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Efficacy of Bat Guano on Growth and Yield of Some Hybrid Sunflower (*Helianthus annus*, *L*) Cultivars in Sudan

Abubaker H. M.Adam[1,*], Abdalla Adam[2], Faiza M.A Magid[3]

[1]Department of Crop Science, College of Agriculture, University of Bahri, Khartoum North, Sudan

[2]Ministry of Agriculture, Wealth and Irrigation-Khartoum State-Sudan

[3]Department of Pests and Plant Health, College of Agriculture, University of Bahri, Khartoum North, Sudan

Abstract

Today; there is an increasing demand for fertilizers due to the intensive and extensive agricultural activity to meet the ever increasing demand for food and fiber by the rapid world population expansion. This study is mainly concern with the Bat Guano which is usually collected from the Caves. This experiment was conducted at the Farm of the College of Agriculture, University of Bahri, Alkadaro, Khartoum North-Sudan during the period from July to November, 2017 with the objective to investigate the efficacy of Bat Guano and Nitrogen fertilizer on growth and yield of Serena and Opera (*Helianthus annus*, *L*.) Hybrid Sunflower cultivars. The study was based on split-plot experiment in randomized complete block design (RCBD) with four (4) replications. Data pertaining Plant Height (cm), Leaf Number (LN), Leaf Area (LA), Leaf Area Index (LAI) and Seed Weight (SW) were studied. The said data were analyzed using Statistic 8- software. The results reflected significant increase in plant height (F= 6.05, P < 0.0001, leaf number (*F=2.37, P<0.0388), leaf area (F= 7.44, P<0.001), leaf area index* (F= 6.53, P < 0.0001) and seed weight of both Sunflower cultivars respectively due to application of Guano and Nitrogen fertilizer compared to the control. It also reflected non-significant difference between all studied traits as application of either Guano or Nitrogen fertilizer. Moreover, all studied characters of the two cultivars have similarly responded to the application of the two types of fertilizers. Further studies are recommended to assess the benefits from the use of Bat Guano as a fertilizer.

Corresponding author: Abubaker H. M. Adam, Department of Crop Science, College of Agriculture, University of Bahri, Khartoum North, Sudan, Email: abubakerharoun@gmail.com

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Introduction

Sunflower is one of the most important oil seed crops in the world. It ranks the 4th_ oil seed plants; proceeded by Soybean, Palm oil and Rapeseed plant. The crop is a native of Mexico and Peru. With the European exploration of the New World, the crop spread out to different parts of the world due to its adaptation to wide range of climatic conditions. It can be grown year around under both rain-fed and irrigation agricultural systems [1,2]. The crop has many uses, such as human use (oil, and non-oil seed as snack food), animal feed, green fodder and silage. But few species have economic importance as ornamentals [3].

Sunflower is grown worldwide. The main ten (10) Sunflower seed producing countries are Ukraine, Russia, China, Romania, Argentina, Bulgaria, Tanzania, Turkey, Hungary, France, while the Sudan share is about 0.1% [4].

Nowadays, fertilizers are commonplace, but 200 years ago synthetic fertilizers were rarely used. Farmers were relying on ash, manure, and bones, to supplement soil, but it was not fully understood why such materials were beneficial. However, by the beginning of the 19th_ century, due to extensive use of American farmlands, soil nutrients were exhausted. Farmers began searching for better fertilizers. Then, in the 1840s, Bird Guano appeared in the United States, Due to the increasing demand for Sunflower; yield improvement became an important issue. Cultural practices including fertilization are among the important approaches to increase crop yield. However, chemical and organic fertilizers are applied to increase the yield, but due to high cost of synthetic fertilizers, many farmers, particularly in the third world began to use organic fertilizers which are less cost including Bat Guano [5].

