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NITROGENOUS NUTRITION OF PASPALUM TURFGRASS GROWN IN SANDY SOIL USING CHEMICAL AND BIOFERTILIZERS
BY

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ABSTRACT

This study was conducted in a private turfgrass nursery in El- kssassin, Ismailia Governorate, during the two successive seasons of 2005/2006 and 2006/2007, with the aim of investigating the response of seashore paspalum (*Paspalum vaginatum*, Swartz cv. Salam) to two N sources: ammonium nitrate (33.5% N) at the rates of 3, 4 or 5 g N/m^2/month, only or cerealin (a commercial product containing *Bacillus polymyxa* and *Azotobacter chroococcum* bacteria) with or without ammonium nitrate at the same rates. Unfertilized plants were used as the control.

All treatments increased plant height, turf density, fresh and dry weights of clippings/m^2 and underground parts/m^2, as well as the leaf contents of pigments (total chlorophylls and carotenoids), total carbohydrates, N, P and K, compared with the control. In general, raising the rate of chemical N fertilization caused steady increases in the values of most parameters. These increases were more pronounced when chemical N fertilization was combined with the use of cerealin. Cerealin + N at 5 g/m^2/month gave the highest values for most of the vegetative growth parameters as well as the different chemical constituents, whereas inoculation with cerealin alone was the least effective treatment.

In most cases, combining cerealin with chemical N fertilization reduced the need for chemical N fertilization by approximately 20-25%. It can be concluded that inoculation of *Paspalum vaginatum*, Swartz cv. Salam plugs with cerealin, followed by chemical N fertilization of the turf at the rate of 4 g N/m^2/month was sufficient to maintain high quality for the above-ground turf, and relatively good characteristics for the underground parts and chemical composition.

INTRODUCTION

During the past few years, large scale urban development has been taking place in Egypt, including the construction of new cities, residential compounds, as well as coastal touristic resorts and hotels. Such projects usually involve extensive landscape development (including large areas of turfgrasses), most of which take place in desert areas, with poor sandy or rocky soils. Seashore paspalum (*Paspalum vaginatum*) is one of the most promising turfgrasse that can be used in the landscape of desert areas, especially when the irrigation water contains a high salinity level (Hussein and Darwish, 2001 and El-Bagoury *et al.*, 2006). However, under such harsh growth conditions, it is necessary to ensure an adequate supply of nutrients to the turfgrass to compensate the nutrients lost by mowing. Chemical fertilization (especially N fertilization) is the most common means of supplying turfgrasses with their nutritional requirements (Aldous, 1999 and Turgeon, 1999). The effect of chemical fertilization on the growth of different *Paspalum* species has been investigated by several researchers, as Ghisi *et al.* (1994) on *P. coryphaeum*, Auken and Bush (1997) on *P. plicatulum*, Hare *et al.* (1999) on *P. atratum*, Singh (1999) on *P. dilatatum*, Paswan and Machahary (2000) on *P. notatum*, and Hussein and Mansour (2001) on *P. vaginatum*. However, factors such as escalating N fertilizer costs, soil structural degradation, environmental pollution, and sustainable land use have generated a growing interest in natural N fixation as a method of providing plants with their N requirements (Subba Rao, 1984). The current trend is to replace a significant portion of mineral fertilizers by biofertilizers which consist mostly of N-fixing bacteria (Hussein and Mansour, 2003).

Biofertilizers are safe for the environment, and they reduce the need for chemical fertilization, thus reducing the cost of fertilizers and labour. In addition to their main function of fixing molecular nitrogen, the enhancing effect of biofertilizers on some plant growth characters was explained by Subba Rao (1984) who attributed this effect to other factors such as (a) the ability of biofertilizers to synthesize and secrete indole acetic acid, cytokinins, gibberellins and cytokinin - or gibberellin-like substances, (b) increasing amino acids content, and (c) producing anti-fungal antibiotics which inhibit a variety of soil fungi. Also, Okon (1984) mentioned that biofertilizers promote the synthesis of some vitamins, including B_{12}. Among the large number of bacteria which have been tested for their nitrogen fixation ability, *Azotobacter chroococcum* and *Bacillus polymyxa* have yielded very good results. *A. chroococcum* bacteria are strictly aerobic, whereas *B. polymyxa* bacteria are facultative anaerobes (Schlegel, 1993).

