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Full Length Research Paper

Comparison of some yield and quality criteria in organically and conventionally-grown lettuce

Polat E.*, Demir H. and Onus A. N

Department of Horticulture, Faculty of Agriculture, Akdeniz University, 07058, Antalya, Turkey.

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The simplest definition organic farming is a production system, which excludes synthetic inputs and resorts to external inputs only where the system cannot be sustained by internal recycling. Recent studies comparing conventional and organic farming have shown an increase in organic matter, nutrient content, and microbial biomass in organically managed soils. The present study was undertaken to evaluate how conventional and organic farming systems affected the yield and some quality properties of lettuce by investigating the effects of some natural substances (blood flour, manure, liquid seaweed extract etc.) on yield, quality and nutrient content of organically versus conventionally-grown lettuces. As a conclusion, results of both years showed that the conventional growing had higher yield than organic growing, respectively 20% in total yield and 21% in marketable yield. On the other hand there was no difference in terms of food nutrition value and quality and that is why it is possible to recommend organic lettuce growing as it has much more positive effects on human health.

Key words: Organic growing, conventional growing, lettuce, yield, quality.

INTRODUCTION

In contemporary agriculture, alternative production methods to eradicate or minimize the long lasting undesired effects of synthetic fertilizers and pesticides are necessary (Altieri and Francis, 1992). The organic agricultural production system, accepted by the European Union (EU) and the Food and Agriculture Organization (FAO) as one of the alternative systems to the conventional agriculture, appears as an environmentally friendly growing system. The simplest definition organic farming is a production system, which excludes synthetic inputs and resorts to external inputs only where the system cannot be sustained by internal recycling (Woodward and Lampkin, 1990). Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. The principal guidelines for organic production are to use materials and practices that enhance the ecological balance of natural systems and that integrate the parts of the farming system into an ecological whole.

Recent studies comparing conventional and organic farming have shown an increase in organic matter, nutrient content, and microbial biomass in organically managed soils (Edmeades, 2003). As an alternative to conventional agricultural, organic production relies on the incorporation of organic material in oil, and not infrequently, by the use of animal manure as fertilizer (Grusenmeyer and Cramer, 1997; Pell, 1997).It is a well-know fact that animal manure is a good source of macro-and micronutrient, and using it as fertilizer is an important disposal method (Madison et al., 1995). This contributes to diminishing the environmental pollution from manure disposal (Choudhary et al., 1996).

In several previous studies carried out to investigate the effect of liquid seaweed extract (Kelpak) on the growth and nutrient content of lettuce, it was found that Kelpak enhanced yield and amount of nutrients (Ca, K and Mg) in the leaves (Grouch and Staden, 1993; Wapham et al., 1994).

The present study was undertaken to evaluate how conventional and organic farming systems affected the yield and some quality properties of lettuce by investigating the effects of some natural substances (blood

*Corresponding author. E-mail: polat@akdeniz.edu.tr.

Table 1. Combinations of application materials used in the study over a 2-year period.

Treatment	Components
COP	Manure (20 t ha^{-1}), Ormin K(350 kg ha^{-1}), Blood flour (900 kg ha^{-1}) + Coplex (400 kg ha^{-1})
MAX	Manure (20 t ha^{-1}), Ormin K(430 kg ha^{-1}), Blood flour (1 t ha^{-1})+ Maxicrop (10.5 kg ha^{-1})
KO-HU	Manure (20 t ha^{-1}), Ormin K(430 kg ha^{-1}), Blood flour (1 t ha^{-1}) + Ko Humax (18 L ha^{-1})
KEL	Manure (20 t ha^{-1}), Ormin K(430 kg ha^{-1}), Blood flour (1 t ha^{-1}) + Kelpak (330 L ha^{-1})
ORM	Manure (20 t ha^{-1}), Ormin K(143 kg ha^{-1}), Blood flour (1 t ha^{-1}) + Ormin K (290 kg ha^{-1} after transplantation)
Control	Manure(20 t ha^{-1}), Triple super phosphate, 260 kg ha^{-1}; ammonium nitrate, 250 kg ha^{-1}; potassium nitrate, 110 kg ha^{-1} before transplantation, 220 kg ha^{-1} after transplantation

Table 2. Monthly values of rainfall (mm) and temperature (ºC) during the study period between the years 2000 and 2002 (Anonymous, 2003).