Guano is an accumulated excretion of Birds and Bats which is utilized as natural fertilizer. It has played a pivotal role in agricultural development in Latin America and Oceania [6]. Historically, the term Guano originated from the Andes area of South America refers to any form of dung used for crop fertilization [7]. The local community of Andes used to collect Guano from islands and the coast of Peru for soil amendment for over 5,000 years [8]. The most important producers of Guano are the Guanay cormorant, the Peruvian pelican and the Peruvian booby [9]. It is stated that Guano is rich in Macro and Micro elements [10]. Nevertheless, studies showed that Bird Guano has high levels of nutrients such as Ammonium and Nitrate. By mass, it is 8–21% nitrogen; the nitrogen content is about 80% uric acid, 7% ammonia, 10% protein, and 0.5% nitrate [11]. Some of Bird Guano's most common chemical elements are phosphorus, calcium, and magnesium [12].

However, Guano is a multi-functional fertilizer that can be used as a soil conditioner, enriching the soil with NPK and trace minerals, improving soil texture. It also has fungicidal effect when applied to leaves, and a compost activator that speeds up the decomposition process of compost and can also control harmful nematodes in the soil. Moreover, the microbes in Guano fertilizer have been reported to aid with cleansing toxicities from the soil, improving the natural balance without increasing alkaline or acid levels, while providing the soil's biological system with fast and slow release nutrients. It also claimed that Guano positively enhances the taste of the produce by making the overall flavor sweeter, richer, and less watery [13].

Researchers found that Bat Guano from three different Bat species, the Frugivory (*Pteropus rodricensis) family Pteropodidae which feeds on fruits, the Sanguivory (Desmodus rotundus) family Phyllostomidae, feeds on animal blood like cows, horses, and pigs, and Insectivory (Tadaridabrasiliensis), family Molossidae feeds on insects, differ in chemical composition due to their different dietary habits [13,14].* The Insectivorous which feed on different nutrition sources in different habitats had elevated Nitrogen in Organic and dry matter (DM), while the Sanguivorous had elevated Carbon in Organic Matter (OM). Both Insectivorous and Frugivorous had elevated Phosphorus. However, Frugivorous had the greatest Carbon-to-Nitrogen ratio (C/N ratio), while Sanguivorous had the greatest Nitrogen-to-Phosphorus ratio and Carbon-to-Phosphorus ratio [15].

It is reported that the freshly excretion of insectivorous Bat Guano contains several mineral elements like Carbon, Nitrogen, Sulfur, Phosphorus, with pH ranging from 5.1 to 7.3, tending to be neutral

or acidic. Nevertheless, as it ages, and becomes strongly acidic with pH ranging from 2.7 to 4. [16].

Generally, the main aim of this study was to investigate the positive influential effects of Bat Guano on different crop parameters, and find out the possibility of its application as economically sound, socially acceptable and environmentally friend organic fertilizer to increase crop yield and contribute to food security in the face of rapid population increase and exponential raising prices of the synthetic fertilizers.

Materials and Methods

This experiment was conducted at the Farm of the College of Agriculture, University of Bahri, at Alkadaro, Khartoum State, Sudan. The farm is situated within the latitudes 13^0 27`-$15^0$.45`N longitudes 32^0. 35`- $40^0$.96`E and altitude of 398 m above the sea level. The area lies in semi-arid region, with temperature ranging between 30-45^{0}C in the summer and between 10-25^{0}C during the winter. The average annual rainfall ranges between 0-100 mm, with relative humidity ranging from 16 to 50 % [17]. The soil of the study area is heavy clay with pH 7.5 – 8, thus, it is classified as saline soil.

This experiment was conducted during the summer of 2017, designed as split-plot experiment based on a randomized complete block design (RCBD), with four replications. The land was well prepared, Sunflower seeds of Serena and Opera (H-16-096\0306) cultivars were treated with fungicide, then sown in rows 75X30 cm apart and 30 cm distance between holes Bad Guano powder and Nitrogen fertilizer were applied pre-sowing at the rate of 60 and 50 kg/fed. respectively. Frequent irrigation was practiced every 7-10 days. Weeds were controlled by application of systemic selective herbicide. Samples of the studied plant characters were taken at random. The collected data were analyzed using Statistic 8 software. The results were presented in tables and figures.

