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PARTIAL REPLACEMENT OF MINERAL NPK FERTILIZERS USING SOME ENVIRONMENTALLY FRIENDLY SUBSTANCES AND THEIR EFFECTS ON BERMUDA GRASS GROWTH

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ABSTRACT: This study was conducted during the two successive seasons of 2021 and 2022 in a private backyard, located in Manqaten Village, Samalout District, Minia Governorate, Egypt. The aim of this work was to examine the ability of partial substitution of mineral fertilizers (NPK) with some environmentally friendly substances (effective microorganisms 'EM', moringa leaf extract, 'MLE' and humic acid, 'HA'), as well as, their combinations on vegetative growth and some chemical constituents of Bermuda grass (*Cynodon dactylon*, L.). Our results showed that the vegetative growth parameters (plant height, covering density, and clipping fresh and dry weights) were augmented with the application of all nine treatments (mineral and/or stimulating substances) during the four cuts in both seasons compared with control treatment, except for the treatment of 50% NPK in some cases. The best treatment was 50% NPK + EM + HA + MLE. Additionally, the photosynthetic pigments and the percentages of N, P and K were improved during the third and fourth cuts in both seasons, more so with 50% NPK + EM + HA + MLE treatment for the photosynthetic pigments and with 100% NPK (full dos treatment) for the percentages of N, P and K.

Keywords: *Cynodon dactylon* L., EM, moringa leaf extract, vegetative growth, chemical constituents.

INTRODUCTION

Bermuda grasses (*Cynodon* spp.) are among the most widely used warm-season grasses. Improved, fine-textured. *Cynodon dactylon,* L. is belonging to Poaceae Family acts as a ground cover (Uddin and Juraimi, 2013). It used throughout the South on golf courses, athletic fields, and in high-profile residential and commercial landscapes where a fine-textured, dense ground cover is desired (Trenholm *et al*., 1991; Santos *et al*., 2008 and Wu and Anderson, 2011).

Obviously, mineral fertilizers enhanced the vegetative growth of turfgrass, but they have negative ecological impacts that affect wildlife and human health (Babb-Hartman, 2020). So, the new trend is to partially substitute the mineral fertilizers with some environmentally friendly substances like humic acid, HA (Abdou *et al*., 2013; Maibodi *et al*., 2015; El-Sayed *et al*., 2016; Desoky *et al*., 2019; Abdou *et al*., 2020 and Sharifiasl *et al*., 2020), effective microorganisms, EM (Mohan, 2008; El-Houssini, 2009; Ali *et al*., 2012; Stamenov *et al*., 2012; Ammar, 2018; Safwat and Matta, 2021 and Abdou *et al*., 2022 a and b) and moringa leaf extract, MLE (Abdel Latef *et al*., 2017; Desoky *et al*., 2019 and Sardar *et al*., 2021) to obtain the same growth of plants either for good quality or quantity.

Therefore, the aim of this investigation was to evaluate the ability of partial

substitution of mineral fertilizers (NPK) with some environmentally friendly substances on the vegetative growth and some chemical constituents of Bermuda grass.

MATERIALS AND METHODS

A field experiment was conducted at a private backyard located in Manqaten Village, Samalout District, Minia Governorate, Egypt during the two successive growing seasons of 2021 and 2022. The aim of this work was to examine the ability of partial substitution of mineral fertilizers (NPK) with some environmentally friendly substances, such as effective microorganisms (EM), moringa leaf extract (MLE) and humic acid (HA), as well as, their combinations on vegetative growth and chemical composition of Bermuda grass (*Cynodon dactylon*, L.).

The physical and chemical analysis of the used soil was determined according to the procedures outlined by Black *et al*. (1981) and are listed in Table (a).

The Bermuda grass seeds were obtained from Al-Walaa Company for trade and distribution, Giza, Egypt, which were imported from USA. EM (bio-fertilizer containing photosynthetic bacteria, lactic acid bacteria and yeasts, 10^7 cells/ml) was obtained from the Ministry of Agriculture and Land Reclamation, El-Dokki, Giza, Egypt. HA in the form of potassium humate (Humic Delta product) contains humic acid and potassium (K_2O) was obtained from Delta Agrochemical Company, Giza, Egypt. Moringa leaves were obtained from the Nursery of Faculty of Agriculture, Minia University. MLE was prepared by mixing 30 g of moringa green leaves in 1.0 L of distilled water in a household blender for 15 minutes at 50 ^oC. The mixture was left to cool, and then, was filtered by filter paper as described by Phiri and Mbewe (2010), and the filtrate was used in the treatments. The chemical analysis of moringa leaf extract was presented in Table (b).

