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Tirth A Patel
Department of Floriculture and landscape Architecture, ASPEE College of Horticulture, Navsari, Gujarat, India

Dipal S Bhatt
Department of Floriculture and landscape Architecture, ASPEE College of Horticulture, Navsari, Gujarat, India

BM Tandel
Department of Fruit Science, ASPEE College of Horticulture, Navsari, Gujarat, India

MA Patel
Department of Floriculture and landscape Architecture, ASPEE College of Horticulture, Navsari, Gujarat, India

HM Patel
Department of Soil Science and Agril. Chemistry, ASPEE College of Horticulture, Navsari, Gujarat, India

AP Chaudhary
Department of Social Science, ASPEE College of Horticulture, Navsari, Gujarat, India

Corresponding Author:
Tirth A Patel
Department of Floriculture and landscape Architecture, ASPEE College of Horticulture, Navsari, Gujarat, India

Efficacy of Pusa hydrogel application to potting media for growth and yield of *Nephrolepis cordifolia* 'Duffii'

Tirth A Patel, Dipal S Bhatt, BM Tandel, MA Patel, HM Patel and AP Chaudhary

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Abstract

An experiment was conducted to study the impact of Pusa hydrogel on growth and yield of *Nephrolepis cordifolia* 'Duffii' for cut foliage during 2023 - 24 at Floriculture Research Farm, ASPEE College of Horticulture, Navsari Agricultural University, Navsari. The experiment was laid out in Completely Randomized Design (CRD) with four repetitions, consisting six treatments *viz.*, T_1: Control (Cocopeat + Vermicompost), T_2: Pusa hydrogel @ 10 g, T_3: Pusa hydrogel @ 20 g, T_4: Pusa hydrogel @ 30 g, T_5: Pusa hydrogel @ 40 g, T_6: Pusa hydrogel @ 50 g. Cocopeat and Vermicompost (2:1 v/v) were used as potting media. The findings showed that, plant height (44.34 cm, 48.73 cm and 53.20 cm), plant spread in N - S directions (34.28 cm, 39.28 cm and 53.88 cm) and E - W directions (34.73 cm, 40.34 cm and 55.35 cm), blade length (33.19 cm, 36.54 cm and 40.41 cm), blade width (15.96 mm, 16.37 mm and 16.66 mm), petiole (stipe) length (10.04 cm, 12.31 cm and 14.38 cm), pinna length (13.89 mm, 14.60 mm and 15.07 mm), pinna width (8.94 mm, 9.13 mm and 9.31 mm) and frond length (43.44 cm, 47.91 cm and 51.94 cm) were observed maximum in plants grown in media containing Pusa hydrogel @ 50 g (T_6) at 60, 120 and 180 days after planting, respectively. Potting media amended with Pusa hydrogel @ 50 g (T_6) resulted maximum fresh weight of 10 fronds (12.19 g) and obtained highest number of cut foliage (77.31 per pot per year). Reduction in irrigation frequency (5.20 days) with minimum consumptive water use (17.56 L/pot) were noted with application of Pusa hydrogel @ 50 g in media (T_6) throughout the crop growth period than control (1.53 days and 59.63 L/pot, respectively).

Keywords: *Nephrolepis cordifolia* 'Duffii', Pusa hydrogel, growth, irrigation frequency, consumptive water use

Introduction

Floriculture is a fast-expanding agri - business in the world as well as in India with respect to cut flowers, loose flower, pot plants, landscape plants, cut greens, nursery *etc.* It has been emerging as a future thrust industry in India and referred as tomorrow's green cultivation. Ornamental plants are often grown in pot or landscape gardening to show a variety of unique or exotic leaf shape, texture and colours. Foliage pot plants are always valued for their foliage beauty, compactness of size and ability to survive under shady conditions. Pot plants can improve indoor air quality for building occupants, as well as just one plant within the work space can significantly enhance staff morale and simultaneously promote well-being and improve performance. Among various ornamental foliage plants, ferns are widely used due to its versatile design, year-round availability and long post-harvest life (D' Souza *et al*., 2006) [6].

Ferns are an attractive addition to any landscape garden due to their graceful foliage, growth habit and ability to grow in low light (Muthukumar and Prabha, 2012) [12]. Ferns are usually sold as hanging baskets or pot plants in a variety of container sizes depending on its growth habit and market demand. They are also known for removing pollutants from the air and contribute to enhance interior air humidity through transpiration. Ferns are extremely diverse in habitat and form with wide range of foliage from dark green to light yellow and others with surprising colours of grey, silver, red and blue - green which increase their utility in floral arrangements.

