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INFLUENCE OF COMPOST, MINERAL AND EFFECTIVE MICROORGANISMS APPLICATION ON SANDY SOIL-GROWN BERMUDA TURFGRASS

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ABSTRACT: Two field experiments were conducted during 2016 and 2017 seasons at the Experimental Farm, Fac. Agric., Minia Univ. to study the effect of compost, mineral NPK and/or Effective microorganisms (E.M.) on the performance and chemical constituents of bermuda grass grown in sandy soil.

Obtained results revealed that compost, especially when added at the high level (22.5 ton/fed), as well as, 75 % NPK + E.M. caused considerable increase in all studied vegetative growth characters, as well as, the three photosynthetic pigments and N, P and K %. However, the high compost level (22.5 ton/fed) in combination with the dual fertilization treatment (75 % NPK + E.M.) resulted in the highest overall grown and the best performance of bermuda turf grass grown in sandy soil.

Key words: bermuda grass, compost, NPK, effective microorganisms (E.M.), vegetative growth, chemical constituents.

INTRODUCTION

Turfgrasses are used for home lawns, commercial landscapes, athletic fields and golf courses to improve quality of life by providing open space, recreational business opportunities, enhancing property values and the conservation of important natural resources, (Duble, 2010). Bermuda grass (*Cynodon dactylon*, L.) is the most common lawn grass in Egypt. Therefore it represents the largest part of the green area of any garden. It is used as front view for trees, shrubs and flower beds. It plays an important role in controlling soil erosion, stabilizing dust, abating noise and dissipating heat. In addition, its use in the playground of soccer and golf-course sports and airports is must.

The present research was planted to substitute, partially or completely the convention, regularly used, mineral NPK fertilizers by compost and/or Effective microorganisms (E.M.) in planting bermuda grass in sandy soils. Many researchers reported the beneficial influences of compost or other organic fertilizers on vegetative growth and/or chemical constituents of different turfgrasses such as Loschinkohi and Boehm (2001), Sellers *et al.* (2002), Lawson (2002), Montemurro *et al.* (2004), Sakr *et al.* (2008), Abd-Elgaber (2010), Ziblim *et al.* (2012), Javahery *et al.* (2012), Abdou *et al.* (2013), Kumar and Nikhil (2016) and Vennila and Sankaran (2017). Some other investigators concluded the desirable effects of E.M. and other related biofertilizer products on numerous turfgrass sp such as Jakab (2008), Stasmenov *et al.* (2012), Yuojen (2015), Dwivedi *et al.* (2016) and Kumar and Nikhil (2016). Similar beneficial effects were pointed out on yarrow (Abdou *et al.*, 2015 and Mohamed, 2016);

lemongrass (El-Nady, 2015) and *Gardenia jasminoides* (Badran *et al.*, 2017). However, the positive effects of mineral NPK on the performance and chemical composition of turfgrasses was reported by Soliman (1992), Trenholm *et al.* (1998), Li *et al*. (2000), Manoly (2000), Hassan (2012), Popovici *et al*. (2012), Badran *et al.* (2015) and Dergham *et al*. (2017).

MATERIALS AND METHODS

The seeds were obtained from Hamza Co., Giza, Egypt. The experiment was arranged in randomized complete block design (RCBD) in split plot design, with three replicates, *i.e.* four compost levels (0, 7.5, 15.0 and 22.5 ton/fed) in the main plots and four (NPK and/or E.M.) treatments (0, 100 % NPK, E.M. and 75 % NPK + E.M.) in the sub-plots. The planting area was digged out to 25 cm depth., then refilled with sandy soil mixed with the assigned levels of compost (0, 7.5, 15.0 and 22.5 ton/fed) according to the tested treatments. Experimental unit was 1.5 × 1.0 meter. Each one of the four compost levels was separated from the other by wood layers. Physical and chemical properties of the used soil are shown in Table (1).

The used compost, with physical and chemical properties as shown in Table (2), which named El-Neel compost was obtained from the Egyptian Co. for Solid Waste Utilization, New Minia City, was mixed thoroughly with the sandy soil before refilling the plots according to the four different compost treatments.

Table 1. Physical and chemical properties of the used soil before planting of Bermuda grass during 2016 and 2017 seasons.

Character	Value		Character		Value	
	2016	2017			2016	2017
Sand (%)	88.00	89.00	**Total N (%)**		0.02	0.02
Silt (%)	8.30	7.40	**Available P (%)**		3.25	3.56
Clay (%)	3.70	3.60	**Exch. K (mg/100 g soil)**		0.90	1.01
Texture	Sandy	Sandy	**DPTA Ext. (ppm)**	**Fe**	1.10	1.18
CaCO3 (%)	14.42	14.91		**Cu**	0.39	0.43
pH	8.17	8.21		**Zn**	0.36	0.30
Organic matter (%)	0.06	0.05		**Mn**	0.60	0.71
E. C. (mmhos/cm)	1.09	1.11				

Table 2. Physical and chemical properties of the used compost.

