

## Impact of Compost Tea Types Application on Germination, Nodulation, Morphological Characters and Yield of Two Lentil Cultivars

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**L**ABORATORY and field experiments were performed at Crop Science Laboratory and the Experimental Farm, respectively, Faculty of Agriculture, Menoufia University, Shebin El-Kom, Egypt, in order to evaluate the response of germination and seedling characters, nodulation, growth, nutrients uptake and yield of two lentil cultivars (Giza 4 and Family 29) to application of various compost tea types prepared from different agricultural residues (sugarcane bagasse, cotton stalk and rice straw) and their grades based on particles size (unfractionated, relatively coarse and fine). Application of compost tea includes twice ways applied together, i.e. seed priming before sowing and foliar application during growth periods (25 and 55 days after sowing). Results showed that Giza 4 significantly surpassed Family 29 for all parameters except germination %. Giza 4 outweighed Family 29 by 19.36 and 11.30% for seed yield/fad in first and second seasons, respectively. The compost tea types produced from the finest particles size (0.6-1mm) of the cotton stalk or rice straw compost revealed maximum values of germination and seedling characters, nodulation, growth, chlorophyll, NPK contents, yield and protein%. The interactions between lentil cultivars and compost tea were found to be significant for studied characters. It could be concluded that treated Giza 4 with compost tea produced from finest particles size (0.6-1mm) of cotton stalk or rice straw compost was found to be the best combination treatment for enhancing germination, nodulation, growth and productivity of lentil, indicating the importance of compost tea application to maximize lentil productivity.

**Keywords:** Agricultural residues, Particles size grades, Compost tea types, Yield, Lentil.

### Introduction

Lentil (*Lens culinaris* Medik.) is a beneficial winter legume crop that has been globally cultivated as an important food source for over 8,000 years (Cokkizgin & Shtaya, 2013 and Mitiku, 2016). Lentil provide a considerable portion of the nutrition of the people in the African countries. From the nutritional view, lentil seeds contains about 22–31% protein, 60–65% total carbohydrate, 0.6% fat, 4% fiber and 2.1% ash. Moreover, because the symbiotic nitrogen fixation attribute, lentil plants can be grown in rotation with cereal crops in order to reduce demand for nitrogenous fertilizers. On the other hand, lentil straw contains about 10.2, 4.4, 50, 1.8, 12.2 and 21.4% moisture, protein, carbohydrate, fat, ash and fiber, respectively, which increase interest for potential using it as forage for animal

feeding (Roy et al., 2010 and Abbeddou et al., 2011), biomass energy crop and other industrial non-food uses (Yadav et al., 2007). However, the cultivated area estimated in Egypt has gradually decreased from 26,636ha ( $\approx$  63,393fad) in 1961 and reached only about 611ha ( $\approx$ 1,454fad) in 2016 with the productivity of 34,434 to 892ton/year, respectively (FAOSTAT, 2017).

In Egypt, the total amount of crop residues produced annually is about 38.7 million tons per year out coming from the cultivated area, which is about 3.7 million hectares (8.8 million fad) with a cropping area of about 6.2 million hectares (about 14.7 million fad) during years 2009-2013. Only about 7 million tons are being utilize as animal feed and about 4 million as organic manure (Hussein & Sawan, 2010). The estimated amount of rice straw, cotton stalk and sugarcane

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bagasse are 3.6, 1.6 and 6.8 million ton per year, respectively, which represent about 9.5, 4.2 and 19.4% of total crop residues, respectively. The crop residues result after harvesting in the form of leaves and stem, which are characterized as coarse plant products and big size, chemically low in protein and fat contents, and high in lignin and cellulosic contents (El-Shimi, 2016 and Elfeki et al., 2017).

The conventional farming has faced many criticisms because it greatly relies on many external inputs with a significant amount of synthetic agro-chemicals like synthetic fertilizers, pesticides or growth regulators to produce the highest possible yield of crops (Lairon, 2010). On the other hand, sustainable or organic farming is an eco-friendly alternative option to conventional farming for stable yield and quality as well as greater spatial stability of soil biotic and abiotic properties (Suja et al., 2017 and Schrama et al., 2018). Under a sustainable farming, attempts are going to employ bioorganic compounds, including compost or its liquid phase (compost tea), for establish successful beneficial biological interactions, maximize reuse and preserve agro-ecosystem quality (Casado & González de Molina, 2009 and Kapoor et al., 2015). In such context, Badawi et al. (2014) documented that the foliar application of bio-enriched compost tea (200L/fad) acts as a good practice for improving the most growth and yield characters of lentil varieties (Sinaa 1 and Giza 9) and leading to healthier food, particularly under sustainable agricultural systems. Seed priming is a pre-sowing procedure impacting seedling development by stimulates pre-germination metabolic activities preceding development of the radicle and enhances seedling vigor (Taylor & Harman, 1990 and Farooq et al., 2007). Soaking seeds contributed to rapid germination of some plants such as tomato, lettuce and lentil seeds and enhance seedling growth as presented by Ghassemi-Golezani et al. (2008), Arancon et al. (2012) and Toklu (2015). Seed germination is a critical stage in the plant development and its life cycle because the seedlings that have a vigorous growth due to hydro or osmotic priming could be able to successfully compete under wide range of conditions and consequently exhibited more yield and yield components of lentil (Koireng & Neupane, 2014). Regarding soil health, compost tea contains microorganisms and their metabolites that acts as plant growth promoting and/or as bio-control agents. Compost tea could be utilized in

organic cultivation for enhancing plant growth by application it into the root zone or foliar application to increase the yield (Kim et al., 2015). Also, El-Gizawy et al. (2013) mentioned that application of compost tea revealed increases the biological activity of soil in terms of increasing the soil total bacteria, as well as dehydrogenase activity and nitrogenase activity that increase the soil fertility.

The current study aims to evaluate the efficacy of the compost tea produced from some agricultural residues depending on particles size of compost on the germination, nodulation, growth and yield of some lentil cultivars.

## **Materials and Methods**

### *Experimental procedures*

Laboratory and field experiments were carried out at the laboratory of Crop Science and Experimental Farm, respectively, Faculty of Agriculture, Menoufia University, Shebin El-Kom, Egypt (latitude 30°31'42"N, longitude 31°04'08"E). Such experiments aimed to study the efficiency of various compost tea derived from various agricultural residues and based on their particles size, i.e., unfractionated, relatively coarse (>2.8mm) and fine (0.6-1mm) on germination and seedling characters, nodulation, morphological characters, yield and quality of two lentil cultivars (Giza 4 and Family 29). Laboratory experiment was conducted on 6<sup>th</sup> November 2017. The germination test was done using filter papers as a substrate in Petri dishes (diameter 150mm). Lentil cultivars (Giza 4 and Family 29) seeds were soaked in the various compost tea in addition to distilled water (as control) for 4h. Thirty primed seeds from each treatment were placed in Petri dishes for germination and incubated for 7 days under temperature 25°C. Laboratory experiment designed in randomized complete block as a factorial trial with four replications.

Field experiment was carried out during two winter growing seasons of 2016/2017 and 2017/2018. Sowing date was 5<sup>th</sup> November in both seasons. Each experiment included twenty treatments, which were the combination of two cultivars and ten compost tea types. The treatments were arranged at random in a split plot design with three replications. Main plots were allocated for lentil cultivars (Giza 4 and Family 29), while compost tea types were assigned in sub-plots as following:

- T0= Without compost tea (water as control).
- T1= Compost tea prepared from unfractionated bagasse compost.
- T2= Compost tea prepared from fraction (>2.8mm particle size) of bagasse compost.
- T3= Compost tea prepared from fraction (0.6-1mm particle size) of bagasse compost.
- T4= Compost tea prepared from unfractionated cotton stalk compost.
- T5= Compost tea prepared from fraction (>2.8 mm particle size) of cotton stalk compost.
- T6= Compost tea prepared from fraction (0.6-1mm particle size) of cotton stalk compost.
- T7= Compost tea prepared from unfractionated rice straw compost.
- T8= Compost tea prepared from fraction (>2.8mm particle size) of rice straw compost.
- T9= Compost tea prepared from fraction (0.6-1mm particle size) of rice straw compost.