Culver *et al.* (2012) stated that in moringa, there is zeatin hormone in a very high concentration between 5 mcg and 200 mcg/g of material. Also, Fuglie (2000) confirmed that this cytokinin-related crop yields when sprayed as an extract from fresh moringa leaves.

Treatments:

1. Control treatment (without the addition of any fertilizer).
2. Recommended dose of NPK (100%), which equals 600 kg/fed (300:200:100), according to Abdou *et al*. (2020).
3. Half of the recommended dose of NPK (50%), which equals 300 kg/fed (150:100:50).
4. 50% NPK + EM (50 ml/l).
5. 50% NPK + HA (9 ml/l).
6. 50% NPK + MLE (30 g/l).
7. 50% NPK + EM + HA.
8. 50% NPK + EM + MLE.
9. 50% NPK + HA + MLE.
10. 50% NPK + EM + HA + MLE.

The treatments were arranged in a randomized complete block design with three replicates. The total units of the assigned experiment were 30 units (10 treatments × 3 replicates). The experimental unit area was 1.5 m^2 (1.5 × 1.0 m). To prevent seepage, 1.0 m was left between experimental units. The experimental area was ploughed twice orthogonally on March 1st in both growing seasons. The soil was flooded with water so that the weeds in it could be grown. After two weeks, the soil was ploughed again and left for cultivation on April 1st in both growing seasons, then, the site was levelled and divided into plots, each plot was 1.5 m^2 (1.5 × 1.0 m).

The seeds were scattered in two perpendicular directions at a rate of 1.0 kg/25 m^2 (60 g/plot, 1.5 m^2). The seeds were covered with sand to prevent them from being swept away by irrigation water. The seeds were irrigated by the end of the first day of April in both of 2021 and 2022 growing seasons. The flood irrigation was

Table a. Physical and chemical properties of the used soil before sowing of bermuda grass during 2021 and 2022 seasons.

Soil character	Values		Soil character	Values	
	2021	2022		2021	2022
Physical properties (%)			**Soluble nutrients (mg/100 g soil)**		
Sand	25.67	24.58	**Ca^{++}**	2.21	2.13
Silt	27.76	26.66	**Mg^{++}**	1.05	1.01
Clay	46.57	48.76	**Na^{+}**	1.60	1.55
Soil texture	Clayey loam	Clayey loam	**K^{+}**	0.95	0.89
Chemical properties			**DTPA-Extractable nutrients (ppm)**		
pH (1:2.5)	7.81	7.79	**Fe**	3.34	3.38
E.C. (dS/m)	1.18	1.16	**Cu**	1.33	1.35
O.M. (%)	1.54	1.52	**Zn**	2.05	2.04
$CaCO_3$ (%)	2.09	2.10	**Mn**	4.56	4.58

Table b. The chemical analysis of 100 g moringa fresh leaf extract.

Nutrient information	value	Nutrient information	value	Amino acids	value
Calories	92	**Sulfur (mg)**	137	**Arginine**	402
Protein (g)	6.7	**Selenium (mg)**	0	**Histidine**	141
Fat (g)	1.7	**Zinc (mg)**	0	**Isoleucine**	422
Carbohydrate (g)	13.4	**Oxalic acid (mg)**	101	**Leucine**	623
Fiber (g)	0.9	**Vitamin A (mg)**	6.8	**Lysine**	288
Calcium (mg)	440	**Vitamin B (mg)**	423	**Methionine**	134
Copper (mg)	1.1	**Vitamin B_1 (mg)**	0.21	**Phenylalanine**	429
Iron (mg)	7	**Vitamin B_2 (mg)**	0.05	**Threonine**	328
Potassium (mg)	259	**Vitamin B_3 (mg)**	0.8	**Tryptophan**	127
Magnesium (mg)	24	**Vitamin C (mg)**	220		
Phosphorus (mg)	70	**Vitamin E (mg)**	0		

daily applied for the first fifteen days (1st to 15th April), followed by irrigation every couple of days during the next fifteen days (16th to 30th April), and then irrigation was done every three days for the following fifteen days (1st to 15th May) in both growing seasons. After that, the irrigation was done every 15 days until the end of the experiment by flood irrigation. The irrigation water was applied at 15 liter/plot added by a 15 liter measuring container.

The mineral NPK fertilization was applied directly before irrigation. The amounts of 100% NPK at full dose were 300 kg/fed of ammonium sulphate (20.6% N), 200 kg/fed of calcium superphosphate (15.5% P_2O_5) and 100 kg/fed of potassium sulphate (48% K_2O), so 100% NPK= 112.5 + 75 + 37.5 g/1.5 m^2 and 50% NPK = 56.3 + 37.5 + 18.8 g/1.5 m^2.