Character	Value	Character	Value
Dry weight of 1 m^3	450 kg	**C/N ratio**	14.1-18.5
Fresh weight of 1 m^3	650-700 kg	**NaCl (%)**	1.10-1.75
Moisture (%)	25-30	**Total P (%)**	0.50-0.75
pH 1:10	7.5-8	**Total K (%)**	0.8-1.0
E.C. (m mhose/cm)	2-4	**Fe (ppm)**	150-200
Total N (%)	1-1.4	**Mn (ppm)**	25-56
Organic matter (%)	32-34	**Cu (ppm)**	75-150
Organic carbon (%)	18.5-19.7	**Zn (ppm)**	150-225

The seeds of bermuda grass were sown by broadcasting method on April 25th of both seasons at the rate of 1 kg/25 m^2 (60 g/1.5 m^2). Irrigation was done promptly every day for the first 10 days, then every two days for the second 10 days and every three days for the fourth week using a hand sprayer, then irrigation was applied regularly thereafter. So, the main plots included four level treatments, namely, zero, 7.5, 15.0 and 22.5 ton/fed compost. While, the sub-plots were consisted of control, 100 % NPK, E.M. and 75 % NPK + E.M. The full dose of NPK (100 %) were 300 kg/fed of ammonium sulphate (20.5 % N) + 200 kg/fed of calcium superphosphate (15.5 % P_2O_5) + 100 kg/fed of potassium sulphate (48 % K_2O), so, the 100 % NPK = 112.5 + 75 + 37.5 g/1.5 m^2 and 75 % NPK = 84.4 + 56.3 + 28.1 g/1.5 m^2. All assigned phosphorus fertilizer amounts were applied to the sandy soil before planting, while those of N and K fertilizers were divided into three equal batches and added at one month intervals starting June 1st for both seasons. Meanwhile, E.M. obtained from the laboratory of biofertilizers, Dept. of Genetics, Fac. Agric., Minia Univ. was applied three times as foliar spray at the rate of 500 cm^3/1.5 m^2 after 38 days from sowing date and each one month thereafter. All other agricultural practices were performed as usual.

Three clippings were taken on the first day of July, August and September for both seasons. Data for vegetative growth were recorded three times for each season for plant height (cm) one day before each clipping, covering density %, clipping fresh weight (kg) and clipping dry weight (g). In addition, the three photosynthetic pigments *i.e.* chlorophyll a, chlorophyll b and carotenoids content (mg/g F.W.) were determined in the third clipping according to Moran (1982), while N, P and K %, taken also from the third clipping, were determined following the methods of Wilde *et al.* (1985), Chapman and Pratt (1975) and Cottenie *et al*. (1982), respectively.

Obtained data for vegetative growth and chemical constituents were tabulated and statistically analyzed according to the method of MSTAT-C (1986).

RESULTS AND DISCUSSION

1. Vegetative growth parameters:

All of the four studied vegetative growth characteristics, plant height, covering density % and fresh and dry weights of the clippings, in the two experimental seasons, were gradually increased from the first clipping and up to the third clipping regardless of compost level treatments and NPK/E.M. treatments.

a. Plant height (cm):

Plant height of bermuda grass became significantly, taller due to the three used compost levels 7.5, 15.0 and 22.5 ton/fed for the three used clippings in comparison with control treatment, in both seasons, as shown in Table (3). Moreover, plant height was gradually increased parallel to the increase in compost level with the tallest plants being obtained due to the high compost level (22.5 ton/fed) in each of the first, second and third clipping. The role of organic fertilizers in promoting plant height was reported by Loschinkohi and Boehm (2001) on two turfgrasses sp.; Montemurro *et al.* (2004), Abd-Elgaber (2010) and Abdou *et al.* (2013) on *Lolium perenne* and Kumar and Nikhil (2016) on vetiver grass. Concerning the other factor, its three treatments, mineral NPK, E.M. and 75 % NPK + E.M. proved to be significantly capable of augmenting plant height of the three clippings in both seasons over the control treatments as clearly indicated in Table (3). Among such three fertilization treatments, the highest values, in descending order, were due to the dual one (75 % NPK + E.M., NPK and E.M.). These results provided to consistently true in the two seasons for the three clippings, (Table, 3). In agreement with results, obtained by mineral NPK were the findings of Soliman (1992) on *Lolium perenne*; Manoly (2000) on bermuda grass; Hassan (2012) on some turfgrasses sp.; Badran *et al*. (2015) on three

Table 3. Effect of compost and mineral NPK and/or E.M. biofertilizer treatments on plant height (cm) of bermuda grass during 2016 and 2017 seasons.

