrient elements (Gundersen *et al.*, 2000). In Greece, the traditional cropping area of the onion set (*Allium cepa* L.) is rapidly decreasing due to the current growing practices and the modern hybrid varieties. Furthermore, the emerging new dynamic markets encourage the replacement of the local varieties, despite their adaptation to the prevailing conditions in the cropping area, by new high productive varieties (Swiader *et al.*, 1992).

Although, the region of Argyra of Achaia is an important onion set production area, the modern cropping practices and the replacement of the local varieties with new high yielding cultivars, resulted in abandoning the traditional low input cultivation modes. Barry *et al.* (2007) reported that changes in cropping practices may lead to the replacement of local rice varieties by modern high-yielding varieties and thus, endanger the conservation of local genetic resources. The traditional onion set cultivation is historically a very old one, directly reflecting the social-economic evolution and the environmental identity of the farming area of the region. This renders inevitable, despite its validity, that certain efforts must be undertaken for this traditional culture to be revealed. The decrease of the traditional cultivation of the local onion set variety Chalkis in Achaia (major onion set cropping region till the beginning of the 90s) during the last years, imperatively forced the need to documenting this traditional knowledge related to the old cropping practices of onion set. The main parameters, influencing the nutrient elements uptake from the plants, are related to the cropping practices. Various comparative tests on the concentration of the nutrient elements in onion set, grown under organic and conventional conditions, have shown that the cropping procedure influences the accumulation of certain nutrients (Gundersen *et al.*, 2000).

The aim of the present study was to evaluate the nutrient element levels of the traditional cultivation of onion set in three different, in terms of texture, soil types, in two cropping seasons at Argyra, Achaia.

MATERIALS AND METHODS

Field experiments: Field experiments were established on three sites with different soil constitution at the Municipal Department of Argyra, Rio Municipality/Achaia Prefecture (Latitude 21°51' N, Longitude 38°17' E) during the cropping seasons 2008 and 2009. Seeds of the traditional onion set (*Allium cepa* L.) variety Chalkidos were used. The main features of the field soil types were: A) field 1: Sandy Clay Loam (SCL) soil, slightly acidic, containing sufficient amounts of Mg, K, P Fe, Zn, Cu, sufficient amounts of B and higher (than the desired) levels of Mn, b) field 2: Clay Loam (CL) soil, of light texture, slightly alkaline (pH 7.32), containing sufficient P, Fe, Zn, Mn elements, with Mg, K, insufficient B and Cu in levels higher than desired and c) field 3: Sandy Loam (SL) soil, of medium texture, containing Mg, P, Fe, Zn, Cu, B. The soil electrical conductivity was low in all three fields (Table 1). All above soil analyses were performed in the Soils and Irrigations laboratory of the Technological Educational Institute of Messolonghi, based on

Table 1: Physical and chemical soil analysis characteristics of three trials of onion set

	Field		
	1	2	3
Characteristics	Sandy Clay Loam (SCL)	Clay Loam (CL)	Sandy Loam (SL)
Soil texture analysis			
Sand	51.00	43.00	75.00
Clay	24.00	28.00	14.00
Silt	25.00	29.00	11.00
Organic matter (%)	2.95	2.61	1.21
Water capacity (%)	44.00	47.00	27.00
pH	6.65	7.32	7.55
$CaCO_3$ (%)	0.00	3.00	23.00
Electrical conductivity mS cm^{-1} (25°)	1.76	1.24	1.26
Ca (meq/100 g)	17.64	22.34	22.17
Mg (meq/100 g)	1.39	1.35	0.78
K (meq/100 g)	0.35	0.56	0.25
Na v (meq/100 g)	0.26	0.26	0.26
P (ppm)	57.00	57.00	31.00
B (ppm)	0.54	0.36	0.26
Fe (ppm)	33.80	24.00	4.78
Zn (ppm)	2.66	2.54	0.78
Mn (ppm)	87.00	30.20	21.80
Cu (ppm)	5.45	7.60	0.66

standard soil analysis techniques (Van Reeuwijk, 2002). All three farms were not cultivated during the five previous years and were considered appropriate for onion set production (Onal *et al*., 1992).

