ORGANIC FERTILIZER AND HUMIC SUBSTANCE EFFECTS ON LETTUCE CHARACTERISTICS AND NUTRITION

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ABSTRACT - The aim of this work was to test organic fertilization, liming, and levels of soil conditioner composed by humic and fulvic acids on the characteristics and nutrition of "iceberg" lettuce. The experimental design was completely randomized in a 5x3x2 factorial scheme, in which 5 levels of soil conditioner (0, 20, 40, 100, 200 L ha^{-1}), 3 fertilizers (chicken manure, organic compost and mineral), and liming (with or without). Lettuce shoot fresh and dry weight, shoot commercial fresh and dry weight, height, circumference, and number of leaves were evaluated. Lettuce grown with chicken manure rendered the greater circumference and higher shoot fresh commercial weight, which are the most important lettuce characteristics affecting consumer purchase decisions. The soil conditioner did not influence on plant growth, except height and dry shoot weight on a very small scale.

Keywords: humic substances, Lactuca sativa L., chicken manure, organic compost, liming.

Introduction

Nowadays, studies on the use of organic materials are very important as the price of fertilizers is increasing globally. Chicken as well as cattle manure complex toxic Al, enhances soil pH, and phosphorus, calcium, and magnesium content. However, there is a small amount of information concerning effects of chicken manure, and organic compost on lettuce characteristics and nutrition. The addition of organic amendments increases soil pH and reduces exchangeable Al regardless of whether lime was applied or not (Mokolobate and Haynes, 2003).

In addition, several kinds of soil conditioners, produced from organic sources, such as organic composts, humus, and coal, are being sold in the market. The humic compounds may be absorbed by roots and transported to shoots, thus enhancing the growth of the whole plant (Lulakis and Petsas, 1995). Effects of soil conditioners on plants were reported to improve the soil chemically, increases cation exchange capacity, stimulates microbial activity, increases soil capacity to complex and solubilize ions, complexes nutrients and toxic aluminum (Stevenson, 1994). Very few works showed the effects of soil conditioner in plant characteristics and nutrition. Besides, the great majority of the studies on the effects of humic substance on plants were held in nutrient solutions, with inert substrates and generally under laboratory experimental conditions and not with soil or under field conditions (Zachariakis et al., 2001). Dantas et al. (2007), however, found no effect of humic substances on the growth of guava tree (Psidium guajava). The divergent findings can be attributed to many factors, including the nature, source and concentration of the humic substance, soil, pH, the plant species and the growth parameter being measured (Lulakis and Petsas, 1995).

The aim of this work was to evaluate effects of organic and mineral fertilizers, liming, and use of soil conditioners on the characteristics and nutrition of "iceberg" lettuce.

Matherial and methods

Physical and chemical characteristics of Typic Dystrudepts used in the experiment were published elsewhere (Marchi et al., 2008). The organic fertilization used was 24.19 g of chicken manure (CKM) kg^{-1} or 54.83 g of organic compost (OCP) kg^{-1} were mixed to the soil to provide the recommended nitrogen doses (300 mg N kg^{-1}, Novais et al., 1991) also considering availability of 50% during the cropping season (CFSEMG, 1999). These amounts of organic fertilizers were equal to 2.27 mg C-CKM g^{-1}, and 7.02 mg C-OCP g^{-1} of soil.

Mineral fertilization was performed by mixing 300 mg simple superphosphate kg^{-1} of soil. Nitrogen (N-urea, 300 mg N kg^{-1}), and potassium (potassium phosphate, 300 mg K kg^{-1}) were supplied to soil in four applications: 7, 15, 21, and 28 days after lettuce planting. Micronutrients (0.5 mg B kg^{-1}, 5.0 mg Zn kg^{-1}, 1.5 mg Cu kg^{-1}, 0.15 mg Mo kg^{-1}) were applied at once ten days after planting.

A soil conditioner (SCN) extracted from leonardite (Table 1), composed of 229 g humic extract L^{-1}, in which 113 g humic acids L^{-1}, and 116 g fulvic acids L^{-1} (Marchi et al., 2008), in liquid form, was applied to soil 7 days after planting lettuce seedlings. The rate of application was 0, 20 (recommended by SCN producer), 40, 100 e 200 L ha^{-1}, based on plant population, i.e.: 0, 0.3986, 0.7972, 1.993, and 3.986 g pot^{-1}, respectively. Total amount of C provided from SCN to pots was 0.9, 1.8, 4.5 e 9.1 μg C g^{-1} of soil, respectively.