Month	2000-2001		2001-2002	
	Temperature (℃)	Rainfall (mm)	Temperature (℃)	Rainfall (mm)
September	25.6	0.0	25.6	2.0
October	20.3	27.8	21.0	16.3
November	16.3	312.4	14.2	907. 2
December	11.8	154.0	11.1	483.2
January	11.4	217.7	9.1	52
February	11.5	96.2	12.5	22.3

flour, manure, liquid seaweed extract etc.) on yield, quality and nutrient content of organically versus conventionally-grown lettuces.

MATERIAL AND METHOD

Experimental site and design

The study was carried out in the experimental farm of Faculty of Agriculture, Akdeniz University (36°53' N, 30°39'E), Antalya in Turkey in two successive years, 2000 and 2002. The selected areas for comparisons of organic and conventional based production systems, where no cultivation was made before were two adjacent fields (side-by-side). Seeds of lettuce (*Lactuca sativa* var. *capitata* cv Gloria, an iceberg type) were sown in seed trays containing peat and perlite mixture. At the third true leaf stage, the plants were transplanted to the soil at a density of 11 plants m^{-2}. The cultivation of lettuce was conducted between September and December in both years. The soil type was a sandy-loam one and no fertilizer was applied before. The soil characteristics of the study area were as follows; pH: 7.9, lime: 6.17 %, EC (mmhos): 2.5, organic matter: 1.88%.

Used materials

Five organic materials, manure, blood flour (contains 13% of N), Ormin K (contains 35.5% of K_2O), Maxicrop, Ko Humax and Kelpak (the last three contain micro elements and some organic acids) were tested in different combinations in organic plots. Details of selected combinations of application materials for evaluation are summarized in Table 1. Manure and blood flour application was conducted only once before planting plants. Drip irrigation system was used in all experimental plots. The choice of organic fertilizers in the study and their usage amounts were based on previous studies (Gianquinto and Borin, 1995; Vural et al., 2000), in which the fertilizers were approved for organic vegetable growing.

Weather rainfall and temperature data with long-term monthly averages for over 2000-2002 are presented in Table 2.

In the present study, the materials permitted by the rules of organic growing were used against the pests and diseases. Arabic soap (1%) against the aphids, a bacterial preparation (*Bacillus thuringiensis* var. kurstaki) against the caterpillars and cupper oxycloride against the lettuce mildew were applied in the organic plots whereas synthetic preparations were used in the conventional plots during the both growing seasons.

Data collection and analysis

Samples (only leaves) were analyzed for total mineral matter. Analyses were carried out according to the method described by Kacar (1972) and the amounts of K, Ca, Na, Mg, Mn, Fe, Zn and Cu were analyzed by atomic absorption spectrophotometer (Varian SpectrA-400 Plus) for each sample. Soluble solids (%), ascorbic acid content (mg 100 ml^{-1}), pH, butt diameter (cm), head height (cm), total yield (kg ha^{-1}), marketable yield (kg ha^{-1}) and head weight (g) were also measured. Each plant was macerated in a blender and the content of soluble solids was measured in the juice of the leaves using a refractometer (Atago model PR-1, Tokyo, Japan). Ascorbic acid was extracted in 1% oxalic acid and measured by using reflectoquant ascorbic acid test strips in a Rqflex

Table 3. The effects of various organic fertilizer on head height, butt diameter, soluble solids, ascorbic acid and pH in Iceberg type lettuce growing.

