Evaluation of some Organic Fertilizers on the Yield and Quality of Lettuce (Lactuca Sativa L. CV. Ahoora)

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ABSTRACT

Lettuce (Lactuca sativa L.) is a leafy plant of considerable agricultural and economic interest. The plant accumulates large quantities of nitrate in its leaves that threatened public health. For the reason an experiment was accomplished to assess the effects of different sources of organic fertilizers on growth, yield and quality properties especially nitrate accumulation of lettuce compared to conventional fertilizers. The experiment comprised of four treatments and control laid in a randomized complete design (RCD), replicated four times. Four types of fertilizers used were comprised of three organic and one inorganic fertilizer. The organic fertilizers included a) bounce back compost (composted chicken manure), b) mixture of animal waste (included blood and feather meal), c) fish meal and a mixture of Urea and Ammonium Nitrate as an inorganic fertilizer. The data collected included plant height, leaf brightness, plant fresh weight and nitrate content. Data analyzed using SPSS software. Results indicated significant differences in growth parameters amongst treatments compared to control. Results showed significant differences in fresh plant weight. The lettuce plants fertilized with animal waste had relatively higher average number of plant weight. Nitrate content was higher in plants treated with inorganic fertilizer and followed in control. No differences observed among three organic fertilizers about this parameter.

INTRODUCTION

Lettuce (Lactuca sativa L.) is a leafy plant of considerable agricultural and economic interest but as a leafy vegetable it accumulates large quantities of nitrate especially when grown in high NO3-N availability and low radiation [11]. It is considered as an excellent nutritive source of minerals, vitamins and fibers as it consumed as fresh green salad. Most of farmers use extreme amount of chemical fertilizers such as urea (46% N) and ammonium nitrate for growing lettuce in Iran. This resulted in residue of nitrate in that plants which are harmful for human health. However, there is little information pertaining to organic lettuce production. Organic fertilizers usually use to reduce the amount of toxic compounds (such as nitrates) produced by conventional fertilizers in vegetables like lettuce. Hence, improving the quality of leafy vegetables produced as well as human health [15]. It is the reason that there is increased demand of organically produced vegetables in view of its health and nutritional benefits.

There are studies about effects of organic fertilizers on lettuce both in soil and hydroponic [11,14,15]. Pavlou et al [18] investigated effects of some organic and nonorganic fertilizers in growth and nitrate accumulation in lettuce. They observed the highest nitrate levels in the medium and maximum inorganic fertilization treatments in all crop seasons. Their results were significantly higher compared to the respective organic fertilization treatments and all other fertilization treatments.

Masarirambi et al [15] conducted an experiment to assess the effects of organic fertilizers on yield and quality of lettuce grown in river sand. The organic fertilizers used were (a) bounce back compost, (b) cattle manure and (c) chicken manure. Results of this experiment showed that inorganic fertilizers were less suitable in lettuce production in river sand when compared to organic fertilizers. They recommended that lettuce can be grown successfully using organic fertilizers.

Santos Filho et al [19] compared the effects of the protected cultivation and open field on growth of lettuce plants (cv. Vitória de Santo Antão) through of morphological parameters. The results of the morphological
parameters revealed that the protected cultivation promotes higher growth and development rates, when compared to open field.

Koudela and Petříková [13] evaluated nutrients content and yield in five cultivars of leaf lettuce (Lactuca sativa L. var. crispa). They concluded that the contents of vitamin C, minerals (K, Na, Ca, Mg), fiber, dry matter and nitrates were significantly influenced by cultivar as well as by growing season and year.

Hanafy Ahmed et al [8] evaluated the effect of four different commercial biofertilizers on the growth, yield, chemical composition and nitrate accumulation of lettuce (Lactuca sativa L., cv. Dark green) plants. They reported that no significant effects could be detected on most of the studied growth characters (shoot height, number of leaves, as well as fresh and dry weights of shoots) as well as yield of the plants treated with biofertilizers when compared with the control-untreated plants. Significant decrease in nitrate accumulation was recorded by the plants treated with all studied biofertilizers.

Several studies have reported the beneficial effects of blood meal, feather meal and compost on the yield and quality of tomato, corn, cabbage and lettuce crops [20,16,3].

An important problem facing lettuce production is nitrate accumulation in this crop. Tests of nitrate accumulation in lettuce showed considerable high values as compared to those standards [1,12,9,8]. Nitrate accumulation in plants occurs as a result of nitrate accumulation in the soil due to the intensive application of nitrogen fertilizers carried out by the farmers which results in unbalancing nutritional status of the plants and consequently high nitrate accumulation as well as soil pollution [9].

There is little information on the use of organic fertilizers for lettuce production in Iran, whereas, growing lettuce in open field using extreme nitrogen sources to achieve maximum yield without considering health rules are common. Therefore, the objective of this study was to assess the effects of different sources of organic fertilizers on growth, yield and quality properties especially nitrate accumulation of lettuce compared to conventional fertilizers.

