(Agricultural use of lacustrine sediments)

AGRICULTURAL USE OF SEDIMENTS FROM THE ALBUFERA LAKE (EASTERN-SPAIN)

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Abstract

Dredging of the Albufera Lake, a very important natural area of Eastern-Spain, has been proposed to remediate the silting, but a very large amount of sediments would be generated. To assess the feasibility of applying these to the sandy agricultural soils surrounding the lake, three rates (180, 360 and 720 tha^{-1}) of four different sediments, corresponding to different degrees and sources of contamination, were tested by mixing with a soil obtained from the area of potential application. The effects on the soil properties and yield and nutrient contents of lettuce (*Lactuca sativa* L.) and tomato (*Lycopersicon esculentum* Mill.) were studied. As the most relevant changes, sediments improved the soil water-retention and cation-exchange capacity of the mixture, but increased its salinity and heavy metal contents. Yield of lettuce increased with parallel to the sediment applications whereas tomato growth and yield remained unaffected. Significant effects were also found on the nutrient contents of the plant tissues, depending on the sediment and application rate used, but no heavy metal accumulation in plants could be detected. According to the results, the application of appropriate rates of sediments to the agricultural soils surrounding the lake seems to be a sound practice to avoid problems arising from the disposal of large amounts of dredged material, and to improve the properties of the sandy soils of the area.

Keywords: lacustrine sediments, soil amendment, heavy metals, soil pollution, vegetable production.

1. Introduction

The Albufera Lake, about five kilometers southwards the city of Valencia, is a humid area of outstanding ecologic relevance as passage and nesting point for more than 250 different species of migratory birds (Docavo, 1979). It was protected as natural reserve by an ordinance of the Consellería de Agricultura y Medio Ambiente de la Generalitat Valenciana (Council for Agriculture and Environment of the Valencian Government) issued on 8th July 1986. The reserve is also a place of touristic interest and about a 34% of the Spanish rice is produced within its bounds (MAPA, 1997).

Despite its importance, the future of the lake is jeopardized by contamination and, especially, silting. In fact, its extension has shrunk from 30000 ha to less than 3000 ha because of the accumulation of the silt carried in irrigation channels flowing into the lake and the drying of some areas for rice production. Contamination is mainly produced by disposal of sewage from towns and industrial facilities surrounding the lake, and the pesticides and fertilizers used for rice cropping. Better control of pollution has been achieved since the area was protected, but silting is a much more difficult problem to deal with, since the intensive agricultural practices and the stormy pattern of rainfall in Eastern-Spain (most of the annual precipitation concentrates in a few days of torrential rains) bring about severe water-erosion of soils.

Dredging of the sediments accumulated in the bottom of the lake has been proposed to remediate the problem of its silting. Apart from the cost and technical problems involved, the removal of sediments would generate a very large amount of material ($12.5\cdot10^6$ $t\cdot m^{-1}$ of the sedimentary layer dredged, according to the typical density and moisture content of the sediments sampled), which should be adequately managed. Several management alternatives have been proposed and investigated during a multidisciplinary study conducted by a number of research groups of the Valencia region, funded by the Consellería de Medio Ambiente de la Generalitat Valenciana (Council for the Environment of the Valencian Government). Agricultural use is probably one of the most promising alternatives since soil application makes good use of the sediment contents of clay and silt, nutrients and organic matter and somehow brings the material back to its original place.

Scientific literature is short of studies dealing with agricultural use of lacustrine sediments, maybe because of the short number of dredging works which generated sufficient amounts of material of the required degree of quality to be applied to agricultural fields. Relevant examples may be the works by Olson and Jones (1987), who tested several combinations of scrubber sludge, soil and sediments dredged from the Lake Springfield, and Van Beusichem (1993) who studied the suitability for agricultural use of sediments from the Maranhao reservoir.

The objective of our work was therefore to study the effects of the application of sediments dredged from the Albufera Lake on vegetable production and relevant physical and chemical properties of a sandy soil typical of the agricultural fields surrounding the lake, their most likely area of use. Four sediments representative of different pollution degrees and three application rates were tested, and the results should be useful to evaluate the soundness of this use and recommend the optimal application rates.