Results and Discussion

The obtained results casted light on studied plant characters and how they were influenced by the application the two types of fertilizers. The results are presented in the following tables and figures followed by discussion.

According to the table (1) and fig.(1) the results showed that plant height of both Serena and Opera cultivars was significantly increased due to application of Guano and Nitrogen (F= 6.05, P < 0.0001), but it exhibited non-significant difference in the plant height of Serena and Opera cultivars as a result of application of either Guano or Nitrogen. It is clear that the plant height of the two cultivars responded equally to Guano and Nitrogen fertilizers (F=5.34, P < 0.1040). Examples of positive effect of Guano on crops are reflected in the experiments on Eggplant *(Solanum melongena* L) *and Moringa oleifera* Lam which revealed significant increase of stem circumference and plant height after the application of Bat Guano compared to the chemicals fertilizer and the control [18]. In another experiment, the effect of Bad Guano on growth parameters of *Vigna radiata* in terms of its root, shoot length and biomass was studied. Applications of Guano demonstrated the best growth in shoot length and biomass compared to the control [19]. Moreover, a study conducted in Turkey during 2014-2015 revealed that application of Bat Guano has significantly increased the total plant height and stem diameter of luttuce (*Lactuca sativa* L.) [20]. Furthermore, the application of Guano has significantly increased the plant height of Onion crop [21].

Considering table (2) and figure (2), they revealed that leaf number of Serena and Opera cultivars was significantly increased as a result of application of Guano and Nitrogen fertilizers (F= 2.37, P< 0.0388). Moreover, the result showed non- significant difference in the leaf number of Serena and Opera cultivars as a result of application of either Guano or Nitrogen. Additionally, the leaf number of Serena and Opera cultivars responded similarly to Guano and Nitrogen (F=6.32, P < 0.0866). Moreover, an experiment result showed the application of Bad Guano has increased the number of leaves of spring Onion; hence it showed better performance on all parameters and the plant fresh weight [21].

The results in the table (3) and fig.(3); demonstrated that the overall leaf area of Serena and Opera cultivars has significantly increased in the field experimental units which treated with Guano and Nitrogen compared with untreated units (F= 7.44, P < 0.001). Moreover, the result showed that there is

Table 1. Effect of Bat Guano on Plant height (cm) of Serena and Opera Sunflower Cultivars (AlKadaro, Sudan,2017)

Cultivar: Serena					
Treatment	Rep.				
	R1	R2	R3	R4	Mean
N0	145.500	258.500	671.075	794.500	467.39
N1	125.893	376.070	586.928	912.928	500.45
N2	183.535	540.208	688.388	884.358	574.12
N3	111.100	402.930	584.000	768.643	474.16
G0	121.375	249.325	656.875	802.750	457.58
G1	103.500	531.713	674.520	910.180	554.98
G2	118.928	486.175	615.428	1038.966	564.87
G3	77.013	534.632	683.357	916.215	552.80
Cultivar: Opera					
Treatment	Rep.				
	R1	R2	R3	R4	Mean
N0	48.325	82.250	118.750	129.575	94.72
N1	132.764	473.800	628.186	882.880	529.40
N2	85.285	352.175	522.960	817.040	444.36
N3	174.965	372.785	649.500	1302.993	544.06
G0	47.400	75.475	107.225	121.575	87.91
G1	81.000	338.670	740.505	919.890	520.01
G2	97.820	632.323	692.885	1146.930	642.48
G3	95.643	406.822	743.787	1195.357	610.40