Traditional farming practices were used for land preparation and sowing. The field was fertilized with 40 kg ha^{-1} ammonium sulphate (21-0-0, 24.4% S) before sowing. Weed control was attempted prior to sowing and prior to emergence for up to 60 days (Armelina, 1980; Qasem, 2006) chemically (chlorthal-dimethyl), whereas during plant vegetation the weeds were removed with herbicide.

Seeds of a local variety of Chalkis type of onion set (*Allium cepa* L.) were used at a density of 12 kg ha^{-1}. The seeds were produced by farmers in the region during the former cropping season. In the first cropping year (2008) due to the prevailing low temperatures during the growth period (risk of frost), sowing of the seeds was performed in March (05/03/2008 in fields 1 and 2 and 17/03/2008 in field 3). In the second cropping year (2009) the sowing of the seeds was performed under favourable weather conditions on 14/01/2009 in field 1, on 07/02/2009 in field 2 and on 17/02/2009 in field 3.

The fields were irrigated once a week by flooding, according to the needs of the plants, assessed by the weather data. Harvesting was performed when the onion set bulbs began to ripen and this was on 18/07/2008 and 21/07/2009. At harvest time, the onion sets were loosened from the soil and were placed in lines for drying.

Onion set analysis: During the cropping period, sampling of the onion set plants was conducted every 15 days, starting approximately on the 50th day after sowing and until the day of harvest, when the onion set bulbs were mature. The experimental design was randomized complete blocks into experimental plots (30 m^2) and in each one of the observations five parts were randomly selected (0.2 m^2 per experimental plot).

The samples were properly prepared, washed with detergent, rinsed in tap water, washed in 0.1 N HCl and finally rinsed in distilled water for three times. After they were dried, the samples were placed into an oven at a 65-70°C temperature regime, where they remained until they were completely dried. They were subsequently grinded and placed into the oven at 105°C for one hour. The following methods were used to determine the concentration of the nutrients:

- **Determination of nitrogen (N):** Wet combustion with H_2SO_4 and distillation using the Kjeldal method (Baker and Thompson, 1992)
- **Determination of boron (B):** Dry combustion at 550°C dissolution in 2 N H_2SO_4 and then determination using the Azomethine method
- **Determination of K, P, Ca, Mg, Na, Fe, Mn, Zn:** Dry combustion at 550°C, ash dissolution in 2N HNO_3 and then determination as follows: For potassium (K) and sodium (Na), using a flame photometer Ìodel Sherwood Scientific, for phosphorous (P), using the Ammonium Molybdonate Vanadic Ammonium method and for calcium (Ca), magnesium (Mg), zinc (Zn), ferrous (Fe) and manganese (Mn) using an ICP-OES spectrometer Thermo Scientific® iCAP 6000 Series

Statistical analysis: All data was tested by the analysis of variance (ANOVA), using the SPSS 12 software. Duncan's multiple range test was performed at p = 0.05 for each of the significant variables measured. In addition, differences between means were compared according to the Student-Newman-Keuls test (Sachs, 1984). The test of Tukey was applied to compare treatment means and the test of Dunnett was used to compare the mean of the control treatment with those of the other treatments.

RESULTS

The concentrations of the elements N, P, K, Ca, Mg of onion sets in the CL soil were significantly lower than the respective mean contents of the plants grown in the SCL and SL soils in both cropping seasons (Fig. 1). Only the Na concentrations were significantly higher in the CL soil compared to the respective values of the SCL and SL soils, in either cropping periods. No significant differences were observed in the concentrations of Ca regardless of the soil type and cropping season. The mean concentration of the N, P, Ca, Mg and K nutrients-save for the concentration of K in the SL soil, in the onion plants show no differences between them in the SCL and the SL soils (Fig. 1).