2. Material and Methods

2.1. SEDIMENT SAMPLING AND PREPARATION

Four different sampling points were selected according to results from preliminary studies: LC (low contamination), AC (average contamination), CrC (high contamination by Cr, because of the proximity of tanning industries), OrgC (area in which the highest levels of contamination by organic pollutants is presumed, because it is the discharge point of the sewers from most of the industrial facilities of the area). About 30 kg of fresh sediment were extracted in each point, using a 100x5 cm PVC cylinder which could be closed after its introduction into the sediment layer at the bottom of the lake. Once in the laboratory, samples were dried at 40ºC over one month, manually ground using a wooden mallet to avoid metal contamination, and passed through a 2 mm plastic mesh. Before the pot trial started, a full analytical characterization of the sediments was performed (Table I).

2.2. EXPERIMENTAL DESIGN

Three rates of the four sediments (180, 360 and 720 t of sediment/ha, roughly equivalent to 5, 10 and 20% sediment-soil mixtures) were evaluated in a pot trial conducted in a temperature and moisture-controlled greenhouse, and compared with a non-amended control. The soil was a loamy-sand (FAO Arenosol, USDA Xeropsamment) obtained from a horticultural orchard in Pinedo (Valencia), in the area surrounding the lake. All treatments were replicated four times in pots with 4 kg of soil, and to identify any possible effect of the increase in substrate volume caused by the addition of sediments, three additional control treatments were prepared (180, 360 and 720 t of soil/ha). Additional volumes (about 10 kg) of all soil-sediment mixtures were also made up and incubated over one month at laboratory temperature for measuring the effects of sediment applications on chemical and physicochemical properties of soil.

Lettuce (*Lactuca sativa* L. cv. *Inverna*) and tomato (*Lycopersicon esculentum* Mill. cv. *Vivaldi*) are the most typical vegetables grown in the area of potential application of sediments. Apart from that, they were selected for the pot experiment given their sensitivity to the main problems that application could cause: increments of soil salinity and heavy metal content. Logan and Chaney (1983) categorized lettuce as a highly sensitive plant to heavy metals whereas tomato was a sensitive one, and lettuce is also sensitive to salinity (Maroto, 2000). After the preparation of the pots with their corresponding treatments, lettuce seedlings were planted and, about two months later, the plants were harvested and weighted. The pots were then emptied, all roots were removed, the soil was remixed and used to fill the pots again up to a fixed mark. Since equal volume of substrate was used now, the soil-amended controls were unnecesary. After the pots were ready, tomato seedlings were planted. Fruits were removed at the very beginning of development and seven weeks after planting, plants were cut and their length and weight measured. Pots were then emptied and the soil, after removing the roots, was mixed, air-dried, and stored for analysis of water-retention capacity. During the experiments, plants were irrigated according to their individual needs, recording the volume of water used in each pot. Irrigation water was sampled and its nitrate content analyzed in a weekly basis. Mineral N, P and K fertilizers were applied by means of fertigation, and the different amounts of nitrate with irrigation water added to each pot were compensated. All plant samples were dried at 60ºC, and ground in a titanium mill to avoid metal contamination.

2.3. SAMPLE AND DATA ANALYSIS

Analytical determinations were made at least three times using the official Methods of the Spanish Ministry of Agriculture, Food and Fisheries (MAPA, 1986), or slight modifications. Contents of available phosphorus and micronutrients were determined by means of the methods by Olsen (1954) and Lindsay and Norvell (1976), respectively. Heavy metals in the samples were determined by flame atomic absorption spectroscopy after digestion in aqua regia reflux (soil and sediments, Berrow and Stein, 1983) or in a $HNO_3/HClO_4$ mixture (vegetal tissues, AOAC, 1980), using a high-performance nebulizer to double the usual sensitivity of this technique. Data were corrected for oven-dry (105ºC) moisture content. Statistical analysis of the results from the pot experiment was performed by ANOVA (*F*-test and Duncan's Multiple Range Test) to investigate whether significant differences between treatments ($p<0.05$) exist, using the Statgraphics 4.0 (Manugistics Inc.) and R 1.3.0. (Ihaka and Gentleman, 1992) software packages.

