

Reducing of water consumption of seashore paspalum using a hydrogel composite

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ABSTRACT

In order to lower the water intake of *Paspalum vaginatum* Swartz while preserving its growth and quality, a trial was carried out at the Nursery of the Horticulture Research Institute in Giza, Egypt, throughout the 2023 and 2024 seasons. The main factors were first, irrigation periods (every 1, 3, 5, and 7 days); second, soil mixing with hydrogel (0, 30, and 50 g/m²), and third, the interaction factors between them. Results indicated that long irrigation intervals led to a significant decrease in turf color quality, turf length, fresh and dry weight per area, and fresh and dry root weight. It also decreased cover density, chlorophyll content, and percentages of nitrogen, phosphorus, and potassium. It significantly increased the proline content of the turf. The addition of hydrogel significantly improved vegetative and root characteristics, turf quality and increased cover density, besides plant nitrogen, phosphorus, and potassium content. The interaction between irrigation periods and hydrogel applications leads to a significant increase in the quality of the grass and its vegetative and root specifications, in addition to the nutritional elements. Proline levels in the grass were also reduced when hydrogel was at a rate of 30 or 50 g/m². The best results were achieved with 50 g/m², eliminating most of the negative effects on the grass when irrigated every 3 or 5 days. Generally, to reduce irrigation water consumption, stimulate coastal paspalum growth, and increase its cover density and greenness, it is recommended to mix the soil with 50 g/m² before planting.

Keywords: Growth, hydrogel, lawns, irrigation periods, *Paspalum vaginatum*.

INTRODUCTION

The use of non-potable water sources for turf grass has increased as a result of freshwater scarcity and conservation efforts, necessitating management and innovative strategies to minimize freshwater use and optimize its benefits. Furthermore, it is critical to maximize landscape irrigation, particularly in regions with limited water supplies (Fadil, *et al.*, 2025). The agricultural sector uses 70% of the world's freshwater, but water availability for farming is going down due to climate change and population growth. To improve water use and meet agricultural needs, water management strategies and precision agriculture technologies are necessary (FAO Statistics, 2020).

Smart irrigation systems and precision agriculture help farmers use resources efficiently and lessen water stress on crops. These systems take into account soil moisture, weather, and plant health to manage when, where, and how much water is delivered. Traditional irrigation methods can lead to over- or under-watering, which can cause nutrient loss, waste

water, and reduce both yield and quality (Bwambale *et al.*, 2021). The *Paspalum turfgrass* is useful for a variety of purposes. important functional roles, as well as providing beauty. Turfs are essential to lowering the soil's susceptibility to wind and water erosion, in addition to managing air pollution, dust, and sun glare. Outdoor activities include football and hockey. Turf is frequently used in golf and lawn tennis. The advertisement sodding is the method used to manufacture products around the world, stolonizing, plugging, and sprigging and/or rhizomes throughout the spring and summer (Nooh and El-Naggar, 2021). Paspalum, specifically *Paspalum vaginatum*, is a type of grass in the Poaceae family, previously called Graminae. It is part of warm-season grasses and is commonly known as Bahia grass. Paspalum includes various species such as dallis grasses, and these grasses thrive in tropical and subtropical regions. Paspalum can reproduce through rhizomes and has leaf blades that are 10 to 19 cm long and 3 to 8 mm wide, often with a blue-green color (El-Naggar, *et al.*, 2024). Hydrogel is a type of polymer that can help reduce the need for regular watering in agriculture, particularly in areas with limited water according to Al-Jabari, *et al.*, (2019). This soil treatment improves the physical, chemical, and biological qualities of the soil, leading to better plant growth (Abobatta, 2018). Hydrogel application boosted plant survival duration because it created sufficient soil moisture. As a result, using it in the soil, especially in drought-stricken, dry, and semi-arid regions, is beneficial for water conservation in the rhizosphere Ayangbenro and Babalola, 2020). Gel-forming composites help retain water, improve water movement, and support soil structure in agriculture and landscaping. They enhance the ability of soils to hold chemicals that protect plants and resist erosion (Novoskoltseva, *et al.*, 2021).