The assigned calcium superphosphate fertilizer was added after the initial cut (15th May in both seasons), which was excluded. The amounts of N and K mineral fertilizers were added after clippings at four equal batches at one-month intervals (10th May, 10th June, 10th July and 10th August, respectively) in both seasons, then, the irrigation was immediately done.

The foliar application of EM, HA and MLE was applied as a foliar spray (500 ml/1.5 m^2). Spraying was repeated four times (two days after every assigned dose of NK fertilizers), i.e. May 12th, June 12th, July 12th and August 12th by hand sprayer, then the plots were immediately irrigated. Control plants were sprayed with tap water.

In order to ensure the homogeneity of the plants in all plots, the plants were clipped at 40 days after planting (May 10th in both seasons) at 3 cm height, and then the fertilization treatments were carried out. The next four consecutive clippings were taken at one-month intervals, starting from the 10th of June, 10th of July, 10th of August and 10th of September in both seasons and were

considered for vegetative characters and chemical constituents' investigations. The other agricultural practices were carried out as usual.

Data recorded:

The following data were recorded for each considered clippings for each season:

1. Plant height (cm) was measured before each clipping.
2. Covering density (%) was determined by the use of wooden quadrate frame (10 × 10 cm) divided into 100 squares by cross-string. This quadrate was dropped at random 6 times for each experimental unit, then the number of squares occupied by grass was counted and the percentage of covered area was calculated according to El-Tantawy *et al*. (1993).
3. Clipping fresh weight (kg/1.5 m^2, plot) was taken immediately after cutting.
4. Clipping dry weight (g/1.5 m^2, plot) was taken after oven dry at 70 ^oC for 48 hours.
5. Chlorophyll a, b and carotenoids were determined in the fresh leaves at the middle of branches, during the 3rd and 4th clippings in the two experimental seasons, using a 0.5 g of the fresh leaves from each replicate for each treatment according to Fadl and Sari El–Deen (1978).
6. The N, P and K percentages in the dry herb, of the 3rd and 4th clippings were determined according to Cottenie *et al*. (1982).

The obtained data were tabulated and statistically analyzed and subjected to ANOVA using MSTAT-C (1986) program. Means were compared using L.S.D. test at 5% level according to Mead *et al*. (1993).

RESULTS

Vegetative growth traits:

1. Plant height (cm) and covering density (%):

Regardless of the fertilizers or growth enhancers treatments, the tallest plants (cm) and the highest covering density (%), in both seasons, were recorded in the fourth cut, while the shortest plants and lowest covering density in both seasons were produced from the first cut (Table, 1).

All applied treatments significantly increased plant height (cm) and covering density (%) during the four cuts in comparison with control in both seasons, except, for the treatments of 50% NPK in the 2nd, 3rd and 4th cuts, and 50% NPK + MLE during the 4th cut in the first season only for plant height, as well as, 50% NPK during the second cut in the first season and 50% NPK + MLE during the first cut in the second season for covering density. The highest values in the four cuts were recorded from the treatment of 50% NPK + EM + HA + MLE in both seasons.

The role of mineral fertilization in increasing plant height (cm) and covering density (%) was emphasized by El-Tantawy *et al*. (1993), Snyder and Cisar (2005), Munshaw *et al*. (2006), Manoly *et al*. (2008), Costa *et al*. (2013), Ali *et al*. (2018), Ihtisham *et al*. (2020) and Abdou *et al*. (2022a) on Bermuda grass.

The positive influence of bio-fertilization (EM) on enhancing plant height (cm) and covering density (%) was denoted by Yu-Jen (2015), Ali *et al*. (2018), Ammar (2018) and Abdou *et al*. (2022 a) on Bermuda grass.

The increment in plant height (cm) and covering density (%) as a result of applying humic acid was detected by Abdou *et al*. (2013), Maibodi *et al*. (2015) and Sharifiasl *et al*. (2020) on turf grass.

It is well known that MLE enhances the vegetative growth of several species. In this regard, Azra (2011) and Azra *et al.* and (2012) on wheat, Culver *et al*. (2012) on rape, Abdalla (2013) on rocket, Iqbal *et al.* (2014) on canola, Abdel Latef *et al*. (2017) on fenugreek, Desoky *et al*. (2019) on Sudan grass, and Sardar *et al*. (2021) on stevia plants showed a positive effect of MLE on growth characters.

Table 1. Effect of mineral NPK fertilization, some stimulating substances and their combinations on plant height (cm) and covering density (%) of Bermuda grass during four cuts in the two growing seasons (2021 and 2022).