No statistical differences were observed in the mean concentrations of Fe in the onion sets (Fig. 2). The mean concentration of Cu was significantly higher in the Clay Loam (CL) soil than the respective one in the Sandy Clay Loam (SCL) and in the Sandy Loam (SL) soil. The last two did not differ from each other and no variation was noticed among years. The mean concentration of Mn was higher in the clay loam soil environment and it was not affected by years. Smaller means were recorded in the silt loam and even smaller in the clay loam soil environments. In Zn, the best mean was noticed in the clay loam environment in the first year. The mean values in the

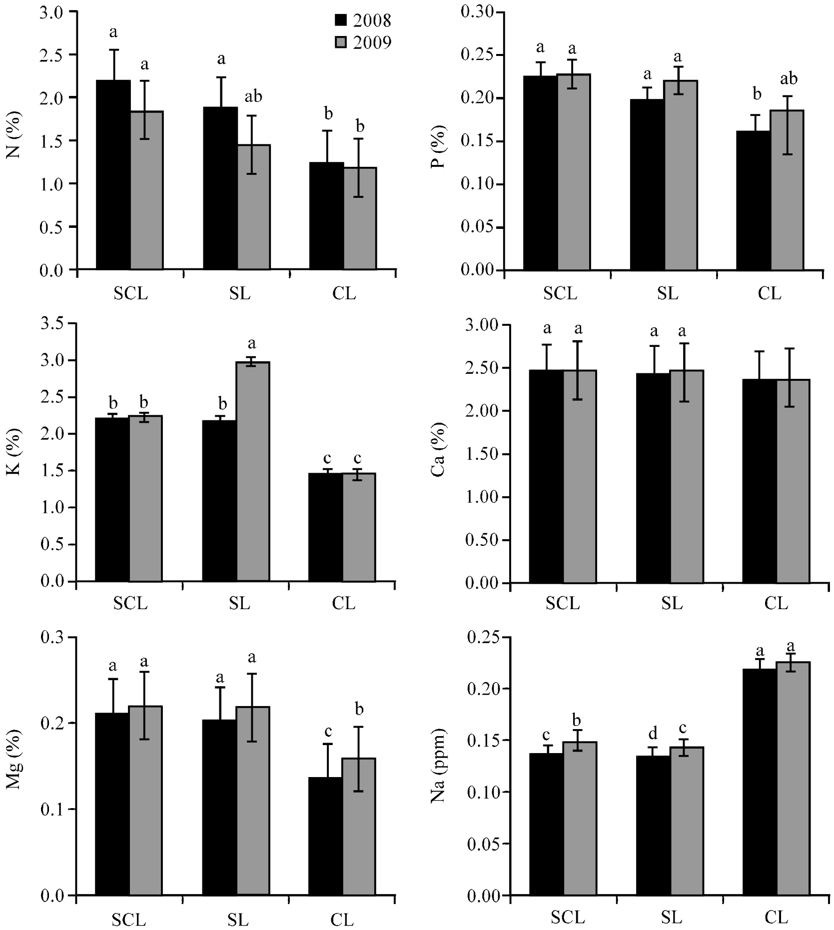

Fig. 1: Macroelements mean concentration during the 2008 and 2009 cropping seasons. Bars with different letters show significant difference at p = 0.05 using Duncan's multiple rang test

other two soil types were identical in the first year, whereas no differentiation was found in the second year. Finally, the mean concentrations of B were significantly lower in the Clay Loam (CL) soil than the corresponding mean concentrations in the Sandy Clay Loam (SCL) and Silt Loam (SL) soils in both cropping seasons.

During the first cropping period (2008), fluctuating rates were recorded in the concentrations of N and Mg (Table 2a). This fluctuation in certain macroelement concentrations (P, K, Ca and Na) exhibited a reducing tendency during both cropping periods, from the first sampling performed on the 50th day after sowing until the day of harvesting, when the onion sets were mature under all soil types. The same tendency was also observed in the fluctuation of the Mn, Cu and Fe microelement concentrations under all soil types and in both cropping seasons (Table 2b).

In mid August the traditional onion set crop was harvested for storage. The mean dry weight of the onion set varied from 3.1 to 4.1 g. In the sandy loam (SL: 4.06-4.08 g) soil, the dry weight of the onion bulbs was significantly higher compared to the respective one in the other two soil types, the sandy clay loam (SC: 3.70-3.67 g) and the clay loam (CL:3.05 g) (Table 3).

