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IMPACT OF FULVIC ACID ON GROWTH AND CHEMICAL CONSTITUENTS OF *PASPALUM VAGINATUM* TURF UNDER DIFFERENT MAGNESIUM CONCENTRATIONS

M.A. El-Ashwah and Taghreed E. Eissa
Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt

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Corresponding author:
M.A. El-Ashwah
mahmoud_elashwah2005@yahoo.com

ABSTRACT: This research was carried out in the open field at the Nursery of Hort. Res. Inst., ARC, Giza, Egypt, during 2022 and 2023 seasons, to assess growth, covering density, and various chemical constituents of *Paspalum vaginatum*, Swartz under distinct fulvic acid rates (0.0, 2, 4, and 6 ml/l), magnesium sulfate concentrations (0. 0, 40, 80, and 120 ppm) as foliar application and the interaction between treatments. The results indicated that plants given fulvic acid or magnesium sulfate, separately or in combination, produced the greatest values in plant height, along with fresh and dry weights of herbs and roots per bed when contrasted with the control. The paspalum plants treated with 6 ml/l alone or in combination with $MgSO_4$ at 120 ppm exhibited the highest percentages of NPK, carbohydrates, and a notable increase in total chlorophyll. Overall, the dual treatment of 6 ml/l of fulvic acid and 120 ppm of magnesium sulfate demonstrated a beneficial effect by enhancing N, P, K, and total carbohydrate percentages along with chlorophyll content that are vital for plant growth and covering density, it contributed to improving the grass appearance under the existing experimental conditions. Therefore**,** it is advisable to apply seashore paspalum with 6 ml/l of fulvic acid and 120 ppm of magnesium sulfate alternately every month to enhance growth and achieve a high coverage rate.

Keywords: lawns, *Paspalum vaginatum*, fulvic, magnesium sulfate, carbohydrates, chlorophyll

INTRODUCTION

Paspalum turf grasses offer economic benefits in sports due to adaptability, low maintenance costs, and positive playing conditions, especially seashore paspalum, which is increasingly recognized for its resilience and quality. In addition, Huang *et al*. (1997) pointed out that seashore paspalum (*Paspalum vaginatum*, Swartz) constitutes a significant multidisciplinary turf grass, predominantly utilized in the establishment of verdant landscapes for both private and public gardens, and it fulfills essential environmental and aesthetic criteria. Furthermore, Trenholm *et al*. (1999) elucidated that seashore paspalum constitutes a succulent warm-season turfgrass species that is classified within the Gramineae family (Poaceae). In addition, seashore paspalum is a warm-season perennial grass, suitable for soils with moisture and salinity. It serves as a turf grass for environmental and aesthetic purposes, exhibiting greater salt tolerance. (Lee, 2000). Also, seashore paspalum, a perennial turf grass native to tropical and coastal regions, is highly tolerant of environmental stresses, producing higher-quality turf in reduced light conditions, pH ranges, waterlogged soils, and high salinity levels (Brosnan and Deputy, 2008 and Shahba, 2010). Furthermore, seashore paspalum is among the most common grasses for lawns in Egypt. Turfgrass growth and quality are significantly influenced by good nutrition and sufficient water, which can be propagated easily using sprigs and stolons (El-Sayed *et al*., 2016). On the other hand, the turfgrass industry in the U.S. generated approximately 57.9 billion US$ in revenue in 2002, highlighting its substantial economic footprint (Mathew *et al*., 2020). turfgrass lawns offer aesthetic and functional benefits like soil erosion control, water purification, noise reduction, air pollution reduction, carbon sequestration, medical therapies, and a billion-dollar industry with high returns per unit area (Mathew, 2021). In conclusion, turfgrasses have been employed by humans for numerous centuries in outdoor athletic venues, including football pitches and golf courses, owing to their economical nature and the provision of a secure recreational environment (Jiuxin and Liebao, 2022).