It can also be used as cut foliage or cut filler either alone in large quantities or in association with flowers as a source of decoration.

Nephrolepis cordifolia 'Duffii' belongs to family Nephrolepidaceae is one of the most pleasant small ferns and can be grow as indoor ornamental plant mainly for pot plant, hanging basket and window boxes. It is also known as lemon button fern, erect sword fern or button sword fern. It is acclimated to humid condition, so when grown as a house plant, it is necessary to maintain moisture and humidity in media. It requires moisture, humidity and continuous watering for better growth (Poole *et al.*, 1984) [15]. In today's urban lifestyle, people are very busy with their daily routines and do not have much time to look after their plants. As a result, growth of the plants may not be good and plants look dull and unattractive due to insufficient care like timely watering, nutrient application *etc*. Frequent watering and maintaining adequate moisture content in indoor potted plants are the major limiting factors. There is a need to explore alternative water holding technologies, especially in tropical climate where water demand is higher. Water saving technologies also help to enhance plant establishment and growth. Moreover water retaining materials also known to improve moisture holding capacity of soil and helps to overcome the moisture stress during crop growth period. The primary goal of modern agriculture is to enhances output by making the best use of available land and water supplies while without endangering the environment or natural resources. In this regards, materials like hydrogel should be prioritized for long term production and improved farm resource utilization.

Hydrogel is a Super Absorbent Polymers (SAP), play an important role in conserving water, reducing irrigation frequency and in releasing sufficient moisture to growing roots of ornamental crops. Use of hydrogels increases the amount of available moisture in root zone and increase intervals between irrigations. Hydrogels can be applied by either mixing with the soil or by spraying (Mohammad *et al.*, 2008) [11]. Large quantity of water retained by the polymer provide extra available water to crops which facilitates better crop growth. Pusa hydrogel is a natural polymer which absorbs 400 times water of its dry weight and gradually releases the same, stable in soil for a minimum period of one year and less affected by salts, required in less quantity (1-2 kg/ ha for horticultural crops and 2.5-5 kg/ ha for field crops), reduces leaching of fertilizers, improves physical properties of soils and other media, improves root growth and density, promotes early and dense flowering and fruiting/ tillering, helps plants withstand prolonged moisture stress, reduces irrigation and fertigation requirements of crops and delay the permanent wilting point. Keeping this point in a view the experiment was conducted to study the impact of Pusa hydrogel in potting media on growth and yield of *Nephrolepis cordifolia* 'Duffii'.

Materials and Methods

The experiment was conducted during June 2023 to May 2024 at Floriculture Research Farm, ASPEE College of Horticulture, Navsari Agricultural University, Navsari. The experimental site is geographically situated at coastal region of the South Gujarat at 20° 37' North latitude and 72° 54' East longitude at an altitude of 11.98 meter above the mean sea level. The experiment was laid out in Completely Randomized Design (CRD) with four repetitions, consisting six treatments *viz.*, T_1: Control (Cocopeat + Vermicompost), T_2: Pusa hydrogel @ 10 g, T_3: Pusa hydrogel @ 20 g, T_4: Pusa hydrogel @ 30 g, T_5: Pusa hydrogel @ 40 g, T_6: Pusa hydrogel @ 50 g. Potting media cocopeat and vermicompost were mixed in proportion of 2:1 V/V. Required quantity of Pusa hydrogel was calculated based on % W/W as per treatments and mixed thoroughly with potting media and then filled in plastic pots, having 15 cm height, 22 cm top diameter and 12 cm bottom diameter. Irrigation was given at 50 % field capacity as per the requirement in each treatment throughout the experimentation. After two weeks of planting, water soluble fertilizer 19:19:19 (NPK) 250 ppm was applied in twice in a month. The plants were critically observed in all the treatments and observations on various growth and yield parameters as well as irrigation frequency (days) and consumptive water use (l/pot) were recorded periodically.

Table 1: Properties of potting mixture

Particulars \ Treatments	T_1	T_2	T_3	T_4	T_5	T_6
pH	6.30	6.70	6.40	6.34	6.16	6.23
EC (dSm^{-1})	0.62	0.66	0.60	0.56	0.59	0.57
Bulk density (g cm^{-3})	0.54	0.51	0.54	0.56	0.48	0.52
Particle density (g cm^{-3})	1.08	1.00	1.09	1.12	0.97	1.03
Water holding capacity (%)	40.65	44.06	48.75	52.97	63.77	68.90

Results and Discussion

Plant height (cm) and Plant spread (cm)

