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Assessment the Effect of Nano and traditional Nitrogen Fertilizers on Lettuce Grown in Sandy Soil

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Abstract

A pot experiment was conducted in sandy soil to assess the effect of Nano Nitrogen loaded on modified zeolite and traditional fertilizers on lettuce. treatments of 100, 75, 50 and 25% of the recommended dose of common N fertilizer and 100, 75, 50 and 25 ml of 1000 ppm Nano N solution were added alone or in combination with the traditional fertilizers to lettuce plants. Vegetative growth and yield characters were recorded. The obtained results indicated that the application of N-Nano resulted in significantly higher vegetation growth parameters such as plant fresh weight (PFW), shoot fresh weight (SFW), plant length (PL), leaf area (LA) and plant dry weight. The partial replacement of common N fertilizers by additional of Nano fertilizers to lettuce plants production could be a useful way to save the amount of common N fertilizers and enhancement of plant growth and increasing nutrients uptake by plants and to avoid nitrate leaching especially under sandy soils and consequently reducing pollution problems.

Keywords
Lettuce, Vegetative growth parameters, Nano-N fertilizers, Traditional fertilizers.

INTRODUCTION

Lettuce (*Lactuca sativa L.*), is an important leafy vegetable grown in Egypt for local consumption and export with leaves of high moisture, minerals and vitamins A, B, C and K (Khalil *et al.*, 2016 and Elings and Raeza, 2017). Therefore, increasing production of such crop is becoming a national target to save the food security for the annually increased population.in addition, the gap between the quantity used for food and the domestic production is still big. The newly reclaimed soils that are sandy soils are ver poor in their organic matter contents, plant nutrient levels. Crops cultivated in such soils need to apply fertilizers especially nitrogen fertilizers which can improve the yield and quality of crops.

Nitrogen is essential for plant growth (Liu and Lal, 2015) and involved in important syntheses and formation of many important substances and compounds plant such as amino acids, enzymes, DNA, RNA and chlorophyll (Khalil et al., 2016), therefore it must be available for plants in adequate amounts. Yield of lettuce and weight per lettuce head depend on the amount of N available for the crop (Hosseny and Ahmed, 2009) but the amount must be adequate not excessive (Liu et al., 2014). Excessive application of N to crops in general leads to unwanted environmental consequences including accumulation of high nitrate and nitrite contents leafy vegetables and fruits, among other problems such as eutrophication, environmental contamination in underground waters used for drinking (Wang et al., 2002 and Bobbink et al., 2012). Nitrates and nitrites may accumulate in edible plant tissues particularly in leafy vegetables (Wang et al., 2002), especially lettuce with contents of up to 2500 mg NO3-N kg^{-1} fresh weight (Dapoigny et al 2000). Consumption of such plants causes detrimental effects on health (Ahmadil et al., 2010). To avoid application of excessive rates of N to crops, particularly the edible leafy ones, foliar spray of N as urea is preferred (Mondal and Mamun, 2011), particularly when in nano forms, a technique which proved effective for plant nutrition due to its high absorption and utilization efficiency by plants (Mondal and Mamun, 2011 and Manjunatha et al., 2016). Foliar spray usually uses low amounts of fertilizer N (Gul et al., 2011), and urea is a source of N with high concentration of N nutrient (Abu-Rayyan et al., 2004 and PEI, 2014). Also, it can be used as foliar spray on plant with no scorching damage on leaves compared with fertilizers of salt nature (Mondal and Mamun, 2011). The use of nano-scale nitrogen as foliar fertilization showed preference to the traditional methods (Manjunatha et al., 2016). Nano particle of any material are particles with extremely small size of less than 100 nm Ø (DeRosa et al., 2010). Nano-fertilization is gaining popularity since it proved practical and highly effective (DeRosa et al., 2010, EL-Aila et al., 2015 and Manjunatha et al., 2016).

From all the above-mentioned facts, the current study objective was formulated to to assess Effect of Nano and traditional Nitrogen Fertilizers on Lettuce Grown in Sandy Soil.