The compost tea was applied by two ways together for all treatments, as seed priming by soaking the lentil seeds in various compost tea types (1kg seed : 0.5L solution) for 4h before sowing and also as foliar application at a rate of 60L/fad (prepared by soaking 6kg mature compost into 60L distilled water), then diluted to 200L water/fad and sprayed two times after 25 and 55 days after sowing (DAS). It is hypothesized that seed priming in compost extracts would contribute to rapid germination and enhance seedling growth whereas the foliar application would supply the seedling and soil with microorganisms (plant growth promoting rhizobacteria "PGPRs"), biologically active metabolites and water extractable mineral nutrients.

#### *Preparation of compost and compost tea*

Compost was prepared at Soil, Water and Environment Research Institute (SWERI), ARC, Giza, Egypt. The tested plant residues (sugarcane bagasse, cotton stalk and rice straw) after chopping were mixed with farmyard manure, rock phosphate, feldspar and bentonite at rates of 10, 5, 5 and 10% w/w, respectively. Also, vinasse

solution and lignocellulosic inoculant (mixture of *Trichoderma harzianum* and *Trichoderma viridi*) were added at rates of 1 and 1% v/w, respectively, as amendments. The compost heaps received the suitable water and turning was done every 15 days for keeping the suitable moisture and aeration along the composting process. After compost maturation (three months), the heaps were bioaugmented with a mixture of rhizobacteria inoculant (*Bacillus polymyxa*, *Serratia mercrescens* and *Pseudomonas fluorescens*) at rate of 1L per ton compost and left for curing for another 30 days (Owis et al., 2016). Composts were physically processed through dry fractionation-based particles size using sieves according to El-Tahlawy et al. (2018). In context, unfractionated compost and two fractions with particles size >2.8 and 0.6-1mm of each compost type were applied for compost tea preparing. Table 1-a represents some physical, chemical and biological properties of applied compost.

Aerated compost tea types were prepared by steeping the mature compost packed into cotton bag and submerged into distilled water with ratio 1:10 (w/v) amended with molasses (0.5%), ammonium nitrate (0.5g/L) and dipotassium phosphate (0.5g/L) as a microbial food source according to Hegazy et al. (2015). The systems were continuously aerated using air pumps for three days brewing cycle. The outcome compost tea types properties are shown in Table 1-b.

Soil samples were randomly taken from the depth of 0-30cm from the soil surface. Samples were analyzed according to Black (1965) and Jackson (1973). The soil physical and chemical properties of both seasons are listed in Table 2-a. Monthly climatic data of experimental site during both growing seasons are listed in Table 2-b.

#### *Crop management*

In the field trial, lentil seeds were sown on 5<sup>th</sup> November in both seasons by hand drilled in beds (width 120cm). Each bed contains 4 rows with distance between rows about 20cm. The area of each experimental plot was 18 m<sup>2</sup> (6m width × 3m long). Empty area (1.2m) was left as buffer area between all sub-plots in order to eliminate any interfere effect of foliar spray. *Rhizobium* inoculation was done using solid carrier of vermiculite and mixture of two *Rhizobium leguminosarum* strains (TAL168 and ICARDA139), were supplied by microbiology department, SWERI, ARC, Giza, Egypt, at a rate of 300g/35kg seeds. Lentil cultivars

seed were obtained annually from Food Legume Research Program, Field Crops Research Institute, ARC, Giza, Egypt. The plant density used under investigation was 120plants/m<sup>2</sup>. The preceding crop was maize in both seasons. During soil preparation, all experimental treatments received

superphosphate fertilizer at a rate of 100kg/fad (15% P<sub>2</sub>O<sub>5</sub>) and potassium sulfate at a rate of 50kg/fad (48% K<sub>2</sub>O). However, nitrogen fertilizer was added at a rate of 15kg N/fad in the form of ammonium sulfate (20.6% N) at sowing as an activation portion.

**TABLE 1-a. Some physical, chemical and biological properties of compost sources.**

Properties	Sugarcane bagasse compost*			Cotton stalk compost*			Rice straw compost*		
	F0	F1	F2	F0	F1	F2	F0	F1	F2
Bulk density (kg/m <sup>3</sup> )	267.3	243.7	262.9	474.9	240.9	439.1	473.2	202.6	322.9
pH	6.23	6.29	5.71	7.71	7.73	7.79	6.53	6.53	6.32
EC (dS/m at 25°C)	3.77	4.53	4.55	4.11	3.86	3.58	4.66	5.11	4.50
Ash %	69.21	57.68	68.83	53.29	65.12	64.35	67.20	62.98	71.86
Organic matter %	30.79	42.32	31.17	46.71	34.88	35.65	32.8	37.02	28.14
Total nitrogen %	1.61	1.67	1.04	1.55	1.58	1.26	1.38	1.21	1.11
C/N Ratio	10.64	14.10	16.66	17.04	12.22	15.77	13.20	17.06	14.22
Total phosphorus %	0.46	0.41	0.51	0.41	0.42	0.52	0.48	0.46	0.41
Total potassium %	1.17	1.31	1.19	1.33	1.05	1.32	1.43	1.37	1.25
Dehydrogenases (mg TPF/g dry weight/hr)	0.61	0.72	0.58	0.56	0.50	0.62	0.68	0.59	0.50
Total bacteria (Log No.cfu/g dry weight)	9.20	10.42	8.60	14.46	8.32	10.35	11.22	10.88	9.90
Total actinobacteria (Log No.cfu/g dry weight)	8.05	9.12	7.53	12.65	7.28	8.39	9.81	9.52	8.67
Total fungi (Log No.cfu/g dry weight)	5.94	5.82	5.25	6.00	5.66	6.10	6.89	5.16	7.81

\* F0, F1 and F2: The unfractionated, relatively coarse (>2.8) and fine (0.6–1mm) of compost, respectively.

**TABLE 1-b. Some chemical and biological properties of produced compost tea.**

Properties	Sugarcane bagasse compost tea			Cotton stalk compost tea			Rice straw compost tea		
	T1	T2	T3	T4	T5	T6	T7	T8	T9
pH	6.76	6.75	6.60	7.14	7.05	6.73	6.88	6.79	6.59
EC (ds/m at 25°C)	2.13	2.00	1.59	2.01	1.84	1.47	2.52	2.83	2.91
Soluble carbon (mg/ml)	2.36	2.59	2.69	2.07	2.37	2.60	2.67	2.92	2.96
Total soluble N (ppm)	121.75	117.35	109.30	109.75	109.62	113.70	102.95	107.95	106.70
Available phosphorus (ppm)	39.46	40.97	40.57	39.97	39.91	43.82	41.78	42.17	42.29
Available potassium (ppm)	121.56	125.62	134.57	122.63	125.37	132.43	124.15	126.14	129.50
E4/E6 ratio*	2.76	3.04	3.31	3.16	3.52	3.39	2.66	2.72	3.09
Dehydrogenases (mg TPF/g dry weight/hr)	46.82	52.25	53.74	40.67	47.47	51.87	53.32	58.59	59.36
Total bacteria (Log No.cfu/ml)	7.42	7.19	7.35	5.26	5.87	7.16	7.26	7.83	7.60
Total actinobacteria (Log No.cfu/ml)	5.56	5.31	5.27	5.16	4.66	5.57	4.31	4.48	6.20
Total fungi (Log No.cfu/ml)	4.32	4.50	4.29	2.36	2.76	4.11	4.29	4.71	4.61

\* E4/E6: Extinction coefficient

**TABLE 2-a. Physical and chemical properties of the experimental soil during both seasons.**

Properties	Texture class	pH	E.C. ds/m	O.M. %	Available nutrients (ppm)					
					N	P	K	Fe	Zn	Mn
2016/17	Clay loam	7.25	0.63	1.82	32.5	9.2	321.3	4.16	0.98	2.71
2017/18	Clay loam	7.12	0.61	1.83	33.6	9.6	332.4	4.09	1.04	2.18

**TABLE 2-b. Average monthly climatic data of the experimental site during growing periods of both seasons.**

Month	2016/2017 season			2017/2018 season		
	Temperature (C°)		Relative humidity (%)	Temperature (C°)		Relative humidity (%)
	Max.	Min.		Max.	Min.	
November	24.07	16.10	56.70	24.33	15.93	55.45
December	18.84	11.52	56.52	22.00	13.74	58.56
January	18.26	9.77	56.71	19.16	11.84	55.63
February	19.96	10.39	59.89	23.50	13.89	51.07
March	23.81	14.84	52.16	27.84	16.39	45.89
April	26.24	16.05	48.57	29.10	18.03	45.95