The soils (2.75 kg pot^{-1}) were incubated for ten days

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before lettuce planting. Lettuce (iceberg, cv. Raider) was planted 35 days after germination when they had four leaves. Plants were harvested 57 days after planting.

The experiment was completely randomized in a factorial scheme 5x3x2. Five doses of soil conditioner (0, 20, 40, 100, 200 L ha^{-1}), 3 fertilizers (CKM, OCP and mineral), with or without liming were studied, with five replications. Analysis of variance was performed to test lettuce nutrients as a function of tested factors (soil conditioner, fertilizers and liming). Analysis of variance was performed to test lettuce production as a function of tested factors (soil conditioner, fertilizers and liming). Scott Knott test, 5% probability was performed. Regression analysis was performed on SCN data.

Results and discussions

Analysis of variance showed that lettuce height data interacted with SCN, fertilizers and liming significantly. Data of other lettuce characteristics, such as number of leaves, circumference, shoot fresh weight, and shoot commercial dry weight interacted significantly only with fertilizers and liming. Data of shoot dry weight and shoot commercial fresh weight interacted significantly only with fertilizers.

When lime was not used, lettuce grown with mineral and CKM fertilizers was taller than with OCP. When lime was applied, lettuce height followed the order: mineral fertilization > CKM > OCP. Mantovani et al. (2003) showed that high doses of compost may decrease lettuce production due to nutrients in excess. A possible cause for the small lettuce height, when produced with OCP, may be excess of boron in this fertilizer (Table 1). The amount of B applied with OCP was very high (11.62 kg ha^{-1}). Average concentration of B in lettuce leaves produced with OCP was 212 and 160 mg kg^{-1} without and with liming, respectively. Symptoms of B toxicity in lettuce produced with OCP appeared at the edges of leaves, and progressed to a browning and drying of margins and tips for most of the fully expanded leaves. Similar symptoms were found by Choi et al. (2006) with 515 mg B kg^{-1} dry leaves lettuce. Adequate values for B in lettuce leaves are around 30 - 60 mg kg^{-1} (van Raij et al. 1997). Except B, content of other nutrients in leaves of plants produced with all studied fertilizers were in adequate proportions (Table 2).

Without liming, increases in soil pH were noticed after CKM and OCP were applied. Increases in pH were probably the main responsible for lettuce greater increase in height with CKM than with mineral fertilizers. However, when lime was applied, lettuce grown with mineral fertilizers was taller than that produced with organic fertilizers. Even though, with the use of mineral fertilizers, soil pH was lower than the soil were organic fertilizers were applied. Karimaei et al. (2004) showed that iceberg lettuce maximum production occurred at pH 5.8. Knight and Mitchell (1983) found that optimum lettuce growth occurred at pH 5.9. The pH was, therefore, best adjusted for the recommended lettuce production with use of mineral fertilizers.

Even though, liming did not change lettuce height when organic fertilizers were used, except with OCP at 200 L SCN ha^{-1}. In spite of that, liming increased lettuce height with mineral fertilizers for all SCN doses, except at 200 L SCN ha^{-1}. Without liming, lettuce plants grown with mineral fertilizers increased in height with increases in SCN doses, according to the equation: $y = 20.53 + 0.0112x$ ($R2 = 0.86$). However, lettuce increases in height at this situation were not meaningful.

Lettuce number of leaves, circumference, shoot fresh weight, and shoot commercial dry weight were greater when grown with CKM than with OCP or mineral fertilizers. Content of P, Ca and Mg in leaves were higher in lettuce grown with CKM than with other used fertilizers, and it may have accounted to the increased lettuce growth characteristics when CKM was used (Table 2). Except the number of leaves, lettuce characteristics did not change with liming when grown with CKM, which were higher without liming. When lettuce was produced with OCP, liming increased all evaluated characteristics, except circumference, which remained the same statistically. When lettuce was produced with mineral fertilizers, only shoot fresh weight increased with liming, the other characteristics remained the same statistically.