MATERIALS AND METHODS

1. The experimental site and soil properties

A sandy soil sample was collected from the soil surface (0-30 cm) of the new reclaimed soil of agriculture farm, Sohag University at New Sohag city which is located at the western border of the Nile valley (26̊.27`.38.1`` N and 31̊.39`.50.6`` E) about 15 km south-west of Sohag city. The soil samples thus collected were shade dried, gently ground with a wooden mallet and sieved through 2 mm sieve and stored in polyethylene bags. These samples were analyzed for pH, EC, organic matter, calcium carbonate% , available nutrients N, P, K, Ca, Mg, Fe, Mn, Zn and Cu, Particle size distribution, soil texture, cations and anions The analytical methods followed for analysis are given in Table (1).

2. Excremental design and treatments:

A Complete randomized pot experiment in the three replicates was carried out in the green house of agriculture farm, Sohag University at New Sohag city. The plastic pots have a diameter of 30 cm and a depth of 20 cm and were filled with 8 kg of dried soil. Lettuce (*Lactuca sativa L.*) plants were transplanting in winter season (17th Nov. 2020) and harvested in (17th Feb. 2021).

2.1. Traditional –fertilizers

The traditional fertilizers were applied as recommended rates according to the Ministry of Agriculture and Land Reclamation at (60 kg N fed-1) as ammonium nitrate (33.5% N), (15 kg P fertilizer fed-1) as super phosphate (15.5 % P2O5) and potassium fertilizer (50 kg K fed-1) as potassium sulphates (48 % K2O) as the source of N, P and K respectively. Each treatment was at the rates of 25, 50, 75 and 100 % from the recommended dose. Ammonium nitrate fertilizer was added in three doses after 15, 30 and 45 days from planting, the super phosphate was added to the soil before planting and after 15 day from planting, while the potassium sulphates was added to the soil after 30 and 45 days from planting.

2.2. Nano –fertilizers

Nano -fertilizers were brought from the Agricultural Research center (ARC), Soil, Water and Environment institute (SWERI), Giza, Egypt. Treatments consist of Nano- N fertilizer (25, 50, 75 and 100 mg l-1). The size of Nano fertilize was Examined at Faculty of Agriculture, Cairo university, Egypt - by transmission electron microscope JEOL (JEM-1400TEM) at the candidate magnification. Images were captured by CCD camera model AMT, optronics camera with 1632 x 1632 pixel format as side mount configuration. This camera uses a 1394 fire wire board for acquisition (Image1). Details of each excrement treatments are shown in (Table 2).

Table (1) The physical and chemical analysis of the experimental soil.

Soil property	Values
Particle size distribution	
Sand (%)	92.16
Silt (%)	2.73
Clay (%)	5.11
Texture grade	Sandy
pH (1:2.5)	7.88
$CaCO_3$ (%)	2.17
O.C (%)	0.11
EC_e (dS/m)	0.35
Soluble cations (meq/l):	
Ca^{+2}	1.40
Mg^{+2}	0.60
Na^{+}	1.17
K^{+}	0.26
Soluble anions (meq/l):	
CO_3^{--}	-
HCO^-_3	2.00
Cl^-	1.00
SO_4^{--}	0.44
Available N (mg kg^{-1})	40.00
NH_4OAc- extractable K (mg kg^{-1})	91.70
$NaHCO_3$- extractable P (mg kg^{-1})	3.21
DTPA- extractable Fe (mg kg^{-1})	4.13
DTPA- extractable Mn (mg kg^{-1})	1.76
DTPA- extractable Zn (mg kg^{-1})	0.93
DTPA- extractable Cu (mg kg^{-1})	0.28

Table (2) The treatments of the investigated study.