*Plant measurements*

In lab trial, germination and seedling characters were measured at the end of germination period at laboratory during the seventh day. Final germination percentage was calculated using the followed formula:

$$\text{Germination (\%)} = \frac{\text{Number of final germinated seeds}}{\text{Total number of tested seeds}} \times 100$$

Shoot and radical lengths (cm) were recorded randomly from twenty seedling. Seedling vigor index was calculated according the formula mentioned by Abdul-Baki & Anderson (1970) as follows:

$$\text{Seedling vigor index} = (\text{shoot length} + \text{radical length}) \times \text{Germination\%}$$

In field trial, nodulation status and morphological characters of the uprooted samples at the growth period (80 DAS) were assayed. Eight plants were uprooted carefully by mattock at random from each experimental plot. Lentil roots were dipped in water to remove soil then washed with distilled water. Nodulation parameters were evaluated with nodules number, nodules dry weight and nitrogenase activity. Nitrogenase enzyme activity in fresh nodulated roots was estimated using acetylene reduction assay as described by Hardy et al. (1973). The morphological characters of plants was described as plant height, number of branches/plant, shoot and root dry weight/plant and root area. The plant roots were detached and images of roots were captured with 300 dots per inch (dpi) resolution using a flatbed scanner (HP

Scanjet G2710). Root area was measured through digital image analysis as described by Lebowitz (1988).

The nutritional status of plant at 80 DAS were represented as nitrogen, phosphorus and potassium contents in shoot. A wet digestion of oven dried plant material was performed using concentrated sulphuric acid and perchloric acid as a catalyst according to Jackson (1973). Using the micro Kjeldahl method to determine total nitrogen as outlined in AOAC (2000). According to Page et al. (1982), phosphorus was determined spectrophotometrically using ammonium molybdate and stannous chloride reagents as well as potassium was determined using Flame-photometer.

Total chlorophyll in lentil leaves was estimated during the great flowering and pod formation periods (80 and 95 DAS) using chlorophyll meter SPAD 502 Plus (Minolta Co. Ltd., Osaka, Japan).

At physiological maturity stage (156 and 154 DAS in the first and second seasons, respectively), seed yield and its components, i.e., number of pods/plant, number of seeds/plant, 1000-seed weight (g.), seed yield/plant (g.) and seed and biological yield/fad (kg) were estimated. The seed and biological yield/fad were determined by harvesting the central two beds from each experimental plots, then the yield converted to fad.

After drying and grinding seed samples, protein % was calculated by multiplying nitrogen percentage by the factor 6.25 as outlined in AOAC (2000).

### *Statistical analysis*

Statistical analysis of data was done by the analysis of variance (ANOVA) according to Snedecor & Cochran (1980). Multiple comparisons of treatment means were done by least significant difference test (LSD) at  $P \leq 0.05$  level. The analysis was performed using CoStat program, ver. 6.4, CoHort software.

## **Results and Discussion**

### *Germination and seedling characters*

Germination and seedling traits were affected by lentil cultivars, seed priming in compost tea and their interaction (Table 3). The recorded data indicated that Giza 4 exhibited significant values above Family 29 for all germination and seedling traits except germination %. These increases were amounted to 4.30, 11.63 and 9.29% for radical length, shoot length and seedling vigor index traits, respectively more than Family 29 cultivar. The variation in seedling traits of lentil cultivars had been shown to be affected by the genetic variability. In this concern, Foti et al. (2018) concluded that germination and early growth potential could be utilized as an active strategy to expose genetic differences in lentil genotypes. Genetic variation in shoot and root of seedling lentil were observed by Sarker et al. (2005).

Concerning compost tea effect, it is appeared from Table 3 and Fig. 1 that seed priming in compost tea prepared from compost either unfractionated or fractionated significantly increased germination %, radical length, shoot length and seedling vigor index compared to seed priming in water (control). The germination and seedling traits recorded increases as the compost particles size decrease with superiority of compost tea prepared from rice straw (T9) followed by cotton stalk (T6) without significant differences in most cases. Priming seeds with compost tea had a better effect on seed germination and seedling traits. This superiority might be due to the great importance of these extractions in stimulate the physiological processes, which probably resulted in increases cell division of seedling. Preprocessing the seeds using priming technique could lead to reduction in the period of seedling formation with uniform in the plants growth. By priming, a partial hydration of seeds lead to modulation in pre-germinative metabolic activities influencing the development of seedling (McDonald, 2000). Similar results were obtained by Bijanzadeh et al. (2010) and Arancon et al.

(2012) who reported that germination percentage and seedling growth were enhanced by priming seeds in compost extracts.

The interaction between lentil cultivars and seed priming with compost tea had a significant effect on germination and seedling traits (Table 3). The highest significant values of germination %, shoot length and seedling vigor index were observed in primed seeds of Giza 4 cultivar with compost tea prepared from finest rice straw compost. Furthermore, primed seeds of Family 29 and Giza 4 with T9 produced the longest radical. On the contrary, the lowest germination %, radical and shoot lengths and seedling vigor index were recorded by primed seeds of Family 29 in water (without compost tea).

### *Nodulation parameters*

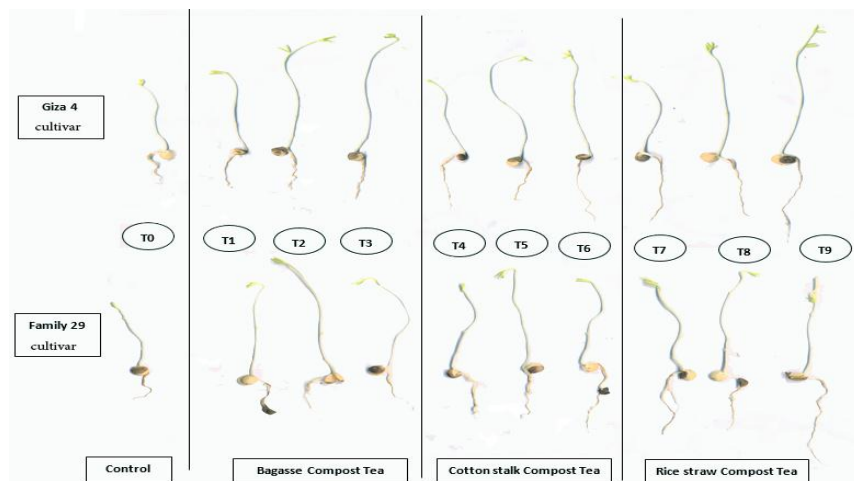
Data in Table 4 shows the nodulation status of lentil plants, at 80 DAS, as an indication to the symbiotic nitrogen fixation. The nodulation status was assayed as number of nodules, dry weight of nodules and nitrogenase activity. Regarding the lentil cultivars, the obtained results revealed that Giza 4 cultivar significantly ( $P \leq 0.05$ ) outweighed Family 29 cultivar by 29.10 and 14.17% in nodules number, 22.87 and 14.92% in nodules dry weight and 22.54 and 14.37% in nitrogenase activity during both growing seasons, respectively. The varietal differences in number and dry weight of nodules were documented by Badawi et al. (2014). Moreover, El-Hersh et al. (2011) found higher significant values of nitrogenase activity and nodules number/plant in Giza 4 cultivar more than in Giza 9 cultivar.

Regarding the effect of compost tea application, the addition of compost tea generally showed a significant ( $P \leq 0.05$ ) improvement in the nodulation status comparing to the control treatment (without compost tea). Except for compost tea prepared from sugarcane bagasse compost, the finest particles of rice straw or cotton stalk surpassed compost tea that prepared from unfractionated compost or relatively coarse fractions for all nodulation parameters during two seasons. The data of nodulation status generally appeared the stimulation effect of compost tea that agree with Badawi et al. (2014) who attributed such stimulation to improvement in the photosynthesis process which enhance nodulation performance or to the promotive effects of promoting rhizobacteria which act to enhance root proliferation and provide more infection sites for rhizobia.