MATERIALS AND METHODS

To achieve the objective of this research, field experiments were conducted during the 2023 and 2024 consecutive seasons at the nursery of the Ornamental Plants and Landscape Research Department at the Horticulture Research Institute in Giza. During both seasons, 36 plots (1.0 x 1.0 m each) were established to study the effect of a hydrogel compound in soil on the response of paspalum (*Paspalum vaginatum* Swartz) to different irrigation intervals. The combined effects of hydrogel concentrations (Super-AB-A-200), respectively Factor A with three graduations: a1- zero (control), a2- 30 g/m², and a3- 50 g/m²)-and irrigation intervals, respectively Factor B with graduations: b1- 1 daily irrigation; b2- irrigation applied every 3 days, b3- irrigation applied every 5, and b4- irrigation applied every 7 days on *Paspalum growth* were investigated with three replicates per treatment. Hydrogel specification in (Table 1).

Table 1. The characteristics of Super-AB-A-200 polymer

Characteristics	Super-AB-A-200 polymer
Shape	granular
Density	1.4–1.5 (gr cm ⁻³)
Size of particles	50–150 (µm)
Maximum stability in soil	7 (year)
Practical capacity of water uptake	220 (g g ⁻¹)

The experimental field was prepared on March 1 by digging the soil (25 cm depth) and applying a sand layer (10 cm). Hydrogels (0, 30, and 50 g/m²) were incorporated into an additional 10 cm sand layer, followed by a 5 cm sand cover. Seashore paspalum sods (1 × 1 m) were planted and covered with a thin (1 cm) sand layer. Irrigation was applied at 10 L/m² daily for two weeks, then at 10 L/m² at intervals of 1, 3, 5, and 7 days thereafter. Fertilization was performed twice (three weeks after planting and two months later) using

ammonium nitrate (125 g, 33.5% N), calcium superphosphate (66 g, 15% P₂O₅), and potassium sulfate (22 g, 39.84% K). Grass response was evaluated based on four cutting cycles (May 1, June 1, July 1, and August 1). The recorded parameters included plant height, fresh and dry biomass (shoot and root) per m², and turf density (%), expressed as tillers/area × 100. Turf quality was visually assessed according to RHS standards (0–9 scale), with ≥ 6 considered acceptable. Total chlorophyll content was measured after the final cut (Wettstein, 1957), proline accumulation was analyzed following Bates et al. (1973), and N, P, K contents were determined according to Page *et al.* (1982). All of the statistical analyses were performed based on a completely randomized experimental design (CRD), and data processing was performed by two-way analysis of variance (two-way ANOVA), in accordance with the experimental structure that included two factors. Duncan's multiple range tests were used to evaluate the means of all therapies at a 5% probability level.

RESULTS AND DISCUSSIONS

The results showed that as irrigation water deficit increased, grass quality declined below 6 degrees (Table 2). Grass color and coverage density improved at 50 g/m² of hydrogel. The best grass color and density were noted with daily irrigation at this amount. Turf irrigated every seven days with 50 g/m² hydrogel saw a 37% increase in density in the first season and about 42% in the second season. Hydrogel application also raised turf height, which decreased with longer dry periods, reaching its peak with 50 g/m² across different irrigation intervals.