Since the late 19^{th} and early 20^{th} centuries, research on plant mineral nutrition has improved our understanding of the relationship between plant growth, development, and physiological processes. For example, using fulvic acid (FA) significantly impacts plant growth, particularly under stress, by improving physiological processes, nutrient uptake, and stress tolerance, leading to improve growth metrics and yields. Moreover, many scientists have explained the role of fulvic acid, for example, Yamauchi *et al*. (1984) found that fulvic acids, which are perpetually found in solution, enhance the soil's capacity for cation exchange. Due to their rapid leaching and water solubility, fulvic acids are present in low concentrations (0.2–1% w/v) when applied topically. It is a non-toxic water binder and mineral chelating agent that boosts plant productivity by optimizing uptake through leaves in organic fertilizers (Malan, 2015). Moreover, soil drenched with fulvic acid is a beneficial agricultural practice and eco-friendly bio-stimulants for *Dendranthema grandiflorum* production. The best vegetative growth values were achieved under clay soil conditions (El-Baset and Kasem, 2022).

Magnesium is crucial for plant health and productivity, with ideal levels varying based on crop type and soil conditions. However, Cakmak and Yazici (2010) found that nitrogen, phosphorus, and potassium are crucial, while magnesium is often overlooked. In addition, magnesium (Mg) is a vital nutrient that significantly contributes to the growth and formation of various sink organs, including seeds and roots (Guo *et al*., 2016). Magnesium nutrition is crucial for plant functions like chlorophyll formation and photosynthetic activity. Deficiency can lead to sugar accumulation in leaves and impact agricultural systems and forestry productivity (Farhat *et al*., 2016 and Hauer-Jákli and Tränkner, 2019). Moreover, maintaining appropriate concentration through foliar application is essential for physiological activities and biochemical functions, such as energy transfer, enzyme activation, glucose metabolism, and protein synthesis (Adnan *et al*., 2021).

Therefore, the main objective of this research was to assess the beneficial effects of fulvic acid and magnesium sulfate as foliar applications on growth traits, including density, certain chemical constituents, and the greening of seashore paspalum turf grasses.

MATERIALS AND METHODS

This research was conducted under direct sunlight at the nursery of Hort. Res. Inst., ARC, Giza Egypt throughout the seasons of 2022 and 2023 to improve growth characteristics, coverage density, some chemical composition, and greening of seashore paspalum plants. The study employed different rates of fulvic acid (0.0, 2, 4, and 6 ml/l) and magnesium sulphate concentrations (0.0, 40, 80, and 120 ppm) as foliar applications on *Paspalum vaginatum*, Swartz turf grasses.

Sodding cultivation and soil analysis:

The seashore paspalum sodding sections were grown in ceramic raised beds measuring

28 cm in width, 40 cm in length, and 28 cm in depth on 1st February. Each bed was topped with a single piece of paspalum sod and packed with 14 kg of sand and clay (1:1 v/v). Moreover, the physical and chemical characteristics of the soil are detailed in Table (1)**.** Following the planting, a light layer (1 cm) of the same soil mixture was spread over the paspalum sod. To ensure the sodding integrated more effectively with the soil mixture, it was carefully hand-compressed. Over two weeks, 1500 milliliters of tap water were applied daily to irrigate the beds.

Source and application of treatment:

The source of fulvic acid (potassium fulvate 10%) and was obtained from GGAP (Green Group for Agricultural Projects) Company, Egypt. Seashore paspalum plants were foliar sprayed monthly with varying quantities of fulvic acid (0.0, 2, 4, and 6 ml/l) and magnesium sulfate (0.0, 40, 80, and 120 ppm). The first time of fulvic acid application was done one month after planting, then one week after each cutting (monthly). Magnesium sulfate was sprayed 3 days after each fulvic acid application. The plants used as controls were sprayed with tap water. Each experimental unit was treated with a five-letter solution, and the spreading agent Super film at 1 ml/l was utilized. The seashore paspalum plants were grown utilizing recommended agricultural procedures.

Experimental design:

A randomized complete block design was utilized to apply the experimental treatments in three replicates, each containing 3 raised beds. The main plots were assigned to foliar spraying with fulvic acid rates, while subplots were treated with magnesium sulfate concentrations.

Data Recorded:

On 1st April (59 days after the planting date), the first cut was done using a perfectly sharp stainless-steel cutter, leaving 3 cm long stubble. Then, at 1-month intervals, the other three cuts were done (on 1st May, 1st June, and 1st July.