3. Results and Discussion

Table II shows the most relevant effects of the sediment application on the soil properties. The application of high rates of sediment nearly doubled the clay contents in soil, changing its textural class from loamy sand to sandy loam, although low and medium rates gave rise to no appreciable changes. Water-retention capacity of soil was clearly increased, changes reaching statistical significance even with the low rates of CrC and OrgC sediments. This effect is particularly interesting, since heavy irrigation is needed to grow vegetables in the area surrounding the Lake, the most suitable place for the sediments to be applied. A higher capacity of the soil to store water would reduce the need of irrigation and protect the crops against the effects of water-stress. Particularly interesting were the increments in organic matter, given the low values typical in the soils surrounding the Lake. The increase of organic matter, together with that of the clay content, gave rise to a noticeable increase in the cation exchange capacity of the soil which could help to prevent the appeareance of micronutrient deficiencies, very common in calcareous soils of the Mediterranean area. As negative points, the increases of electrical conductivity or harmful ions such as Cl^- or Na^+ were considerable even with the low application rates, given the high contents of salts in the sediments. This must undoubtedly be considered an issue, and the application of appropriate volumes of irrigation water should therefore be recommended after the addition of sediments to wash out any excess of salts produced. Besides, small amounts of heavy metals were introduced into the soil, although the very low contents of metals in the soil used in the experiment contributed to the low final concentrations. In fact, the most polluting treatment (high rate of CrC sediment) led to a final Cr concentration (55.1±1.8 mg/kg) which may be found in untreated agricultural soils of Eastearn-Spain (Canet et al., 1997, 1998). As shown in Table III, the amounts of microelements occurring in available form were also increased even with the lowest rates of sediments, while only a slight increase in available phosphorus was observed, except in the case of the highest rate of OrgC.

The application of sediments always increased the yield of lettuce (Table IV), no negative effects by salts or pollutants being therefore noticed. Since irrigation was carefully managed to prevent any water-stress, the increment of water-retention capacity of the soil may not be accountable for these yield increases, which should be caused by the nutrient contents of the sediments and, perhaps, to the improvement of the soil cation exchange capacity. On the contrary, no significant effects on the size and yield of the tomato plants were observed, although significant but not easily interpretable changes were found in the fresh weight of leaves (data not presented). Since no significant effects of the substrate volume on yields were observed, lettuce samples corresponding to soil-180, soil-360 and soil-720 control treatments were excluded from further analysis.

Table V shows the effect of the sediments on the macronutrient contents in lettuce tissues. In all cases significant effects were found, depending on the sediment and application rate used. The decreases of P, Ca and Mg contents, probably due to the higher production of plant biomass, and the increase of those of Na probably caused by the high salt contents of the sediments, were the most remarkable findings. The effects of the sediments on the macronutrient contents in the tomato plants were remarkably different (Table VI). Data variability was much higher, no significant effects for N, P and Na were observed, and for K, Ca and Mg only a few treatment brought about results significantly different from the control. There seemed to be a certain trend to increase Mg levels after sediment applications, but the effects on K and Ca contents depended on the sediment and rate used.

While most treatments reduced Cu and increased Zn contents in lettuce plants, those of Mn were increased by all sediments but OrgC, which slightly reduced them (Table VII). No significant effect was found for Fe, neither in lettuce nor in tomato plants (Table VII). In the latter, the effects of treatments on Cu, Zn and Mn contents strongly depended on the sediment and application rate used, and no general trend could be discerned. Heavy metal analysis of all vegetal samples did not result in any detectable amounts of Cd, Cr, Ni or Pb.

4. Conclusions

According to the results of the trial, the application of sediments to the agricultural soils surrounding the Albufera Lake may be a sound procedure to avoid the enviromental issues derived from the disposal of large amounts of dredged materials, and improve the properties of the sandy soils of the area. Even though the increases of the water-retention and cation-exchange capacities of the poor soils typical of the place would suffice to make this application adviceable, the positive response of lettuce to the nutrients included in the sediments adds further interest. No salt washing out took place during the experiment, since water was not allowed to drain from the pots, but no negative effect by a salt excess was found, even in a slightly salt-sensitive plant such as lettuce (Maroto, 2000). Nevertheless, any salt accumulation in soils in which large amounts of sediments could be applied should be washed out by means of repeated irrigation and rainfall. Although no heavy metal accumulation in the plant tissues could be observed, it could be argued that repeated applications of sediments containing high amounts of Cr would concentrate this metal in the receiving soils. The pattern of metal contamination in the bottom of the lake is nevertheless well-known, and the use of the most polluted sediments may thus be easily avoided even without preliminary analysis.