Treatment	Head height (cm)		Butt diameter (cm)		Soluble solids (%)		Ascorbic acid (mg 100 ml^{-1})		pH	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
COP	12,61	15,97	2.57	1.96	3.87 a*	3.93 ab	16.45 ab	13.22	6.42 b	6.08
MAX	12,70	15,57	2.40	2.01	4.07 a	3.87 ab	15.33 b	13.59	6.45 b	6.10
KO-HU	12,71	15,43	2.53	2.01	4.07 a	3.53 bc	14.67 b	15.09	6.57 a	6.09
KEL	12,67	15,87	2.49	1.98	3.93 a	4.00 a	18.23 a	12.85	6.61 a	6.10
ORM	12,32	15,73	2.56	2.00	3.80 a	4.00 a	16.67 ab	13.41	6.42 b	6.10
Control	13,00	16,73	2.34	2.11	3.40 b	3.40 c	15.78 b	13.77	6.39 b	6.09
LSD 5%	NS**	NS	NS	NS	0.33	0.40	2.05	NS	0.11	NS

*Values in a column followed by different letters are significantly different ($p < 0.05$).
NS: Not significant.

reflectometer (Merk, Darmstadt, Germany). The pH was determined in a 50 ml filtrate obtained from a mixture of 10 g material blended with 100 ml deionized water.

The experimental design was completely randomized with three replicates; each replication consists of 25 plants. Data were subjected to analysis of variance and means were separated by LSD at the 0.05 level.

RESULTS

The effects of various organic fertilizer applications on head height (cm), butt diameter (cm), soluble solids (%), ascorbic acid (mg 100 ml^{-1} leave juice) and pH in Iceberg type lettuce growing are given in Table 3. In the first and second year results, there were no statistically significant differences among the applications on head height and butt diameter in Iceberg type lettuce growing. In the same way in the second year results, there were no statistically significant difference among the applications on ascorbic acid and pH in Iceberg type lettuce growing as well. On the other hand, in the both years, the effects of soluble solids and in the first year ascorbic acid and pH in Iceberg type lettuce growing on applications were statistically significant. In the first year, the effects of Kelpak application on ascorbic acid and pH were obtained by 18.23 mg and 6.61, respectively.

In the first year, the effects of various organic fertilizer applications on total yield, marketable yield and head weigh in Iceberg type lettuce were no significant difference, but in the second year the effects of them were important. . The highest total yield and marketable yield were obtained from conventional growing as 74.49 and 59.44 ton ha^{-1}, respectively, and also the similar results for head weight repeated.

The effects of various organic fertilizer applications on some micro- nutrition in iceberg type lettuce leaves were given on Table 5. In the first and second year, the effects of applications on some micro- nutrition were just determined in content of Zn in lettuce leaves. In the second year, the effects of Ko humax, Maxicrop, Kelpak applications on content of Ca, Na and Fe in lettuce leaves were statistically significant, respectively.

DISCUSSION

In the first year, although the differences among the treatments were not statistically significant, in the second year, there were statistically significant differences on total yield, marketable yield and head weight favoring the conventional growing. It is assumed that the rain as a climatic factor played an important role in the yield differences between two years as growing season. In the region it is possible to see heavy rains within a short period of time. Heavy rains, naturally, leach some given organic plant nutrition elements from the soil and that is why some nutrition problems in plant growing can take place. In the first year of the experiment, there was no heavy rain but in the second year several heavy rains took place during the growing period (Table 2) and leached the applied organic plant nutrition elements. Leaching was prevented in conventional growing (control) system, since the drip irrigation system was used and fertilizers were given after heavy rains. On the other hand, in organic growing main fertilizers, consist of chicken manure, Ormin K and blood flour, were applied just before planting, and top fertilizers used as micro elements were given 3 times with 10 days intervals during growing period. That is why higher amount of total yield, marketable yield and head weight was obtained from control in second year (Table 4).