Vegetative growth and covering density:

Plant height (cm) before each cut, as an average for the four cuts, was registered, and total herb and roots fresh and dry weights (g/bed) for each cut of the resulting clippings. According to Mahdi (1953), the percentage of covering density was calculated by counting the number of tillers/area. These growth traits were presented as an average of four cuts during both seasons.

Chemical constituents and pigments content:

Before the last cut (on 1st July), total nitrogen (Naguib, 1969), phosphorus (Hucker and Catroux, 1980) and potassium (Brown and Lilleland, 1946)) percentages were determined in the dry leaves of seashore paspalum. Also, in the dry leaves, the total carbohydrate percentage was determined by utilizing Dubois *et al.* (1956) method. In addition, total chlorophyll (a + b) content (mg/g fresh leaves) was determined after the 1st cut each season as presented by (Moran,1982).

Table 1. Experimental soil mixture of mechanical and chemical properties Chapman and Pratt (1978).

Mechanical analysis			Soil texture
Clay (%)	**Silt (%)**	**Sand (%)**	**Sandy**
32.44	11.68	55.88	

Chemical analysis														
pH	**E.C. (dSm^{-1})**	**Soluble cations (mmol/l)**					**Soluble anions (mmol/l)**			**Available (ppm)**				
		Ca^{++}	**Mg^{++}**	**Na^{+}**	**Zn^{++}**	**Mo^{++}**	**Cl^{-}**	**HCO_3^{-}**	**SO_4^{--}**	**N**	**P**	**K**		
7.69	0.57	1.78	0.96	2.06	0.44	0.63	2.17	1.61	1.11	98	38	63		

Statistical analysis:

All collected data were analyzed with analysis of variance (ANOVA) procedure using the Statistix version 9 (Analytical Software, 2008). Differences between means were compared by using least significant difference (LSD at a 5% level) test according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth traits and covering density:

Data recorded in Tables (2 and 3) showed that spraying seashore plants with fulvic acid significantly increased plant height and total herb fresh and dry weights over the control. The highest values of plant height (29.42 and 27.33 cm), total herb fresh (280.18 and 263.13 g), and dry weight (59.84 and 62.43 g) per bed were achieved with 6 ml/l fulvic acid compared to control and the lowest rates under study (2 and 4 ml/l) in both seasons. The increases in roots fresh and dry weights per bed values were (98.44 and 82.29 g/bed) for fresh weight and (34.11 and 30.54 g/bed) for dry weight in both seasons for 6 ml/l rate in comparison with control, in both seasons, respectively (Table, 4). The highest values in covering density (75.50 and 82.83%) were recorded with 6 ml/l of fulvic acid rate (Table, 5). Consequently, there are gradual increases in plant growth traits and covering density were noticed with increasing fulvic acid rates in both seasons. In general, fulvic acid (FA) occupies a pivotal position in augmenting plant growth and facilitating nutrient absorption, particularly concerning magnesium (Mg) and its implications for diverse plant taxa, including paspalum. In addition, the utilization of fulvic acid has been demonstrated to enhance the bioavailability of critical nutrients within the edaphic environment, thereby promoting their assimilation by plants. Research has indicated that fulvic acid possesses the capacity to markedly enhance growth parameters in a diverse array of ornamental flora. For example, Esringü *et al*. 2015 on *Impatiens wallerian* found that fulvic acid increased plant growth. Also, Moradi *et al.* (2017) elucidated that fulvic acid possesses the capacity to effectively bind or chelate minerals such as magnesium, thereby enabling direct transport to plants, which is indispensable for their physiological processes and overall development. Furthermore, El-Baset and Kasem (2022) observed that the utilization of humic and fulvic acids resulted in elevated

Table 2. Effect of fulvic acid, magnesium and their interaction on plant height (cm) of *Paspalum vaginatum* plants during 2022 and 2023 seasons.