**TABLE 3. Germination % and seedling characters of lentil cultivars as affected by various compost tea priming.**

		Germination (%)	Radical length (cm)	Shoot length (cm)	Seedling vigor index
<b>Cultivars (Cv)</b>					
Giza 4		97.88	3.64	7.58	1098.79
Family 29		97.65	3.49	6.79	1005.38
LSD <sub>0.05</sub>		NS	0.08	0.65	67.91
<b>Compost tea (CT)</b>					
T0*		96.13	2.38	4.85	694.30
T1		97.25	2.70	6.24	869.36
T2		97.63	2.81	7.87	1041.42
T3		98.00	2.94	7.44	1017.24
T4		98.13	3.64	6.53	997.51
T5		98.13	3.71	8.20	1168.11
T6		98.25	4.34	8.08	1219.44
T7		97.50	4.30	6.52	1054.49
T8		98.13	4.17	7.85	1179.37
T9		98.50	4.67	8.32	1279.63
LSD <sub>0.05</sub>		0.95	0.62	1.48	152.11
<b>Interaction (Cv X CT)</b>					
Giza 4	T0	96.50	2.45	5.51	768.14
	T1	97.50	2.70	6.02	850.20
	T2	97.25	2.81	8.51	1100.87
	T3	98.00	3.06	8.06	1089.76
	T4	98.50	3.82	6.54	1020.46
	T5	98.00	3.75	8.73	1223.04
	T6	98.50	4.43	8.62	1285.43
	T7	97.75	4.42	6.50	1067.43
	T8	98.00	4.28	8.51	1253.42
Family 29	T9	98.75	4.63	8.83	1329.18
	T0	95.75	2.30	4.18	620.46
	T1	97.00	2.70	6.46	888.52
	T2	98.00	2.80	7.22	981.96
	T3	98.00	2.82	6.82	944.72
	T4	97.75	3.46	6.51	974.57
	T5	98.25	3.66	7.67	1113.17
	T6	98.00	4.24	7.53	1153.46
	T7	97.25	4.18	6.53	1041.55
T8	98.25	4.05	7.20	1105.31	
LSD <sub>0.05</sub>		1.32	0.87	2.09	173.56

\*T0= Without compost tea (water), T1= Compost tea from unfractionated bagasse compost, T2= Compost tea from fraction (>2.8 mm particle size) of bagasse compost, T3= Compost tea from fraction (0.6-1mm particle size) of bagasse compost, T4= Compost tea from unfractionated cotton stalk compost, T5= Compost tea from fraction (>2.8mm particle size) of cotton stalk compost, T6= Compost tea from fraction (0.6-1mm particle size) of cotton stalk compost, T7= Compost tea from unfractionated rice straw compost; T8= Compost tea prepared from fraction (>2.8mm particle size) of rice straw compost and T9= Compost tea from fraction (0.6-1mm particle size) of rice straw compost.



**Fig. 1. Seedling characters of lentil cultivars as affected by compost tea priming.**

Concerning the interaction between cultivars and the compost tea types, a significant variation ( $P \leq 0.05$ ) was recorded. The response to various types of compost tea was depended on the lentil cultivar. Giza 4 cultivar shows higher values more than Family 29 with the compost tea prepared from finest fractions of rice straw or cotton stalk. The maximum values 33.33 and 33.67 nodule/plant, 167.76 and 178.34 mg/plant for nodule dry weight and 19.02 and 19.64  $\mu\text{mol C}_2\text{H}_4/\text{g d.wt. nodules/h}$  for nitrogenase activity were attained by treated Giza 4 cultivar with compost tea prepared from finest particles of rice straw compost (T9) in two seasons, respectively, compared with other tested combination. Treated the same cultivar (Giza 4) with compost tea prepared from the finest particles of cotton stalk compost (T6) recorded the next ranked without significant differences in most cases. The variation in compost raw materials and particle size may lead to a quantitative and qualitative variation in microbial or nutritional content of the produced compost tea leading to varied influence lentil-*Rhizobium* symbiotic relationship.

#### *Morphological parameters*

Data in Table 5 shows the values of morphological parameters (at 80 DAS) of lentil cultivars under the effect of various compost tea application. Regarding the varietal differences, the data shows that Giza 4 cultivar was significantly ( $P \leq 0.05$ ) surpassed Family 29 in all parameters. The recorded increases were 6.68 and 9.99% in plant height, 10.61 and 11.11 in number of branches, 5.70 and 5.05% in shoot dry weight, 17.51 and 11.29% in root dry weight, 18.52 and 22.05% in root area in both growing seasons, respectively. The superiority of Giza 4 cultivar in the

total dry weight may be attributed to the increase in its plant height, number of branches and root area (Table 5) and nodulation parameters (Table 4) which caused an increase in the amount of metabolites synthesized. Similar results were obtained by Gahoonia et al. (2006), Rizk et al. (2011), Mekkei & El-Haggan (2013) and Choudhary et al. (2017).

Concerning the effect of compost tea, data in shows a significant ( $P \leq 0.05$ ) predictable improvement in all morphological parameters of lentil due to the application of compost tea as compared with control. The fractionation process of compost led to produce compost tea, which causes a positive effect on all morphological characters of the growing plants. The maximum values were recorded by compost tea prepared from finest particle (0.6-1mm) of cotton stalk compost followed with that produced from the rice straw of the same size. The average increases in plant height, number of branches/plant, shoot dry weight/plant, root dry weight/plant and root area/plant were 51.45 and 27.52%, 49.39 and 39.30%, 23.36 and 20.51%, 12.15 and 10.68% and 162.25 and 161.41%, respectively by application of the finest particles of cotton stalk compost tea (T6) and rice straw compost tea (T9) over the untreated plants (T0). The variation in vegetative growth due to the fractionation process of the compost used for tea preparation which potentially may cause by the variation in enzyme activities, available nutrients and/or microbial metabolites in compost tea produced (Table 1-b). The stimulation effect of compost tea on the vegetative growth of some legume crops were previously documented by other researchers such as Kim et al. (2015) and Ahmadpour & Bahrami (2016).



**TABLE 4. Nodulation status of lentil cultivars as affected by various compost tea application.**

	2016/17 season			2017/18 season			
	Nodules (No./plant)	Nodules dry weight (mg/plant)	Nitrogenase ( $\mu\text{mol C}_2\text{H}_4/\text{g}$ D.Wt. nodules/h)	Nodules (No./plant)	Nodules dry weight (mg/plant)	Nitrogenase ( $\mu\text{mol C}_2\text{H}_4/\text{g}$ D.Wt. nodules/h)	
<b>Cultivars (Cv)</b>							
Giza 4	26.04	130.39	15.06	24.97	131.21	15.04	
Family 29	20.17	106.12	12.29	21.87	114.18	13.15	
LSD <sub>0.05</sub>	2.05	5.06	1.69	2.14	3.71	1.05	
<b>Compost tea (CT)</b>							
T0*	10.33	55.00	6.72	12.67	68.25	8.09	
T1	25.00	131.42	15.16	23.00	120.71	13.93	
T2	21.33	111.70	12.93	20.83	107.74	12.36	
T3	19.17	96.21	11.40	18.17	96.27	11.32	
T4	21.17	102.40	11.77	22.17	116.11	13.44	
T5	24.17	123.68	14.13	25.83	133.72	15.56	
T6	28.67	147.17	16.81	29.83	155.09	17.65	
T7	22.83	120.46	14.11	23.33	122.05	14.04	
T8	25.87	132.00	15.39	27.67	142.34	16.20	
T9	32.50	162.51	18.37	31.50	164.71	18.32	
LSD <sub>0.05</sub>	2.49	7.99	2.87	3.68	4.41	1.65	
<b>Interaction (Cv X CT)</b>							
Giza 4	T0	11.33	56.68	7.03	13.00	69.27	8.33
	T1	28.33	147.62	17.09	23.67	122.68	14.07
	T2	25.33	131.91	15.31	21.67	110.30	12.65
	T3	24.33	115.30	13.65	19.33	101.34	11.75
	T4	25.33	114.70	13.16	24.33	130.81	15.16
	T5	27.67	141.11	15.87	29.67	154.15	17.80
	T6	32.33	161.27	18.37	32.00	166.72	18.83
	T7	24.33	126.48	14.76	25.00	131.82	15.29
	T8	28.07	141.07	16.36	28.33	146.71	16.83
T9	33.33	167.76	19.02	32.67	178.34	19.64	
Family 29	T0	9.33	53.31	6.40	12.33	67.22	7.86
	T1	21.67	115.22	13.22	22.33	118.74	13.78
	T2	17.33	91.49	10.55	20.00	105.19	12.07
	T3	14.00	77.13	9.15	17.33	91.20	10.89
	T4	17.00	90.10	10.38	19.00	101.41	11.71
	T5	20.67	106.24	12.39	22.00	113.28	13.32
	T6	25.00	133.07	15.25	27.67	143.47	16.47
	T7	21.33	114.44	13.45	21.67	112.28	12.79
	T8	23.67	122.93	14.42	27.00	137.97	15.57
T9	31.67	157.27	17.72	29.33	151.07	16.99	
LSD <sub>0.05</sub>	3.52	11.30	4.06	5.20	6.23	2.33	

\*T0= Without compost tea (water), T1= Compost tea from unfractionated bagasse compost, T2= Compost tea from fraction (>2.8mm particle size) of bagasse compost, T3= Compost tea from fraction (0.6-1mm particle size) of bagasse compost, T4= Compost tea from unfractionated cotton stalk compost, T5= Compost tea from fraction (>2.8 mm particle size) of cotton stalk compost, T6= Compost tea from fraction (0.6-1mm particle size) of cotton stalk compost, T7= Compost tea from unfractionated rice straw compost, T8= Compost tea prepared from fraction (>2.8mm particle size) of rice straw compost and T9= Compost tea from fraction (0.6-1mm particle size) of rice straw compost.