The favourable effect of *Azotobacter* bacteria was attributed to an increase in the water and mineral uptake from the soil, which might be ascribed to increase in root surface area, root hairs and root elongation (Hanafy *et al.*, 1997). On the other hand, the beneficial effect of *Bacillus polymyxa* may be attributed not only to its N-fixation ability, but also to its solubilization of organic phosphate compounds (Subba Rao, 1984), suppression of pathogenic organisms in the rhizosphere and the bacterial production of indoleacetic acid (Holl *et al.*, 1988) and caused an increase in aggregated soil particles by 57% which led to a more porous structure within the rhizosphere soil and, consequently, enhanced water retention and nutrient transfer in the rhizosphere (Gouzou *et al.*, 1993). Generally, Omar *et al.* (1991) reported that the inoculation of wheat with *Bacillus polymyxa* can save 41.6% of the nitrogen fertilizer.

Cerealin biofertilizers are a group of commercial products that contain different species of bacteria, depending on the crop. Omar and Hamouda (1998) concluded that wheat plants inoculated with cerealin (containing *Bacillus* *polymyxa*) supplied plants with 50.4% of the nitrogen in their tissues through nitrogen fixation. Kotb (1998) mentioned that the maximum effect of cerealin(containing *Azospirillum lipoferum* and *B. polymyxa*) was achieved when it was combined with chemical N fertilization. El-Hawary *et al.* (1998) and Hussein and Mansour (2003) stated that inoculating wheat or *Pennisetum clandestinum*, respectively with cerealin (containing *Bacillus polymyxa* and *Azotobacter chroococcum* bacteria) followed by chemical N fertilization was sufficient to maintain high quality growth and chemical composition.

MATERIALS AND METHODS

This study was conducted in El-kssassin, Ismailia Governorate, during the two successive seasons of 2005/2006 and 2006/2007, with the aim of investigating the response of seashore paspalum (*Paspalum vaginatum*, Swartz cv. Salam) to two N sources (conventional chemical fertilization and biofertilization), and assessing the possibility of using cerealin to reduce the need for chemical N fertilization.

The physical and chemical characteristics of the soil are presented in Table (1). The experimental soil was watered, and a non-selective herbicide (Round-Up) was sprayed two weeks later at a rate of 1 L/feddan to eliminate all vegetation prior to planting. The soil was throughly plowed twice and well prepared. During soil preparation, calcium superphosphate (15.5% P_2O_5) was applied at the rate of 40 g/m^2. The experimental soil was divided into thirty two square beds (plots) of 1m x 1m.

Every 10g of cerealin [a commercial biofertilizer, produced by Egyptian Ministry of Agriculture, and containing *Bacillus polymyxa* and *Azotobacter chroococcum* bacteria, each at 10^7 colony forming units (CFU)/g carrier] were mixed with 40 g of vermiculite in order to obtain a cerealin/vermiculite mixture (sufficint for inoculation of 10 m^2). The plugs of biofertilization treatments (sixteen beds) were inoculated by wetting their bases and immersing them in the cerealin/vermiculite mixture. Plugs of other treatments (mineral N fertilizer or unfertilized control) were immeresed in vermiculite only.

On March 20th, 2005 and 2006 (in the two seasons, respectively), plugs of *Paspalum vaginatum*, Swartz cv. Salam were planted in the beds at a spacing of 15 x 15 cm (one square meter of sod gave enough plugs to plant about 8 m^2). The planting beds were irrigated daily (at the rate of 6 l/m^2) from planting till May 30th, at which time the turfgrass had become well-established. During the active growing season (from May 30th till October 15th), the plants were irrigated daily at the rate of 7 l/m^2, whereas the irrigation rate was reduced to 4 l/m^2/ day during the period from October 15th till January 15th.