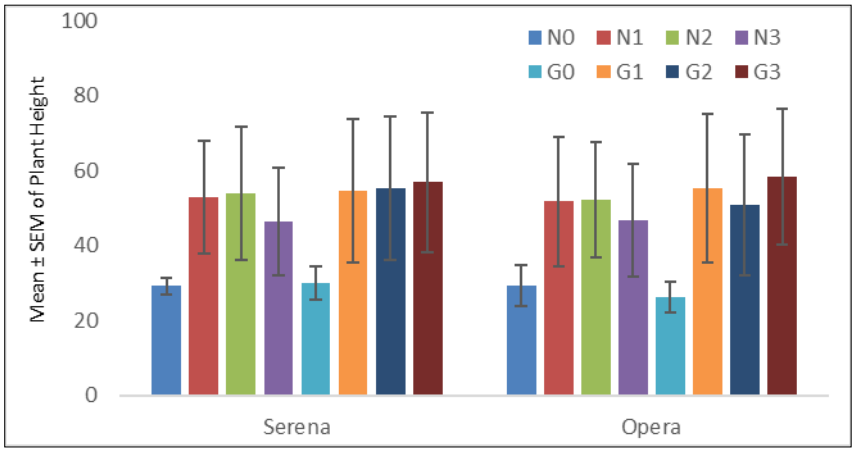

Figure 1. Impact of Guano and Nitrogen on Plant Height of Serena and Opera cultivars (AlKadaro, 2017)

Table 2. Effect of Bat Guano on Leaf Number of Serena on Opera Sunflower Cultivars (AlKadaro, Sudan,2017/)

Cultivar: Serena					
Treatment	Rep.				
	R1	R2	R3	R4	Mean
N0	13	25	27	30	23
N1	18	28	33	40	29
N2	12	24	27	31	23
N3	15	24	27	28	23
G0	16	19	25	40	25
G1	12	22	26	30	22
G2	12	23	26	29	22
G3	11	24	26	28	23
Cultivar: Opera					
Treatment	Rep.				
	R1	R2	R3	R4	Mean
N0	15	22	21	20	19
N1	13	20	27	30	22
N2	11	21	27	30	22
N3	14	21	27	30	23
G0	16	20	26	23	21
G1	12	22	26	29	22
G2	12	22	27	31	23
G3	13	21	25	28	21

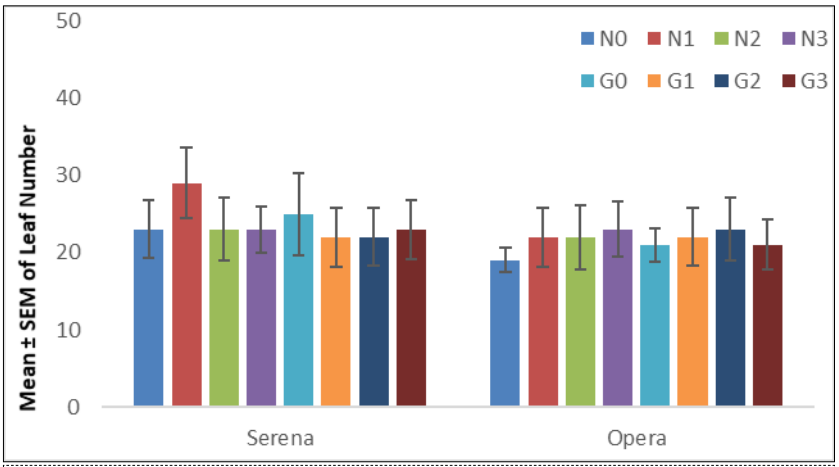

Figure 2. Impact of Guano on Leaf Number of Serena and Opera cultivars (AlKadaro,Sudan, 2017)

Table 3. Effect of Nitrogen and Bat Guano on Leaf Area.of Serena and Opera Sunflower Cultivars (AlKadaro, Sudan, 2017)