**TABLE 5. Morphological characters of lentil cultivars as affected by various compost tea application.**

	2016/17 season					2017/18 season					
	Plant height(cm)	Branches No./plant	Shoot D.Wt. (g/plant)	Root D.Wt. (mg/plant)	Root area (cm <sup>2</sup> )	Plant height (cm)	Branches No./plant	Shoot D.Wt. (g/plant)	Root D.Wt. (mg/plant)	Root area (cm <sup>2</sup> )	
<b>Cultivars (Cv)</b>											
Giza 4	38.33	3.65	2.04	938.4	3.84	43.94	4.00	2.08	975.8	3.93	
Family 29	35.93	3.30	1.93	798.6	3.24	39.95	3.60	1.98	876.8	3.22	
LSD <sub>0.05</sub>	0.19	0.23	0.01	30.22	0.24	0.32	0.34	0.02	21.05	0.29	
<b>Compost tea (CT)</b>											
T0*	29.76	2.75	1.73	797.8	1.76	33.35	3.00	1.78	870.9	1.79	
T1	33.02	3.00	2.16	840.4	3.63	39.33	3.50	2.21	919.0	3.74	
T2	39.07	3.34	1.95	865.8	3.15	41.60	3.75	1.98	913.2	3.23	
T3	40.28	3.59	2.00	854.2	2.89	41.52	3.67	2.03	935.1	3.02	
T4	37.33	3.50	1.88	880.3	3.44	42.77	3.84	1.96	919.9	3.19	
T5	43.15	3.59	1.96	891.1	3.96	47.54	4.17	2.00	942.6	4.18	
T6	46.36	4.09	2.14	910.8	4.69	49.22	4.50	2.19	960.7	4.62	
T7	32.31	3.42	1.93	864.6	3.23	38.40	3.67	2.00	919.6	3.33	
T8	33.76	3.67	1.97	884.7	4.01	41.55	3.75	2.04	930.8	4.04	
T9	36.30	3.84	2.08	895.5	4.67	44.18	4.17	2.15	951.4	4.61	
LSD <sub>0.05</sub>	0.28	0.35	0.03	35.25	0.25	0.39	0.39	0.06	26.57	0.37	
<b>Interaction (Cv X CT)</b>											
Giza 4	T0	31.31	3.00	1.75	891.2	1.85	35.51	3.33	1.79	930.0	2.24
	T1	35.60	3.33	2.22	916.6	3.86	41.83	3.67	2.26	981.4	4.09
	T2	39.50	3.67	1.99	925.4	3.36	44.05	4.00	2.00	954.3	3.50
	T3	44.15	3.50	2.09	912.5	3.04	42.87	3.67	2.12	988.6	3.12
	T4	36.40	3.67	1.92	942.3	4.07	45.2	4.00	2.00	964.7	3.74
	T5	42.00	3.67	2.03	960.4	4.08	49.02	4.33	2.06	986.9	4.40
	T6	47.65	4.50	2.17	984.1	5.12	50.58	5.00	2.22	997.7	4.94
	T7	33.92	3.50	1.97	930.8	3.40	39.94	3.67	2.04	978.5	3.54
	T8	34.40	3.67	2.05	956.3	4.49	44.06	4.00	2.09	984.3	4.70
T9	38.37	4.00	2.17	964.6	5.13	46.31	4.33	2.23	991.7	5.03	
Family 29	T0	28.20	2.50	1.72	704.4	1.67	31.19	2.67	1.76	811.9	1.35
	T1	30.43	2.67	2.11	764.2	3.40	36.83	3.33	2.16	856.5	3.39
	T2	38.64	3.00	1.92	806.2	2.93	39.15	3.50	1.96	872.0	2.96
	T3	36.40	3.67	1.92	795.9	2.74	40.17	3.67	1.94	881.6	2.93
	T4	38.25	3.33	1.85	818.2	2.80	40.33	3.67	1.91	875.1	2.63
	T5	44.30	3.50	1.88	821.8	3.84	46.06	4.00	1.93	898.3	3.95
	T6	45.06	3.67	2.11	837.4	4.25	47.85	4.00	2.15	923.7	4.31
	T7	30.69	3.33	1.88	798.3	3.07	36.86	3.67	1.96	860.6	3.12
	T8	33.11	3.67	1.90	813.1	3.53	39.04	3.50	1.98	877.2	3.38
T9	34.22	3.67	2.00	826.3	4.21	42.04	4.00	2.07	911.1	4.19	
LSD <sub>0.05</sub>	0.39	0.50	0.07	49.85	0.35	0.56	0.54	0.09	37.56	0.60	

\*T0= Without compost tea (water), T1= Compost tea from unfractionated bagasse compost, T2= Compost tea from fraction (>2.8 mm particle size) of bagasse compost, T3= Compost tea from fraction (0.6-1mm particle size) of bagasse compost, T4= Compost tea from unfractionated cotton stalk compost, T5= Compost tea from fraction (>2.8mm particle size) of cotton stalk compost, T6= Compost tea from fraction (0.6-1mm particle size) of cotton stalk compost, T7= Compost tea from unfractionated rice straw compost, T8= Compost tea prepared from fraction (>2.8mm particle size) of rice straw compost and T9= Compost tea from fraction (0.6-1mm particle size) of rice straw compost.

Regarding the interactions between lentil cultivars and compost tea types for morphological parameters, Giza 4 cultivar positively showed a higher response to compost tea treatments than Family 29 especially with application of compost tea prepared from fine fractions of cotton stalk or rice straw more than sugarcane bagasse. On the other hand, untreated Family 29 plants recorded the lowest values of morphological parameters. The increment percentage obtained by the best interaction treatment (treated Giza 4 with T6) amounted to 65.40, 83.75, 26.15, 30.70 and 233.11 more than the lowest one (treated Family 29 cultivar with T0) for plant height, number of branches/plant, shoot dry weight/plant, root dry weight and root area, respectively as an average of both seasons. The superiority effect of compost tea obtained herein may be due to its roles in enhancing nodulation and the uptake and translocation of nutrients especially in the case of lentil cultivar that have more root area. In this concern, Badawi et al. (2014) mentioned that treated Giza 9 plants with bio-enriched compost tea at a rate of 200L/fad splitted in three equal doses was the best combination to enhance the growth characters of lentil.

#### *Nutritional status*

The data of nutritional status of plant (at 80 DAS) are presented in Table 6 as affected by cultivars, compost tea types and their interaction. Concerning the cultivars effect, shoots of Giza 4 surpassed Family 29 in NPK contents. These increases were amounted to 13.52% in nitrogen content, 18.61% in phosphorus content and 19.19% in potassium content as an average of the two growing seasons. Uptake of nutrients (P, K, Fe, Mn, Cu, Zn and Mo) significantly differed ( $P \leq 0.05$ ) among lentil genotypes, in favor of Barimasur 4 and Barimasur 3 genotypes that have more root hair structure (Gahoonia et al., 2006).

Regarding compost types, the results of nutritional status took the same trend of the vegetative growth and nodulation parameters in stimulation effects of compost tea and affirmed that compost tea prepared from finest particle size of cotton stalk or rice straw had a positive effect more than other unfractionated or relatively coarse fractions compost. Compost tea prepared from finest fraction of cotton stalk (T6) and rice straw (T9) revealed average increases during both seasons by 126.28 and 102.47% in nitrogen content, 105.59 and 79.61% in phosphorus content and 112.27 and 103.82% in potassium content, respectively over control (untreated plants). Furthermore, improve symbiotic nitrogen fixation as

an indicator by nitrogenase activity led to increase the nitrogen content in plants treated with compost tea. Also, compost tea as a source of PGPRs which play a vital role in soil health and nutrient availability according to various studies that confirmed such roles (Fritz et al., 2012; El-Gizawy et al., 2013 and Badawi et al., 2014). In this concern, Ali (2015) pointed out that treated faba bean plants with compost tea caused significant increases in the absorption rates of nutrients.