Fulvic acid (ml/l) (A)	Magnesium sulfate (ppm) (B)				
	0.0	40	80	120	Mean
			Plant height (cm)		
			2022 season		
0.0	19.00	25.00	25.67	26.33	24.00
2.0	24.00	26.33	27.67	26.67	26.17
4.0	25.67	27.00	29.33	28.67	27.67
6.0	26.00	28.67	30.67	32.33	29.42
Mean	23.67	26.75	28.33	28.50	
L.S.D. at 5%	A= 0.91		B= 0.77	A×B= 1.61	
			2023 season		
0.0	19.33	21.00	23.00	25.33	22.17
2.0	21.00	23.67	25.00	27.67	24.33
4.0	22.33	24.00	26.33	29.00	25.42
6.0	23.00	27.00	29.00	30.33	27.33
Mean	21.42	23.92	25.83	28.08	
L.S.D. at 5%	A= 0.82		B= 0.72	A×B= 1.49	

Table 3. Effect of fulvic acid, magnesium and their interaction treatments on fresh and dry weights of herb per bed (g) of *Paspalum vaginatum* plants during 2022 and 2023 seasons.

Fulvic acid (ml/l) (A)	Magnesium sulfate concentration (ppm)				
	0.0	**40**	**80**	**120**	**Mean**
			Fresh weight of herb per bed (g)		
			2022 season		
0.0	148.79	181.74	212.59	220.12	190.81
2.0	206.64	223.44	233.30	262.43	231.45
4.0	192.54	222.31	236.58	245.84	224.32
6.0	269.95	277.94	282.49	290.33	280.18
Mean	204.48	226.36	241.24	254.68	
L.S.D. at 5%	A= 2.10		B= 1.79	A×B= 3.73	
			2023 season		
0.0	160.49	173.48	193.03	210.34	184.34
2.0	170.93	203.11	218.89	241.99	208.73
4.0	161.64	192.02	202.63	223.94	195.06
6.0	252.77	260.10	268.30	271.34	263.13
Mean	186.46	207.18	220.71	236.90	
L.S.D. at 5%	A= 3.65		B= 3.47	A×B= 7.02	
			Dry weight of herb per bed (g)		
			2022 season		
0.0	35.97	40.80	48.66	49.76	43.80
2.0	46.26	52.69	56.20	60.87	54.01
4.0	45.20	55.14	59.18	63.88	55.85
6.0	47.48	58.15	63.70	70.03	59.84
Mean	43.73	51.70	56.94	61.13	
L.S.D. at 5%	A= 0.64		B= 0.77	A×B= 1.47	
			2023 season		
0.0	37.32	40.66	44.15	49.11	42.81
2.0	43.31	47.69	51.80	59.45	50.56
4.0	43.23	46.84	50.72	63.28	51.02
6.0	49.79	59.72	67.12	73.09	62.43
Mean	43.41	48.73	53.45	61.23	
L.S.D. at 5%	A= 0.61		B= 0.54	A×B= 1.11	

Table 4. Effect of fulvic acid, magnesium and their interaction on fresh and dry weights of roots per bed (g) of *Paspalum vaginatum* plants during 2022 and 2023 seasons.

Fulvic acid (ml/l) (A)	Magnesium sulfate concentration (ppm)				
	0.0	40	80	120	Mean
			Fresh weight of roots per bed (g)		
			2022 season		
0.0	33.83	34.19	37.18	38.08	35.82
2.0	51.49	54.74	62.60	65.58	58.60
4.0	58.12	62.18	75.37	80.33	69.00
6.0	78.67	96.27	99.43	119.40	98.44
Mean	55.53	61.85	68.65	75.85	
L.S.D. at 5%	A= 3.59		B= 2.37	A×B= 5.43	
			2023 season		
0.0	32.66	35.10	36.45	37.54	35.44
2.0	50.58	56.52	58.30	63.24	57.16
4.0	56.76	64.35	76.36	82.86	70.08
6.0	63.85	80.99	81.99	102.32	82.29
Mean	50.96	59.24	63.28	71.49	
L.S.D. at 5%	A= 1.97		B= 2.61	A×B= 4.92	
			Dry weight of roots per bed (g)		
			2022 season		
0.0	9.08	9.17	9.98	10.34	9.64
2.0	11.39	12.02	12.93	14.46	12.70
4.0	12.75	13.65	15.64	19.62	15.41
6.0	19.34	32.31	38.64	46.14	34.11
Mean (B)	13.14	16.79	19.30	22.64	
L.S.D. at 5%	A= 1.25		B= 0.66	A×B= 1.69	
			2023 season		
0.0	7.36	8.54	9.44	10.25	8.90
2.0	15.04	17.12	18.02	19.92	17.53
4.0	19.38	21.82	23.36	25.34	22.48
6.0	17.90	28.87	36.20	39.18	30.54
Mean	14.92	19.09	21.76	23.67	
L.S.D. at 5%	A= 0.95		B= 0.29	A×B= 1.07	