T_1	$100\%N_{traditional}+100\%P_{traditional}+100\%K_{traditional}$
T_2	$75\%N_{traditional}+100\%P_{traditional}+100\%K_{traditional}$
T_3	$50\%N_{traditional}+100\%P_{traditional}+100\%K_{traditional}$
T_4	$25\%N_{traditional}+100\%P_{traditional}+100\%K_{traditional}$
T_5	
T_6	$100\%N_{nano}+100\%P_{nano}+100\%K_{nano}$
T_7	$75\%N_{nano}+100\%P_{nano}+100\%K_{nano}$
T_8	$50\%N_{nano}+100\%P_{nano}+100\%K_{nano}$
T_9	$25\%N_{nano}+100\%P_{nano}+100\%K_{nano}$
T_{10}	$75\%N_{traditional}+25\%N_{nano}+100\%P_{traditional}+100\%K_{traditional}$
T_{11}	$50\%N_{traditional}+50\%N_{nano}+100\%P_{traditional}+100\%K_{traditional}$
T_{12}	$25\%N_{traditional}+75\%N_{nano}+100\%P_{traditional}+100\%K_{traditional}$

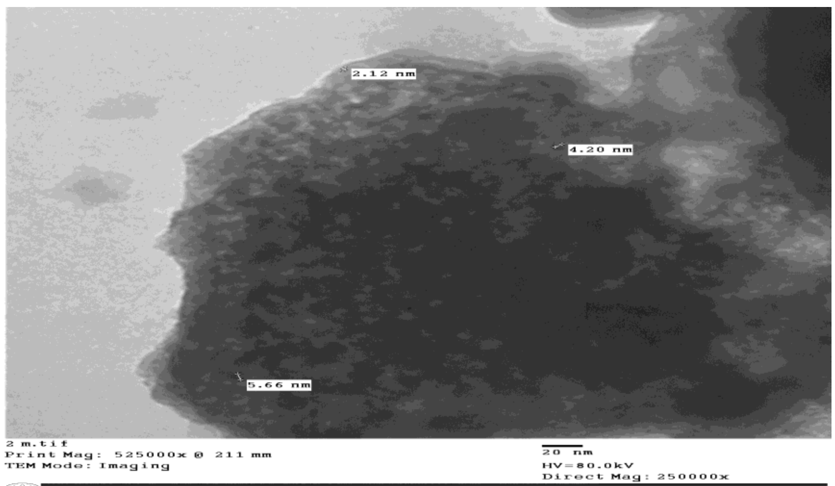

Image (1) Nano particles of nitrogen ranges between 8.63 and 23.4 nm.

3. Recorded data

3.1 Vegetative growth

Plant fresh weight (g): The whole plant was weighed including leaves and root.

Shoot fresh weight (g): Leaves were weighed after removing the root.

Root weight (g): The root was weighed after separating from the leaves.

Root length (cm): The root of the plant was measured in centimeters.

Plant length (cm): Plant length was measured from the tip of the leaves to the end of the root.

Leaf area index (cm^2): was determined by the dry weight method using a disc known area (4 cm^2).

$$\text{Leaf Area (LA)} = \frac{X}{Y} \times m$$

Where x and y represent the leaf segment area (cm^2) and its dry weight (g) respectively, while m represents the weight (g) of the entire leaf (Kaushik *et al* ., 2021).

Dry matter production of plant (%).

The samples were shade dried initially and then dried in hot air oven at 70°C till attained constant weight. From the dried samples the dry matter production (DMP).

$$DM\ \% = \frac{\text{Sample fresh weight} - \text{Sample dry weight}}{\text{Sample fresh weight}} \times 100$$

Chlorophyll content (mg/cm^2).

Chlorophyll content (mg/cm^2) was measured using SPAD chlorophyll meter, and convert its reading to (mg/cm^2) according the formula described by Dash et al. (2007) as following:

$$Y = 0.118\, x^2 + 0.919\, x + 7.925$$

Where: y = chlorophyll concentration (mg cm-2) and x = SPAD reading.

4. Statistical Analysis

The measured data were subjected to analysis of variance in completely randomized design using SAS software (SAS ver. 9.2, SAS Institute 2008), acceding to Gomez and Gomez (1984). The least significant. Differences (LSD) between means. for studied parameters analysis, were estimated according to (Snedecor and Cochran, 1989). The correlation coefficient analysis were analyzed for all studied parameters in SAS ver. 9.2.