The findings (Table 2) showed that application of Pusa hydrogel @ 50 g in media (T_6) increased plant height (44.34 cm, 48.73 cm and 53.20 cm), plant spread in East - West direction (34.73 cm, 40.34 cm and 55.35 cm) as well as in North - South direction (34.48 cm, 39.28 cm and 53.88 cm) at 60, 120 and 180 days after planting, respectively. An increase in plant height and plant spread might be due to higher Pusa hydrogel content which has high potential to absorb water and conserve in a media which reduced the drought stress and provides efficient water retention and gradual release, ensuring a consistent moisture supply that enhances nutrient absorption and metabolic activities. Furthermore, sufficient water availability and supply of nutrients provided by super absorbent polymer resulted increase in the activity of cell division, cell expansion and cell elongation ultimately leading to stem elongation and plant height. Hydrogel also enhance soil physico - chemical properties like water holding capacity, porosity etc. which may improves uptake of nutrients and aeration and ultimately enhanced root growth and plant growth. Improvement in plant height with Pusa hydrogel amended media was also observed by Anupama *et al.* (2007) [4] and Thumar *et al*. (2020) [17] in chrysanthemum, Kumar *et al.* (2016) [9] in pot mums, Abdul *et al.* (2018) [1] in coleus, Madhu Bala (2018) [10] in philodendron, Aditya *et al.* (2023) [3] in marigold, Fazal *et al.* (2023) [8] in petunia and Soliman *et al.* (2024) [16] in calendula.

Blade length (cm) and Blade width (cm)

The findings (Table 2) showed that application of Pusa hydrogel @ 50 g in media (T_6) increased blade length (33.19 cm, 36.54 cm and 40.41 cm) and blade width (15.96 mm, 16.37 mm and 16.66 mm) at 60, 120 and 180 days after planting, respectively. Application of Pusa hydrogel at 40 g and 50 g along with substrate helps to achieved good quality of blades with respect to width and length might be due to hydrogel polymer to potting media enhanced the accessibility of water in the substrate, provides suitable micro climate for uptake and translocation of the nutrients which finally resulted in growth and development of plant and also enhances of photosynthesis and improves the quality of leaves. Furthermore, this super absorbent polymer releases absorbed moisture slowly through diffusion mechanism which gives additional benefit during stress or adverse conditions. Various stress conditions can mitigate the damage to plant's photosynthetic apparatus by applying a water retaining hydrogel. The present findings are in accordance with the results observed by Anupama *et al*. (2007) [4] and Thumar *et al.* (2020) [17] in chrysanthemum, Nazarli *et al.* (2010) [14] in sunflower crop, Abdul *et al.* (2018) [1] in coleus and Madhu Bala (2018) [10] in *Philodendron xanadu.*

Petiole (stipe) length (cm)

It is evident from the data that petiole (stipe) length significantly affected due to different treatments of Pusa hydrogel (Table 3). Longest petiole (stipe) (10.04 cm, 12.31 cm and 14.38 cm) were found in Pusa hydrogel @ 50 g (T_6) at 60, 120 and 180 days after planting, respectively. Significant increase in petiole length at higher dose of Pusa hydrogel might be due to adequate and continuous moisture to plant which encourage the root establishment and maintain various metabolic processes and cell elongation. Due to inadequate moisture availability in without Pusa hydrogel application, petiole length was observed shorter. Similar finding was also reported by Madhu Bala (2018) [10] in philodendron.

Pinna length (mm) and Pinna width (mm)

Maximum pinna length (13.89 mm, 14.60 mm and 15.07 mm) and pinna width (8.94 mm, 9.13 mm and 9.31 mm) were found in Pusa hydrogel @ 50 g (T_6) at 60, 120 and 180 days after planting, respectively. Higher concentration of hydrogel resulted the maximum pinna length and pinna width as it maintains the sufficient moisture in potting media for proper growth of ferns. Adequate amount of water maintains the turgor pressure inside the cells resulting expansion of cell and increase the cell volume thereby maximize the leaf area. Whereas, water deficit lowers the turgor pressure subsequently concentrates solutes in cells as a result decrease in cell volume due to cell shrinkage ultimately reduces the pinna size. Clough and Milthorpe, 1975 [5] observed water deficit reduced the leaf area and shown to reduce the rate of leaf initiation. The findings are in accordance with the earlier findings of Anupama *et al*. (2007) [4] in chrysanthemum, Namita *et al.* (2012) [13] in coleus, Madhu Bala (2018) [10] in philodendron, Verma *et al*. (2019) [18] in gerbera and Aditya *et al.* (2023) [3] in marigold.