A basal dressing of the cerealin/vermiculite mixture was added after 20 and 50 days from planting, at the rate of 5 g/m^2, and the turfgrass was irrigated immediately thereafter, while vermiculite was added alone at the same rate to beds receiving no biofertilization. In each season, the turf was mowed to a height of 3 cm when necessary till May 30th (when coverage was complete), then the chemical fertilization treatments were initiated. Chemical N fertilization was added using ammonium nitrate (33.5% N) at the rates of 9, 12 or 15 g/m^2/month (equivalent to approximately 3, 4 or 5 g N/m^2/month). Each of the chemical N fertilization rates was applied to 4 inoculated and 4 un-inoculated planting beds (replicates). Also, four inoculated beds and four un-inoculated beds were left with no chemical fertilization. All plots were supplied with potassium sulphate (48% K_2O) at the rate of 30 g/m^2, divided into two equal doses. The first dose was applied after 45 days from planting, and the second dose 45 days later.

The layout of the experiment was a randomized complete blocks design, with 4 replicates, each consisting of 8 planting beds (one for each treatment).

The turf was mowed every 15 days to a height of 3 cm, starting May 30th (2005 and 2006 in the first and second seasons, respectively), till the end of each season. The plant height was recorded before mowing, starting June 15th. The fresh and dry weights of the clippings were also recorded after each mowing. For each fertilization treatment, the values recorded every 15 days were averaged to determine the average plant height before mowing, as well as the average fresh and dry weights of the clippings. At the termination of each season, turf density (number of tillers/100 cm^2), as well as the fresh and dry weights of underground parts (to a depth of 30 cm) were also recorded. In addition, fresh clipping samples were chemically analyzed to determine their total chlorophylls and carotenoids contents (using the method described by Nornai, 1982), while the total carbohydrates content was determined in dried clipping samples (using the method recommended by Dubois *et al.* (1956). Also, dried clipping samples were digested to extract nutrients (as described by Piper, 1947), and the extract was analyzed to determine its contents of N (using the modified micro-Kjeldahl method as described by Pregl, 1945), phosphorus (according to Jackson, 1967) and potassium (estimated photometrically using a Jenway flamephotometer).

Table (1): Physical and chemical characteristics of the soil used for growing *Paspalum vaginatum*, Swartz cv. Salam during the 2005/2006 and 2006/2007 seasons.

Physical characteristics					
Soil texture	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Field capacity (% V)
Sandy	38.5	52.4	6.3	2.8	14.6

Chemical characteristics							
pH	Organic matter (%)	$CaCO_3$ (%)	EC (dS/m) (1:25)	CEC (meq/100 g)	Available macro - nutrients (ppm)		
					N	P	K
7.4	1.03	0.63	0.76	4.1	18.2	1.1	56.0

The data on the vegetative growth characteristics and the chemical constituents were subjected to statistical analysis of variance, and the means were compared using the "Least Significant Difference (L.S.D.)" test at the 5% level, as described by Little and Hills (1978).

RESULTS AND DISCUSSION

I- Vegetative growth characteristics

1- Plant height

In both seasons, plants receiving any of the tested fertilization treatments were significantly taller than the control plants (Table 2). The only exception to this trend was recorded in both seasons with the plants received cerealin only which had insignificantly taller plants than the unfertilized control plants. Moreover, plant height was progressively increased with increasing the rate of chemical nitrogenous fertilization (with or without cerealin). Similar increases in the plant height as a result of increasing N fertilization rates have been reported by Allam (1993) on *Lolium perenne* and Hussein and Mansour (2003) on *Pennisetum clandestinum*. In this concern, Taiz and Zeiger (2002) stated that nitrogen activated division and elongation of meristematic cells.

The beneficial effect of cerealin on plant elongation was clear in both seasons, since the treatments including cerealin and chemical nitrogenous nutrition resulted in taller plants than the plants which received the same chemical nitrogenous nutrition rates only. Cerealin + 5 g N/m^2/month treatment produced the significantly taller plants as compared to most treatments in both seasons. It is worth mentioning that the treatment including cerealin + 4 g N/m^2/month gave insignificantly shorter plants, as compared to those fertilized with 5 g N/m^2/month. The favourable effect of treatments including cerealin on plant height may be explained by the ability of biofertilizers to synthesize and secrete indole acetic acid and gibberellins or gibberellin-like substances (Subba Rao, 1984 and Holl *et al.*, 1988).

In contrast, the least effective treatment for increasing plant height was the application of cerealin alone.