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TABLE I

Analytical characteristics of the soil and sediments used in the experiment (mean±standard deviation, n≥3)

	Sediment				Soil
	LC	AC	CrC	OrgC	
Moisture (%)	53.5	51.0	63.7	54.8	ND[c]
Texture	clay	clay	clay	silty-clay	loamy-sand
· sand (%)	10.0	11.7	10.0	14.1	85.0
· silt (%)	37.3	31.3	38.7	43.8	7.50
· clay (%)	52.7	57.0	51.4	42.1	7.50
EC[a] (1:5 water-extract, $dS \cdot m^{-1}$)	2.23±0.06	2.16±0.06	2.21±0.06	1.74±0.05	0.11±0.01
pH (1:5 water-extract)	7.96±0.07	7.80±0.06	7.85±0.19	7.93±0.09	8.95±0.01
CEC[b] ($meq \cdot 100\ g^{-1}$)	19.1±0.4	18.3±0.05	20.9±0.9	18.8±1.0	2.83±0.03
Organic matter (%)	5.79±0.06	5.43±0.06	8.81±0.13	5.63±0.18	0.37±0.02
Organic N (%N)	0.206±0.007	0.173±0.005	0.353±0.002	0.244±0.001	0.025±0.000
Ammonia (%N)	0.012±0.000	0.005±0.000	0.011±0.000	0.015±0.000	<0.001
Nitrate+nitrite (%N)	<0.001	<0.001	<0.001	<0.001	<0.001
C/N ratio	16.3	18.2	14.5	13.4	8.8
Available P ($mg \cdot kg^{-1}$)	38±5	18±3	41±1	61±3	17±2
Na (%)	0.29±0.02	0.28±0.02	0.26±0.00	0.19±0.01	0.019±0.004
K (%)	0.79±0.09	0.79±0.12	0.58±0.00	0.57±0.08	0.197±0.007
Ca (%)	17.6±0.7	17.7±0.3	18.6±0.2	16.9±0.2	13.5±0.4
Mg (%)	1.54±0.07	1.65±0.08	1.17±0.03	1.08±0.04	1.10±0.06
Cu ($mg \cdot kg^{-1}$)	17.5±1.7	15.0±0.2	20.7±0.0	45.0±1.2	6.54±0.19
Zn ($mg \cdot kg^{-1}$)	53.4±6.2	46.2±4.7	83.4±4.5	151.8±4.5	13.6±0.3
Mn ($mg \cdot kg^{-1}$)	312±6	322±5	311±5	303±5	178±6
Fe ($mg \cdot kg^{-1}$)	19300±100	19700±500	16600±200	20000±300	6140±250
Cd ($mg \cdot kg^{-1}$)	0.31±0.13	0.19±0.04	0.26±0.00	0.39±0.22	<0.4
Cr ($mg \cdot kg^{-1}$)	56.3±2.3	52.8±1.2	489.6±14.8	58.0±4.5	9.8±0.5
Ni ($mg \cdot kg^{-1}$)	17.3±0.8	16.3±0.3	16.3±0.0	20.9±0.4	2.9±0.2
Pb ($mg \cdot kg^{-1}$)	11.8±0.3	10.9±0.5	23.1±1.3	30.3±1.1	5.5±0.7

[a]EC: electrical conductivity; [b]CEC: cation exchange capacity; [c]ND: not determined

LC: low contamination, AC: average contamination, CrC: chromium contamination, OrgC: organic contamination.

TABLE II

Effect of the sediment application on selected soil properties (mean±standard deviation, n≥3)

Treat	CE[a] (dS·m^{-1})	Cl$^-$ (mg·L^{-1})	Na$^+$ (mg·L^{-1})	Organic matter (%)	CEC[b] (meq·100 g^{-1})	Water-retention capacity[c] (%)
soil	0.11±0.01	9.0±2.0	5.2±1.2	0.37±0.02	2.83±0.03	18.0a
LC-180	0.26±0.02	33.2±0.2	24.9±0.8	0.60±0.00	3.45±0.04	19.5abc
LC-360	0.43±0.03	61.0±6.0	49.0±4.0	0.88±0.02	3.96±0.07	21.7ed
LC-720	0.64±0.01	96.0±2.0	76.0±3.0	1.28±0.05	5.10±0.20	23.8f
AC-180	0.25±0.00	34.0±1.0	27.0±0.5	0.60±0.00	3.38±0.07	19.1ab
AC-360	0.37±0.08	58.5±0.7	48.0±3.0	0.88±0.04	3.94±0.15	21.8ed
AC-720	0.63±0.00	98.0±2.0	74.0±2.0	1.37±0.02	4.70±0.50	23.7f
CrC-180	0.25±0.01	37.0±2.0	27.2±1.2	0.85±0.03	3.60±0.20	19.9bc
CrC-360	0.38±0.01	65.0±1.0	45.3±0.3	1.27±0.02	3.80±0.10	21.8ed
CrC-720	0.59±0.03	104.0±2.0	72.8±0.3	1.85±0.05	5.80±0.80	23.4ef
OrgC-180	0.23±0.01	31.4±0.5	20.2±1.2	0.68±0.04	3.30±0.20	21.1cd
OrgC-360	0.32±0.01	48.0±1.0	30.6±0.9	0.88±0.00	4.30±0.20	22.8edf
OrgC-720	0.48±0.01	79.0±1.0	51.9±0.4	1.36±0.05	5.60±0.20	24.3f