RESULTS AND DISCUSSIONS

Effect of treatments on growth characteristics of lettuce

Various observations of the experiment with the direct test crop of lettuce are presented in the table 3 and demonstrated in Figures from (1) to (8). Various growth attributes of crop viz., plant fresh weight, shoot fresh weight, plant length, root weight root length, leaf area, and plant dry weight and Chlorophyll content were recorded and presented.

Table (3) Effectiveness of N Nano -fertilizers and their bulk on the vegetative growth of lettuce (Lactuca sativa var. Roman) plants.

	PFW (g)	SFW (g)	PL (cm)	LA (cm^2)	PDW (g)	RW (g)	RL (cm)	CC (mg/cm^2)
N-Traditional								
100%	248.06^{BA}	230.57^{BA}	20.69^{B}	148.7^{A}	16.88^{A}	16.83^{A}	14.25^{A}	246.3^{B}
75%	263.25^{A}	248.94^{A}	21.88^{A}	125.57^{B}	14.93^{B}	14.04^{BA}	10.75^{B}	259.74^{B}
50%	237.15^{BA}	223.82^{BA}	21.38^{A}	143.88^{A}	14.6^{B}	9.93^{BA}	12.38^{BA}	262.95^{A}
25%	203.77^{B}	195.14^{B}	21.38^{A}	147.44^{A}	15.88^{A}	8.08^{B}	11^{BA}	274.42^{A}
LSD 5%	46.83	43.57	0.58	18.09	1.85	7.32	3.33	15.93
N-Nano								
100%	278.12^{A}	258.03^{A}	22.50^{B}	154.88^{B}	15.42^{A}	19.64^{A}	11.75^{B}	219.06^{A}
75%	257.52^{B}	241.73^{B}	21.75^{B}	143.55^{B}	14.61^{B}	15.39^{BA}	11.88^{B}	203.45^{B}
50%	277.06^{A}	260.40^{A}	23.75^{A}	159.56^{A}	15.46^{A}	16.07^{BA}	13.38^{A}	227.71^{A}
25%	256.96^{B}	244.09^{A}	22.25^{B}	175.60^{A}	14.79^{A}	12.98^{B}	12.25^{A}	231.12^{A}
LSD 5%	**19.69**	**13.82**	**1.20**	**18.32**	**0.66**	**5.93**	**1.43**	**17.28**
N-Mixed								
75%	264.55^{A}	252.74^{A}	21.88^{B}	175.53^{A}	14.77^{A}	11.62^{BA}	12.0^{A}	216.82^{A}
50%	248.36^{A}	238.17^{A}	23.00^{A}	119.09^{B}	13.70^{BA}	10.12^{B}	11.5^{B}	193.41^{B}
25%	231.53^{B}	218.09^{B}	21.88^{B}	168.79^{A}	12.04^{B}	13.17^{A}	11.1^{B}	191.70^{B}
LSD 5%	**18.67**	**16.85**	**0.82**	**28.76**	**2.20**	**2.35**	**0.73**	**21.54**

Plant fresh weight (PFW)

The plant fresh weight (PFW) of lettuce plants ranged from (203.77 g pot^{-1}) for 25% N-traditional to (277.06 g pot^{-1}) for the treatment of 50% N- Nano. The obtained result showed that application of N Nano and N-mixed resulted in significantly higher (PFW) per pot (figure 1). In addition, the same trend was observed in straw fresh weight. This results are in full agreement with the findings obtained by Li *et al.* (2013) who reported that using ammonium- and potassium-loaded zeolite (NK-Z) as carriers for fertilizer and for slow released nitrogen (N) increased the total harvest weight and the leaf fresh weight of kale (*Brassica alboglabra Bailey*).