Cultivar: Serena					
Treatment	Rep.				
	R1	R2	R3	R4	Mean
N0	17.127	19.575	74.200	85.852	49.18
N1	50.860	129.925	148.975	206.950	134.17
N2	42.725	126.125	160.625	200.100	134.39
N3	26.425	94.050	136.200	179.325	108.98
G0	13.650	18.000	128.500	149.375	77.38
G1	24.025	94.975	157.425	212.275	122.17
G2	27.525	112.450	143.450	242.425	131.46
G3	19.775	123.775	156.950	212.875	128.26
Cultivar: Opera					
Treatment	Rep.				
	R1	R2	R3	R4	Mean
N0	16.250	20.500	69.500	82.225	47.11
N1	32.080	105.280	180.340	191.470	127.29
N2	22.975	82.100	122.050	319.800	136.73
N3	28.500	90.525	162.600	83.975	91.4
G0	18.025	26.000	64.775	75.250	46.01
G1	18.550	79.026	172.825	214.650	69.293
G2	22.475	147.300	162.175	246.075	144.50
G3	21.750	95.975	161.450	278.800	139.49

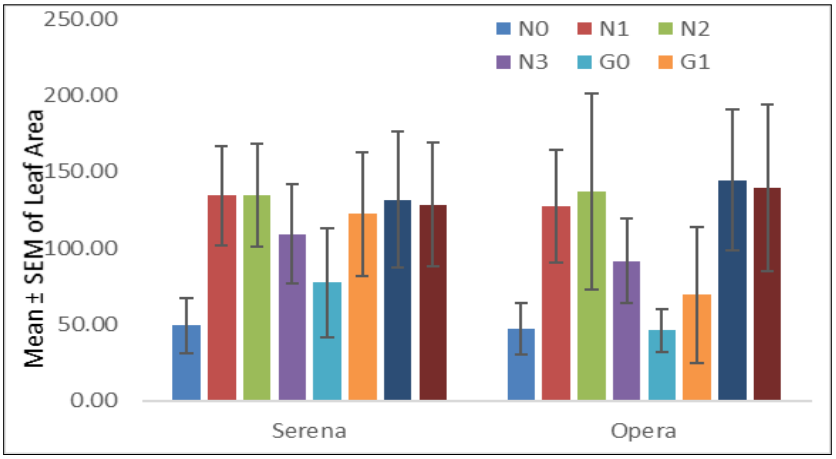

Figure 3. Impact of Guano and Nitrogen on Leaf Area of Serena and Opera cultivars (AlKadaro, Sudan, 2017)

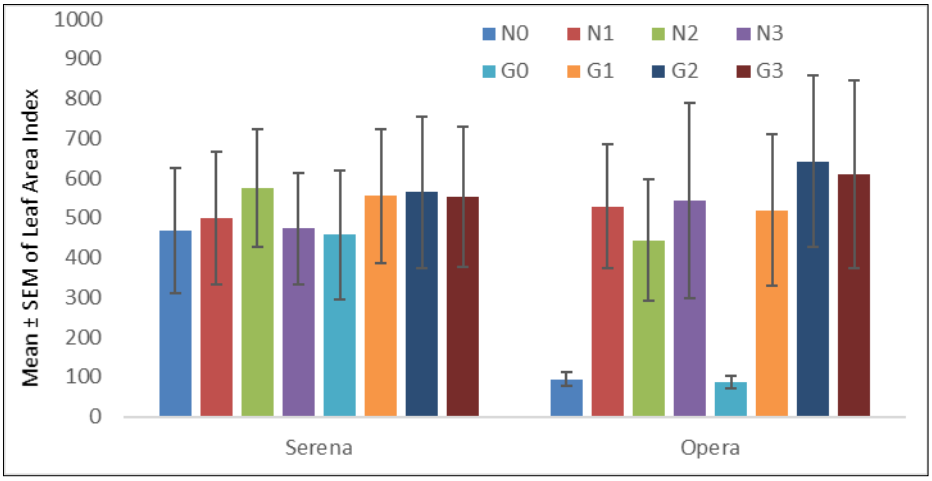

Figure 4. Impact of Guano and Nitrogen on Leaf Area Index of Seren and Opera cultivars (AlKadaro, Sudan, 2017)

Table 4. Effect of Bat Guano on Leaf Area Index of Serena and Opera Sunflower Cultivars (AlKadaro, Sudan,2017)