We should also emphasize that uptake of chemical fertilizers by plant is much easier than organic fertilizers. Since lettuce growing period is rather short compared to other vegetable crops, plants cannot utilize organic fertilizers in a short time due to soil and climatic conditions, such as low air and soil temperature in late autumn, and that can be another reason of obtaining higher amount of total yield, marketable yield and head weight in conventional growing.

Table 4. The effects of various organic fertilizers on total yield, marketable yield and head weight in Iceberg type lettuce.

Treatment	Total yield (kg ha^{-1})		Marketable yield (kg ha^{-1})		Head weight (g)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year
COP	36490	49850 b*	27600	38870 b	248.4	349.9 b
MAX	38570	51470 b	29190	40290 b	262.7	362.7 b
KO-HU	36750	52130 b	28820	39260 b	259.4	353.4 b
KEL	37710	50010 b	28130	38600 b	253.2	347.4 b
ORM	37140	53610 b	28830	39210 b	259.5	352.9 b
Control	40690	74490 a	31080	59440 a	279.7	534.9 a
LSD 5%	NS	1003	NS	1022	NS	74.60

*Values in a column followed by different letters are significantly different ($p < 0.05$).
NS: Not significant.

Table 5. The effects of various organic fertilizers on some micro-nutrition elements in Iceberg type lettuce leaves (mg kg^{-1} dry weight).

Treatment	Ca (%)		K (%)		Mg (mg kg^{-1})		Na (mg kg^{-1})		Fe (mg kg^{-1})		Mn (mg kg^{-1})		Cu (mg kg^{-1})		Zn (mg kg^{-1})	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
COP	1.45	0.80 b	4.46	5.01	2586	2017	953	958 a	240.77	96.11 c	73.73	46.67	25.07	13.26	25.85 c	64.12 ab
MAX	1.47	0.79 b	4.09	5.18	2538	2169	1115	922 ab	232.44	155.35 a	78.05	50.27	28.29	14.00	31.16 abc	68.01 a
KO-HU	1.49	0.89 a	4.07	4.90	2381	2063	949	1016 a	240.11	137.36 a	78.50	47.34	31.00	12.51	35.76 a	70.86 a
KEL	1.45	0..83 b	4.22	5.19	2486	2093	1091	826 bc	233.33	103.71 bc	79.10	46.77	30.60	14.71	32.41 ab	59.48 b
ORM	1.31	0.78 b	4.35	5.13	2518	2332	1208	800 c	208.06	101.11 bc	70.82	43.57	31.82	12.91	33.74 a	48.47 c
Control	1.55	0.83 b	4.12	5.01	2558	2146	1111	806 c	213.29	87.27 c	74.07	48.95	26.91	13.26	30.37 abc	48.17 c
LSD 5%	N.S.	0.05	N.S.	N.S.	N.S.	N.S.	N.S.	111	N.S.	19.30	N.S.	N.S.	N.S.	N.S.	6.289	7.69

*Values in a column followed by different letters are significantly different ($p < 0.05$).
NS: Not significant.

Plants treated with organic fertilizers had higher level of vitamin C in first year and soluble solids in both years compared to control plant with chemical fertilizers (see Table 3) and these cases can be considered as advantages of organic growing.

Results of present study revealed that mineral content of organically grown plants was not less than conventionally grown plants (almost equal) but higher for Fe and Zn mineral elements (see Table 5). This is because some organic fertilizers are rich in terms of minerals and organic acids as reported by Grouch and Staden (1993), Wapham et al. (1994), Hong et al. (1995).

As a conclusion, results of both years showed that the conventional growing had higher yield than organic growing, 20% in total yield and 21% in marketable yield. On the other hand there was no difference in terms of food nutrition value and

quality and that is why it is possible to recommend organic lettuce growing as it has much more positive effects on human health.

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