Mineral NPK and/or E.M. biofertilizer treatments (B)	Compost level treatments (ton/fed) (A)									
	1st season (2016)					2nd season (2017)				
	0.0	7.5	15.0	22.5	Mean (B)	0.0	7.5	15.0	22.5	Mean (B)
					1st Clipping					
Control	8.5	14.8	16.5	18.3	8.5	10.3	17.3	19.3	21.2	17.0
100 % NPK	13.8	19.5	22.3	24.4	13.8	15.2	24.3	24.4	24.9	22.1
E.M. biofertilizer	13.1	19.4	21.3	23.7	13.1	16.0	21.9	23.9	24.9	21.7
75 % NPK + E.M.	16.4	23.3	24.0	24.2	16.4	19.4	25.0	27.0	27.3	24.7
Mean (A)	13.0	19.3	21.0	22.7	13.0	15.2	22.1	23.7	24.5	21.4
L.S.D. at 5 %	A : 1.0		B : 1.2		AB : 2.4	A : 0.8		B : 1.2		AB : 2.4
					2nd Clipping					
Control	10.3	13.6	21.8	21.8	16.9	14.4	16.7	23.5	23.6	19.6
100 % NPK	15.1	19.8	22.3	26.3	20.9	21.4	24.4	24.0	23.2	23.3
E.M. biofertilizer	17.7	21.2	20.5	20.9	20.1	17.5	22.6	22.1	24.1	21.6
75 % NPK + E.M.	20.9	24.3	24.3	26.3	24.0	22.5	25.7	27.2	28.3	25.9
Mean (A)	16.0	19.7	22.2	23.8	20.5	19.0	22.4	24.2	24.8	22.6
L.S.D. at 5 %	A : 1.2		B : 1.7		AB : 3.4	A : 0.6		B : 1.7		AB : 3.4
					3rd Clipping					
Control	14.4	15.4	20.4	22.2	18.1	18.3	18.8	23.0	25.3	21.4
100 % NPK	18.5	22.6	25.4	26.8	23.3	23.3	25.3	27.3	29.3	26.3
E.M. biofertilizer	22.2	23.3	21.0	22.1	22.2	22.7	21.7	25.3	25.7	23.9
75 % NPK + E.M.	22.8	25.8	25.4	27.3	25.3	25.3	28.0	31.0	33.0	29.3
Mean (A)	19.5	21.8	23.1	24.6	22.2	22.4	23.5	26.7	28.3	25.2
L.S.D. at 5 %	A : 1.2		B : 1.0		AB : 2.0	A : 1.0		B : 2.1		AB : 4.2

warm season turfgrasses and Dergham *et al*. (2017) on seashore paspalum and concerning biofertilizers were those of Stasmenov *et al.* (2012) on English rye grass; Dwivedi *et al.* (2016) and Kumar and Nikhil (2016) on vetiver grass; Mohamed (2016) on yarrow and Badran *et al.* (2017) on *Gardenia jasminoides*. The interaction among compost levels and NPK+E.M. treatments were significant in both seasons for the three clippings. The highest values were obtained due to the application of the medium or high compost levels (15.0 or 22.5 ton/fed) in combination with the dual NPK+E.M. fertilization treatment (75 % NPK + E.M.).

b. Covering density %:

All applied compost levels, for the three clippings and in the two seasons proved to be significantly effective in increasing the covering density % of bermuda grass in comparison with control plants. Moreover significant differences were existed between each two successive compost levels with gradual increase in covering density % parallel to the gradual increase in the level of the applied compost. Such results were typically similar for the three clippings in both seasons as shown in Table (4). The covering density %, due to the use of the

Table 4. Effect of compost and mineral NPK and/or E.M. biofertilizer treatments on covering density % of bermuda grass during 2016 and 2017 seasons.

Mineral NPK and/or E.M. biofertilizer treatments (B)	Compost level treatments (ton/fed) (A)									
	1st season (2016)					2nd season (2017)				
	0.0	7.5	15.0	22.5	Mean (B)	0.0	7.5	15.0	22.5	Mean (B)
					1st Clipping					
Control	26.7	33.7	42.7	48.0	37.8	32.3	39.0	46.3	53.3	42.7
100 % NPK	30.3	37.7	52.7	59.0	44.9	37.0	47.7	52.7	62.0	49.9
E.M. biofertilizer	27.7	38.7	47.7	55.3	42.4	34.7	40.7	49.7	59.0	46.0
75 % NPK + E.M.	37.3	51.0	61.0	74.0	55.8	49.7	63.3	65.0	74.7	63.2
Mean (A)	30.5	40.3	51.0	59.1	45.2	38.4	47.7	53.4	62.3	50.5
L.S.D. at 5 %	A : 3.7		B : 1.9		AB : 3.8	A : 2.6		B : 1.7		AB : 3.4
					2nd Clipping					
Control	34.3	40.7	49.0	58.7	45.7	37.7	41.0	49.3	55.3	45.8
100 % NPK	41.7	54.7	61.0	71.3	57.2	45.7	58.3	63.7	74.3	60.5
E.M. biofertilizer	37.0	46.7	51.7	65.0	50.1	41.3	50.0	55.0	65.0	52.8
75 % NPK + E.M.	49.7	58.7	75.3	77.0	65.2	53.0	74.7	75.7	82.0	71.4
Mean (A)	40.7	50.2	59.3	68.0	54.6	44.4	56.0	60.9	69.2	57.6
L.S.D. at 5 %	A : 3.1		B : 2.5		AB : 5.0	A : 1.6		B : 1.4		AB : 2.8
					3rd Clipping					
Control	40.7	47.3	55.3	66.0	52.3	38.0	46.3	53.7	63.7	50.4
100 % NPK	48.7	61.0	67.7	77.3	63.7	46.3	59.0	65.7	83.7	63.7
E.M. biofertilizer	45.7	53.3	59.0	70.7	57.2	41.7	51.7	56.7	67.7	54.5
75 % NPK + E.M.	55.7	76.3	78.0	84.0	73.5	53.3	71.3	73.7	85.0	70.8
Mean (A)	47.7	59.5	65.0	74.5	61.7	44.8	57.1	62.5	75.0	59.9
L.S.D. at 5 %	A : 4.2		B : 2.1		AB : 4.2	A : 1.7		B : 1.7		AB : 3.4