Throughout the crop year 2008, total soluble solid constituents of plants ranged between 6.47-12.60 brix. In 2009 an increase in the prices of total ingredients (8.87-12.74 brix) was noticed

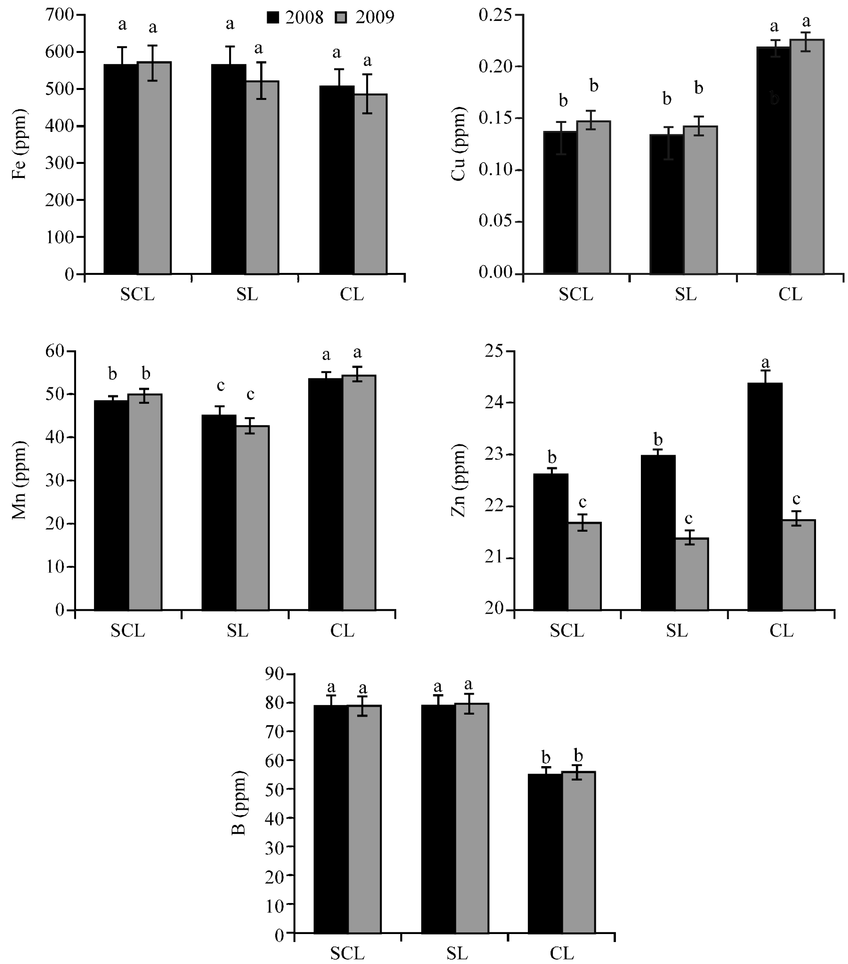

Fig. 2: Microelements mean concentration during the 2008 and 2009 cropping seasons. Bars with different letters show significant difference at p = 0.05 using Duncan's multiple rang test

Table 2a: Macroelements concentration in onion set in Sandy Clay Loam (SCL), Sandy Loam (SL) and Clay Loam (CL) soils, during the 2008 and 2009 cropping seasons

		N (%)		P (%)		K (%)		Ca (%)		Mg (%)	
Soil	DFS*	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
SCL	54	3.71	1.71	0.25	0.25	3.46	3.46	3.43	3.43	0.24	0.24
	68	2.08	2.06	0.22	0.22	2.68	2.71	1.36	1.38	0.28	0.29
	82	0.98	0.99	0.22	0.23	2.23	2.26	3.96	3.98	0.09	0.12
	99	1.11	1.06	0.24	0.24	1.86	1.88	2.38	2.39	0.12	0.13
	115	2.66	2.61	0.21	0.21	1.53	1.55	1.86	1.88	0.26	0.27
	150	2.65	2.60	0.21	0.21	1.52	1.54	1.85	1.87	0.26	0.26
SL	54	3.07	1.10	0.22	0.25	3.43	4.43	3.40	3.42	0.24	0.26
	68	2.05	1.45	0.19	0.22	2.65	3.65	1.33	1.35	0.27	0.29
	82	0.95	1.61	0.19	0.22	2.20	3.20	3.93	3.95	0.08	0.10
	99	1.08	1.58	0.21	0.24	1.83	2.83	2.35	2.37	0.12	0.14
	115	2.63	1.67	0.18	0.21	1.50	2.30	1.83	1.85	0.26	0.27
	150	2.62	1.17	0.18	0.18	1.49	1.51	1.82	1.84	0.25	0.26