Shoot fresh weight (SFW)

The shoot fresh weight recorded at final harvest of direct test crop of pot experiment is presented in table (3) and figure (2). The treatments imposed exhibited significant influence on shoot fresh weight of plants. The maximum (SFW) of plants per pot (260.40 g pot^{-1}) was recorded in the treatment of 50% N-Nano. Whereas, the treatment of 25% N-traditional fertilizer gave the lowest shoot fresh weight per pot. The results showed that application of N Nano significantly increased the SFW per pot. These results were coincidence with the results obtained by (Li *et al.*, 2018; El-Henawy *et al.*, 2018 and Al-Juthery *et al.*, 2019).

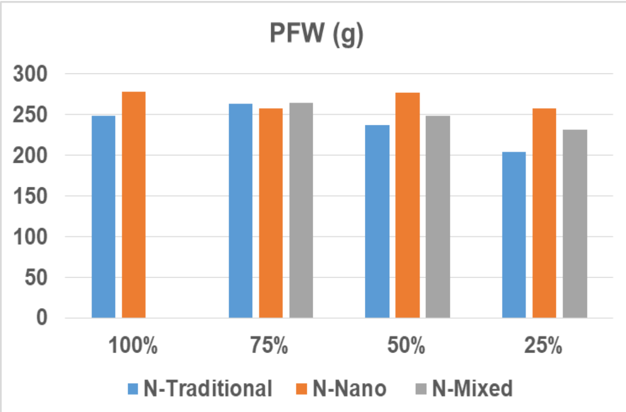

Figure (1) Effect of different treatments on PFW of lettuce.

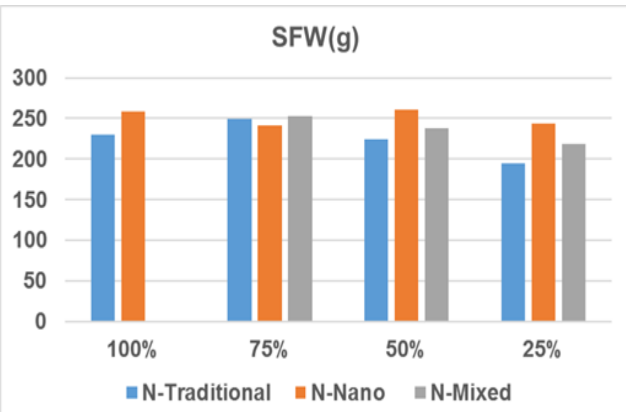

Figure (2) Effect of different treateants on SFW of lettuce.

Plant dry weight (PDW)

All treatments exhibited significant influence on plant dry weight (PDW). The results of plant dry weight production as influenced by the different treatments are presented in table 3 and figure (3). The 100% N-traditional was significantly superior to all other treatments which recorded a value of (16.88 g pot^{-1}). The lowest (PDW) was recorded in the treatment of 25% N-Nano with a value of (12.04 g pot^{-1}). The growth attributes of lettuce plant were increased by the application of nitrogen in Nano form because nitrogen use efficiency was increased and consequently the chlorophyll contents were increased. In addition, Chlorophyll contents enhanced the rate of photosynthesis, increased the accumulation of glucose and improved fresh and dry weight of plants (Eleiwa et al.,2012 and Elhindi et al., 2016).

Root weight (RW) and Root length (RL)

The data on root length and weight is given in the table (3) and figures (4 and 5). Statistically significant difference was observed among treatments at the harvest of lettuce crop. At the end of experiment the 100% N-Nano showed highest value of root weight with a recorded value of (19.64 g pot^{-1}) and lowest root weight was found in 25% N-traditional (8.08 g pot^{-1}). Significant values were recorded for root length was at the end of experiment. The highest (RL) of plants were observed in the 50% N-Nano (13.38 cm).The lowest value of root length (10.75 cm) was recorded in 100% N-traditional.