high compost level (22.5 ton/fed) recorded 59.1, 68.0 and 74.5 % for the first, second and third clippings, respectively in the first season against 30.5, 40.7 and 47.7 %, respectively for the control treatment. Similar trend was observed in the second season, (Table 4). The role of organic fertilization in promoting the coverage % was found on different turfgrass species such as different turfgrass sp. (Loschinkohi and Boehm, 2001 and Sellers *et al.,* 2002); *Zoysia japonica* (Sakr *et al.,* 2008); *Lolium perenne* (Abd-Elgaber, 2010) and Napier grass (Vennila and Sankaran, 2017). On the other hand, mineral NPK and/or E.M. fertilizers emphasized also, their capability in inducing the covering density % of bermuda grass plants in both seasons and along the three clippings as illustrated in Table (4). The differences among each one of the three compost treatments and the control one were significant in both seasons for the three clippings. But among such three fertilization treatments, the dual one (75 % NPK + E.M.) overgrew significantly the other two treatments (100 % NPK or E.M.). In the second place came the 100 % NPK treatment, while, E.M. registered the lowest covering density %, (Table 4). In agreement with these results concerning NPK were those found on bermuda grass (Trenholm *et al.,* 1998); four turfgrass cultivars (Li *et al.*, 2000); different turfgrasses (Trenholm *et al.,* 2000); three warm season turfgrasses (Badran *et al.,* 2015) and seashore paspalum (Dergham *et al.,* 2017) and concerning biofertilizers were those indicated on *Lolium perenne* (Jakab, 2008); English ryegrass (Stasmenov *et al.*, 2012); lemongrass (El-Nady, 2015) and paspalum grass (Dwivedi *et al.,* 2016). Table (4) showed that the interaction between the two involved factors was significant in the two seasons and for the three clippings. The highest overall covering density % were obtained when bermuda grass plants were supplied with the high compost level (22.5 ton/fed) in combination with the dual treatment of 75 % NPK + E.M. Covering density % due to this superior treatment reached 74.0, 77.0 and 84.0 % in the first season and 74.7, 82.0 and 85.0 % in the second season for the first, second and third clipping, respectively as shown in Table (4).

c. Clipping fresh weight:

The three clippings fresh weight, in the two seasons, were gradually and consistently increased parallel to the gradual increase in the applied compost level from zero to 22.5 ton/fed with significant differences being detected between each two consecutive levels. The increase in the three clippings for both seasons due to the high compost level (22.5 ton/fed) was dramatic as it reached more than three folds in comparison with those given by control treatment (zero ton/fed). In agreement with these results were the findings of Loschinkohi and Boehm (2001) on two turfgrasses sp.; Montemurro *et al*. (2004), Abd-Elgaber (2010) and Abdou *et al.* (2013) on *Lolium perenne* and Kumar and Nikhil (2016) on vetiver grass. Concerning mineral NPK and/or E.M. biofertilizer treatments, all of them in the two seasons and along the three clippings, caused considerable and significant increase in clipping fresh weight in comparison with unfertilized control treatment as shown in Table (5). Among the three fertilization treatments, the highest clipping fresh weight was obtained from the dual treatment (75 % NPK + E.M.), followed by 100 % NPK, while E.M. treatment gave the lowest values. These findings were similar in the two seasons and along the three clippings. In accordance with these results concerning mineral NPK were those reported by Soliman (1992) on *Lolium perenne*; Trenholm *et al.* (1998) on bermuda grass and Li *et al.* (2000), Trenholm *et al.* (2000) and Hassan (2012) on different turfgrass sp. In agreement with our results dealing with biofertilizers were the findings of Stasmenov *et al.* (2012) on English rye grass; Dwivedi *et al.* (2016) on paspalum turfgrass; Kumar and Nikhil (2016) on vetiver grass; Mohamed (2016) on yarrow plants and Badran *et al.* (2017) on *Gardenia jasminoides*. The interaction between compost levels and NPK+E.M. treatments were significant in the two seasons and for the three clippings, with the heaviest overall clipping fresh weight being obtained due to the application of the high compost level (22.5 ton/fed) in combination with 75 % NPK + E.M. dual treatment.

d. Clipping dry weight (g):

Clipping dry weight of bermuda grass, in the two seasons and along the three clippings in response to compost levels, NPK/E.M. treatments and the interaction between them, took the same trend like that illustrated for clipping fresh weight. Each one of the three compost levels, in both seasons and for the three clippings produced significantly heavier dry weight than that of the control treatment, with a gradual increase be observed according to the increase in compost level. The numerical increase due to 7.5, 15.0 and 22.5 ton compost/fed reached 57.9, 170.3 and 218.5 % in the first clipping; 116.9, 237.7 and 304.5 % in the second clipping and 87.4, 162.1 and 196.1 % in the third clipping in the first season in comparison with control treatment. Almost similar findings were recorded in the second

Table 5. Effect of compost and mineral NPK and/or E.M. biofertilizer treatments on clippings fresh weight (kg) of bermuda grass during 2016 and 2017 seasons.