Regarding the interaction effect, data revealed that Giza 4 treated with any compost tea type exhibited increases in nutrient NPK contents over untreated plants with superiority of compost tea produced by finest particles of cotton stalk or rice straw compost. The result of nutrition status is a reflectance to the role of compost tea which develop a root system of plants (Tables 4 and 5) and thereby improve nutrients uptake. Badawi et al. (2014) stated that treated Giza 9 with bio-enriched compost tea at a rate of 200 or 300L/fad exhibited significant increases in nutrients content per shoots more than untreated Sinaa 1 plants.

#### *Chlorophyll content*

Data illustrated in Fig. 2 referred that the tested lentil cultivars significantly varied ( $P \leq 0.05$ ) in their chlorophyll content at 80 and 95 DAS in both seasons. Chlorophyll content was gradually increased with advanced age from 80 up to 95 DAS. The data showed that cultivar Giza 4 has a higher content of chlorophyll in their leaves at the two growth periods (35.03 and 38.18) in first season and (46.35 and 50.34) in second season, respectively. Kumar et al. (2012) showed significant genetic variability for chlorophyll content (SPAD value) in lentil genotypes (EC 208362, VKS 16/11, DPL 53, JL 1, and IPL 98/193). Significant increments in chlorophyll content were obtained by treated lentil plants with various compost tea compared to untreated plants (water only). Application of T6 (compost tea from fraction 0.6-1mm particle size of cotton stalk) performed the highest values (37.45 and 40.87) at 80 DAS and (47.23 and 53.50) at 95 DAS. Moreover, T9 took the next rank without significant differences with T6, which recorded (36.43 and 39.43) at 80 DAS and (46.16 and 52.37) at 95 DAS in the first and second seasons, respectively. The increment in chlorophyll content due to application compost tea more than untreated plants may be due to the positive effects of compost tea for enhancing the nutrients content. Chlorophyll content was significantly correlated with nitrogen content (Bojović & Marković, 2006).

TABLE 6. Nutritional status of lentil cultivars as affected by various compost tea application.

	2016/17 season			2017/18 season			
	Nitrogen content (mg/plant)	Phosphorus content (mg/plant)	Potassium content (mg/plant)	Nitrogen content (mg/plant)	Phosphorus content (mg/plant)	Potassium content (mg/plant)	
<b>Cultivars (Cv)</b>							
Giza 4	61.84	20.80	72.61	63.75	21.72	71.89	
Family 29	54.40	17.08	59.87	56.23	18.77	61.36	
LSD <sub>0.05</sub>	2.10	1.15	3.27	3.33	1.44	2.29	
<b>Compost tea (CT)</b>							
T0*	32.77	12.19	37.93	37.32	13.22	41.03	
T1	65.46	21.16	74.48	63.83	20.25	70.53	
T2	49.74	18.62	62.83	53.89	19.54	66.25	
T3	45.48	15.99	55.45	48.83	14.72	54.82	
T4	54.99	17.36	57.81	58.39	19.41	63.11	
T5	63.91	20.37	68.45	61.67	24.24	71.80	
T6	77.68	25.86	85.11	80.92	26.38	82.50	
T7	54.10	16.26	64.12	57.77	18.49	65.93	
T8	65.79	19.74	73.87	66.68	22.40	71.74	
T9	71.27	21.84	82.36	70.64	23.80	78.58	
LSD <sub>0.05</sub>	4.38	3.50	3.38	3.95	2.84	3.71	
<b>Interaction (Cv X CT)</b>							
Giza 4	T0	35.04	12.62	39.45	38.93	14.24	43.13
	T1	72.79	23.10	80.37	71.57	21.68	77.72
	T2	52.19	20.75	71.26	55.71	21.13	73.74
	T3	47.53	17.43	60.56	49.69	15.76	56.92
	T4	57.54	19.58	64.26	60.75	20.86	68.25
	T5	66.53	22.46	76.36	63.75	25.78	75.09
	T6	83.15	28.52	94.63	87.06	27.81	91.28
	T7	58.12	18.17	71.37	62.02	19.93	68.67
	T8	70.08	21.16	80.48	73.55	23.89	78.35
Family 29	T9	75.44	24.23	87.31	74.49	26.07	85.78
	T0	30.51	11.76	36.40	35.71	12.2	38.92
	T1	58.13	19.22	68.58	56.08	18.82	63.33
	T2	47.28	16.50	54.39	52.06	17.94	58.75
	T3	43.43	14.54	50.34	47.96	13.67	52.72
	T4	52.43	15.14	51.36	56.02	17.95	57.97
	T5	61.29	18.29	60.54	59.58	22.69	68.51
	T6	72.22	23.20	75.59	74.78	24.94	73.71
	T7	50.08	14.34	56.87	53.52	17.04	63.19
T8	61.50	18.31	67.25	59.80	20.91	65.12	
LSD <sub>0.05</sub>	6.20	4.95	4.78	5.86	4.02	5.25	

\*T0= Without compost tea (water), T1= Compost tea from unfractionated bagasse compost, T2= Compost tea from fraction (>2.8mm particle size) of bagasse compost, T3= Compost tea from fraction (0.6-1mm particle size) of bagasse compost, T4= Compost tea from unfractionated cotton stalk compost, T5= Compost tea from fraction (>2.8mm particle size) of cotton stalk compost, T6= Compost tea from fraction (0.6-1mm particle size) of cotton stalk compost, T7= Compost tea from unfractionated rice straw compost, T8= Compost tea prepared from fraction (>2.8mm particle size) of rice straw compost and T9= Compost tea from fraction (0.6-1mm particle size) of rice straw compost.

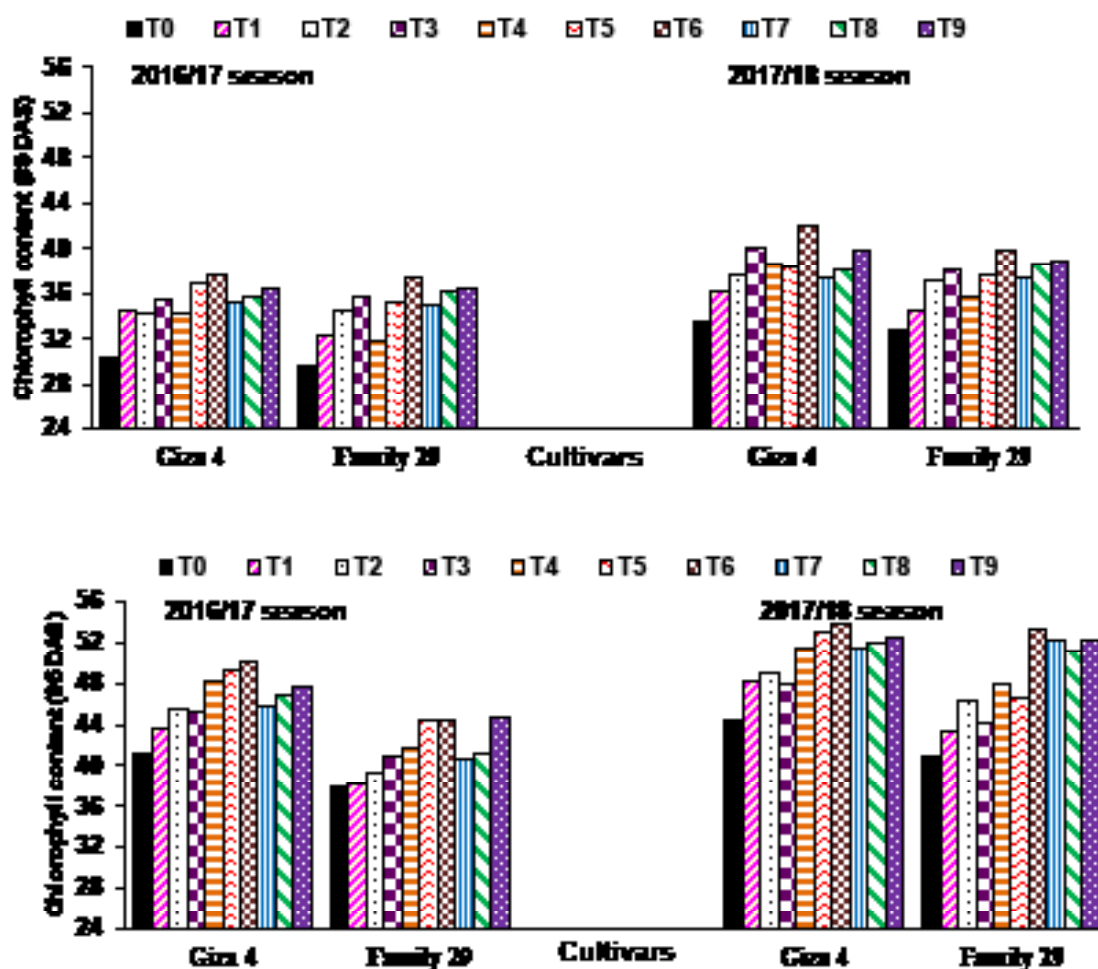


Fig. 2. Chlorophyll content of lentil cultivars as affected by compost tea application.