Cultivar: Serena					
Treatment	Rep.				
	R1	R2	R3	R4	Mean
N0	24.250	27.750	30.200	34.825	29.25
N1	15.850	44.225	64.550	86.800	52.85
N2	14.62	35.250	71.775	93.875	53.88
N3	16.150	29.750	61.750	78.400	46.51
G0	18.325	29.100	33.000	39.500	29.98
G1	13.375	31.625	77.725	95.775	54.62
G2	14.050	33.400	77.075	96.900	55.35
G3	10.550	43.700	80.475	92.700	56.85
Cultivar: Opera					
Treatment	Rep.				
	R1	R2	R3	R4	Mean
N0	13.175	29.750	32.575	39.225	29.43
N1	13.040	34.460	70.500	88.860	51.71
N2	18.725	34.400	71.225	84.550	52.22
N3	17.475	25.125	63.850	80.500	46.73
G0	14.575	26.750	29.850	33.750	26.23
G1	10.950	35.900	75.050	99.625	55.38
G2	11.550	32.525	60.400	98.975	50.86
G3	15.800	42.100	79.575	95.950	58.35

Table 5. Effect of Bat Guano and Nitrogen on (1000) Seed weight of Serena Sunflower Cultivar (AlKadaro, Sudan,2017)

Treatment	Mean Seed weight
N0	24.650
N1	24.880
N2	47.713
N3	30.978
G0	18.025
G1	36.320
G2	36.018
G3	46.417

Table 6. Effect of Bat Guano and Nitrogen on (1000) Seed Weight of Opera Sunflower Cultivar (AlKadaro, Sudan,2017)

Treatment	Mean Seed weight
N0	13.100
N1	38.952
N2	31.467
N3	43.232
G0	12.950
G1	39.130
G2	33.355
G3	41.873

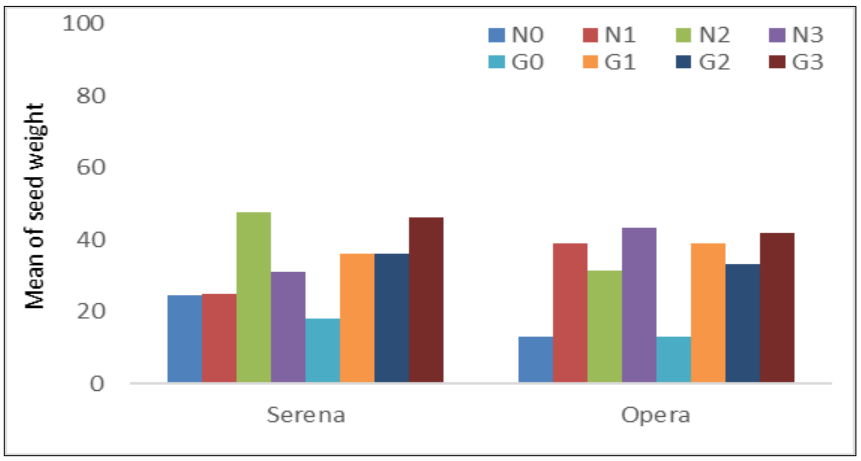

Figure 5. Impact of Guano and Nitrogen on Seed Weight of Serena and Opera cultivars (AlKadaro, Sudan, 2017)

Appendix

Analysis of Variance Table (1): Plant height (cm)

Source	DF	SS	MS	F	P
REPLICATI (A)	3	37279.9	12426.6		
VARIETY (B)	1	20.9	20.9	5.34	0.1040
Error A*B	3	11.7	3.9		
FERTILIZE (C)	7	7683.9	1097.7	6.05	0.0001
B*C	7	62.1	8.9	0.05	0.9998
Error A*B*C	42	7626.1	181.6		
Total	63	52684.7			