Mineral NPK and/or E.M. biofertilizer treatments (B)	Compost level treatments (ton/fed) (A)									
	1st season (2016)					2nd season (2017)				
	0.0	7.5	15.0	22.5	Mean (B)	0.0	7.5	15.0	22.5	Mean (B)
					1st Clipping					
Control	0.222	0.733	1.278	1.400	0.908	0.226	0.748	1.304	1.428	0.926
100 % NPK	0.457	0.812	1.603	1.967	1.210	0.466	0.828	1.635	2.006	1.234
E.M. biofertilizer	0.412	0.798	1.543	1.807	1.140	0.420	0.814	1.574	1.843	1.163
75 % NPK + E.M.	1.223	1.303	1.823	2.057	1.602	1.247	1.329	1.859	2.098	1.634
Mean (A)	0.579	0.912	1.562	1.808	1.215	0.591	0.930	1.593	1.844	1.239
L.S.D. at 5 %	A : 0.082		B : 0.061		AB : 0.122	A : 0.091		B : 0.067		AB : 0.134
					2nd Clipping					
Control	0.328	1.025	1.320	1.763	1.109	0.335	1.046	1.346	1.798	1.131
100 % NPK	0.633	0.923	2.017	2.517	1.523	0.646	0.941	2.057	2.546	1.548
E.M. biofertilizer	0.440	1.217	1.850	2.132	1.410	0.449	1.241	1.887	2.175	1.438
75 % NPK + E.M.	0.837	1.617	2.367	2.633	1.864	0.854	1.649	2.414	2.686	1.901
Mean (A)	0.560	1.196	1.889	2.261	1.136	0.571	1.220	1.927	2.301	1.505
L.S.D. at 5 %	A : 0.072		B : 0.068		AB : 0.124	A : 0.083		B : 0.071		AB : 0.142
					3rd Clipping					
Control	0.733	1.600	1.717	2.223	1.568	0.748	1.632	1.751	2.267	1.599
100 % NPK	1.017	1.747	2.923	3.121	2.202	1.037	1.782	2.981	3.174	2.244
E.M. biofertilizer	0.833	1.800	2.800	3.050	2.121	0.850	1.836	2.856	3.111	2.163
75 % NPK + E.M.	1.267	2.233	2.883	3.267	2.413	1.292	2.278	2.941	3.332	2.461
Mean (A)	0.963	1.845	2.581	2.915	2.076	0.982	1.882	2.633	2.971	2.117
L.S.D. at 5 %	A : 0.116		B : 0.074		AB : 0.148	A : 0.121		B : 0.079		AB : 0.158

season (Table 6). In agreement with these results were those found by Sellers *et al.* (2002) on three turfgrasses sp.; Sakr *et al.* (2008) on *Zoysia japonica*; Abdou *et al.* (2013) on *Lolium perenne*; Kumar and Nikhil (2016) on vetiver grass and Vennila and Sankaran (2017) on Napier grass. In relation to NPK and/or E.M. fertilization treatments, each one of them was capable of augmenting clipping dry weight in both seasons and along the three clippings as shown in Table (6). The heaviest dry weight, in descending order, was obtained due to the dual treatment (75 % NPK + E.M.), 100 % NPK and E.M. This trend proved to be true in both first and second seasons and along the three clippings. In close agreement with these results concerning mineral NPK were the findings of Li *et al.* (2000) and Trenholm *et al.* (2000) on different turfgrasses; Manoly (2000) on bermuda grass; Badran *et al.* (2015) on the three warm seasons turfgrasses and Dergham *et al.* (2017) on seashore paspalum. Meanwhile, the role of biofertilizers was pointed out by Jakab (2008) on *Lolium perenne*; Yuojen (2015) on bermuda grass; Dwivedi *et al.* (2016) on paspalum grass; Kumar and Nikhil (2016) on

Table 6. Effect of compost and mineral NPK and/or E.M. biofertilizer treatments on clippings dry weight (g) of bermuda grass during 2016 and 2017 seasons.