Abdel-Aziz et al. (2016) noticed that treatment supplied with 10 percent Nano NPK exhibited an increase in root length, shoot length, plant height, leaf area, in wheat when compared with conventional fertilizer and control. Gerdini (2016) pointed out that foliar application of potassium Nano fertilizer applied at 2.5 ml l^{-1} resulted in improved plant height, number of branches per plant, fresh weight, dry weight and also increased the tolerance to pest and diseases under the drought conditions. Finally the obtained results were showed that Nano N fertilizer had a favorable effect on lettuce growth comparing to the traditional ammonium nitrate. The smaller particles size and the high specific surface areas of the Nano - fertilizers could be the reason due to their higher dissolution rate and extent in water/soil solution than the related bulk solids from traditional fertilizers (Liu and Lal, 2015). Furthermore, to enhance the fertilizer use efficiency, essential nutrients were applied in Nano form and improved the plant growth. Fertilizer use efficiency significantly enhanced by the application of nutrients in Nano form because Nano - fertilizers once enters the plant, bind with carrier proteins like aquaporin, ion channels and endocytosis (Schwab et al., 2016). This behavior of Nano - fertilizers lead to the formation of new openings that penetrate the cell wall and stimulate the absorption of water and other essential nutrients that encourage the growth of plant (Abyaneh and

Maryam, 2014). It was reported that non fertilizers were more effective and efficient than the traditional fertilizers due to their positive effects on the growth, quality nutrition of crops and as well as reduced the stress in plants (Morales-Diaz et al., 2017).

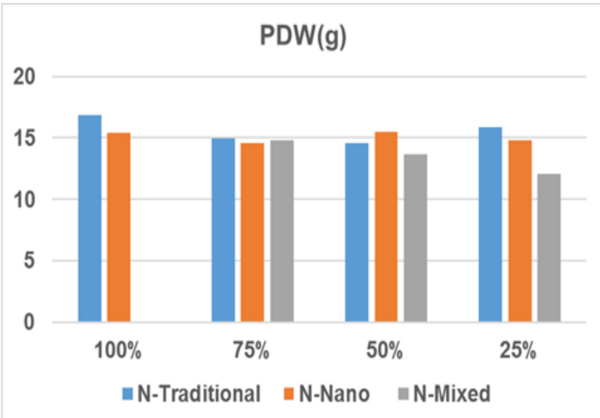

Figure (3) Effect of different treatments on PDW of lettuce.

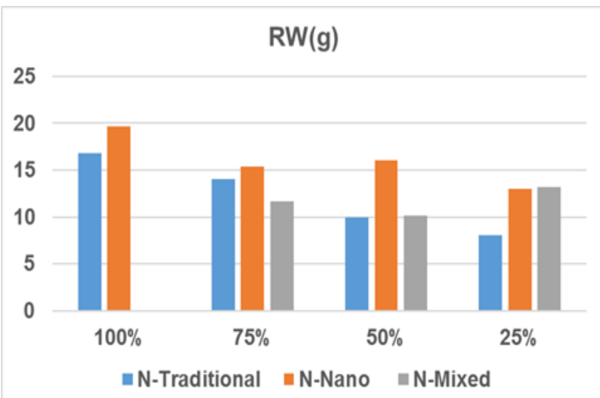

Figure (4) Effect of different treateants on RW of lettuce.

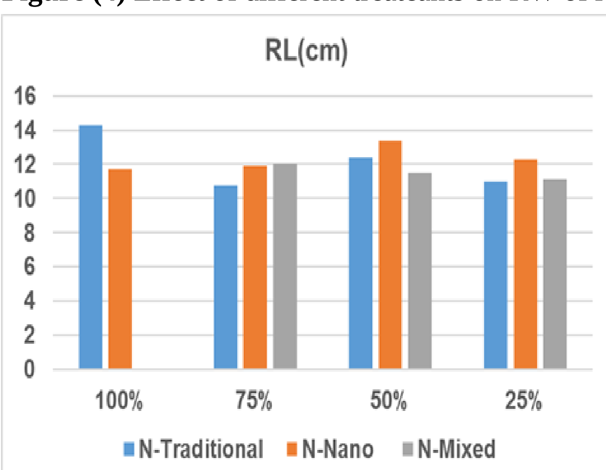

Figure (5) Effect of different treateants on RL of lettuce.