Table 5. Effect of fulvic acid, magnesium and their interaction on covering density (%) of *Paspalum vaginatum* plants during 2022 and 2023 seasons.

Fulvic acid (ml/l) (A)	Magnesium sulfate concentration (ppm)				
	0.0	**40**	**80**	**120**	**Mean**
			Covering density (%)		
			2022 season		
0.0	56.00	64.33	69.67	71.33	65.33
2.0	59.00	69.67	72.00	74.00	68.67
4.0	60.33	72.00	76.33	78.67	71.83
6.0	65.67	72.00	79.00	85.33	75.50
Mean	60.25	69.50	74.25	77.33	
L.S.D. at 5%	A= 1.44		B= 1.09	A×B= 2.36	
			2023 season		
0.0	60.00	65.67	70.67	71.67	67.00
2.0	64.33	69.00	73.67	76.33	70.33
4.0	70.00	76.00	77.33	84.00	76.83
6.0	73.67	79.67	84.00	94.00	82.83
Mean	67.00	72.58	76.42	81.50	
L.S.D. at 5%	A= 1.00		B= 0.78	A×B= 1.67	

measurements of plant height, an increase in the number of branches, an expanded leaf area, and an overall enhancement of plant spread in *Dendranthema grandiflorum*.

All magnesium concentrations significantly increased seashore plant height compared to control during both tested seasons (Table, 2). The highest values were obtained with 120 ppm magnesium sulfate. During the two seasons, seashore paspalum treated with magnesium sulfate as the foliar spray showed a significant increase in both fresh and dry weights of herb (Table, 3) and roots (Table, 4) when compared to the control. The fresh and dry weights of the herb and roots increase progressively as the concentration of magnesium increases (from 40, 80 to 120 ppm). In comparison to the control, the increases in seashore paspalum fresh weight of the herb were about 24.55 and 27.05 % for $MgSO_4$ at 120 ppm concentration, in both seasons, respectively. The highest values in covering density (77.33 and 81.50%) were recorded with 120 ppm of $MgSO_4$ (Table, 5).

Moreover, magnesium is the primary atom of the chlorophyll molecule and is crucial to the phosphate transfer activities in general. The effects of foliar $MgSO_4$ treatment may be attributed to their vital function in plant growth, which is linked to respiration, photosynthesis and other physiological and biochemical processes. In this concern, Cakmak and Kirkby (2008) found that early Mg deficiency severely impaired sucrose phloem export, without noticeable changes in shoot growth, chlorophyll concentration, or photosynthetic activity. Also, Masuda (2008) reported that magnesium is essential for the biosynthesis of chlorophyll. Furthermore, Metwally *et al*. (2015) indicated that foliar application of magnesium at 50 ppm positively influenced growth traits (plant height, leaf area, leaf count, and both fresh and dry weight) and increased leaves pigments (chlorophyll a, b, and carotenoid) in *Epipremnum aureum* plants. Over the past few decades, numerous studies have investigated the correlation between magnesium (Mg) nutrition and plant growth in various higher plants (Fontenot *et al*., 2015; Farhat *et al*., 2016; Chen and Lee, 2018 and Hauer-Jákli and Tränkner, 2019).

