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Influence of organic fertilizer on growth yield and quality of lettuce (*Lactuca sativa* L.): A review

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Abstract
Lettuce (*Lactuca sativa* L.) is a cool season leafy vegetable grown throughout the world. Due to its high nutritious profile it is regarded as one of the most significant salad crop. Due to the high demand of lettuce in the market, producers are using huge amount of chemical fertilizers to satisfy that market needs. However, extensive use of synthetic fertilizers is creating negative impact on human health, soil health and environment health, which is forcing growers to seek for better options. In such a scenario scientists have come up with organic fertilizers as promising and better alternative to inorganic fertilizers. Natural fertilizers are derived naturally from different substances such as animal waste, plant waste or human excreta. Some of the noted perks of using organic fertilizer in lettuce are increased plant height, number of leaves, fresh plant weight, Plant dry weight, fresh and dry weight of root, yield and nutritional value. As application of organic fertilizers can significantly improve the growth, yield and quality of lettuce without negatively impacting the environment and human health therefore, the current knowledge describing the effect and relevance of organic fertilizers in lettuce production is reviewed here.

Keywords: Lettuce, organic fertilizers, yield, quality, vermicompost, poultry manure, growth

Introduction
Lettuce (*Lactuca sativa* L.) is one of the most significant leafy vegetable which belongs to Asteraceae family. It is known as a major salad crop, therefore is commonly found in salad mixture and sandwiches. The leaf of lettuce is known to be the most commonly used part of lettuce, but in countries like China and Egypt stems of lettuce are also eaten very commonly by cooking, pickling, drying or raw as it is. Leaf of lettuce is also used for making cigarette, a cigarette which does not contain nicotine. Seeds of lettuce are used for making oil. Latex derived from stem of lettuce is used for making sedative**.** A wild lettuce relative *Lactuca virosa* L. is used to produce Lactucarium, Lactucarium is used in pharmaceuticals to make sleep inducing pills (Ryder, 1986) [24]. Lettuce originated in the Mediterranean region (Lindqvist, 1960) [14]. The Portuguese or the British most likely introduced letuce India during 16th century. *L. serriola* seems probable progenitor of cultivated lettuce. (Lindqvist, 1960; de Vries, 1990, 1997; Kesseli *et al*., 1991) [14, 5, 6, 13]. Lettuce is a cool-season crop that grows on all continents, particularly in temperate and subtropical climates. More than 22 million tons of lettuce was produced worldwide in 2005. (Mou, 2008) [15]. China is the world's leading lettuce grower, largely for lettuce stems. 13% of world's total lettuce production is covered by Western Europe. Other nations that grow lettuce economically include India, Japan, Mexico, and Turkey. Lettuce is a vegetable that possesses wide variety of shape, size and color. It has been differentiated into various varieties based on leaf shape, leaf size, leaf texture, head development, and stem type. Lettuce has been divided into 6 types. Different types of lettuce have different nutrient content. Higher amount of vitamin and minerals are found in Romaine and leaf lettuces, whereas, higher amount of iron is found in stem lettuce. Lettuce contains good amount of vitamin K, folate, vitamin A and vitamin C. Research has concluded that women who consume lettuce daily will have less risk of hip fracture as compared to the women who do not consume lettuce daily (Feskanich *et al.,* 1999) [8]. As lettuce is one of the most nutritious salad vegetable it's demand is increasing day by day. To meet the high market demand of lettuce producers are exploiting synthetic fertilizers which is impacting human and environment health negatively.
Different types of lettuce are mentioned in table 1.