Table 2. Effect of Hydrogel, irrigation periods and their interaction on turf color, covering density and plant height on *Paspalum vaginatum*

Hydrogel (g) (A)	Irrigation periods (days) (B)									
	b1-1	b2-3	b3-5	b-7	Mean (A)	b1-1	b2-3	b3-5	b-7	Mean (A)
Turf colors (in 9° scale)										
Season 2023					Season 2024					
a1-0.0	7.13e	6.80g	5.80i	5.53j	6.32c	7.47c	7.10d	5.87f	5.5g	6.48c
a2-30	7.57c	7.20e	6.10h	6.00h	6.72b	8.00b	7.37c	6.33r	6.30r	7.00b
a3-50	8.00a	7.77b	7.33d	7.00f	7.53a	8.20a	8.00b	7.47c	7.17d	7.71a
Mean (B)	7.57a	7.26b	6.61c	6.18d		7.89a	7.49b	6.56c	6.32d	
Covering density (%)										
Season 2023					Season 2024					
a1-0.0	94.00a	83.77b	70.47d	59.33e	76.89c	93.97a	82.77b	68.43bc	55.17f	75.08c
a2-30	95.01a	92.17a	79.43bc	75.27cd	85.48b	92.10a	90.73a	75.53cd	70.27de	82.16b
a3-50	98.03a	95.47a	94.57a	81.33bc	92.35a	96.83a	94.67a	94.17a	78.23bc	90.98a
Mean (B)	95.70a	90.47b	91.49c	72.00d		94.30a	89.39b	79.38	67.89d	
Plant height (cm)										
Season 2023					Season 2024					
a1-0.0	20.37f	18.53g	12.63j	10.16k	15.42c	22.27e	20.37g	14.43j	12.35k	17.35c
a2-30	23.40c	22.47d	20.33f	15.57i	20.44b	24.63c	23.90d	22.03ef	17.13i	21.93b
a3-50	25.67a	24.27b	20.83e	17.58hh	22.09a	26.10a	25.13b	21.90f	18.93h	23.02a
Mean (B)	23.14a	21.76b	17.93c	14.43d		24.33a	23.13b	19.46c	16.14d	

The 0.05 probability level was used in Duncan's Multiple Range Test (Duncan, 1955) to indicate that means assigned the same letter are not significantly different.

In the study, it was found that the amount of water used for irrigation affected the fresh and dry weight of grass over two years (Table 3). The best results came from applying 50 g/m² of hydrogel, with fresh weights reaching 1319. 18 g/m² in the first year and 1395. 63 g/m² in the second year. These weights were significantly higher than those from irrigation only once every week. Similarly, dry weight was also much greater with daily irrigation at 197. 90 g/m² compared to 111. 63 g/m² for weekly irrigation. The harmful effects of drought include all aspects of plant growth, and this is agreed upon by Shahba *et al.*, (2014), who found that the quality of three seashore paspalum cultivars degraded linearly when less irrigation water was used, the visual quality of the turf declined, but the leaf proline level increased noticeably. According to the findings, hydrogel enhances the qualities of sandy soil for plant growth by absorbing and holding water in the soil for a longer period of time, which lowers the need for irrigation.

Table 3. Effect of Hydrogel, irrigation periods and their interaction on herb fresh and dry Weights on *Paspalum vaginatum*

Hydrogel (g) (A)	Irrigation periods (days) (B)									
	b1-1	b2-3	b3-5	b-7	Mean (A)	b1-1	b2-3	b3-5	b-7	Mean (A)
Herb fresh weight (g/m ²)										
Season 2023						Season 2024				
a1-0.0	1265.00c	1020.33e	790.00g	605.33h	920.17d	1337.23d	1123.60g	888.33i	550.00k	974.79c
a2-30	1306.67b	1298.33bc	1026.97e	773.83g	1101.45b	1405.00b	1370.43c	1169.23f	851.83j	1199.13b
a3-50	1385.87a	1298.53bc	1138.27d	862.53f	1171.30a	1444.67a	1440.00a	1258.33e	983.10h	1281.523a
Mean (B)	1319.18a	1205.73b	985.08c	747.23c		1395.63a	1311.34b	1105.30c	794.98d	
Herb dry weight (g/m ²)										
	Season 2023					Season 2024				
a1-0.0	177.10d	142.68f	106.65i	78.63j	126.26c	186.90d	157.23f	123.97h	71.37i	134.87c
a2-30	196.00c	194.75c	158.15e	119.17h	167.02b	196.70c	191.86cd	163.69e	119.26h	167.88b
a3-50	220.60a	206.23b	181.19d	137.10g	186.28a	221.47a	201.60b	192.97cd	137.63g	188.42a
Mean (B)	197.90a	181.22b	148.66c	111.63d		201.69a	183.56b	160.21c	109.42d	

The 0.05 probability level was used in Duncan's Multiple Range Test (Duncan, 1955) to indicate that means assigned the same letter are not significantly different.