It is clear from the data in Tables (2, 3, 4 and 5) that the interaction between fulvic acid at 6 ml/l with magnesium sulfate at 120 ppm was the optimal combination treatment for plant height, fresh and dry weights of herb and roots per bed as well as covering density percentage. Meanwhile, as previously noted, seashore paspalum plants' fresh and dry weights increased in response to both fulvic acid and magnesium sulfate; when combined, their effects may be maximal, resulting in the tallest plant and heaviest herb and roots weight per bed.

These results are due to, Fulvic acid promotes root development and respiration, improving plant growth and yield, similar to findings from Ali *et al.* (2008) on gerbera and Rongting *et al.* (2017) on mums' plants. Also, these findings are like those reported by Radkowski *et al*. (2017) who found that the application of magnesium sulfate and ascorbic acid (30 g ha^{-1}) significantly increased dry matter yield and organic and mineral content in timothy grass. Furthermore, Kumar *et al*. (2018) confirmed that magnesium, a crucial element in chlorophyll, chromosomes, and polyribosomes, aids plant growth, oil synthesis, starch translocation, and catalytic processes.

In a mixed sward of creeping bent grass and annual bluegrass, Mg/Fe applications increased the proportion of annual bluegrass in shade but had no discernible effect in full sun, according to a linear comparison between plots getting Mg/Fe and plots not receiving it (Stiegler *et al*., 2003). Fertilization with magnesium at 0.5 or 1.0% rate caused an increase in the total dry matter yield of timothy grass cv. Egida compared to control (Radkowski *et al*., 2017). Furthermore, Merwad *et al*. (2017) noted that the greatest values of fresh and dry weights of Sudan grass plants at different salinity levels were obtained with the use of K fulvate.

Chemical constituents and pigments content:

Tables (6 and 7) presents data indicating a significant increase in the total nitrogen and phosphorus percentages in the leaves of seashore paspalum plants treated with any rate of fulvic acid, as compared to control through the two successive seasons. The greatest percentages of potassium (1.36 and 1.34%), as well as total carbohydrates (14.43 and 14.35%), were obtained when seashore plants were sprayed with fulvic acid at 6 ml/l. In both seasons, the total chlorophyll content (a + b) was significantly improved with the application of all rates of fulvic acid (Table, 8) in comparison to the control. The control plants exhibited the lowest values (2.08 and 2.14, mg/100 g as fresh weight) in this regard. Likewise, the treatment of fulvic acid with or without spraying moringa leaf extract gave the highest values of total chlorophyll content and available NPK under the salinity levels (Merwad *et al*., 2017).

The data in Tables (6, 7 and 8) showed that the seashore paspalum, which received the greatest amount of magnesium sulfate (120 ppm) exhibited the highest levels of total nitrogen, total phosphorus, total potassium, and total carbohydrates percentages, and chlorophyll content when compared to the control in both seasons. Consequently, the chemical constituents of seashore paspalum grass were generally significantly improved by the concentration of magnesium sulfate at 120 ppm. These results may be due to magnesium, a crucial element in seashore paspalum grasses' physiological and biological processes, entering plant tissues through stomata, resulting in increased chlorophyll levels. In addition, fulvic acid, a humic substance, enhances plant development by improving nutrient absorption and soil characteristics, acting as a biostimulant, facilitating root growth, and increasing nutrient accessibility. In this concern, Canellas *et al.* (2015) highlighted the biostimulatory properties of humic and fulvic acids in horticulture, potentially improving nutrient assimilation and plant efficacy. Also, El-baset and Kasem (2022) found that fulvic acid significantly improves growth metrics in various plant species, suggesting its potential to enhance NPK absorption in paspalum.

Table 6. Effect of fulvic acid, magnesium and their interaction on total nitrogen and total phosphorus percentages of *Paspalum vaginatum* plants during 2022 and 2023 seasons.