Ali et al. (2007) reported that lettuce weight may be lower when there is low N availability, however, in the present experiment, N amount was leveled to all treatments. Then, organic matter mineralization is the only way N availability may change lettuce growth.

Lettuce grown with CKM produced the same weight of dry shoot than with mineral fertilizers. However, shoot commercial fresh weight, important lettuce characteristic which attract consumers, was greater when produced with CKM than with mineral fertilizers. This difference, between dry and fresh weight for lettuce is the water content. Malathi et al. (1986) showed that, in cowpea plants with increased levels of calcium in tissue, the plant water holding capacity was higher, and the rate of water loss from the leaves of Ca^{2+} enriched plants was lower. Calcium content in lettuce grown with CKM was higher than with mineral fertilizers (Table 2). Even though, adequate values for Ca in lettuce leaves are from 15 to 25 g kg^{-1} (van Raij et al. 1997). For lettuce produced with OCP, the weight for both characteristics was smaller than that produced with CKM and mineral fertilizers.

Conclusions

Lettuce grown with chicken manure rendered the greater circumference and higher shoot fresh commercial weight, which are the most important lettuce characteristics affecting consumer purchase decisions. The soil conditioner did not influenced on plant growth, except height and dry shoot weight on a very small scale.

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Table 1 Organic fertilizers and soil conditioner characteristics[1]

Characteristics§	CKM*	OCP	SCN
pH in water	8.90	7.60	14.30
N-total (g kg^{-1})	25.80	12.00	4.00
P (g kg^{-1})	25.75	4.24	34.44
K (g kg^{-1})	22.28	6.81	37.12
Na (g kg^{-1})	-	-	115.00
Ca (g kg^{-1})	102.50	25.48	1.66
Mg (g kg^{-1})	6.12	3.02	0.26
S-sulphate (g kg^{-1})	5.23	5.23	7.50
B (mg kg^{-1})	35.00	106.00	-
Cu (mg kg^{-1})	68.00	43.00	0.00
Fe (g kg^{-1})	2.18	48.38	102.10
Mn (mg kg^{-1})	552.00	468.00	7.10
Zn (mg kg^{-1})	503.00	473.00	16.20
Humidity (dag kg^{-1})	16.58	6.16	-
OC (mg g^{-1})	94.00	128.00	59.00
Density (g cm^{-3})	-	-	1.23

[1]Marchi et al. (2008), §Embrapa (1999), #EC = electrical conductivity, *CKM = dry chicken manure, OCP = dry organic compost, SCN = soil conditioner, OC = organic carbon (dry basis).

Table 2 Nutrient content (means±standard error) in lettuce plants grown in a Typic Dystrudepts

Liming	N[§]	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	g kg^{-1}						mg kg^{-1}				
					CKM*						
Without	19.77±5.83	4.99±0.53	11.99±3.07	8.52±1.23	2.46±0.46	2.19±0.31	59.79±15.22	10.33±1.08	90.95±15.56	93.99±29.31	25.17±2.53
With	20.00±3.87	4.20±0.28	11.32±1.81	8.80±1.22	2.29±0.36	2.16±0.18	58.13±18.02	9.86±0.53	91.20±12.47	74.70±24.32	24.15±3.87
					OCP						
Without	19.75±2.84	3.42±0.30	11.12±2.85	7.27±1.16	1.73±0.28	1.27±0.44	195.84±38.79	8.09±0.54	85.57±19.11	66.66±11.17	61.81±14.33
With	21.36±3.90	3.64±0.23	10.77±1.85	7.69±0.90	1.88±0.26	1.62±0.20	160.37±34.96	8.47±0.89	97.00±30.99	61.21±11.37	38.63±4.77
					Mineral						
Without	31.80±5.87	3.24±0.27	10.81±2.57	7.00±1.41	0.83±0.11	2.80±0.25	53.47±7.65	9.34±0.78	85.45±11.90	72.75±20.33	68.41±14.63
With	24.56±3.19	3.12±0.26	11.05±2.54	7.08±1.15	1.69±0.22	2.71±0.22	53.02±12.03	8.58±0.66	89.38±16.82	59.33±17.67	50.42±9.70

[§]Embrapa (1999), N-total, *CKM = dry chicken manure, OCP = dry organic compost.