Mineral fertilization and/or stimulating substances treatments	Cutting number									
	1st Cut	2nd Cut	3rd Cut	4th Cut	Mean	1st Cut	2nd Cut	3rd Cut	4th Cut	Mean
	The 1st season (2021)					The 2nd season (2022)				
	Plant height (cm)									
Control	7.18	9.10	10.68	12.65	9.90	8.70	10.40	13.35	14.33	11.70
100% NPK	11.83	13.00	14.65	17.48	14.24	13.35	15.08	18.43	19.65	16.63
50% NPK	9.95	10.30	11.75	13.88	11.47	10.85	12.83	15.33	17.10	14.03
50% NPK +EM	11.55	12.43	13.73	16.75	13.62	12.98	14.60	17.45	19.15	16.05
50% NPK+HA	10.90	11.70	12.93	15.58	12.78	12.38	14.05	17.00	18.40	15.46
50% NPK+MLE	10.50	10.70	12.48	14.55	12.06	11.48	13.30	16.60	17.53	14.73
50% NPK +EM+HA	13.28	14.58	16.70	19.78	16.09	14.98	16.98	19.28	20.93	18.04
50% NPK+ EM+MLE	12.53	14.03	15.35	18.88	15.20	14.23	16.03	19.10	20.58	17.49
50% NPK+ HA+MLE	12.30	13.60	15.03	18.25	14.80	13.88	15.60	18.63	20.05	17.04
50% NPK + EM + HA + MLE	13.55	15.20	17.53	20.30	16.65	15.23	17.60	19.83	21.45	18.53
Mean	11.36	12.46	14.08	16.81		12.81	14.65	17.50	18.92	
L.S.D. at 5%	1.48	1.64	1.57	2.20		1.27	1.72	1.29	1.84	
	Covering density (%)									
Control	42.49	47.60	55.44	60.55	51.52	44.24	49.35	57.33	62.09	53.25
100% NPK	59.08	63.42	72.66	80.22	68.85	60.90	64.75	74.34	81.48	70.37
50% NPK	49.70	53.06	62.93	69.16	58.71	50.47	55.09	63.28	71.26	60.03
50% NPK +EM	56.42	59.92	68.46	76.79	65.40	55.44	60.48	70.42	78.05	66.10
50% NPK+HA	53.06	57.54	65.45	73.43	62.37	54.18	59.15	68.88	74.69	64.23
50% NPK+MLE	50.54	55.79	64.61	71.54	60.62	53.20	57.05	66.43	72.59	62.32
50% NPK +EM+HA	63.49	68.32	76.72	84.07	73.15	65.10	70.00	78.19	87.29	75.15
50% NPK+ EM+MLE	60.62	66.50	74.69	82.39	71.05	62.58	67.97	77.42	84.98	73.24
50% NPK+ HA+MLE	57.61	60.90	70.28	78.54	66.83	59.08	62.93	72.24	79.73	68.50
50% NPK + EM + HA + MLE	64.54	70.14	77.70	88.20	75.15	66.15	71.96	80.01	89.39	76.88
Mean	55.76	60.32	68.89	76.49		57.13	61.87	70.85	78.16	
L.S.D. at 5%	1.64	6.01	1.59	7.55		9.43	3.61	2.43	5.82	

EM: effective microorganisms, HA: humic acid, MLE: moringa leaf extract

2. Clipping fresh and dry weights (g):

Regardless of the treatments, either clipping fresh or dry weights were the heaviest in the 4th cut, while, the lightest weights were obtained from the first cut, in both seasons. Meantime, the 2nd and 3rd cuts recorded intermediate values in both seasons.

All used nine treatments significantly augmented clipping fresh weight during the four cuts compared with control in both seasons (Table, 2). So, the heaviest clipping fresh weight was obtained from the treatment of 50% NPK + EM + HA + MLE in the fourth cut in both seasons.

Similarly, data presented in Table (2) showed that all used treatments significantly increased clipping dry weight during the four cuts in comparison with control in both seasons, except for the treatment of 50% NPK in the 4th cut in both seasons. The heaviest dry weight overall was obtained due to 50% NPK + HA + EM + MLE, followed by 50% NPK + EM + HA, then 100% NPK with significant differences among the three superior treatments.

The capability of chemical NPK on increasing herb fresh and dry weights was reported by Doernoden *et al*. (1991), Snyder and Cisar (2005), Manoly *et al*. (2008),

Table 2. Effect of mineral NPK fertilization, some stimulating substances and their combinations on clipping fresh and dry weights (g) of Bermuda grass during four cuts in the two growing seasons (2021 and 2022).