Results in hand indicated that reducing irrigation intervals negatively affects the shoot and root systems of *Paspalum vaginatum*. The fresh and dry weight of the paspalum grass declined, the plant height decreased, and the grass color quality dropped below a level of six when it was subjected to prolonged drought. These results agree with previous studies by Jespersen *et al.*, (2019), who reported that the biomass of shoot and root systems of *Paspalum vaginatum* declined with increasing drought severity, the phosphorus level in the aerial mass rose, and the nitrogen content in plants remained unchanged.

The results obtained showed that the fresh weight of the roots increased with increasing irrigation regime and hydrogel concentrations (Table 4). On average of factor B (hydrogel combination) was registered. This result is similar to that when hydrogels were combined with sandy soil or used alone, the water content of the subsurface layer increased. Additionally, compared to the control group, hydrogel-treated sand markedly boosted the above- and below-ground biomass of *Agrostis stolonifera*. Compared to the control group, the 0.4% hydrogel modification to the sand boosted the water usage efficiency of the grass by a factor of eight. In hydrogel-amended soil, the hydrogel increased the effectiveness of

water use by encouraging the development of a thick root system and root aggregation, which improved root contact with moisture (Agaba, *et al.*, 2011).

Table 4. Effect of hydrogel, irrigation periods and their interaction on roots fresh and dry weights on *Paspalum vaginatum*

Hydrogel (g) (A)	Irrigation periods (days) (B)									
	b1-1	b2-3	b3-5	b-7	Mean (A)	b1-1	b2-3	b3-5	b-7	Mean (A)
Roots fresh weight (g/m²)										
Season 2023					Season 2024					
a1-0.0	265.23e	251.83f	222.70g	204.63h	236.10c	274.73f	260.33g	230.33h	213.67i	244.77c
a2-30	316.16b	291.43d	288.10d	252.10f	286.95b	323.33b	299.33d	294.33d	261.00g	294.50b
a3-50	348.67a	317.33b	300.33c	271.33e	309.43a	355.33a	323.33b	312.33c	283.33e	318.58c
Mean (B)	310.02a	286.86b	270.38c	242.69d		317.80a	294.33b	279.00c	252.67d	
Roots dry weight (g/m²)										
Season 2023					Season 2024					
a1-0.0	45.01e	37.79g	28.74h	24.57i	34.03c	48.70f	41.05h	33.16i	27.79j	37.57c
a2-30	56.86c	46.17e	40.83f	27.79h	42.91b	58.61c	52.04e	46.11g	33.45i	47.55b
a3-50	76.52a	63.55b	51.09d	40.73f	57.97a	80.76a	67.07b	55.10d	47.94f	62.72a
Mean (B)	59.47a	49.16b	40.22c	31.03d		62.69a	53.39b	44.79c	36.39d	

The 0.05 probability level was used in Duncan's Multiple Range Test (Duncan, 1955) to indicate that means assigned the same letter are not significantly different.

The chlorophyll content of grass can be considered the primary determinant of grass color quality. Mixing the soil with hydrogel increased the chlorophyll content of the grass, which decreased due to the reduction in water amount. In addition, the herb's proline content (Table 5). As the water supply to the grass decreased for one, two, three, and five days at a time, proline accumulation gradually increased, reaching its highest content in the leaves when watered every 7 days. The water stored in the hydrogel beads, on the other hand, decreased the proline concentration of the grass. The findings revealed overall, longer irrigation gaps reduce grass height, resilience, visual quality, uniformity, root length, and weight while increasing proline levels (Darini, *et al.*, 2015).