Mineral NPK and/or E.M. biofertilizer treatments (B)	Compost level treatments (ton/fed) (A)									
	1st season (2016)					2nd season (2017)				
	0.0	7.5	15.0	22.5	Mean (B)	0.0	7.5	15.0	22.5	Mean (B)
					1st Clipping					
Control	28.8	95.3	165.9	182.0	118.0	29.4	97.2	169.2	185.6	120.4
100 % NPK	59.4	105.9	208.4	272.3	161.5	60.6	108.0	212.6	277.7	164.7
E.M. biofertilizer	53.3	103.8	200.6	234.9	148.2	54.4	105.9	204.6	239.6	151.2
75 % NPK + E.M.	159.0	169.4	237.0	267.4	208.2	162.2	172.8	241.7	272.7	212.4
Mean (A)	75.1	118.6	203.0	239.2	159.0	76.6	121.0	207.1	244.0	162.2
L.S.D. at 5 %	A : 14.7		B : 8.8		AB : 17.6	A : 12.1		B : 7.1		AB : 14.2
					2nd Clipping					
Control	42.7	133.3	171.6	229.2	144.2	43.6	136.0	175.0	233.8	147.1
100 % NPK	57.2	167.2	240.5	329.5	198.6	58.3	170.5	245.3	333.3	201.9
E.M. biofertilizer	82.3	120.0	262.2	275.2	184.9	83.9	122.4	267.4	280.7	188.6
75 % NPK + E.M.	108.6	210.2	307.7	342.3	242.2	110.8	214.4	313.9	349.1	247.0
Mean (A)	72.7	157.7	245.5	294.1	192.5	74.2	160.9	250.4	299.2	196.2
L.S.D. at 5 %	A : 9.3		B : 8.9		AB : 17.8	A : 14.6		B : 8.20		AB : 16.40
					3rd Clipping					
Control	95.3	208.0	223.2	289.0	203.9	97.2	212.2	227.7	294.8	208.0
100 % NPK	132.2	227.1	380.0	405.8	286.3	134.8	231.6	387.6	412.7	291.7
E.M. biofertilizer	108.3	234.0	364.0	396.5	275.7	110.5	238.7	371.3	404.4	281.2
75 % NPK + E.M.	176.0	290.3	374.8	424.7	316.5	179.5	296.1	382.3	433.2	322.8
Mean (A)	128.0	239.9	335.5	379.0	270.6	130.6	244.7	342.2	386.3	275.9
L.S.D. at 5 %	A : 14.5		B : 9.7		AB : 19.4	A : 18.3		B : 11.1		AB : 22.2

vetiver grass and Mohamed (2016) on yarrow plants. In relation to the interaction between compost and NPK/E.M. treatments, it was significant in both seasons and for the three clippings as clearly shown in Table (6). The heaviest clipping dry weight was obtained when bermuda grass was supplied with the high compost level (22.5 ton/fed) in combination with either 75 % NPK + E.M. or 100 % NPK.

2. Chemical constituents:

a. Photosynthetic pigments:

The three photosynthetic pigment contents, namely, chlorophyll a, chlorophyll b and carotenoids were gradually promoted, in both seasons, parallel to the gradual increase in the applied compost level. The differences for the three compost levels in both seasons, on one hand and the control treatment on the other hand, were significant for the three pigments as illustrated in Table (7). On the line with these results were those reported by Lawson (2002), Montemurro *et al.* (2004), Abd-Elgaber (2010) and Abdou *et al.* (2013) on *Lolium perenne* and Javahery *et al.* (2012) on sport lawn. Similar positive effect of mineral NPK and/or E.M. was observed for the three photosynthetic pigments which were significantly induced,

Table 7. Effect of compost and mineral NPK and/or E.M. biofertilizer treatments on photosynthetic pigments (chlorophyll a, b & carotenoids) (mg/g F.W.) of bermuda grass during 2016 and 2017 seasons.

Mineral NPK and/or E.M. biofertilizer treatments (B)	Compost level treatments (ton/fed) (A)									
	1st season (2016)					2nd season (2017)				
	0.0	7.5	15.0	22.5	Mean (B)	0.0	7.5	15.0	22.5	Mean (B)
	Chlorophyll a (mg/g F.W.)									
Control	2.200	2.413	2.447	2.557	2.404	2.266	2.485	2.520	2.634	2.476
100 % NPK	2.700	2.760	2.823	2.840	2.781	2.781	2.843	2.908	2.925	2.864
E.M. biofertilizer	2.500	2.550	2.590	2.663	2.576	2.575	2.627	2.668	2.743	2.653
75 % NPK + E.M.	2.817	2.847	2.943	2.953	2.890	2.902	2.932	3.031	3.042	2.977
Mean (A)	2.554	2.643	2.701	2.753		2.631	2.722	2.782	2.836	
L.S.D. at 5 %	A : 0.057		B : 0.052		AB : 0.104	A : 0.053		B : 0.059		AB : 0.118
	Chlorophyll b (mg/g F.W.)									
Control	0.714	0.810	0.881	0.906	0.828	0.728	0.826	0.899	0.924	0.845
100 % NPK	0.812	0.861	0.929	0.940	0.886	0.828	0.878	0.948	0.959	0.904
E.M. biofertilizer	0.768	0.842	0.912	0.932	0.864	0.783	0.859	0.930	0.951	0.881
75 % NPK + E.M.	0.849	0.870	0.939	0.959	0.904	0.866	0.887	0.958	0.978	0.922
Mean (A)	0.786	0.846	0.915	0.934		0.802	0.863	0.933	0.953	
L.S.D. at 5 %	A : 0.013		B : 0.012		AB : 0.024	A : 0.012		B : 0.010		AB : 0.020
	Carotenoids (mg/g F.W.)									
Control	1.009	1.117	1.153	1.210	1.122	1.029	1.139	1.176	1.234	1.144
100 % NPK	1.087	1.180	1.203	1.267	1.184	1.109	1.204	1.227	1.292	1.208
E.M. biofertilizer	1.065	1.167	1.187	1.247	1.167	1.086	1.190	1.211	1.272	1.190
75 % NPK + E.M.	1.111	1.200	1.270	1.303	1.221	1.133	1.224	1.295	1.329	1.245
Mean (A)	1.068	1.166	1.203	1.257		1.089	1.189	1.227	1.282	
L.S.D. at 5 %	A : 0.015		B : 0.012		AB : N.S.	A : 0.017		B : 0.019		AB : 0.038