Effect of compost tea is dependable on lentil cultivars. It can be observed that the highest significant values of total chlorophyll were obtained when treated plants of Giza 4 cultivar with T6 which recorded (37.55 and 42.02) at 80 DAS and (50.13 and 53.74) at 95 DAS in the first and second seasons, respectively. On the other side, the lowest values (29.55 and 34.45) at 80 DAS and (37.80 and 40.87) at 95 DAS in the first and second seasons, respectively were achieved by untreated plants of Family 29 cultivar. This indicated that high pigments activity was produced and hence more photosynthetic activity was appeared by treated Giza 4 with compost tea prepared from finest fraction of cotton stalk.

*Yield and its components*

The average performance data of two lentil cultivars for yield characters studied are

presented in Table 7. The data showed that the tested cultivars significantly differed. Giza 4 cultivar produced the highest significant values of numbers of pods and seeds/plant, seed index, seed yield/plant and seed and biological yields/fad over than Family 29 cultivar. These increases were amounted to 16.64 and 11.65% for number of pods/plant, 19.95 and 14.66% for number of seeds/plant, 19.36 and 11.30% for seed yield/fad in the first and second seasons, respectively. The superiority of Giza 4 cultivar may be due to the raising in its number of nodules, nodules weights, nitrogenase activity and NPK contents. In this concern, Katerji et al. (2001), Mekkei & El-Haggan (2013) and Biçer et al. (2018) found variation among lentil varieties in their seed yield and its components.

Significant differences ( $P \leq 0.05$ ) were

detected in yield and its components by application of various compost tea in both seasons (Table 7). The positive effects were observed by application of cotton stalk followed by rice straw. However, bagasse took the next rank. Compost tea application resulted in superior seed yield/fad in terms of numbers of pods and seeds/plant, seed index, seed yield/plant than untreated treatment. Generally, yield and its components were significantly increased with fine fraction (0.6-1mm particle size) much than those of the fraction (>2.8mm particle size) or unfractionated compost. As an average of the two seasons, the increases in seed yield and biological yield/fad obtained from application of compost tea prepared from cotton stalk (T6) were amounted to 45.29 and 35.17% and reached by application of rice straw (T9) about 41.55 and 38.83%, respectively more than untreated plants (control treatment). The positive effect of compost tea on yield and its components may be attributed to its beneficial effects on seedling characters and during vegetative growth through enhancing nodulation, photosynthesis and nutrients uptakes. In this context, Badawi et al. (2014), Ali (2015) and Toklu (2015) obtained similar results.

The interaction between cultivars and compost tea application had significant effect on yield and its components. The data showed that treated Giza 4 plants with compost tea from fraction (0.6-1mm particle size) of cotton stalk (T6) or compost tea from fraction (0.6-1mm particle size) of rice straw (T9) were the best combination for achieving maximum yield and its components in the two seasons. As an average of both seasons, it can be noticed that these combination treatments caused increases amounted to 61.17 and 58.49% for seed yield/fad, 48.37 and 57.19% for biological yield more than untreated Family 29 cultivar plants, respectively. These increases might be explained on the basis of the increases in the number of branches/plant and shoots dry weight and consequently increase the photosynthesis surface where more photosynthates were available to increase pod setting and hence seed yield/plant. From these results, it could be concluded that the application of the previous combined treatments (treated Giza 4 with T6 or T9) may be recommended for promoting the plant growth characteristics and yield. In this concern, Badawi et al. (2014) mentioned that treated Giza 9 plants with bio-enriched compost tea at a rate of 200L/fad was

the best combination to enhance the yield and its components of lentil.

#### *Protein %*

Seed protein percentage was significantly affected by both cultivars and compost tea application as well as their interaction. Data depicted in Fig. 3 showed that the plants of Giza 4 cultivar produced the highest significant value of protein (27.72 and 28.19%) than Family 29 in both seasons, respectively.

The data showed increases in protein percentage when the tested compost tea were applied in favor of T6 (29.64 and 29.67%) followed by T9 (29.56 and 29.28%) without significant differences between them which produced the highest increases than the other compost tea types and untreated plants. Similar trend was obtained by Ali (2015).

Interaction data depicted in Fig. 3 shows that Giza 4 cultivar surpassed Family 29 in the protein percentage when their plants were applied with the finest compost tea (0.6-1mm particle size) T6 or T9 which produced the highest protein (30.57 and 30.02%) as an average of the two seasons, respectively. The stimulating effect of these combinations in increasing the protein % may be mainly due to their roles in enhancing nodulation parameters (Table 4) and nitrogen percentage in shoot (Table 6).

#### **Conclusion**

The obtained results showed the importance of recycling agricultural residues. Application of compost tea can be efficient organic fertilizer that maximizes lentil yield. The response of lentil was significantly differed by various cultivars. The combinations between Giza 4 cultivar and compost tea produced from fractions of small particles size (0.6-1mm) of cotton stalk or rice straw was found to be the best combination treatment for maximize lentil productivity under study conditions. This fractionation of compost based on particle size could be activated as a perfect practice for enhancing compost tea produced and this will in turn plant growth and yield improving. Therefore, it is necessary for further studies on compost fractionation of many various compost materials based on particles size to produce compost tea with specific characters more suitable for different crops.