Regarding the interaction between irrigation intervals and hydrogel, leaf proline content decreased in all interaction treatments. Grasses irrigated every 7 days decreased their proline content from 1111.67 and 1205.67 in both seasons to 443.33 and 455.00 $\mu\text{g}\cdot\text{g}^{-1}$ fresh wt. in both seasons, respectively, after the addition of 50 g hydrogel/m². This was consistent across all interaction treatments. The water-holding capacity of sandy soil was enhanced by adding hydrogel. When the hydrogel dose was increased, the water-holding capacity and plant retention of available water rose gradually, while the drainage capacity fell when compared to the control treatments. The hydrogel additive slowed the rate at which the soil dried out, restricting the amount of water that plants could access. When drought occurred, the hydrogel treatment had a beneficial impact on plant development, increasing the length of time that plants survived by 66% (Baran, *et al.*, 2015). Under water-scarce conditions, hydrogel can reduce irrigation frequency by half, saving approximately 50% of water, and preventing excessive nutrient leaching, thus enhancing growth (Tan, *et al.*, 2021).

Table 5. Effect of hydrogel, irrigation periods and their interaction on total chlorophyll content (a + b) and proline content on *Paspalum vaginatum*

Hydrogel (g) (A)	Irrigation periods (days) (B)									
	b1-1	b2-3	b3-5	b-7	Mean (A)	b1-1	b2-3	b3-5	b-7	Mean (A)
Total chlorophyll content (a + b) (mg/100 g as fresh weight)										
Season 2023					Season 2024					
a1-0.0	2.96e	2.74h	2.32c	2.21k	2.56c	3.04d	2.83e	2.45g	2.31h	2.66c
a2-30	3.24c	3.10d	2.90f	2.55i	2.95b	3.28b	3.19c	3.10cd	2.65f	3.07b
a3-50	3.38a	3.31b	3.12d	2.81g	3.16a	3.40a	3.33ab	3.15c	2.91e	3.20a
Mean (B)	3.19a	3.05b	2.78c	2.52d		3.24a	3.12b	2.90c	2.63d	
Proline content (µg·g⁻¹ fresh wt)										
Season 2023					Season 2024					
a1-0.0	327.00f	434.33d	823.00b	1111.67a	674.08a	316.33i	407.33e	918.00b	1205.67a	711.83a
a2-30	332.67f	356.67e	438.33d	653.33c	445.25b	353.33g	373.33f	411.33e	681.33c	454.83b
a3-50	330.00f	323.33f	331.33f	443.33d	357.00c	352.00g	331.33h	333.67h	455.00d	368.00c
Mean (B)	329.89d	271.44c	531.00b	737.11a		340.56d	370.67c	554.33b	780.67a	

The 0.05 probability level was used in Duncan's Multiple Range Test (Duncan, 1955) to indicate that means assigned the same letter are not significantly different.

It is known that drought negatively affects the plant's absorption of nutrients, while hydrogel retains water and nutrients. This was evident with increasing hydrogel concentration, as nitrogen, phosphorus, and potassium absorption rates progressively rose, with considerable variance. In contrast, the N, P, and K uptake rates dropped with longer irrigation intervals. The addition of hydrogel at 30 or 50 g/m² was effective in raising the N, P, and K absorption rate in the face of limited irrigation water, as the N concentration in both seasons reached 2.45 and 2.36, respectively, compared to 2.07 and 2.00 for grass that was irrigated every seven days (Table 6).