2- Turf density (number of tillers/100 cm^2)

The results recorded in both seasons (Table 2) showed that *Paspalum vaginatum* plants which received the different fertilization treatments had significantly more tillers than the unfertilized (control) ones, in most cases. Moreover, in plants supplied with chemical nitrogenous fertilization alone, raising the application rate caused a steady increase in the number of tillers. Raising the chemical nitrogenous fertilization rate from 4 to 5 g N/m^2/month caused a non significant increase in turf density. This increase in turf density as a result of increasing N rate is in agreement with the findings of Razmjoo and Kaneko (1993) on *Lolium perenne*, Razmjoo *et al.* (1996) on *Agrostis palustris*, Oral and Acikgoz (2001) on a turfgrass mixture consisting of *Lolium perenne*, *Poa pratensis*, *Festuca rubra* var. rubra and *Festuca rubra* var. commutata, and the findings of Hussein and Mansour (2003) on *Pennisetum clandestinum*.

Table (2): Effect of nitrogenous chemical fertilizer and biofertilization on plant height and the turf density (number of tillers/100cm²) of *Paspalum vaginatum* turfgrass in the 2005/2006 and 2006/2007 seasons.

*Fertilization treatments	Plant height (cm)		Turf density (number of tillers/100 cm²)	
	First season (2005/2006)	Second season (2006/2007)	First season (2005/2006)	Second season (2006/2007)
Control	4.5	4.9	164.3	175.1
N1	5.2	6.2	186.2	190.8
N2	6.1	6.6	221.1	210.3
N3	6.5	6.9	228.0	215.2
Cerealin	4.8	5.2	168.8	181.0
Cerealin + N1	5.6	6.3	191.0	195.1
Cerealin + N2	6.4	6.7	221.3	206.8
Cerealin + N3	6.8	6.9	234.0	225.1
LSD (0.05)	**0.5**	**0.4**	**11.1**	**14.5**

* N1, N2 and N3 = N at 3, 4 or 5 g/m²/month, respectively.

Combining chemical N fertilization with cerealin caused a further increase in number of tillers produced by *Paspalum vaginatum*, as compared to the values recorded with plants which received the same chemical fertilization only, in most cases. In both seasons, the highest number of tillers was formed on plants fertilized with 5 g N/m²/month + cerealin. On the other hand, the application of cerealin (with no chemical fertilization) was less effective in increasing number of tillers, compared to treatments which included chemical N fertilization. Plants which received cerealin only produced insignificantly more tillers than the unfertilized control plants. This conclusion is in agreement with the findings of Hussein and Mansour (2003) on *Pennisetum clandestinum* turfgrass, who reported that plants which received cerealin only produced more tillers than the unfertilized control plants but lower than the values recorded with the treatments which included chemical N fertilization.

It is also worth mentioning that in many cases, the use of cerealin reduced the need for chemical N fertilization. For example, results recorded in the second season showed that plants fertilized with cerealin only produced insignificantly fewer tillers than those produced by plants fertilized with 3 g N/m²/month. Also, in both seasons, plants fertilized with 4 g N/m²/month + cerealin gave insignificantly fewer tillers than those produced by plants fertilized with 5 g N/m²/month alone.

3- Fresh and dry weights of clippings/m²

The results recorded in the two seasons (Table 3) showed that the fresh and dry weights of clippings/ m² were significantly increased by most of fertilization treatments over the control. Raising mineral N fertilization rate, with or without cerealin, steadily increased fresh and dry weights of clippings. In both seasons, cerealin + 5 g N/m²/month treatment resulted in the significantly higher fresh and dry weights of clippings, as compared to the other fertilization treatments in most cases. Such results are reasonable, since plant height and turf density attained a parallel trend. These findings are in accordance with those obtained by Razmjoo and Kaneko

(1993) on *Lolium perenne*, Soni *et al.* (1993) on *Zoysia matrella*, Paswan and Machahary (2000) on *Paspalum notatum*, Sistana and Mays (2001) on *Paspalum notatum* and Hussein and Mansour (2003) on *Pennisetum clandestinum*.

On the other hand, cerealin alone resulted in the lightest fresh and dry weights of clippings, as compared to all other fertilization treatments. This result is in agreement with the findings of Kapustka *et al.* (1985) on *Lolium perenne* and Hussein and Mansour (2003) on *Pennisetum clandestinum*, they mentioned that nitrogen-fixing bacteria alone (including *Azotobacter* and *Bacillus* bacteria) are not capable of supplying sufficient N to the plants.