Grand Mean 46.845
CV(REPLICATI*VARIETY) 4.22
CV(REPLICATI*VARIETY*FERTILIZE) 28.77

Analysis of Variance Table (2): Leaf number

Source	DF	SS	MS	F	P
REPLICATI (A)	3	2400.92	800.307	-	-
VARIETY (B)	1	74.39	74.391	6.32	0.0866
Error A*B	3	35.30	11.766		
FERTILIZE (C)	7	105.61	15.087	2.37	0.0388
B*C	7	99.73	14.248	2.24	0.0496
Error A*B*C	42	267.03	6.358		
Total	63	2982.98	-	-	-

Grand Mean 23.016
CV(REPLICATI*VARIETY) 14.90
CV(REPLICATI*VARIETY*FERTILIZE) 10.96

Analysis of Variance Table (3) Leaf area

Source	DF	SS	MS	F	P
REPLICATI (A)	3	230194	76731.4		
VARIETY (B)	1	230	229.6	3.26	0.1687
Error A*B	3	211	70.4		
FERTILIZE (C)	7	70119	10016.9	7.44	0.0000
B*C	7	3090	441.4	0.33	0.9369
Error A*B*C	42	56535	1346.1		
Total	63	360378	-		
Grand Mean	108.62	-	-		
CV(REPLICATI*VARIETY)	7.73		-		
CV(REPLICATI*VARIETY*FERTILIZE)	33.78				

Analysis of Variance Table (Leaf area index_

Source	DF	SS	MS	F	P
REPLICATI (A)	3	4678076	1559359		
VARIETY (B)	1	85408	85408	14.76	0.0311
Error A*B	3	17357	5786		
FERTILIZE (C)	7	942914	134702	6.53	0.0000
B*C	7	572312	81759	3.96	0.0021
Error A*B*C	42	866169	20623		
Total	63	7162236			
Grand Mean	480.83				

CV(REPLICATI*VARIETY) 15.82
CV(REPLICATI*VARIETY*FERTILIZE) 29.87

non-significant difference in the leaf area of Serena and Opera cultivars due to application of either Guano or Nitrogen. Furthermore, the two cultivars "Serena and Opera" responded similarly (F= 3.26, P < 0.1687) to Guano and Nitrogen treatments.

According to the table (4) and figure (4) there is a significant increase in leaf area index of both Serena and Opera due to application of Guano or Nitrogen (F= 6.53, P < 0.0001). Moreover; the result displayed non- significant difference in the leaf area index of the two cultivars as a result of application of either Guano or Nitrogen. Furthermore, the leaf area index of the two cultivars responded differently to the application of Guano and Nitrogen (F=14.76, P < 0.0311).

As far as the (1000) Seed Weight concern, the result (tables 5, 6 and fig. 5) reflected that application of both Guano and Nitrogen increased the average seed weight of both cultivars. But the two cultivars responded different to Bat Guano and Nitrogen fertilizer. A study conducted in Turkey during 2014-2015 revealed that application of Bat Guano has significantly increased the total yield of lettuce (*Lactuca sativa* L.) [20]. Results of study on Wheat crop demonstrated that Bat Guano proved to be more effective than farmyard manure by increasing thousand grain weight by 6%, number of spikes in m2 by 66%, stem yield by 87%, grain yield by 35%, plant height by 8.4% and hectoliter weight by 5% [22].

Conclusion and Recommendations

Bat Guano is a multifunctional. It has numerous benefits, among which: Improves soil texture and structure, enriches the soil with macro and micro nutrient elements, acts as a fungicide when applied to leaves, improves the natural balance without increasing alkaline or acid levels, Its application rates are smaller than those of other manure, low to non-existent odor, fast action in the process of decomposition process in comparison to other natural manures. It speeds up the decomposition process of compost matter and can also control harmful nematodes in the soil

Different field and vegetable crops showed positive response to the application of natural organic fertilizer namely the bad Guano as well as the Nitrogen fertilizer.

A shift from application of synthetic to organic fertilizer is a great success towards the organic farming.

Further studies are recommended to assess the benefits from the use of Bat Guano as a fertilizer.

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