Table 2a: Continue

Soil	DFS*	N (%) 2008	N (%) 2009	P (%) 2008	P (%) 2009	K (%) 2008	K (%) 2009	Ca (%) 2008	Ca (%) 2009	Mg (%) 2008	Mg (%) 2009
CL	54	2.40	1.22	0.18	0.17	2.13	1.94	3.69	3.67	0.24	0.23
	68	1.32	1.25	0.17	0.16	2.16	2.18	1.50	1.52	0.14	0.15
	82	1.14	1.13	0.16	0.16	1.53	1.57	3.38	3.40	0.07	0.06
	99	1.37	1.35	0.11	0.11	0.98	1.01	1.88	1.90	0.09	0.10
	115	0.98	1.00	0.10	0.11	1.03	1.06	1.90	1.92	0.19	0.21
	150	1.35	1.11	0.11	0.25	0.97	1.05	1.86	1.90	0.08	0.20
**Sufficient fluctuation of rates		4.57-2.60		0.44-0.34		4.18-3.68		1.60-1.28		0.47-0.29	

*Days after sowing, **According to Reuter and Robinson (1997)

Table 2b: Microelements concentration in onion set in Sandy Clay Loam (SCL), Sandy Loam (SL) and Clay Loam (CL) soils, during the 2008 and 2009 cropping seasons

Soil	DFS*	Na (ppm) 2008	Na (ppm) 2009	Mn (ppm) 2008	Mn (ppm) 2009	Zn (ppm) 2008	Zn (ppm) 2009	Cu (ppm) 2008	Cu (ppm) 2009	Fe (ppm) 2008	Fe (ppm) 2009	B (ppm) 2008	B (ppm) 2009
SCL	54	0.16	0.16	101.80	101.80	20.65	21.25	0.16	0.16	1574	1574	75	75
	68	0.19	0.21	35.60	38.40	23.36	21.80	0.19	0.21	453	455	64	64
	82	0.17	0.20	44.40	48.80	24.59	21.80	0.17	0.20	392	396	86	86
	99	0.11	0.12	50.20	51.40	22.81	21.81	0.11	0.12	477	478	81	82
	115	0.10	0.11	30.60	31.80	22.70	21.81	0.10	0.11	289	290	105	105
	150	0.09	0.09	25.00	25.00	21.70	21.70	0.09	0.09	233	233	62	62
SL	54	0.16	0.35	98.80	96.80	23.33	21.33	0.16	0.17	1572	865	75	76
	68	0.18	0.30	32.60	30.60	24.56	22.55	0.18	0.19	451	449	64	65
	82	0.16	0.25	41.40	39.40	22.78	20.77	0.16	0.17	390	388	86	87
	99	0.11	0.16	47.20	45.20	22.67	20.53	0.11	0.12	475	493	81	82
	115	0.10	0.10	27.60	21.40	21.67	21.67	0.10	0.11	287	450	105	105
	150	0.09	0.15	22.00	22.00	21.51	21.60	0.09	0.09	231	494	62	62
CL	54	0.17	0.34	97.60	96.60	23.48	21.76	0.35	0.34	1233	1232	70	70
	68	0.19	0.30	75.60	76.80	23.75	21.78	0.30	0.30	538	539	67	68
	82	0.17	0.29	73.00	77.40	23.89	21.77	0.25	0.29	487	490	54	55
	99	0.12	0.19	26.60	29.40	24.38	21.77	0.16	0.19	284	286	44	44
	115	0.11	0.12	20.80	23.60	25.00	21.77	0.10	0.12	194	197	47	48
	150	0.09	0.11	25.60	22.60	24.38	21.77	0.15	0.11	283	196	44	48
**Sufficient fluctuation of rates					20-55						30-45		