in both seasons, due to 100 % NPK, 75 % NPK + E.M. and E.M. However, the dual treatment (75 % NPK + E.M.) was superior to the other two single treatments. Ranked second the 100 % NPK, while E.M. gave the least values (Table, 7). In agreement with these results concerning mineral NPK were the findings of Soliman (1992) on *Lolium perenne*; Manoly (2000) on bermuda grass; Hassan (2012) on some turfgrass sp.; Popovici *et al.* (2012) on three turfgrass mixtures and Badran *et al.* (2015) on three warm season turfgrasses and regarding biofertilizers were those of Yuojen (2015), Abdou *et al.* (2015), Kumar and Nikhil (2016) and Badran *et al.* (2017) on bermuda grass, yarrow, vetiver grass and *Gardenia jasmenoides*. Concerning the interaction between the two studied factors, compost and NPK, E.M., it was significant except that of carotenoids in the first season. The highest overall values for the three pigments were those obtained due to the high compost level (22.5 ton/fed) in combination with 75 % NPK + E.M. as shown in Table (7).

b. Nitrogen, phosphorus and potassium percentage:

Data in Table (8) indicated the existence of significant increase, in both seasons, in each of N, P and K % due to the use of all three compost levels over those of control treatment. Among the three compost levels N, P and K % were gradually promoted parallel to the gradual promoted parallel to the gradual increase in compost level with significant differences being detected between each compost level and the following one. Therefore, the high compost level (22.5 ton/fed) resulted in the highest values of N, P and K % in the two seasons as shown in Table (8). The role of organic fertilization in promoting N, P and K % was found on *Lolium perenne* (Lawson, 2002; Montemurro *et al.*, 2004 and Abd Elgaber, 2010); *Zoysia japonica* (Sakr *et al.*, 2008) and bermuda grass (Ziblim *et al.*, 2012). Concerning NPK and/or E.M. fertilization treatments, N, P and K % in bermuda grass were significantly induced due to the use of any one of the three fertilizers over those of control treatments, in both seasons as shown in Table (8).

Table 8. Effect of compost and mineral NPK and/or E.M. biofertilizer treatments on nitrogen, phosphorus and potassium percentages of bermuda grass during 2016 and 2017 seasons.

Mineral NPK and/or E.M. biofertilizer treatments (B)	Compost level treatments (ton/fed) (A)									
	1st season (2016)					2nd season (2017)				
	0.0	7.5	15.0	22.5	Mean (B)	0.0	7.5	15.0	22.5	Mean (B)
	N %									
Control	2.689	2.841	3.010	3.128	2.917	2.678	2.709	2.741	2.775	2.726
100 % NPK	2.797	2.953	3.113	3.240	3.026	2.760	2.791	2.823	2.859	2.808
E.M. biofertilizer	2.738	2.892	3.062	3.179	2.968	2.719	2.749	2.782	2.816	2.767
75 % NPK + E.M.	2.838	2.995	3.156	3.284	3.068	2.782	2.813	2.846	2.872	2.828
Mean (A)	2.766	2.920	3.085	3.208		2.735	2.766	2.798	2.831	
L.S.D. at 5 %	A : 0.105	B : 0.041	AB : 0.082			A : 0.030	B : 0.021	AB : 0.042		
	P %									
Control	0.299	0.316	0.334	0.348	0.324	0.289	0.314	0.335	0.351	0.322
100 % NPK	0.311	0.328	0.346	0.360	0.336	0.317	0.329	0.353	0.374	0.343
E.M. biofertilizer	0.304	0.321	0.340	0.353	0.330	0.308	0.319	0.341	0.359	0.332
75 % NPK + E.M.	0.315	0.333	0.351	0.365	0.341	0.318	0.335	0.360	0.382	0.349
Mean (A)	0.307	0.325	0.342	0.357		0.308	0.324	0.347	0.367	
L.S.D. at 5 %	A : 0.012	B : 0.005	AB : 0.010			A : 0.015	B : 0.007	AB : 0.014		
	K %									
Control	1.344	1.420	1.505	1.561	1.458	1.360	1.422	1.527	1.583	1.473
100 % NPK	1.437	1.488	1.575	1.641	1.535	1.423	1.524	1.612	1.655	1.554
E.M. biofertilizer	1.385	1.465	1.550	1.603	1.501	1.381	1.482	1.573	1.625	1.515
75 % NPK + E.M.	1.416	1.497	1.583	1.631	1.532	1.402	1.501	1.591	1.648	1.536
Mean (A)	1.396	1.468	1.553	1.609		1.392	1.482	1.576	1.602	
L.S.D. at 5 %	A : 0.051	B : 0.011	AB : 0.022			A : 0.025	B : 0.019	AB : 0.038		