**MATERIALS AND METHODS**

The experiment was conducted in an open field located in Imam Khomeini Higher Education Center (IHEC) in Alborz province in Iran during two seasons of summer (September to November) at 2011 and 2012 (Table 1). The experiment comprised of four treatments and control laid in a randomized complete design (RCD), replicated four times. The gross experimental area in each plot was 3m × 12m (36m2) and the net experimental area was 3m × 2m (6m2) included 30 plants.

The lettuce variety used was an Iranian breeding seed known as Ahoora which is becoming prominent among vegetable growers and consumers of that province. Seedlings were transplanted at the age of four weeks after sowing. There were four types of fertilizers used. They were three organic and one inorganic fertilizer. The organic fertilizers included a) bounce back compost (composted chicken manure), b) mixture of animal waste (included blood and feather meal), c) fish meal and a mixture of Urea and Ammonium Nitrate as an inorganic fertilizer.

Data were collected after harvesting. The data collected included the following parameters: plant height, leaf brightness, plant fresh weight and nitrate content. Data were collected from at least ten sample plants from inside rows per plot. Data analyzed using SPSS (v. 16) software. Analysis of variance (ANOVA) was undertaken on data collected so as to determine if there were any significant differences amongst treatments. Mean separation where significant differences were detected was done by Duncan’s Test.

**RESULT AND DISCUSSIONS**

Results indicated significant differences in growth parameters amongst treatments compared to control (Table 2). Plant height exhibited no significant difference in all treatments. The results, also, showed significant (P<0.01) differences in fresh plant weight. The lettuce plants fertilized with animal waste had relatively higher average number of plant weight, followed by fish meal and inorganic fertilizer, respectively. The lettuce plants fertilized with inorganic fertilizers exhibited the least number of weights amongst treatments.

Organic fertilizers had relatively more brightness leaves compared to others. Among these, animal waste had the most and chicken manure had the least.

There was a significant (P<0.01) difference on nitrate content between plants treated with organic fertilizers and inorganic. In fact nitrate content was higher in plants from the inorganic fertilizer and followed in control. No differences observed among three organic fertilizers about this parameter. Nitrate accumulation data as affected by different organic treatments are presented in Table 3. All organic treatments decreased nitrate concentration in the midrib of lettuce leaves in both samples and seasons (Table 3).
It is very important for farmers to understand how supply nutrients to the crops that gain maximum yield and incoming as well as public health. This study is the first report on cultivar Ahoora (an Iranian breeding seed) that investigates effect of fertilizer type on yield and quality of it. According to differences between soil cultivation and hydroponic for root uptake, it was necessary to evaluate quality of lettuce cultivated in soil especially nitrate content in the open field.

Most of studies on lettuce limited to greenhouse experiments. It is demonstrated that the protected cultivation promotes higher growth and development rates, when compared to open field, in which the protected cultivation is indicated to maximize the yield in Lactuca sativa [19] although Zhao et al., [24] showed that the high tunnel environment generally reduced phenolic levels in lettuce relative to the open field. For the reason, we studied growth parameters and nitrate contents in open field.

There are a few reports that stated vegetables grown with organic fertilizers grew better and resulted in a higher total yield than those grown with chemical fertilizers [15,23]. This might be that industrial fertilizers do not possess good characteristics of aggregating the soil particles. As a result, the plants produced by inorganic fertilizers showed relatively lower yield compared to organic materials [17]. Because of higher yield of lettuce observed in plants were treated by organic fertilizers, our findings are in agreement with previous studies.

Plants which had been fertilized with animal wastes had the highest growth parameters and marketable yield. Similar results have been reported [21].

Plant height is a character that less considered. If a lettuce plant is over mature, shoot elongation take places and means that the plant changed to reproductive phase resulted in changing taste and losing marketable. Results showed that none of treatments cause shoots elongation in lettuce. No significant differences observed amongst treatments in plant height.

Organic wastes derived from slaughterhouses (feather, blood and meat meal), fish and seafood processing (fish and crab-shell meal), and cheese making (whey) have been shown to be the best sources of organic fertilizers [4]. Animal wastes degraded fast because of the easy degradation nitrogenous structural components of animal and dairy products. On the other hand, carbon compounds like cellulose and hemicellulose, which compose plant residues, are easily broken down and then can exert a considerable depressing effect on the nitrification of the low-N materials. This could cause temporary immobilization of N in the soil, which would thus interfere with plant growth [4]. Our finding about observing high yield of lettuce for plants treated by animal wastes could be explained by the reason.