*Days after sowing, **According to Reuter and Robinson (1997)

Table 3: Weight and total soluble solids of the onion set bulb

Parameter	2008 SCL	2008 SL	2008 CL	2009 SCL	2009 SL	2009 CL
Weight of bulb (g)	3.70 ± 0.2^{b}	4.06 ± 1.1^{a}	3.05 ± 1.1^{c}	3.67 ± 1.6^{b}	4.08 ± 1.6^{a}	3.05 ± 1.6^{c}
Total soluble solids (^{0}Brix)	7.96 ± 0.09^{c}	8.68 ± 0.1^{b}	9.85 ± 0.1^{a}	8.33 ± 0.19^{c}	9.01 ± 0.1^{b}	9.99 ± 0.1^{a}

Values are followed by the same letter are not statistically different at a significance level of 5% ($p<0.05$)

Table 4: Total soluble solids (⁰Brix) of the onion sets in the Sandy Clay Loam (SCL) Sandy Loam (SL) and Clay Loam (CL) soils, at each cropping season

	Cropping season					
	2008			2009		
Days after sowing	SCL	SL	CL	SCL	SL	CL
50	7.68	8.01	10.60	8.91	8.38	11.00
68	8.34	6.96	7.06	8.75	7.36	7.46
82	8.35	6.90	6.97	8.75	7.30	7.37
92	8.31	6.47	6.92	8.71	6.87	7.32
115	7.34	10.33	12.34	7.74	10.56	12.74
130	7.81	11.49	12.60	8.19	11.89	12.16
190	7.87	10.61	12.47	7.24	10.70	11.86

that differs from those of the 2008 growing season (Table 4). The average value of soluble total solid constituents of plants differs significantly between the three farms. The highest value (9.99 brix) was found in plants of CL soil and the smallest value in plants of SCL soil (7.96 brix) (Table 3).

DISCUSSION

Indigenous knowledge is valuable to the agricultural scientists striving to improve conditions in rural areas (Warren, 1991). However, much less emphasis has been put to valorize traditional agronomic practices which may be of value. Indigenous farmers are the holders of traditional knowledge about the use of onion set farming. The development and adaptation of plants to different ecological conditions, such as soil constitution, is the product outcome of the traditional knowledge. Traditional knowledge relating to onion set cultivation, where it still exists, is not practiced any longer, resulting in decrease of its importance. The question that arises has to do with the possible changes of macro- and microelements concentration that could be observed under traditional farming conditions, regardless of the soil constitution on which the plants are grown. The results of the present work revealed that, under traditional cropping conditions, the concentration levels of certain elements (K, N, P, Mg) were lower than those referred in literature. On the other hand, the concentrations of other elements (Ca, B) were higher (Reuter and Robinson, 1986). The concentration of Zn was measured at normal levels. Traditional cropping practices (irrigation by flooding) may have affected the uptake of nutrients by the plants, while comparative studies have shown that the cultivation method affects the concentration of some crop elements (Gundersen *et al*., 2000).

Onions are vulnerable in extracting nutrients from soil, because of their shallow and un-branched root system (Brewster, 1994). This results in lower concentrations in nutrient levels in the onion bulbs, especially as the plant grows. The fact that the onion bulbs contain insufficient macroelement contents (N, P and K) than they primarily need (Marschner, 1995) is further complicated when the onion set is grown on insufficiently supplied fields with such elements. The nitrogen uptake levels by onion set crops may vary depending on the cultivar, the climate, the plant density, the fertilization and the yield levels (Hegde, 1986; Salo, 1999; Pire *et al*., 2001).

The mean macroelements concentrations in onion set in three soil types [Sandy Clay Loam (SCL), Silty Loam (SL) and Clay Loam (CL)] and in two cropping seasons (2008 and 2009) were lower (N:1,62%, K:2,09%, P:0,20%, Mg:0,19%,) than those referred in literature (Reuter and Robinson, 1997). The documentation of this study's values can be used for verification of traditional culture authenticity and the conservation of local variety, Chalcidos of the onion set. Of course, further comprehensive research is needed by the agricultural scientists in order to improve the traditional cropping practices for producing the onion set locally at the traditional cropping areas.

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