Plant length (PL)

Data in tables (3) and Figure (6) revealed that with N fertilizer application. The highest (PL) was found in 50% N-Nano (23.75 cm), On the other hand, the application of 100% of N-traditional resulting in the decrease of (PL). The mean values of plant length were significantly greater in the case of N-Nano fertilization than the other N treatments. The data were harmony with the results of Saleem *et al.* (2020) who indicated that potassium ferrite ($KFeO_2$) Nano coated diammonium phosphate (DAP) fertilizer (recommended NP +10% $KFeO_2$ Nano -coated DAP) boosted wheat plant height, shoot fresh and dry weight. In addition, Valojai *et al.* (2021) showed that application of conventional and Nano -fertilizers, particular in NPK, Nano NPK and its combination (NPK + Nano NPK) led to get highest grain yield quality in rice and milled rice.

Leaf area (LA)

The different treatments imposed significantly influenced the leaf area of lettuce test crop and the results are presented in tables (3) and figure (7). The highest value of (LA) was recorded in 25% N-Nano treatment (175.60 cm^2). While the lowest one (119.09 cm^2) was observed in 50%N-mixed treatment. Similarly, leaf area was significantly varied with the effect of different treatments. The average of leaf area was significantly greater in the case of Nano nitrogen, than the other treatments. The results were coordinated with Nofal et al. (2021) who reported that soil application of Nano NPK at the rates of (0, 12.5, 25, 50 %) of the recommended dose significantly boosted the vegetative growth such as plant fresh weight, leaf area head fresh weight, head size, firmness, total yield and in demand yield. Also, Moosapoor et al. (2013) reported that foliar application of Nano - fertilizers play a significant role in photosynthesis, increased leaf area and consequently increased yield.

Chlorophyll content (CC)

The effect of treatments on chlorophyll content was found to be significant during crop growth. The details of chlorophyll content were given in the tables (3) and figure (8). At the harvest, maximum chlorophyll content (274.42 mg cm^2) was recorded on 25%N-traditional. At the end of experiment the average of results indicated that the highest chlorophyll content (260.90 mg cm^2 , 250.62 mg cm^2 , 214.54 mg cm^2) was followed by NPK-traditional respectively. Minimum content of total chlorophyll (TCC) (200.60 mg cm^2, 179.25 mg cm^2, 174.80 mg cm^2) was reported on NPK-mixed. Among the all treatments the total chlorophyll content the treatment of 25% K-mixed (25% K-traditional +75% K-Nano) showed the lowest content of chlorophyll. Alzreejawi and Al-Juthery (2020) reported the significant advantage of Nano NPK (12-12-36) spray in reaching the highest means for all studied indicators on maize plant (*Zea mays L.*) contained within chlorophyll at ease in leaves (SPAD unit), plant height (m), stem diameter (cm), biological yield (ton h^{-1}), grains yield (ton h^{-1}), harvest index (%).

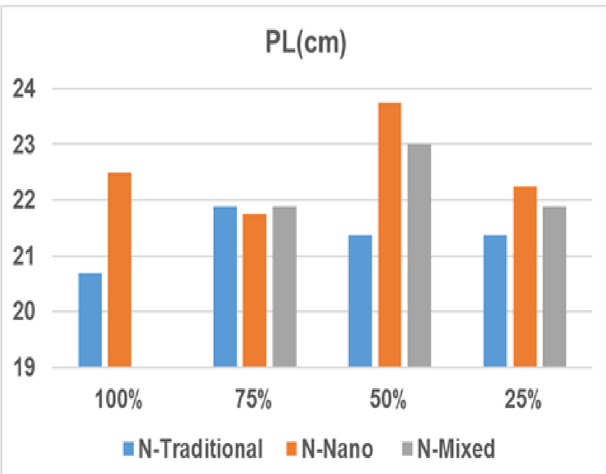

Figure (6) Effect of different treateants on PL of letttuce.