Fulvic acid (ml/l) (A)	Magnesium sulfate concentration (ppm)				
	0.0	**40**	**80**	**120**	**Mean**
			Total nitrogen (%)		
			2022 season		
0.0	1.49	1.74	1.81	1.87	1.73
2.0	1.68	1.83	1.94	2.04	1.88
4.0	1.89	1.99	2.12	2.36	2.09
6.0	1.78	2.22	2.31	2.55	2.22
Mean	1.71	1.95	2.05	2.21	
L.S.D. at 5%	A= 0.02		B= 0.01	A×B= 0.03	
			2023 season		
0.0	1.60	1.75	1.92	1.98	1.81
2.0	1.62	1.83	2.04	2.14	1.91
4.0	1.84	2.02	2.26	2.43	2.14
6.0	1.90	2.25	2.33	2.68	2.29
Mean	1.74	1.96	2.14	2.31	
L.S.D. at 5%	A= 0.01		B= 0.01	A×B= 0.03	
			Total phosphorus (%)		
			2022 season		
0.0	0.193	0.205	0.214	0.223	0.209
2.0	0.221	0.227	0.224	0.236	0.227
4.0	0.221	0.247	0.255	0.264	0.257
6.0	0.221	0.258	0.270	0.282	0.258
Mean	0.214	0.234	0.241	0.252	
L.S.D. at 5%	A= 0.001		B= 0.003	A×B= 0.005	
			2023 season		
0.0	0.198	0.211	0.221	0.226	0.214
2.0	0.202	0.222	0.243	0.251	0.230
4.0	0.228	0.256	0.260	0.267	0.253
6.0	0.233	0.271	0.284	0.300	0.272
Mean	0.215	0.240	0.252	0.261	
L.S.D. at 5%	A= 0.004		B= 0.002	A×B= 0.005	

Table 7. Effect of fulvic acid, magnesium and their interaction on potassium and total carbohydrates percentages of *Paspalum vaginatum* plants during 2022 and 2023 seasons.

Fulvic acid (ml/l) (A)	Magnesium sulfate concentration (ppm)				
	0.0	40	80	120	Mean
			Potassium (%)		
			2022 season		
0.0	1.06	1.16	1.18	1.29	1.17
2.0	1.15	1.25	1.33	1.34	1.27
4.0	1.14	1.22	1.30	1.35	1.25
6.0	1.21	1.32	1.45	1.47	1.36
Mean	1.14	1.24	1.32	1.36	
L.S.D. at 5%	A= 0.01		B= 0.01	A×B= 0.02	
			2023 season		
0.0	1.11	1.21	1.20	1.30	1.21
2.0	1.12	1.27	1.33	1.37	1.27
4.0	1.17	1.27	1.34	1.41	1.30
6.0	1.20	1.28	1.42	1.46	1.34
Mean	1.15	1.26	1.32	1.39	
L.S.D. at 5%	A= 0.01		B= 0.02	A×B= 0.03	
			Total carbohydrates (%)		
			2022 season		
0.0	13.51	13.69	13.82	13.99	13.75
2.0	13.61	13.89	14.36	14.20	14.01
4.0	13.65	13.89	12.24	14.45	14.06
6.0	14.19	14.29	14.63	14.63	14.43
Mean	13.74	13.94	14.26	14.32	
L.S.D. at 5%	A= 0.03		B= 0.03	A×B= 0.06	
			2023 season		
0.0	13.61	13.70	13.88	13.95	13.79
2.0	13.66	13.72	14.14	14.34	13.97
4.0	13.88	14.27	14.44	14.63	14.30
6.0	13.93	14.14	14.55	14.79	14.35
Mean	13.77	13.96	14.25	14.43	
L.S.D. at 5%	A= 0.05		B= 0.03	A×B= 0.08	

Table 8. Effect of fulvic acid, magnesium and their interaction on total chlorophyll content a + b (mg/g as fresh weight) of *Paspalum vaginatum* plants during 2022 and 2023 seasons.

Fulvic acid (ml/l) (A)	Magnesium sulfate concentration (ppm) (B)				
	0.0	40	80	120	Mean
	Total chlorophyll content a + b				
	2022 season				
0.0	1.91	2.06	2.21	2.15	2.08
2.0	2.04	2.25	2.35	2.51	2.29
4.0	1.98	2.25	2.45	2.42	2.27
6.0	2.01	2.40	2.58	2.77	2.44
Mean	1.99	2.24	2.40	2.46	
L.S.D. at 5%	A= 0.04		B= 0.03	A×B= 0.06	
	2023 season				
0.0	1.89	2.19	2.23	2.26	2.14
2.0	2.21	2.39	2.60	2.73	2.84
4.0	2.37	2.61	2.67	2.87	2.63
6.0	2.10	2.61	2.86	3.03	2.65
Mean	2.15	2.45	2.59	2.72	
L.S.D. at 5%	A= 0.03		B= 0.03	A×B= 0.06	