Data presented in Table (3) also showed that in many cases, the use of biofertilization decreased the amounts of chemical nitrogenous fertilizers needed for the production of new growth between mowings. In both seasons, fertilization with cerealin + 3 g N/m^2/month gave insignificantly different values, compared to those obtained from plants fertilized with 4 g N/m^2/month (without cerealin), in most cases. Moreover, plants fertilized with cerealin + 4 g N/m^2/month gave fresh and dry weights of clippings that were insignificantly different than those obtained with fertilization using the highest mineral N rate only (5 g N/m^2/month). These results showed that inoculation with cerealin reduced the need for chemical N fertilization by 20-25%. Such results are in agreement with the findings of Omar *et al.* (1991) who reported that inoculation of wheat with *Bacillus polymyxa* can save 41.6% of the nitrogen fertilizer. Quarles (1996) concluded that application of biofertilization treatments to golf courses (using *Azospirillum brasilense*) reduced the need for fertilizer applications and Hussein and Mansour (2003) reported that inoculation of *Pennisetum clandestinum* with cerealin reduced the need for chemical N fertilization by 25-33%.

Table (3): Effect of nitrogenous chemical fertilizer and biofertilization on the fresh and dry weights of clippings/m^2 of *Paspalum vaginatum* turfgrass in the 2005/2006 and 2006/2007 seasons.

*Fertilization treatments	Fresh weight of clippings (g/m^2)		Dry weight of clippings (g/m^2)	
	First season (2005/2006)	Second season (2006/2007)	First season (2005/2006)	Second season (2006/2007)
Control	25.3	24.1	5.1	4.2
N1	34.6	36.1	6.4	7.0
N2	39.9	47.6	6.8	8.1
N3	41.5	51.2	8.0	10.2
Cerealin	28.5	25.8	4.6	4.7
Cerealin + N1	38.9	43.5	7.0	9.4
Cerealin + N2	43.5	48.0	8.5	9.5
Cerealin + N3	47.0	54.1	9.0	11.7
LSD (0.05)	**3.8**	**4.1**	**0.6**	**0.8**

* N1, N2 and N3 = N at 3, 4 or 5 g/m^2/month, respectively.

4- Fresh and dry weights of underground parts/m²

The fresh and dry weights of underground parts were significantly increased by most of the fertilization treatments, compared to the unfertilized control plants (Table 4). Raising the rate of chemical nitrogenous fertilization (with or without cerealin) caused a steady increase in the recorded values. Such results were similarly recorded by Hussein and Mansour (2003) on *Pennisetum clandestinum* turfgrass.

Although the least effective treatment for increasing the fresh and dry weights of underground parts was the inoculation with cerealin only, the favourable effect of biofertilization on the growth of underground parts was very clear in both seasons when cerealin was combined with the addition of chemical N fertilization. In both seasons, plants which received cerealin + 4 g N/m^2/month gave insignificantly different fresh and dry weights of underground parts than those obtained from plants receiving the highest chemical N fertilization only (5 g N/ m^2/month). Moreover, the plants which received cerealin + 3 g N/ m^2/month gave significantly heavier dry weight of underground parts in the first season and insignificantly different dry weight of underground parts in the second one, when compared to the plants which received chemical N fertilization only at 4 g N/ m^2/month. These results are in agreement with the findings of Hanafy *et al.* (1997) on *Corchorus olitorius* and *Raphanus sativus.* Also, Hussein and Mansour (2003) reported that inoculation of *Pennisetum clandestinum* with cerealin (with or without chemical N fertilizatio) increased the fresh and dry weights of underground parts.

Table (4): Effect of nitrogenous chemical fertilizer and biofertilization on the fresh and dry weights of underground parts/m² of *Paspalum vaginatum* turfgrass in the 2005/2006 and 2006/2007 seasons.