Mineral fertilization and/or stimulating substances treatments	Cutting number									
	1st Cut	2nd Cut	3rd Cut	4th Cut	Mean	1st Cut	2nd Cut	3rd Cut	4th Cut	Mean
	The 1st season (2021)					The 2nd season (2022)				
	Clipping fresh weight (g)									
Control	753.75	925.00	1145.0	1350.0	1043.44	766.88	970.00	1175.00	1361.25	1068.28
100% NPK	1228.50	1348.75	1547.75	1693.13	1454.53	1284.75	1453.75	1621.25	1743.75	1525.88
50% NPK	787.50	1011.25	1197.50	1389.38	1096.41	855.00	1090.00	1233.13	1417.50	1148.91
50% NPK +EM	1010.25	1186.38	1328.75	1470.00	1248.85	1018.13	1191.25	1392.50	1500.00	1275.47
50% NPK+HA	952.50	1119.63	1300.25	1440.00	1203.10	976.88	1216.75	1358.75	1466.25	1254.66
50% NPK+MLE	896.63	1058.13	1227.50	1417.50	1149.94	915.00	1114.38	1317.50	1441.88	1197.19
50% NPK +EM+HA	1269.38	1393.75	1565.00	1723.13	1487.82	1406.25	1427.50	1591.25	1711.88	1534.22
50% NPK+ EM+MLE	1134.38	1262.50	1471.25	1599.38	1366.88	1192.50	1333.75	1501.25	1616.25	1410.94
50% NPK+ HA+MLE	1065.00	1200.63	1377.50	1533.75	1294.22	1128.75	1277.50	1422.50	1586.25	1353.75
50% NPK + EM + HA + MLE	1299.38	1416.25	1587.50	1747.50	1512.66	1338.75	1487.50	1628.75	1768.13	1555.78
Mean	1039.73	1192.23	1374.80	1536.38		1088.29	1256.24	1424.19	1561.31	
L.S.D. at 5%	6.50	5.20	4.08	4.35		5.17	5.58	5.35	8.26	
	Clipping dry weight (g)									
Control	120.60	166.50	217.55	283.50	197.04	138.04	184.30	225.00	285.86	208.30
100% NPK	270.27	323.70	402.42	457.14	363.38	290.44	371.15	409.25	462.21	391.51
50% NPK	161.39	201.04	233.23	269.33	216.25	173.85	245.16	257.50	273.96	237.62
50% NPK +EM	191.95	237.28	292.33	338.10	264.92	203.63	273.99	302.50	345.00	281.28
50% NPK+HA	180.98	223.93	286.06	331.20	255.54	195.38	267.69	298.75	337.24	274.77
50% NPK+MLE	133.88	192.14	251.48	305.66	220.79	162.45	228.90	263.13	311.85	241.58
50% NPK +EM+HA	291.96	348.44	406.90	499.71	386.75	295.49	392.51	415.25	505.69	402.24
50% NPK+ EM+MLE	238.22	277.75	353.10	415.84	321.23	262.35	333.44	361.25	420.23	344.32
50% NPK+ HA+MLE	223.65	264.14	330.60	383.44	300.46	248.33	319.38	342.50	396.56	326.69
50% NPK + EM + HA + MLE	298.86	354.06	428.63	506.78	397.08	321.30	416.50	439.75	512.76	422.58
Mean	211.18	258.90	320.23	379.07		232.43	303.30	331.49	385.14	
L.S.D. at 5%	1.01	1.20	1.22	1.43		6.37	6.56	5.53	6.17	

EM: effective microorganisms, HA: humic acid, MLE: moringa leaf extract

AbdelKader and Alhumaid (2012), Costa *et al*. (2013), Ali *et al*. (2018), Ihtisham *et al*. (2020) and Abdou *et al*. (2022a) on Bermuda grass.

In accordance with current results, the efficiency of bio-fertilization treatments in augmenting herb fresh and dry weights was insured by Ali *et al*. (2018), Ammar (2018) and Abdou *et al*. (2022a) on Bermuda grass.

Concerning the effect of humic acid, these results are parallel with those reported by Abdou *et al*. (2013), Maibodi *et al*. (2015) and Sharifiasl *et al*. (2020) on turf grass.

Moreover, the positive effect of MLE on enhancing herb fresh and dry weights was proved by Desoky *et al*. (2019) on Sudan grass, Prabhu *et al.* (2010) on basil, Abdalla (2013) on rocket, Iqbal *et al.* (2014) on canola, Hassan and Abd El-Samee (2015) on roselle, Abdel Latef *et al*. (2017) on fenugreek and Sardar *et al*. (2021) on stevia.

Chemical constituents:

1. Photosynthetic pigments (mg/g fresh weight):

Data recorded in Table (3) showed that the contents of photosynthetic pigments (chlorophyll a, b and carotenoids) were increased in the 4th cut compared with the 3rd cut in both seasons, regardless of the applied treatments.