Nitrate accumulation in plants has been related to genetic characteristics and management factors, such as nitrogen fertilization. The literature presents various strategies developed to decrease the concentration of nitrate in leafy vegetables. Some methods are related to nutrient solution changes, for example replacement a part of NO3-N concentration by urea [25], proteinate fertilizer [6], NH4-N and amino acid [6] or replacement of all NO3-N during the last week before harvesting (URRESTARAIZU et al. 1998). However, these methods have not always been possible to match the requirements of a high yield and simultaneously, a low content of nitrate. Some authors reported that some of the lettuce cultivars needed more time to respond the treatment with low N supply. One of the possible explanations that the reduction of NO3-N concentration in lettuce plants by reducing NO3-N supply during the last growing day failed is the fact that nitrate and other components such as minerals, vitamins and sugars differ during the development stages [11]. ZHU et al [25] reported that the nitrate content in lettuce plants was reduced by about 40 % when urea contributes 75 % of the total N supply. GÜNES et al [5] stated that the replacing a small part (20 %) of the nitrate supply by combination amino acid and urea with NH4Cl caused the heaviest decreases in nitrate contents [11]. We arrange the experiment with a treatment

### Table 1: physical and chemical features of soil farm

<table>
<thead>
<tr>
<th>Source</th>
<th>C (mg/kg)</th>
<th>N (% for whole)</th>
<th>P (ppm)</th>
<th>K (ppm)</th>
<th>Saturation (%)</th>
<th>Ef- Ca (%)</th>
<th>Soil texture</th>
<th>Clay (%)</th>
<th>Si (%)</th>
<th>Sand (%)</th>
<th>Mg (%)</th>
<th>Zn (ppm)</th>
<th>B (ppm)</th>
<th>Fe (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>28.4a</td>
<td>29.1a</td>
<td>3.5a</td>
<td>3.4a</td>
<td>584.33a</td>
<td>567.3a</td>
<td>29.7c</td>
<td>29.9c</td>
<td>26.5a</td>
<td>29.9c</td>
<td>29.3a</td>
<td>4.6c</td>
<td>4.5c</td>
<td>4.6c</td>
</tr>
<tr>
<td>Bounce back compost</td>
<td>29.93a</td>
<td>29.6a</td>
<td>3.9b</td>
<td>3.9bc</td>
<td>725.2b</td>
<td>761.6b</td>
<td>27.3b</td>
<td>27.6b</td>
<td>26.4a</td>
<td>26.5a</td>
<td>29.3a</td>
<td>4.6c</td>
<td>4.5c</td>
<td>4.6c</td>
</tr>
<tr>
<td>Animal waste</td>
<td>32.4b</td>
<td>30.3a</td>
<td>4.4c</td>
<td>4.3bc</td>
<td>1073.6d</td>
<td>1103d</td>
<td>26.4a</td>
<td>26.5a</td>
<td>29.9c</td>
<td>29.9c</td>
<td>29.3a</td>
<td>4.6c</td>
<td>4.5c</td>
<td>4.6c</td>
</tr>
<tr>
<td>Fish meal</td>
<td>31.7ab</td>
<td>30.8a</td>
<td>4.6c</td>
<td>4.6c</td>
<td>864.7c</td>
<td>852.4c</td>
<td>27.1b</td>
<td>27.3b</td>
<td>29.9c</td>
<td>29.9c</td>
<td>29.3a</td>
<td>4.6c</td>
<td>4.5c</td>
<td>4.6c</td>
</tr>
</tbody>
</table>

### Table 2: Analysis of variance for yield parameters of lettuce.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Df</th>
<th>Sum of squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Weight</td>
<td>4</td>
<td>232693.4</td>
<td>48.82**</td>
</tr>
<tr>
<td>Height</td>
<td>4</td>
<td>332.347</td>
<td>18.609**</td>
</tr>
<tr>
<td>Nitrates content</td>
<td>4</td>
<td>5432.345</td>
<td>36.96**</td>
</tr>
<tr>
<td>Weight × height</td>
<td>8</td>
<td>67.459</td>
<td>11.83**</td>
</tr>
</tbody>
</table>

### Table 3: Mean comparison of characteristics for growth and N content in lettuce for two years.

<table>
<thead>
<tr>
<th>Plant Fresh Weight(g)</th>
<th>Nitrate content (g/Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>2010</td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>Bounce back compost</td>
<td></td>
</tr>
<tr>
<td>Animal waste</td>
<td></td>
</tr>
<tr>
<td>Fish meal</td>
<td></td>
</tr>
</tbody>
</table>
containing mixture of nitrogen element as N-urea, N-Nitrate and N-ammonia to investigate whether these replacements can reduce nitrate content of lettuce. Our results showed that replacement of other form of nitrogen cannot change nitrate accumulation in lettuce.

HE and LEE [10] reported that high solar radiation and low root zone temperature had an important effect to a formation of a compact lettuce head and higher shoot and root biomass. According to DREWES et al [2] increased global irradiation resulted in increased values for head weights. We accomplished the experiment in open field to evaluate whether direct solar radiation can reduce nitrate content in lettuce comparing to organic fertilizers. Our findings showed that cultivation in open field with direct radiation cannot reduce nitrate content of plants as well as organic fertilizers; although much more studies are needed.

**Conclusion:**

Effects of different sources of organic fertilizers on growth, yield and quality properties especially nitrate accumulation of lettuce compared to conventional fertilizers showed that organic fertilizers especially, animal wastes, had relatively higher yield and quality rather than inorganic fertilizers.

**REFERENCES**