Table 6. Effect of hydrogel, irrigation periods and their interaction on nitrogen, phosphorus, and potassium on *Paspalum vaginatum*

Hydrogel (g) (A)	Irrigation periods (days) (B)									
	b1-1	b2-3	b3-5	b-7	Mean (A)	b1-1	b2-3	b3-5	b-7	Mean (A)
Nitrogen (%)										
Season 2023					Season 2024					
a1-0.0	2.56f	2.49g	2.34i	2.07k	2.36c	2.43g	2.37h	2.24j	2.00k	2.26c
a2-30	2.89c	2.64e	2.55f	2.25f	2.58b	2.76c	2.53e	2.49f	2.31i	2.52b
a3-50	3.04a	2.99b	2.75d	2.45h	2.80a	3.11a	2.90b	2.68d	2.36h	2.76a
Mean (B)	2.83a	2.71b	2.54c	2.26d		2.77a	2.60b	2.47c	2.22d	
Phosphorus (%)										
Season 2023					Season 2024					
a1-0.0	0.225h	0.215j	0.201k	0.182l	0.206c	0.215i	0.211j	0.210j	0.168k	0.201c
a2-30	0.268d	0.256f	0.236g	0.222i	0.246b	0.271d	0.262f	0.243g	0.231h	0.252b
a3-50	0.301a	0.298b	0.288c	0.259e	0.287a	0.322a	0.307b	0.300c	0.266e	0.299a
Mean (B)	0.265a	0.256b	0.242c	0.221d		0.270a	0.260b	0.251c	0.222d	
Potassium (%)										

	Irrigation periods (days) (B)									
	Season 2023					Season 2024				
a1-0.0	2.58e	2.36g	1.91i	1.50j	2.09c	2.78e	2.55g	2.06i	1.65j	2.26c
a2-30	3.07c	3.00c	2.37g	2.15h	2.65b	3.36c	3.28c	2.59g	2.37h	2.90b
a3-50	3.44a	3.24b	2.82d	2.49f	3.00a	3.72a	3.50b	3.05d	2.69f	3.24a
Mean (B)	3.03a	2.87b	2.37c	2.05d		3.29a	3.11b	2.57c	2.23d	

The 0.05 probability level was used in Duncan's Multiple Range Test (Duncan, 1955) to indicate that means assigned the same letter are not significantly different.

Hydrogel not only holds water but also the fertilizers applied to the soil, releasing them later. The turf to which hydrogel was applied had greater amounts of N, P, and K than the soil to which hydrogel was not added, according to the findings of this study. In agreement with these results. Also, Martin del Campo, *et al.*, (2021) on *Agrostis stolonifera* L-93 turf, used in golf courses, found that adding hydrogel to the soil succeeded in retaining water for a long period and significantly reducing nitrogen fertilizer leaching.

The impact of hydrogel on the most prevalent grass species (*Festuca rubra*, *Festuca ovina*, and *Lolium pyrene*) cultivated under regulated drought conditions was examined in a study by (Hadam, 2010), who found that this water-absorbing substance enhanced the tested species' germination, growth, and dry matter content. Also data in (Table 6) showed that the percentage of phosphorus rose to 0.259 and 0.266 with the addition of 50 g/m² hydrogel, compared to 0.182 and 0.168 for the same treatment, and the concentration of K reached 2.49 and 2.69%, respectively, compared to 1.50 and 1.65 in the first and second seasons (Table 6).

All other findings point to a notable rise in the absorption rates of nitrogen, phosphorus, and potassium across all hydrogel treatments. Del Campo, *et al.*, (2019) also found that adding hydrogel to soil for grass on golf courses reduced nitrogen and phosphorus leaching. It also increased these nutrients in the grass compared to soil without hydrogel or with only peat.

CONCLUSIONS

Longer irrigation intervals negatively affected turf quality, length, and weight, reduced cover density and nutrient content, while increased proline levels. Applying hydrogel at 50 g/m² mitigated these adverse effects, retained water, and promoted turf growth and quality by increasing plant development, coverage density, color quality, total chlorophyll content, and N, P, and K levels. Therefore, it is recommended to add hydrogel at a rate of 50 g/m² to reduce irrigation water consumption while maintaining grass quality.

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