*Fertilization treatments	Fresh weight of underground parts (g/m²)		Dry weight of underground parts (g/m²)	
	First season (2005/2006)	Second season (2006/2007)	First season (2005/2006)	Second season (2006/2007)
Control	301.5	280.6	63.5	63.1
N1	369.6	310.1	85.0	72.6
N2	430.0	360.5	88.2	93.8
N3	470.6	440.5	106.4	111.0
Cerealin	345.1	305.9	70.9	65.5
Cerealin + N1	380.4	323.7	102.3	90.3
Cerealin + N2	455.5	415.5	106.6	114.7
Cerealin + N3	493.5	443.6	130.8	118.0
LSD (0.05)	**33.5**	**29.7**	**6.4**	**5.6**

* N1, N2 and N3 = N at 3, 4 or 5 g/m^2/month, respectively.

II- Chemical composition

1 - Leaf pigments content (total chlorophylls and carotenoids)

In both seasons, the synthesis and accumulation of leaf pigments (total chlorophylls and carotenoids) were significantly increased by the application of most fertilization treatments, as compared to the control (Table 5). Raising the rate of chemical N fertilization caused a gradual significant increase in the recorded values, in most cases. This increase in the content of total chlorophylls and carotenoids as a result of raising the rate of chemical N fertilization coincides with the findings of Allam (1993) on *Lolium perenne*. Also, increasing the rate of chemical N fertilization caused an increase in the chlorophylls content of *Paspalum notatum* (Paswan and Machahary, 2000).

Using cerealin alone was the least effective treatment for increasing the leaf pigments content compared to the other fertilization treatments. Combining cerealin with chemical N fertilization gave higher values than those obtained with chemical fertilization alone (at the same rates), in most cases. Among the different fertilization treatments, the application of cerealin + 5 g N/m^2/month gave the significantly higher contents of total chlorophylls and carotenoids, as compared with most treatments.

Table (5): Effect of nitrogenous chemical fertilizer and biofertilization on the total chlorophylls, carotenoids and total carbohydrates contents of *Paspalum vaginatum* turfgrass in the 2005/2006 and 2006/2007 seasons.

Fertilization treatments	Total chlorophylls content (mg/g fresh matter)		Total carotenoids content (mg/g fresh matter)		Total carbohydrates content (% of dry matter)	
	First season (2005/6)	Second season (2006/7)	First season (2005/6)	Second season (2006/7)	First season (2005/6)	Second season (2006/7)
Control	1.65	1.32	0.46	0.33	19.5	18.6
N1	1.84	1.63	0.61	0.47	21.9	21.4
N2	2.11	1.80	0.74	0.56	23.6	21.9
N3	2.55	2.25	0.99	0.81	24.2	24.8
Cerealin	1.72	1.49	0.60	0.45	21.0	20.5
Cerealin + N1	1.98	1.89	0.79	0.70	23.1	22.3
Cerealin + N2	2.30	2.01	0.87	0.80	23.8	24.6
Cerealin + N3	2.68	2.23	1.15	0.98	24.6	25.3
LSD (0.05)	**0.15**	**0.12**	**0.14**	**0.09**	**1.1**	**1.4**

* N1, N2 and N3 = N at 3, 4 or 5 g/m^2/month, respectively.

The promotion of the synthesis and accumulation of chlorophyll as a result of mineral N fertilization or the use of N-fixing bacteria may be attributed to the role of nitrogen as an essential component in the structure of porphyrines, which are found in many metabolically active compounds, including chlorophylls. Chlorophylls are bound to, and perhaps even embedded within protein molecules (Devlin, 1975). The results presented in Table (5) also showed that in both seasons, the total chlorophylls and carotenoids content of plants fertilized with cerealin + 3 g N/m2/month were insignificantly differen or significantly higher than the values of plants which received 4 g N/m2/month alone. Moreover, carotenoids content of the plants received cerealin + 4 g N/m2/month were insignificantly different than the values of plants which received 5 g N/m2/month alone. These results indicated that biofertilization may cause some reduction in the requirements of chemical N fertilization (approximately 20-25%) needed by *Paspalum vaginatum* for the synthesis of pigments. Such result was obtained by Hussein and Mansour (2003) on *Pennisetum clandestinum.*