Also, data in the same Table proved that all used treatments significantly increased the photosynthetic pigments in the third and fourth cuts relative to the control, except, for the treatment of 50% NPK in both cuts during both seasons for chlorophyll b, and 50% NPK in the fourth cut only for carotenoids in the second season. The highest values were obtained from the treatments of 50% NPK + EM + HA + MLE and 50% NPK + EM + HA, then 100% NPK for the three previous traits with significant differences among themselves in most cases.

The efficiency of chemical NPK in augmenting photosynthetic pigments (chlorophyll a, b and carotenoids) was stated by El-Tantawy *et al*. (1993), Trenholm *et al*. (2000) Richardson (2002) Trenholm and Unruk (2005), Snyder and Cisar (2005), Munshaw *et al*. (2006), Manoly *et al*. (2008), AbdelKader and Alhumaid (2012), Ihtisham *et al*. (2018), Ihtisham *et al*. (2020), Lindsey *et al*. (2020) and Abdou *et al*. (2022 b) on Bermuda grass.

The enhancement of photosynthetic pigments (chlorophyll a, b and carotenoids) due to applying bio-fertilization treatment (EM) was revealed by Ali *et al*. (2018), Ammar (2018) and Abdou *et al*. (2022b) on bermuda grass. Similarly, Stamenov *et al*. (2012) on English ryegrass recorded the same trend.

The enhancement of photosynthetic pigments due to humic acid treatment was reported by Schmidt and Zhang (1998), Aamlid and Hanslin (2009), Maibodi *et al*. (2015) and Sharifiasl *et al*. (2019 and 2020) on turf grass, Zhang *et al*. (2003) on bentgrass, and Desoky *et al*. (2019) on Sudan grass.

Additionally, our results are in agreement with the previous reports of Bashir *et al*. (2015) on turf grass, Desoky *et al*. (2019) on Sudan grass, Abdalla (2013) on rocket, Emongor (2015) on snap bean, who found that application of MLE alone or in combination with HA increased chlorophyll a, b and carotenoids.

2. NPK (%):

Data presented in Table (4) revealed that all used treatments significantly enhanced the percentages of N, P and K in both cuts during both seasons compared to the control, except for the treatment of 50% NPK in both cuts in the two seasons for potassium. The highest N, P and K percentages were obtained with the treatments of 100% NPK followed by 50% NPK + HA + EM + MLE, then 50% NPK + HA + EM.

The enhancement of (N, P and K%) due to mineral NPK fertilization was obtained by Trenholm and Unruk (2005), Manoly *et al*. (2008), Schnell *et al*. (2009), Ziblim *et al*. (2012), Lindsey *et al*. (2019) and Abdou

Table 3. Effect of mineral NPK fertilization, some stimulating substances and their combinations on photosynthetic pigments (mg/g F.W.) of Bermuda grass during the two cuts in the two growing seasons (2021 and 2022).

Mineral fertilization and/or stimulating substances treatments	Cutting number								
	3rd Cut	4th Cut	Mean	3rd Cut	4th Cut	Mean	3rd Cut	4th Cut	Mean
	Chlorophyll a			Chlorophyll b			Carotenoids		
	The 1st season (2021)								
Control	2.11	2.15	2.13	0.71	0.75	0.73	1.01	1.04	1.03
100% NPK	2.92	2.98	2.95	0.92	0.95	0.94	1.20	1.23	1.22
50% NPK	2.22	2.35	2.29	0.75	0.78	0.77	1.03	1.06	1.05
50% NPK +EM	2.44	2.52	2.48	0.79	0.83	0.81	1.09	1.11	1.10
50% NPK+HA	2.56	2.66	2.61	0.82	0.84	0.83	1.11	1.15	1.13
50% NPK+MLE	2.31	2.41	2.36	0.77	0.78	0.78	1.06	1.07	1.07
50% NPK +EM+HA	3.04	3.06	3.05	0.94	0.99	0.97	1.24	1.26	1.25
50% NPK+ EM+MLE	2.67	2.73	2.70	0.85	0.88	0.87	1.15	1.17	1.16
50% NPK+ HA+MLE	2.80	2.86	2.83	0.89	0.92	0.91	1.17	1.20	1.19
50% NPK + EM + HA + MLE	3.16	3.18	3.17	0.97	1.07	1.02	1.27	1.28	1.28
Mean	2.62	2.69		0.84	0.88		1.13	1.16	
L.S.D. at 5%	0.06	0.05		0.06	0.08		0.01	0.01	
	The 2nd season (2022)								
Control	2.15	2.06	2.11	0.82	0.87	0.85	1.02	1.06	1.04
100% NPK	2.98	3.08	3.03	0.97	1.07	1.02	1.23	1.24	1.24
50% NPK	2.25	2.32	2.29	0.80	0.89	0.87	1.07	1.07	1.07
50% NPK +EM	2.50	2.71	2.61	0.84	0.95	0.88	1.11	1.12	1.12
50% NPK+HA	2.60	2.73	2.67	0.85	0.99	0.92	1.15	1.16	1.16
50% NPK+MLE	2.44	2.38	2.41	0.86	0.92	0.89	1.09	1.08	1.09
50% NPK +EM+HA	3.14	2.97	3.06	1.06	1.10	1.08	1.25	1.27	1.26
50% NPK+ EM+MLE	2.72	2.78	2.75	0.88	1.03	0.96	1.18	1.18	1.18
50% NPK+ HA+MLE	2.87	2.82	2.85	0.93	1.08	1.01	1.19	1.21	1.20
50% NPK + EM + HA + MLE	3.21	3.28	3.25	1.05	1.12	1.09	1.28	1.29	1.29
Mean	2.69	2.71		0.91	1.00		1.16	1.17	
L.S.D. at 5%	0.09	0.09		0.03	0.03		0.05	0.02	