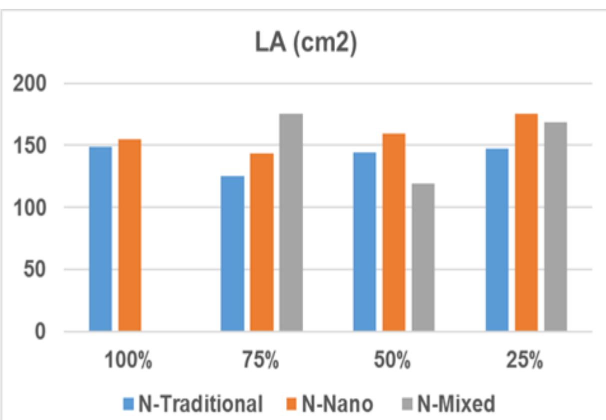

Figure (7) Effect of different treateants on LA of lettuce.

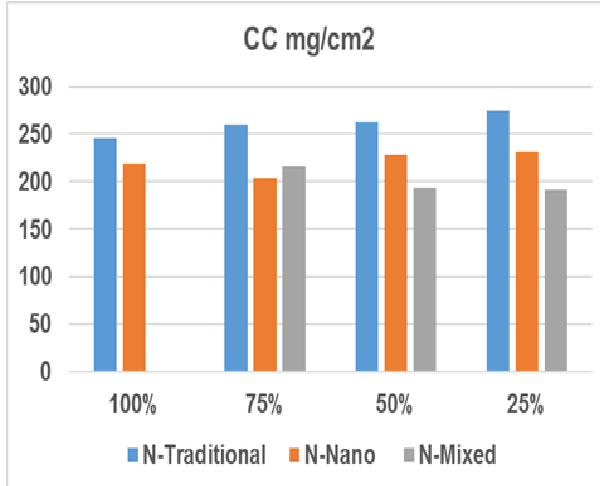

Figure (8) Effect of different treatments on CC of lettuce.

CONCLUSION

Nanotechnology contributes a significant boost for food production. The shortage of fresh water can be managed by adopting different efficient irrigation methods, also promote the quality and quantity of agricultural crops. By keeping in view, the above all, pot experiment was recommended for lettuce high growth, yield and quality. The application of N in Nano forms not only increase the fertilizer use efficiency at lower dose than recommended, also reduce the extra losses and environmental contamination. The best results were obtained when the plants were fertilized by different rates of N demand as foliar application in Nano form tracked by different rates of mixture Nano forms and bulk fertilizers and the application in bulk form N fertilizers in Nano form at different rates as foliar application. Foliar application of Nano NPK is significantly enhancing the growth parameters.

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تقييم أثر أسمدة النيتروجين النانو والتقليدى علي الخس النامي في أراضي رملية

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يهدف هذا البحث إلى دراسة تأثير أسمدة النانو للنيتروجين والتقليدى منها على نمو ومحصول الخس. أجريت تجربة أصص في تربة رملية لتقييم تأثير النيتروجين المحمّل على الزيوليت المعدل والأسمدة التقليدية على الخس. تمت إضافة معاملات 100 و 75 و 50 و 25٪ من الجرعة الموصى بها من سماد النيتروجين العادي و 100 و 75 و 50 و 25 مل من 1000 جزء في المليون من محلول النانو نانو بمفردها أو بالاشتراك مع الأسمدة التقليدية لنباتات الخس. تم تسجيل صفات النمو الخضرى والمحصول. أشارت النتائج المتحصل عليها إلى أن استخدام N-Nano أدى إلى ارتفاع معنوي في معاملات نمو الغطاء النباتي مثل الوزن الرطب للنبات (PFW) والوزن الرطب للنبات (SFW) وطول النبات (PL) ومساحة الورقة (LA) والوزن الجاف للنبات. يمكن أن يكون الاستبدال الجزئي للأسمدة N الشائعة بإضافة أسمدة نانو لإنتاج نباتات الخس طريقة مفيدة لتوفير كمية الأسمدة الشائعة N وتعزيز نمو النبات وزيادة امتصاص العناصر الغذائية من قبل النباتات وتجنب ترشيح النترات خاصة تحت التربة الرملية والأراضي الرملية. وبالتالي تقليل مشاكل التلوث.