Table 1: Common name of different types of lettuce

Lettuce type	Common name
Crisphead	Ice berg, Head lettuce
Butterhead	Cabbage lettuce
Romaine	Roman or cos lettuce
Leaf	Leaf or cutting
Stem	Celtuce, stalk, or asparagus lettuce
Latin	Grassé lettuce

Inorganic fertilizers are plant nutrient supplements that are manufactured artificially and contains synthetic chemicals or minerals, it can quickly increase growth, yield and productivity of a plant, as it has high nutrient content and it releases nutrients quickly, but its continuous use cause harmful impact on human and environment health, whereas, organic fertilizers are derived naturally from different substances such as animal waste, plant waste or human excreta. (Ngoc Son *et al*., 2004) [21]. Organic fertilizers have low nutrient concentration and it releases nutrients slowly because the nutrients present in it has to be converted into inorganic form (Vanlauwe *et al.*, 2010) [30]. The conversion is done by soil bacteria and fungi. Conversion is necessary as without it the nutrients present in organic fertilizer cannot be used by the plants (Sarkar *et al*., 2003) [26].

Though the nutrient present in organic fertilizer is less and released slowly in soil surface it is far better than inorganic fertilizer and it gives tremendous benefits in long run. Some of the noted benefits after application of organic fertilizers are improvement in soil texture, improvement in water holding capacity of soil, improved air circulation of soil, increased growth and yield of plant, improvement in quality of plants, increase cation exchange capacity improved drainage and elevation of beneficial microorganisms in the soil (Ortiz and N.V, 2007) [22]. These changes brought by organic fertilizer positively boost plant growth and development and at the same time maintain the soil health and fertility. Whereas, in other hand chemical fertilizers are quick fix, but in long run it depletes soil nutrients and makes it unproductive, thus organic fertilizer is a good and effective alternative identified through research and rigorous investigation, which can boost the plant growth without negatively impacting human and environment health. Thus considering the importance of use of organic fertilizers, many scientists have performed research on influence of organic fertilizers on the growth, productivity and quality of lettuce. Thus, this review paper includes the work of many such scientists.

Table 2: Important organic fertilizers and its NPK content

Name of organic fertilizer	Nitrogen content (N %)	Phosphorous content (P2O5 %)	Potassium content (K2O %)
Farm yard manure	0.5	0.2	0.5
Vermi compost	1.6	0.6	0.8
Poultry manure	3.03	2.63	1.4
Compost	2	0.5-1	2
Blood meal	10-12	1-2	1.0
Bone meal	3-4	20-25	-

Effect of organic fertilizer on growth and yield of lettuce

Lettuce is a leafy vegetable; therefore, leaf count, leaf height, leaf width and leaf fresh weight are 4 main characteristics of lettuce that determines its yield and growth. Many researchers have worked on improving these characteristics to increase the yield of lettuce. Improvement of these 3 characteristics majorly depends upon nutrient availability in the soil. To enhance the soil nutrient profile different fertilizers can be used, however many research have proved organic fertilizers to be the best. Lettuce grown on high level of chicken manure (60 t/ha > 40 t/ha) showed increased number of leaves per plant, increased plant height and superior marketable yield as compared to the lettuce grown on low level of chicken manure, whereas lettuce fertilized with inorganic fertilizers performed poorest among all the treatments. Synthetic fertilizers are bad at binding soil particles together as it possess low soil moisture holding capacity because of which lettuce produced by using synthetic fertilizers resulted in poorer growth and output than chicken manure-grown plants (Masarirambi *et al*., 2012) [17]. An experiment was conducted where different doses of organic fertilizers such as 6.5t ha-1, 13 t ha-1, 26 t ha-1 and recommended dose of chemical fertilizer for lettuce was used as various treatments. The result showed use of organic fertilizer at the dose of 13 t ha-1 is best for lettuce production as it showed significant increase in leaf size that is both length and breadth, it was also successful in increasing plant fresh weight and dry weight when compared to other doses of organic fertilizers and the recommended dose of chemical fertilizer for lettuce (Hossain and Ryu, 2017) [10].