EM: effective microorganisms, HA: humic acid, MLE: moringa leaf extract

et al. (2022 b) on Bermuda grass, which support our results.

The improvement of NPK % as a result of applying EM has been proved by Ali *et al*. (2018), Ammar (2018) and Abdou *et al*. (2022b) on Bermuda grass, Stamenov *et al*. (2012) on English ryegrass.

The positive effect of HA on enhancing the content of NPK (%) was proved by Maibodi *et al*. (2015) and Sharifiasl *et al*. (2020) on turf grass and Desoky *et al*. (2019) on Sudan grass.

Similarly, increasing the percentages of N, P and K due to MLE has been proved by

Table 4. Effect of mineral NPK fertilization, some stimulating substances and their combinations on NPK (%) in dry herb of Bermuda grass during the two cuts in the two growing seasons (2021 and 2022).

Mineral fertilization and/or stimulating substances treatments	Cutting number								
	3rd Cut	4th Cut	Mean	3rd Cut	4th Cut	Mean	3rd Cut	4th Cut	Mean
	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	The 1st season (2021)								
Control	2.07	2.51	2.29	0.29	0.36	0.33	2.53	2.85	2.69
100% NPK	2.81	3.22	3.02	0.37	0.43	0.40	3.18	3.54	3.36
50% NPK	2.21	2.61	2.41	0.30	0.37	0.34	2.63	2.97	2.80
50% NPK +EM	2.35	2.78	2.57	0.32	0.39	0.36	2.78	3.11	2.95
50% NPK+HA	2.45	2.87	2.66	0.33	0.40	0.37	2.87	3.21	3.04
50% NPK+MLE	2.27	2.72	2.50	0.31	0.38	0.35	2.72	3.04	2.88
50% NPK +EM+HA	2.73	3.11	2.92	0.35	0.41	0.38	3.09	3.42	3.26
50% NPK+ EM+MLE	2.53	2.93	2.73	0.34	0.40	0.37	2.95	3.27	3.11
50% NPK+ HA+MLE	2.63	3.06	2.85	0.34	0.41	0.38	3.02	3.35	3.19
50% NPK + EM + HA + MLE	2.78	3.18	2.98	0.36	0.43	0.40	3.14	3.51	3.33
Mean	2.48	2.90		0.33	0.40		2.89	3.23	
L.S.D. at 5%	0.14	0.10		0.01	0.01		0.11	0.13	
	The 2nd season (2022)								
Control	2.27	2.63	2.45	0.30	0.38	0.34	2.58	3.21	2.90
100% NPK	3.01	3.35	3.18	0.38	0.46	0.42	3.31	3.87	3.59
50% NPK	2.41	2.79	2.60	0.32	0.39	0.36	2.68	3.33	3.01
50% NPK +EM	2.55	2.94	2.75	0.33	0.41	0.37	2.84	3.48	3.16
50% NPK+HA	2.65	3.02	2.84	0.34	0.42	0.38	2.93	3.57	3.25
50% NPK+MLE	2.47	2.85	2.66	0.32	0.40	0.36	2.77	3.40	3.09
50% NPK +EM+HA	2.93	3.24	3.09	0.37	0.45	0.41	3.18	3.79	3.49
50% NPK+ EM+MLE	2.73	3.08	2.91	0.35	0.43	0.39	2.99	3.63	3.31
50% NPK+ HA+MLE	2.83	3.17	3.00	0.36	0.44	0.40	3.07	3.73	3.40
50% NPK + EM + HA + MLE	2.98	3.33	3.16	0.38	0.46	0.42	3.26	3.84	3.55
Mean (A)	2.68	3.04		0.35	0.42		2.96	3.59	
L.S.D. at 5%	0.14	0.16		0.02	0.01		0.12	0.14	

EM: effective microorganisms, HA: humic acid, MLE: moringa leaf extract

Bashir *et al*. (2015) on turf grass, Desoky *et al*. (2019) on Sudan grass and Sardar *et al*. (2021) on stevia.