[a]EC: electrical conductivity; [b]CEC: cation exchange capacity. Electric conductivity and ion contents measured in 1:5 water-soil extracts. [c]values in each column followed by the same letter are not different according Duncan's Multiple Range Test ($p<0.05$)

TABLE III

Effect of the sediment applications on the soil contents of available phosphorus and micronutrients (mean±standard deviation, n≥3)

Treat	P ($mg·kg^{-1}$)	Fe ($mg·kg^{-1}$)	Mn ($mg·kg^{-1}$)	Cu ($mg·kg^{-1}$)	Zn ($mg·kg^{-1}$)
soil	17±2	4.6±0.3	6.6±0.7	0.81±0.02	1.4±0.1
LC-180	17±1	7.1±0.4	8.7±0.2	0.95±0.01	1.9±0.2
LC-360	22±4	8.9±0.2	9.7±0.2	1.04±0.03	2.1±0.2
LC-720	21±4	11.5±0.1	11.2±0.1	1.20±0.04	2.5±0.1
AC-180	21±1	7.2±0.3	10.4±0.1	0.91±0.02	1.6±0.3
AC-360	23±2	9.8±0.3	10.4±0.3	0.99±0.06	2.0±0.5
AC-720	24±2	13.0±0.4	11.7±0.5	1.11±0.05	2.1±0.1
CrC-180	22±1	6.6±0.2	8.0±0.2	1.14±0.05	2.9±0.2
CrC-360	23±1	8.6±0.3	8.8±0.5	1.51±0.13	4.2±0.4
CrC-720	22±1	12.6±0.3	10.5±0.2	1.98±0.06	6.2±0.3
OrgC-180	21±4	13.9±1.2	9.2±0.2	1.92±0.09	4.7±0.2
OrgC-360	25±2	23.6±1.2	11.6±0.4	2.84±0.06	7.5±0.3
OrgC-720	41±2	36.8±1.1	14.8±0.4	4.39±0.12	12.6±0.3

TABLE IV

Effect of the sediment applications on the yield and growth of lettuce and tomato.

Treatment	Lettuce		Tomato		
	fresh weight (g)	dry weight (g)	plant length (cm)	plant fresh weight (g)	plant dry weight (g)
soil	110a	9.9a	89.5	110	20.8
soil-180	103a	10.8a	---	---	---
soil-360	107a	11.6ab	---	---	---
soil-720	111a	11.0a	---	---	---
LC-180	129bc	13.8b	91.0	114	21.2
LC-360	145de	19.2de	97.0	107	20.7
LC-720	171g	19.7e	98.0	104	20.2
AC-180	124b	14.0b	90.5	111	21.0
AC-360	127bc	13.6b	89.3	106	20.3
AC-720	139cd	18.7de	89.3	102	18.7
CrC-180	129bc	13.7b	87.8	117	22.2
CrC-360	154ef	17.0cd	88.8	116	21.9
CrC-720	191h	22.5f	87.0	111	20.7
OrgC-180	136bcd	15.4bc	89.0	111	20.7
OrgC-360	162fg	19.0de	89.0	120	22.8
OrgC-720	194h	23.6f	83.5	108	20.9

Values in each column followed by the same letter are not different according Duncan's Multiple Range Test ($p<0.05$). Absence of letters indicates no statistical significance of the treatments.