Cattle manure applied at the rate of 25 tons/ha (T5) to lettuce plants increased no of leaves per plant, leaves length and leaves breadth, however, overall yield per hectare of lettuce plants increased by the combination of 25tons/ha cattle manure + cow dung. The highest gross return of BDT (Bangladesh Taka) 1168800/ha and net return of BDT 683229/ha with the benefit cost ratio of 1.40 was acquired from the application of 25tons/ha cattle manure (T5) (Islam *et al.*, 2012) [11]. Application of 75 kg/ha of N + 30 tons/ha of farmyard manure is ideal for lettuce production as among all the treatments used in the research this treatment was successful in giving highest yield of lettuce that is 31.34 tons/ ha, moreover plants grown under this treatment possessed maximum number of leaves, longest root and tallest height (Yeshiwas *et al.*, 2018) [31]. An experiment was carried out to determine the influence of farm yard manure on yield and yield component of lettuce. Four treatments were used for the research purpose. T1 did not consist any farm yard manure, T2 – 5 t ha-1, T3- 10 t ha-1 and T4-15 t ha-1. The result showed that T4 which consisted farmyard manure at 15t ha-1 was successful in increasing the yield and yield attributes of lettuce. Plant stature, leaf area, leaf number, fresh leaf mass, root length and number of roots per plants were more in T4 (Melese, 2016) [18]. Combining green manure with farm yard manure produced more leaves per plant, longer and broader leaves, increased fresh weight, and produced greater yields (71.8 and 76.5 t ha-1) than all other treatments (inorganic fertilizers, single application of FYM, and green manure) (Caliskan *et al.*, 2014) [3]. Four different doses of vermi compost (0 kg/ha, 4000 kg/ha, 8000 kg/ha and 12000 kg/ha) was used for the production of lettuce. The result showed that application of vermin compost at 8000 kg/ha increased fresh mass, plant height, number of leaves, leaf length, leaf breadth and dry matter of each plant (Sevinç *et al*., 2018) [28]. Combination of inorganic fertilizer (60 kg N ha-1 + 45 kg P ha-1+ 30 kg K ha-1 +vermin compost (4 t ha-1) +bio fertilizer (7.5 l ha-1) was successful in advancing crop height, crop spread, leaf area, leaves per plant, fresh weight of leaf, yield

per plot, yield per hectare of lettuce, whereas the same combination also helped in reducing the number of days to first harvest. Efficiency of inorganic fertilizers increases with combination of vermicompost and biofertilizers beacuse of decrease in compaction of soil, increase in soil porosity and improvement in supply of both major and minor nutrients to the plants (Rather *et al*., 2018) [25]. Use of vermicompost improved growth attributes and yield of lettuce in comparison to the use of inorganic fertilizer for the production of lettuce in both spring and winter season (Papathanasiou *et al*., 2012) [23]. Use of 75 kg ha-1 of N + 30 t ha-1 of FYM gave maximum yield of lettuce (31.34 t ha-1), therefore, combination of organic and inorganic fertilizer should be preferred by growers for fertilization of lettuce plants over inorganic fertilizer to achieve better results (Yeshiwas *et al*., 2018) [31]. Lettuce grown with treatment comprising 75% advised fertilizer dose + farm yard manure and vermin compost at ratio of 1:1 which is equitable to 25% suggested dose of nitrogen + azotobacter + phosphosrous solubilizing bacteria produced greater leaf yield per plant (300.15 g), higher yield per hectare (27.00 t) and increased benefit cost ratio (Mantur, *et al*., 2018) [19]. Some of the references are given in table number 3 below.