However, the dual treatment (75 % NPK + E.M.), as well as, 100 % NPK treatment were much more effective than the E.M. treatment in producing the highest values of N, P and K % in the two experimental seasons. The role of mineral NPK fertilization in promoting N, P and K % was reported on bermuda grass (Manoly, 2000); some turfgrass sp (Hassan, 2012); tree turfgrass mixtures (Popovici *et al.,* 2012); three warm season turfgrasses (Badran *et al.*, 2015) and seashore paspalum (Dergham *et al.,* 2017). While that of biofertilizers was revealed on lemongrass (El-Nady, 2015); yarrow (Abdou *et al*., 2015); paspalum grass (Dwivedi *et al.,* 2016) and *Gardenia jasminoides* (Badran *et al.* 2017). Concerning the interaction between compost levels and NPK/E.M. treatments, it was significant in both seasons for N, P and K % with the highest values being obtained due to the high compost level (22.5 ton/fed) in combination with either 100 % NPK or 75 % NPK + E.M. as clearly shown in Table (8).

In order to explain the beneficial effects of compost, mineral NPK and Effective microorganoisms (E.M.) on vegetative growth and chemical constituents of bermuda grass it is the time to discuss, physiologically, such desirable roles. Many authors reported the advantages of adding compost or other organic fertilizers such as compost increasing macro and micro-nutrients availability increasing water retention and porosity of the soil and improving soil structure, (Fitzpatrick *et al*., 2005). In addition to minimizing the loss of nutrients by leaching, adding considerable quantities of humus, increasing microbial activities in the root zone and releasing carbon dioxide and certain organic acids during decomposition as illustrated by Saber (1997), Mashali (1997) and Taiwo *et al.* (2002). Concerning mineral NPK fertilization, their vital physiological roles in plant growth and development are well known, however the application of such fertilizers could stimulate the vegetative growth of bermuda grass by increasing the availability of nutrients, thereby stimulating plant height and leaves fresh and dry weights which means an increase in the size of photosynthesing surface that reflect, in turn, in promoting fresh and dry weights of leaves, stolons and roots (King *et al.,* 1999). Moreover, Bravdo (2000) pointed out that the differences in the mobility of various elements expose the roots to a wide rang of mineral availability and rapid branching of small rootlets, thus increasing the absorbing surface area of the root system and producing numerous active root tips which, in turn, produce plant growth regulators mostly gibberellins and cytokinins. An explanation to increase in the leaves contents of N, P and K and the three photosynthetic pigments due to NPK fertilization might be attributed to the fact that nitrogen is an important constituent of proteins, and/or to the fact that nitrogen is an important constituent of chlorophyll molecule and cytochrome, (Bidwell, 1974). In relation the Effective microorganisms (E.M.), it contains many useful microorganisms such as photosynthetic bacteria, lactic acid bacteria, yeasts and many others. It was revealed to have positive effects on growth, development and yield of plants through various mechanisms such as biological nitrogen fixation, vitamin production, production of growth substances, providing plants with available phosphorus, increasing the amounts of nutrients in the rhizosphere and used as biocontrol agents, (Dobbelaere *et al.,* 2003 and Berg, 2009).

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تأثير التسميد بالكمبوست والسماد المعدني والكائنات الدقيقة النافعة على مسطحات البرمودا النامية في الاراضي الرملية

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تجربتان حقليتان خلال موسمي ٢٠١٦ و ٢٠١٧ بمزرعة التجارب الخاصة بكلية الزراعة جامعة المنيا بهدف دراسة تأثير التسميد بالكمبوست والسماد المعدني NPK و المعاملة (بالكائنات الدقيقة النافعة) على أداء النمو الخضري والمكونات الكيماوية لمسطحات البرمودا النامية بالأرض الرملية.

أوضحت النتائج المتحصل عليها أن الكمبوست وخاصة بالمعدل المرتفع (٢٢,٥ كن للفدان) وكذلك التسميد بمعدل ٧٥ % من السماد المعدني NPK مقترنا بالـ E.M. قد أدى إلى زيادة معنوية في الصفات الخضرية وكذلك الصبغات الضوئية الثلاثة ونسبة كل من النتروجين والفوسفور والبوتاسيوم. ولقد أدى استعمال المعدل العالي من الكمبوست (٢٢,٥ طن للفدان) ومعه المعاملة المزدوجة من السماد المعدني والحيوي (٧٥ % E.M. + NPK) إلى الحصول على أعلى معدل من النمو الخضري وأفضل أداء لمسطح البرمودا البرمودا عند نموه بالأراضي الرملية.