2- Total carbohydrates%

Fertilization of *Paspalum vaginatum* with the different treatments significantly increased the total carbohydrates%, compared to that of control plants (Table 5). Raising the rate of chemical N fertilization with or without cerealin caused a steady increase in the recorded values. The favourable effect of the different fertilization treatments on the synthesis and accumulation of carbohydrates may be attributed to the increase in the chlorophylls content of fertilized plants, and to the role played by nitrogen in the structure of porphyrine molecules (as previously mentioned), which are found in the cytochrome enzymes essential in photosynthesis. This increase in the contents of chlorophylls and cytochrome enzymes results in an increase in the rate of photosynthesis, and a promotion in carbohydrate synthesis and accumulation (Devlin, 1975). The obtained reaults are in agreement with the findings of Allam (1993) on *Lolium perenne* and Hussein and Mansour (2003) on *Pennisetum clandestinum.*

The favourable effect of combining biofertilization with chemical N fertilization was clear in both seasons, with plants fertilized using cerealin + chemical N fertilization giving higher total carbohydrates content than the plants received the same chemical N fertilization only. Moreover, the plants fertilized with cerealin + 3 g N/m^2/month gave insignificantly different total carbohydrates than the values recorded with the plants fertilized with 4 g N/m^2/month alone. Also, the plants received cerealin + 4 g N/m^2/month gave insignificantly lower total carbohydrates% than the values recorded with the plants fertilized with 5 g N/m^2/month alone. The highest mineral N (5 g N/m^2/month) combined with cerealin resulted in the highest total carbohydrates%, in both seasons. These results are in agreement with the findings of Hussein and Mansour (2003) on *Pennisetum clandestinum.* On the other hand, the least effective treatment for increasing the total carbohydrates% was the inoculation with cerealin only, in both seasons.

3- N, P and K% of dry matter in clippings

N, P and K% of dry matter in clippings of *Paspalum vaginatum* were significantly increased as a result of most fertilization treatments, compared to the control (Table 6). In both seasons, raising the rate of chemical N fertilization with or without cerealin resulted in a steady increase in the percentages of the three nutrients.

A similar increase in the N content of *Zoysia matrella* as a result of increasing the rate of N application (from 0 to 40 g N/m^2/year) was reported by Soni *et al.* (1993). Also, Razmjoo *et al.* (1996) on *Agrostis palustris* and Hussein and Mansour (2003) on *Pennisetum clandestinum* found that the N, P and K percentages were increased as a result of increasing chemical N fertilization rate.

The effect of fertilization on N, P and K percentages was generally more pronounced when chemical N fertilization was combined with the application of biofertilization. Plants fertilized with cerealin + chemical N fertilization gave significantly higher N, P and K percentages than the plants received the same chemical N fertilization rate only. Accordingly, the highest values were obtained from plants fertilized with cerealin + 5 g N/m^2/month.

Table (6): Effect of nitrogenous chemical fertilizer and biofertilization on N, P and K% of dry matter in clippings of *Paspalum vaginatum* turfgrass in the 2005/2006 and 2006/2007 seasons.

Fertilization treatments	N (% of dry matter)		P (% of dry matter)		K (% of dry matter)	
	First season (2005/6)	Second season (2006/7)	First season (2005/6)	Second season (2006/7)	First season (2005/6)	Second season (2006/7)
Control	1.15	1.29	0.09	0.05	1.11	1.21
N1	1.35	1.66	0.15	0.09	1.20	1.37
N2	1.39	1.79	0.20	0.18	1.26	1.54
N3	1.61	1.86	0.26	0.27	1.43	1.59
Cerealin	1.30	1.48	0.11	0.07	1.16	1.30
Cerealin + N1	1.47	1.70	0.19	0.14	1.34	1.62
Cerealin + N2	1.73	1.98	0.29	0.24	1.50	1.70
Cerealin + N3	1.79	2.01	0.29	0.28	1.59	1.89
LSD (0.05)	**0.13**	**0.11**	**0.03**	**0.03**	**0.10**	**0.15**

* N1, N2 and N3 = N at 3, 4 or 5 g/m^2/month, respectively.