DISCUSSION

Reducing mineral fertilization (full dose) to 50% (half dose) in combination with some environmentally friendly substances (EM, MLE and HA), led to a significant increase in all previous traits compared with control. Meantime, it could be noticed that, 50% NPK plus any one of the EM, MLE and HA recorded the best results than the control, with the highest values obtained with the treatment of 50% NPK + HA + EM + MLE. Thus, reflect the supportive effect of such

environmentally friendly substances to reduce using of mineral fertilizers (NPK). The physiological role of these materials is as follows: the stimulatory effect of humic substances has been correlated with enhanced uptake of macronutrients. A small fraction of lower molecular weight components in humic substances can be taken up by plants. These components seem to increase cell membrane permeability and may have hormone-like activity (Chen and Aviad, 1990). HA stimulates the production of antioxidants and enhances photosynthetic activity, resulting in greater turf grass tolerance of abiotic and biotic stresses, including disease infection. Foliar spray of humic substances can boost photosynthesis and improve turfgrass growth and development, especially when applied before stresses increase (Schmidt and Zhang, 1998 and Zhang *et al*., 2003).

Moringa leaves are rich source of zeatin, ascorbate, phenolic compounds, calcium and potassium, so being explored as natural crop growth enhancer (Basra *et al*., 2011). Also, they are rich in mineral contents: calcium, phosphorus, magnesium, potassium, sodium, sulphur, zinc, copper, manganese, iron and selenium. Moringa leaves are also containing 17 fatty acids, amino acids and some vitamins. The values of amino acids, fatty acids, minerals and vitamins and many other compounds are known for their growth-promoting potential (Moyo *et al*., 2011; Nouman *et al*., 2012; Abdel-Nabey *et al*., 2015, Zulfiqar *et al*., 2020 and Sardar *et al*., 2021).

Effective microorganisms, EM improved of permeability and aeration capacity of soils which increased the leaching of soils and raised plant yields (Cóndor_Golec *et al*., 2007). EM contain several beneficial microorganisms such as five families and ten genera as well as more than 80 types of aerobic and anaerobic microbes like lactic acid bacteria, photosynthesis bacteria, fungi, actinomycetes, and yeast (Safwat and Matta, 2021). EM produces substances that play the role of antioxidants (Mayer *et al*., 2010). EM can also help prevent the growth of pathogenic bacteria (Safwat and Rozaik, 2017).

CONCLUSION

From the current results, it could be concluded that applying EM, HA, and MLE as eco-friendly growth enhances improved growth and chemical constituents of Bermuda grass. Applying such natural growth enhancers can reduce the chemical fertilizers by 50% to prevent pollution and achieve sustainable cultivation under Minia Governorate conditions.

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الاستبدال الجزئي للتسميد المعدني NPK بإستعمال مواد صديقة للبيئة وتأثيراتها علي نمو نجيل البرمودا

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أجريت هذه الدراسة بحديقة خاصة بقرية منقطين، مركز سمالوط، محافظة المنيا خلال موسمي النمو ٢٠٢١ و ٢٠٢٢ بهدف دراسة قابلية الإستبدال الجزئي للتسميد المعدني (NPK) ببعض المواد الصديقة للبيئة (الميكروبات الدقيقة النشطة، مستخلص أوراق المورينجا، حمض الهيوميك)، وكذلك التوليفات بينها على النمو الخضري وبعض المكونات الكيميائية لنجيل البرمودا (*Cynodon dactylon*, L.). أشارت النتائج إلي أن صفات النمو الخضري (ارتفاع النبات، الغطاء النباتي، الوزن الطازج والجاف/الحشة) قد زادت زيادة معنوية نتيجة إستخدام أيٍ من المعاملات التسع المستخدمة خلال موسمي النمو في الحشات الأربع مقارنة بمعاملة الكنترول، ما عدا معاملة ٥٠٪ NPK في بعض الحالات. وكانت أفضل معاملة هي ٥٠٪ NPK + الميكروبات الدقيقة النشطة + حمض الهيوميك + مستخلص أوراق المورينجا. أيضاً، تحسنت صبغات البناء الضوئي والنسبة المئوية للعناصر (N, P, K) في الحشة الثالثة والرابعة. وكانت أفضل النتائج هي معاملة ٥٠٪ NPK + الميكروبات الدقيقة النشطة + حمض الهيوميك + مستخلص أوراق المورينجا للصبغات النباتية، ومعاملة ١٠٠٪ NPK بالنسبة للعناصر N, P, K.