TABLE V

Effect of the sediment applications on the lettuce content of macronutrients

Treat	N (%)	P (%)	Na (%)	K (%)	Ca (%)	Mg (%)
Soil	1.43d	0.217de	0.456a	1.19abcde	0.946d	0.395e
LC-180	1.31bcd	0.184bcd	0.603bc	1.23cdef	0.835bcd	0.319bc
LC-360	1.14a	0.159abc	0.680cd	1.26def	0.725ab	0.273a
LC-720	1.44d	0.181bcd	0.997e	1.28f	0.748abc	0.303b
AC-180	1.36cd	0.235e	0.599bc	1.27ef	0.940d	0.331bcd
AC-360	1.28abcd	0.196cd	0.741d	1.21bcdef	0.876cd	0.310bc
AC-720	1.15ab	0.131a	0.765d	1.20bcdef	0.666a	0.262a
CrC-180	1.39cd	0.210de	0.645bc	1.19abcde	0.919d	0.351d
CrC-360	1.31bcd	0.196cd	0.742d	1.16abc	0.858bcd	0.309bc
CrC-720	1.37cd	0.151ab	0.920e	1.21bcdef	0.752abc	0.305bc
OrgC-180	1.30abcd	0.184bcd	0.589b	1.17abcd	0.861bcd	0.336cd
OrgC-360	1.24abc	0.162abc	0.601bc	1.12ab	0.802abcd	0.320bc
OrgC-720	1.39cd	0.134a	0.745d	1.11[a]	0.737abc	0.319bc

Values in each column followed by the same letter are not different according Duncan's Multiple Range Test (p<0.05). Absence of letters indicates no statistical significance of the treatments.

TABLE VI

Effect of the sediment applications on the tomato content of macronutrients

Treat	N (%)	P (%)	Na (%)	K (%)	Ca (%)	Mg (%)
Soil	1.07	0.092	0.353	0.93abc	3.07abc	0.81a
LC-180	0.98	0.104	0.337	0.88ab	3.26abc	0.93abcd
LC-360	0.95	0.116	0.369	0.88ab	3.38bc	1.14de
LC-720	0.97	0.116	0.575	1.04bcd	3.81c	1.34f
AC-180	0.99	0.113	0.381	0.94abc	3.40bc	1.02abcde
AC-360	0.95	0.102	0.388	0.93abc	3.07abc	1.03bcde
AC-720	0.98	0.101	0.365	0.91abc	2.97ab	1.10cde
CrC-180	0.94	0.102	0.362	0.87a	3.23abc	0.97abcde
CrC-360	0.98	0.098	0.343	0.96abc	3.04ab	0.98abcde
CrC-720	0.97	0.098	0.397	0.94abc	3.23abc	1.18ef
OrgC-180	0.86	0.108	0.383	0.99abcd	3.10abc	0.90abc
OrgC-360	0.81	0.108	0.317	1.05cd	2.53a	0.85ab
OrgC-720	0.95	0.096	0.348	1.12d	2.71ab	0.94abcd

Values in each column followed by the same letter are not different according Duncan's Multiple Range Test ($p<0.05$). Absence of letters indicates no statistical significance of the treatments.

TABLE VII

Effect of the sediment applications on the lettuce and tomato contents of micronutrients

Treat	Fe ($mg \cdot kg^{-1}$)		Cu ($mg \cdot kg^{-1}$)		Zn ($mg \cdot kg^{-1}$)		Mn ($mg \cdot kg^{-1}$)	
	lettuce	tomato	lettuce	tomato	Lettuce	tomato	lettuce	tomato
Soil	51.5	101.4	9.42e	11.58cd	18.6[a]	46.4a	45.0bc	63.7cde
LC-180	60.4	96.8	7.21bcd	10.92bcd	21.4ab	53.6ab	51.2de	63.6cde
LC-360	68.7	107.2	5.95abc	9.49ab	23.0abc	57.4bc	50.4cd	70.9de
LC-720	59.4	119.0	5.48ab	9.50ab	26.3bcd	63.3c	62.3fg	78.7e
AC-180	49.2	83.2	8.36de	10.16abc	32.4de	53.1ab	55.5de	64.0cde
AC-360	49.0	90.9	7.05bcd	9.39ab	26.6bcd	51.1ab	66.0g	73.3de
AC-720	61.8	99.9	4.96a	9.04a	25.2abcd	52.1ab	57.4ef	60.1cde
CrC-180	49.8	82.9	7.80de	9.79ab	30.3cde	52.3ab	51.2de	63.1cde
CrC-360	63.2	95.0	7.35cd	11.04bcd	34.2ef	55.2abc	53.0de	53.0bcd
CrC-720	53.1	92.2	5.93abc	10.78bcd	36.6ef	51.6ab	53.2de	57.0cd
OrgC-180	54.8	81.0	7.40cd	12.35de	30.5de	46.7a	40.6b	49.3abc
OrgC-360	52.6	89.0	8.40de	12.37de	31.8de	55.6abc	33.2a	35.3ab
OrgC-720	63.5	106.0	7.21bcd	13.61e	40.9f	64.1c	42.3b	33.1a

Values in each column followed by the same letter are not different according Duncan's Multiple Range Test ($p<0.05$). Absence of letters indicates no statistical significance of the treatments.