The favourable effect of combining cerealin with chemical N fertilization was generally clear on the N and K percentages in both seasons and P percentage in the first season, since plants fertilized with cerealin + 3 g N/m^2/month had insignificantly different percentage than those fertilized with 4 g N/m^2/month only. Moreover, in both seasons, plants fertilized with cerealin + 3 g N/m^2/month had insignificantly different percentage of K than those fertilized with 5 g N/m^2/month (without cerealin). Also, plants fertilized with cerealin + 4 g N/m^2/month had higher N and K percentages in both seasons, and P percentage in the first season, than those supplied with chemical N fertilization alone, even at the highest rate (5 g N/m^2/month). Such results are in agreement with the results recorded on *Festuca pratensis*, which showed an increase in the N content as a result of inoculation with *Klebsiella*, *Enterobacter* (Haahtela, 1986) or *Azospirillum brasilense* (Yurko, 1997). Also, Kotb (1998) reported that N and P uptake by wheat plants fertilized with 50 kg N/fed. in combination with bacterial inoculation was more or less similar to that of plants fertilized with 75 kg N/fed. alone.

CONCLUSION

From the above results, it can be concluded that in most cases, combining cerealin with chemical N fertilization treatments reduced the need for chemical N fertilization by approximately 20-25%. Thus, inoculation of *Paspalum vaginatum* plugs with cerealin, followed by chemical N fertilization of the turf at the rate of 4 g N/m^2/month, is recommended. This was sufficient to maintain high quality for the above-ground turf, and relatively good characteristics for the underground parts and chemical composition.

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التغذية النتروجينية للمسطح الأخضر "باسبالم" النامى فى تربة رملية بإستخدام الأسمدة الكيماوية و الحيوية

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أجرى هذا البحث فى مشتل مسطحات خضراء خاص بالقصاصين بمحافظة الإسماعيلية، خلال الموسمين المتتاليين ٢٠٠٥/٢٠٠٦ و ٢٠٠٦/٢٠٠٧، بهدف دراسة إستجابة مسطحات الباسبلم (*Paspalum vaginatum*, Swartz cv. Salam) لمصدرين من النتروجين: نترات النشادر (٣٣,٥% ن) بمعدلات ٣، ٤ أو ٥ جم نتروجين/م٢/ شهر فقط أو بالسيريالين (منتج تجارى يحتوى على بكتريا *Bacillus polymyxa* و *Azotobacter chroococcum*) فقط أو مع سماد نترات النشادر بنفس المعدلات. بالإضافة إلى نباتات غير مسمدة للمقارنة (كنترول).

أدت جميع المعاملات المستخدمة إلى زيادة إرتفاع النباتات قبل القص وكثافة المسطح والأوزان الطازجة والجافة لناتج القص وللأجزاء الأرضية لكل متر٢، و كذلك

محتوى الأوراق من الصـبغـات (الكلـوروفـيـلات الكليـة و الكاروتينويـدات) والكربوهيدرات الكلية والنتروجين والفوسفور والبوتاسيوم مقارنـة بالنباتـات الغيـر مسمدة (الكنترول). وبصفة عامة فإن زيادة معدلات التسميد النتروجيني الكيماوي أدت إلى زيادة طردية في القيم المسجلة لمعظم هذه الصـفات، وكانت هذه الزيـادة أكثـر وضوحاً عند الجمع ما بين التسـميد النتروجيني الكيماوي وإستخدام السيريالين. وقـد أدى إسـتخدام السيريالين + التسـميد الكيماوي بمعدل ٥ جم نتروجين/ م٢/ شهر إلى الحصول على أعلى القيم لمعظم صفات النمـو الخضـري و المكونـات الكيميائيـة المختلفة، بينما كان التلقيح بالسيريالين فقط أقل المعاملات فعالية.

وفي معظم الأحيان أدى الجمع مـا بـين إسـتخدام السـيريالين و التسـميد النتروجيني الكيماوي إلى التقليل مـن إحتياجـات التسـميد النتروجينـي الكيمـاوي بمقدار ٢٠-٢٥% تقريباً. و يمكن إستنتاج أن تلقيح غرز الـ *Paspalum vaginatum,* Swartz cv. Salam بالسيريالين مع التسميد النتروجيني الكيماوي بعد الزراعة بمعدل ٤ جم نتروجين/م٢/شهر كان كافياً للحفاظ على جودة عالية لنمـو المجمـوع الخضـري للمسطح، و كذلك صفات جيدة للأجزاء الأرضية و المكونات الكيميائية.