**TABLE 7. Yield and its components of lentil cultivars as affected by various compost tea application.**

	2016/17 season					2017/18 season							
	Pods No./ plant	Seeds No./ plant	1000-seed wt. (g)	Seed yield/ plant (g)	Seed yield/ fad (kg)	Biological yield/ fad (kg)	Pods No./ plant	Seeds No./ plant	1000-seed wt. (g)	Seed yield/ plant (g)	Seed yield/ fad (kg)	Biological yield/fad (kg)	
<b>Cultivars (Cv)</b>													
Giza 4	35.60	38.30	48.57	1.408	669.47	2200.26	38.43	40.05	50.01	1.518	673.78	2197.41	
Family29	30.52	31.93	46.20	1.270	560.87	1943.67	34.42	34.93	44.49	1.380	605.33	1984.53	
LSD <sub>0.05</sub>	2.05	3.16	0.90	0.13	24.12	35.68	2.68	4.11	1.40	0.11	11.68	31.90	
<b>Compost tea (CT)</b>													
T0*	24.09	24.50	42.46	1.060	482.96	1544.56	28.92	27.00	43.02	1.136	524.23	1852.21	
T1	27.34	29.50	44.19	1.154	522.91	1760.49	32.42	33.50	44.63	1.338	560.58	1928.82	
T2	33.67	37.84	43.87	1.373	596.29	2003.99	35.42	36.09	45.18	1.469	590.92	1957.49	
T3	29.92	29.67	44.94	1.238	568.42	1932.54	33.17	35.00	45.66	1.321	632.04	2048.49	
T4	34.50	39.17	48.33	1.501	659.19	2201.31	40.92	38.67	48.69	1.564	663.32	2146.53	
T5	39.42	38.59	50.29	1.517	646.65	2303.61	39.00	42.83	49.31	1.584	686.10	2147.41	
T6	42.34	45.34	50.63	1.581	727.70	2367.32	43.09	46.75	49.72	1.623	735.61	2224.03	
T7	28.09	32.50	49.35	1.062	594.53	2106.45	33.50	39.42	48.15	1.382	640.47	2082.38	
T8	34.17	34.50	48.76	1.352	634.23	2152.02	38.00	35.59	48.18	1.457	655.48	2153.93	
T9	37.09	39.59	51.01	1.554	718.81	2347.32	39.84	40.09	49.99	1.615	706.86	2368.42	
LSD <sub>0.05</sub>	4.13	5.89	1.62	0.21	36.57	47.87	5.05	4.76	3.40	0.27	29.57	53.06	
<b>Interaction (Cv X CT)</b>													
Giza 4	T0	26.50	28.33	43.35	1.160	504.54	1608.90	31.50	30.50	45.14	1.206	541.61	1915.37
	T1	28.67	31.50	44.91	1.265	588.61	1824.66	34.33	35.33	47.32	1.339	602.84	1996.47
	T2	36.33	40.67	45.35	1.476	660.31	2046.61	37.50	38.67	46.27	1.551	634.21	2023.03
	T3	31.50	34.00	46.11	1.312	622.20	2021.82	35.67	36.00	48.63	1.532	653.79	2109.30
	T4	37.50	41.33	50.13	1.511	707.23	2347.32	41.33	39.67	51.09	1.584	691.65	2224.50
	T5	43.33	40.67	51.22	1.592	732.47	2425.44	40.00	44.33	52.20	1.616	718.64	2205.47
	T6	45.67	49.00	52.08	1.629	783.66	2522.16	44.50	50.50	52.89	1.675	776.79	2328.30
	T7	30.50	36.50	50.94	1.074	654.83	2339.88	36.33	42.33	51.91	1.510	672.31	2261.03
	T8	36.33	38.33	50.03	1.455	662.62	2364.06	40.50	38.50	51.38	1.497	689.62	2273.33
	T9	39.67	42.67	51.54	1.607	778.19	2501.70	42.67	44.67	53.25	1.669	756.38	2637.27
Family 29	T0	21.67	20.67	41.56	0.960	461.38	1480.21	26.33	23.50	40.89	1.065	506.85	1789.05
	T1	26.00	27.50	43.47	1.043	457.21	1696.32	30.50	31.67	41.94	1.337	518.31	1861.17
	T2	31.00	35.00	42.39	1.270	532.27	1961.37	33.33	33.50	44.09	1.387	547.62	1891.94
	T3	28.33	25.33	43.77	1.164	514.63	1843.26	30.67	34.00	42.68	1.109	610.28	1987.67
	T4	31.50	37.00	46.53	1.491	611.15	2055.30	40.50	37.67	46.28	1.544	634.98	2068.56
	T5	35.50	36.50	49.35	1.442	560.82	2181.78	38.00	41.33	46.42	1.552	653.55	2089.35
	T6	39.00	41.67	49.17	1.533	671.74	2212.47	41.67	43.00	46.54	1.570	694.42	2119.76
	T7	25.67	28.50	47.75	1.049	534.23	1873.02	30.67	36.50	44.38	1.253	608.63	1903.72
	T8	32.00	30.67	47.49	1.249	605.84	1939.98	35.50	32.67	44.98	1.417	621.34	2034.53
	T9	34.50	36.50	50.47	1.501	659.43	2192.94	37.00	35.50	46.73	1.561	657.34	2099.56
LSD <sub>0.05</sub>	5.84	8.32	2.30	0.30	51.70	67.68	7.15	6.73	4.80	0.38	41.80	75.03	

\*T0= Without compost tea (water), T1= Compost tea from unfractionated bagasse compost, T2= Compost tea from fraction (>2.8mm particle size) of bagasse compost, T3= Compost tea from fraction (0.6-1mm particle size) of bagasse compost, T4= Compost tea from unfractionated cotton stalk compost, T5= Compost tea from fraction (>2.8mm particle size) of cotton stalk compost, T6= Compost tea from fraction (0.6-1mm particle size) of cotton stalk compost, T7= Compost tea from unfractionated rice straw compost, T8= Compost tea prepared from fraction (>2.8mm particle size) of rice straw compost and T9= Compost tea from fraction (0.6-1mm particle size) of rice straw compost.

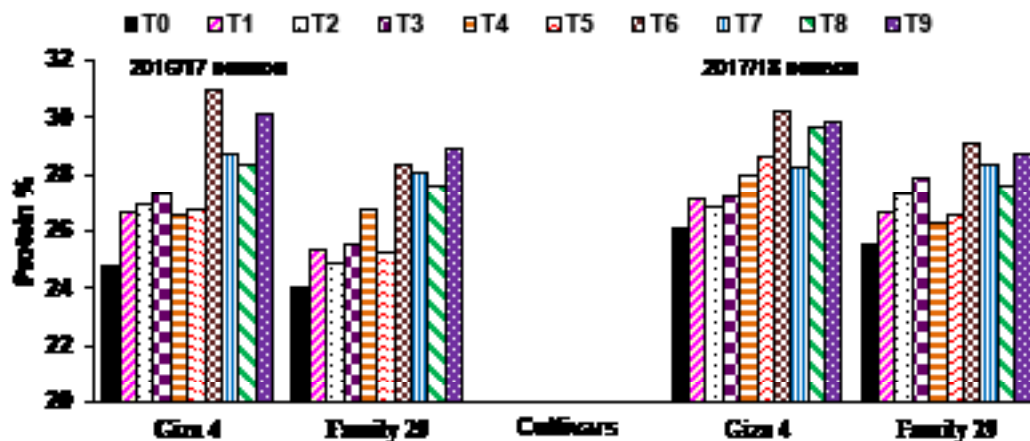


Fig. 3. Protein percentage of lentil seed cultivars as affected by compost tea application.

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## تأثير إضافة أنواع مختلفة من شاي الكمبوست على الإنبات وتكوين العقد الجذرية والصفات المورفولوجية والمحصولية لصنفين من العدس

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أجريت تجربتان معملية وحقلية بمعمل قسم المحاصيل، بالمزرعة التجريبية لكلية الزراعة بشبين الكوم جامعة المنوفية – مصر بهدف دراسة استجابة صنفى العدس (جيزة 4 و عائلة 29) للإنبات وصفات البادرات، تكوين ونشاط العقد الجذرية، النمو الخضري، امتصاص العناصر الغذائية، الصفات المحصولية عند إضافة شاي الكمبوست الناتج من مصادر مختلفة من المخلفات الزراعية (مصاص القصب، سيقان القطن و قش الأرز) ودرجات مختلفة على أساس حجم حبيبات الكمبوست المنتج (بدون تدريج – خشن نسبياً – ناعم). و قد تمت إضافة شاي الكمبوست بطريقتان نقعاً للبذور قبل الزراعة علاوة على الإضافة الورقية خلال فترات النمو (بعد 25 و 55 يوم من الزراعة). هذا وقد أظهرت النتائج تفوق الصنف جيزة 4 تفوقاً معنوياً على صنف عائلة 29 في جميع الصفات المدروسة باستثناء نسبة الإنبات، حيث تفوق صنف جيزة 4 على صنف عائلة 29 بمقدار 19.36 و 11.30% لصفة محصول البذور خلال الموسم الأول والثاني على الترتيب.

سجلت معاملات شاي الكمبوست الناتج من كمبوست سيقان القطن أو قش الأرز ذو حجم الحبيبات الناعم (1-0.6 مم) أعلى قيم لصفات نسبة الإنبات وصفات البادرات، تكوين العقد الجذرية ونشاطها، النمو الخضري، محتوى المجموع الخضري للنبات من العناصر الغذائية (النيتروجين، الفوسفور و البوتاسيوم)، محتوى الأوراق من الكلورفيل، المحصول ومكوناته، نسبة البروتين بالبذور مقارنة ببقية مصادر ودرجات الكمبوست الأخرى .

تُشير نتائج التفاعل بين أصناف العدس و أنواع شاي الكمبوست المختبرة إلى وجود اختلافات معنوية لمعظم الصفات المدروسة. هذا وقد اختلفت استجابة صنفى العدس لإضافة أنواع شاي الكمبوست المختبرة حيث أدى معاملة صنف العدس جيزة 4 بشاي الكمبوست الناتج من كمبوست سيقان القطن أو قش الأرز ذو حجم الحبيبات الناعم (1-0.6 مم) إلى تحقيق أعلى قيم لصفات تكوين العقد الجذرية ونشاطها، للصفات المورفولوجية والمحصولية للعدس، مما يشير إلى أهمية استخدام شاي الكمبوست في تعظيم إنتاجية العدس .