Table 3: Effect of organic fertilizer on growth and yield of lettuce

Application of organic fertilizers	Response/effect	References
Application of poultry manure	Showed significantly higher growth performance in lettuce plants.	(Uddin *et al*., 2009) [29]
Application chicken manure + farm yard manure + compost	Showed prominent increase in biomass production, fresh and dry weight, root development, water content, and yield in lettuce plants.	(Mohammed *et al*., 2019) [20]
Application of 5 t ha-1 vermicompost	Increased crop height, leaf count, fresh crop weight, crop dry weight, and shoot root ratio in lettuce plants.	(Frasetya *et al*., 2019) [9]
Application of chicken manure at 40 t ha-1	Increased number of leaves, plant height, marketable yield and mean leaf dry mass	(Masarirambi *et al.*, 2010) [17]
Application of organic fertilizers	Facilitates the growth of Red lettuce 'Veneza Roxa' in sand, whereas, Inorganic fertilizers are less ideal for growing red lettuce on a sand medium.	(Masarirambi *et al.*, 2010) [17]
Application of organic fertilizer	Increased plant growth rate, leaf number and Improved production growth and biochemical quality.	(Draghici *et al*., 2015) [7]
Application of poultry manure	Increased Dietary fiber content in leaves of lettuce	(Akubugwo *et al*., 2007). [1]
Application of poultry manure + Cow dung	Boost the growth and yield of lettuce,	(Jin *et al*., 1996) [12]
Application of organic fertilizer	Regulate the nitrate content of lettuce leaves.	(Manjlovic *et al*., 2010) [16]
Application of vermicompost	Raised ascorbic acid content of lettuce grown in fall-winter season.	(Chiesa *et al*., 2009) [2]

Effect of organic fertilizer on quality of Lettuce

Lettuce grown by the use of Green manure + farm yard manure had higher vitamin C (9.43 mg 100g-1) and Zinc content (55.7 mg kg-1) compared to inorganic fertilizers and other sole organic fertilizers. It was also observed that lettuce grown by using Green manure + commercial organic fertilizer had higher copper content (22.7 mg kg-1). Manganese content was highest in lettuce leaves grown by the use of Green manure (43.7 mg kg-1), whereas no notable differences was seen in the content of pH and soluble solid in leaves of lettuce grown under conventional and organic fertilizers (Caliskan *et al*., 2014) [3]. Use of fruit and vegetable flour (FVF) as organic fertilizer for growing lettuce shows remarkable increase in antioxidant levels and phenolic content in the leaves of lettuce (Cavalheiro *et al*., 2021) [4]. Lettuce grown with chicken compared to the leaves of lettuce grown in inorganic fertilizer where zinc, calcium and iron content were manure at 60 t/ha has highest calcium content, additionally it was also noted that the calcium content in lettuce leaves decreased with less application of chicken manure, moreover, lowest calcium content was seen in lettuce leaves grown in inorganic fertilizer (Masarirambi *et al*., 2012) [17]. Leaves of lettuce showed increased rate of photosynthesis by application of fertilizers made from animals such as guano, cattle and goats, however the same research also concluded lowest rate of photosynthesis was observed by the application of manure compost (Slamet *et al*., 2017) [27]. Use of chicken manure 2.5 m^3/fed + farm yard manure 5 m^3/fed + compost 3.7m^3/fed can be utilized to increase lettuce plant storability by lowering weight loss and polyphenol oxidase activity. It was also shown that combining those treatments preserved chlorophyll and total phenolic contents during storage and provided lettuce plants a decent look even after 12 days (Mohammed *et al*., 2019) [20]. Calcium (7.70a mg/100g), iron (4.91a mg/100g) and zinc (3.18a mg/100g) content were higher in lettuce leaves grown by the use of bounce back compost as 0.91c mg/100g, 2.82b mg/100g and 0.00c mg/100g respectively (Masarirambi *et al*., 2010) [17].

Conclusions

Organic fertilizers are important component of organic farming and sustainable agriculture and also the best alternative to inorganic fertilizers. Chemical fertilizers are quick fix, it gives desired results to the growers immediately after its use, but continuous use and exploitation of such agents can bring numerous human health and environmental health problems. On the other hand, natural fertilizers are slow paced, it releases its nutrients slowly and as these fertilizers are made from natural materials its application on crop production do not cause human health and environmental health deterioration. Moreover, fertilizers that have been derived naturally have sown positive effect on growth, yield and quality characters of lettuce plants. With proper and scientific use of natural fertilizers producers can attain maximum output from their lettuce field and meet the growing market demand of lettuce easily. In light of the reviews from different scientist, Organic fertilizers are effective alternatives as a source of macro and micronutrients and have a great potential to improve the growth, yield and quality parameters of lettuce.

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