As listed in Tables (6, 7 and 8) when fulvic acid and magnesium application interacted, the chemical constituents (N, P, K, and carbohydrates) and total chlorophyll content improved in comparison to the control plants (which were sprayed with water and did not receive any fulvic or/and magnesium). Additionally, these parameters of seashore paspalum increased when 120 ppm of magnesium sulfate was applied in comparison to fulvic acid at the same concentration alone in both seasons. In general, the combination treatment of 120 ppm of magnesium in both seasons and fulvic acid at 6 ml/l produced the greatest values in this connection. On the other hand, Aboelgoud *et al*. (2021) found that the total chlorophyll content in Sudan grass plants was significantly affected by either individual or combined applications of organic and bio-fertilizers along with different ratios of mineral fertilizers. Additionally, Sharavdorj *et al*. (2022) pointed out that spraying *Trifolium pratense* and *Festuca arundinacea* grasses with $MgSO_4$ significantly enhanced concentrations of P and K^+ and Mg^{2+} in the stem, leaf, and root compared to the control.

CONCLUSION

According to the results above, it is recommended to spray *Paspalum vaginatum* plants at a rate of 6 ml/l with fulvic acid and 120 ppm of magnesium sulfate, with a one-month intervals to improve their growth, covering density and greening.

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تأثير حمض الفولفيك على نمو والمحتوي الكيميائي لمسطح نجيل جزر البحر تحت معدلات الماغنسيوم المختلفة

محمود عبد الفتاح السيد الأشوح و تغريد السيد عيسى
قسم بحوث الزينة وتنسيق الحدائق، معهد بحوث البساتين مركز البحوث الزراعية، الجيزة، مصر

تم إجراء هذه الدراسة في الحقل المفتوح بمشتل معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر خلال عامي ٢٠٢٢ و٢٠٢٣، لتقييم النمو وكثافة التغطية وبعض المكونات الكيميائية لنبات نجيل جزر البحر تحت معدلات مختلفة من حمض الفولفيك (صفر، ٢، ٤ و٦ مللي/لتر)، وتركيزات كبريتات الماغنيسيوم (صفر، ٤٠,٨٠ و١٢٠ جزء في المليون) كرش ورقي ومعاملات التفاعل بينهما. أظهرت النتائج أن النباتات التي تم رشها بحمض الفولفيك أو كبريتات المغنيسيوم بصورة فردية أو متداخلة قد أدت الى زيادة معنوية في ارتفاع النبات ووزن العشب والجذور الطازج والجاف لكل حوض مقارنة بالكنترول. أظهرت نباتات نجيل جزر البحر التي تم رشها بمعدل ٦ مللي/لتر بمفردها أو بالتداخل مع كبريتات الماغنيسيوم بتركيز ١٢٠ جزء في المليون أعلى النسب المئوية من النيتروجين والفسفور والبوتاسيوم والكربوهيدرات وزيادة معنوية في الكلوروفيل الكلي. وبشكل عام، فإن معاملة التداخل (٦ مللي/لتر من حمض الفولفيك +١٢٠ جزء/المليون من كبريتات المغنيسيوم) أظهرت تأثيراً إيجابياً بسبب إثراء النسب المئوية من النيتروجين والفوسفور والبوتاسيوم والكربوهيدرات الكلية بالإضافة إلى المحتوى من الكلوروفيل الضروري لنمو النبات وزيادة كثافة الغطاء، مما أدى إلى تحسين مظهر العشب تحت الظروف التجريبية السائدة. ومن ثم يمكن التوصية برش نجيل جزر البحر ب ٦ مللي/لتر من حمض الفولفيك و١٢٠ جزء في المليون من كبريتات المغنيسيوم بالتبادل مرة واحدة شهريا لتحسين النمو ونسبة تغطية مرتفعة.