Frond length (cm)

The data regarding the frond length affected by various treatments of Pusa hydrogel have been presented in Table 3. The data revealed that maximum frond length (43.44 cm, 47.91 cm and 51.94 cm) was recorded with Pusa hydrogel @ 50 g (T_6) at 60, 120 and 180 days after planting, respectively. This might be due to Pusa hydrogel's superior performance to its efficient water retention and gradual release, ensuring a consistent moisture supply that enhances nutrient absorption and metabolic activities. Furthermore, this super absorbent polymer improves the porosity and particle density enhanced better aeration in the root zone subsequently improves root development which helps in more nutrient absorption and ultimately increased frond length. The findings are in accordance with the earlier results of the Kumar *et al.* (2016) [9] in pot mums, Abdul *et al.* (2018) [1] in coleus Verma *et al*. (2019) [18] in gerbera, Thumar *et al.* (2020) [17] in chrysanthemum and Soliman *et al.* (2024) [16] in calendula.

Fresh weight of 10 fronds (g)

Various treatments of Pusa hydrogel along with potting media showed significant effect on fresh weight of 10 fronds (Table 3). Significantly maximum fresh weight of fronds (12.19 g) was recorded from plants grown in Pusa hydrogel @ 50 g (T_6). While, the minimum fresh weight of fronds (5.38 g) was noted in Control (T_1). The fresh weight of 10 frond may be increased due to potting mixture containing hydrogel acted as best substrate for better aeration and water retentive capabilities as it helps in maintaining cell turgor pressure and improves the quality of plant with respect to blade length, blade width, pinna size and consequently increase the fresh weight of fronds. Similar findings were also reported by Anupama *et al*. (2007) [4] in chrysanthemum, Abdul *et al*. (2018) [1] in coleus and Soliman *et al.* (2024) [16] in Calendula.

Number of cut foliage/pot/year

The data revealed that number of cut foliage/pot/year was significantly affected by different treatments of Pusa hydrogel have been presented in Table 3. The highest number of cut foliage/pot/year (77.31) was obtained from the Pusa hydrogel @ 50 g (T_6) which was statistically at par with Pusa hydrogel @ 40 g (T_5) *i.e.*, 73.40. While, the lowest number of cut foliage/pot/year (61.03) was obtained from untreated plants (T_1 - Control). An increase in yield with respect to number of cut foliage might be due to significant amount of water in hydrogel structure and subsequently, putting the absorbed water into the soil around plant roots, thereby increasing water holding capacity and providing a buffer against the product loss during the time between two irrigations. Because of the uninterrupted water availability, plants obtained continuous supply of water and nutrients and thereby increased indirectly nutrients supplied by the SAP to the plants under water stress condition, which in turn lead to better translocation of water, nutrients, photosynthates and improves cell membrane development by balancing nutrient substances and higher CO_2 fixation through prolonged stomata opening ascribed to the increase in yield attributes. Further hydrogel provides reservoir of soil water in the root zone by preventing leaching and deep percolation layers. Ferns require a steady supply of water during their growth and development for the maximum production with better quality. Any interpretation in the water supply will likely reduces final yields and crop quality. Results are in conformity with the findings of Abdulhamid (2019) [2] in date palm, Anupama *et al.* (2007) [4] in chrysanthemum and Aditya *et al.* (2023) [3] in marigold.

Irrigation Frequency (days)

Plants grown in media with amended Pusa hydrogel @ 50 g (T_6) resulted in significant reduction in irrigation frequency (5.20 days) over Control (T_1) *i.e.*,1.53 days.

Consumptive Water Use (L/pot)

The perusal of data clearly indicated that consumptive water use was significantly affected by different treatments of

Pusa hydrogel. The minimum consumptive water use (17.56 L/pot) recorded by plants grown in Pusa hydrogel @ 50 g (T_6). While the maximum consumptive water use (59.63 L/pot) was noted in untreated plants (T_1 - Control).

Pusa hydrogel @ 50 g (T_6) resulted in increased water use efficiency due to significant reduction in frequency of irrigation and quantity of water use in *Nephrolepis cordifolia* 'Duffii' by application of Pusa hydrogel might be due to increasing water holding capacity and moisture level of media. Hydrogels are polymers capable of absorbing large amounts of water due to hydrophilic in nature and fixing it to potting media, which promote plant establishment and growth by increasing soil water retention, influence soil permeability, density, structure, texture, evaporation, infiltration rates and delay the permanent wilting point. It is a soil conditioner that can maximize the usage of fertilizer by maintaining and making available a higher concentration of macronutrients in the substrate, stimulating greater plant development. Additionally, the hydrogel induced maintenance of moisture in the root zone of plants, may encourage the growth of plants. The increase water use efficiency may be due to decrease in evapo-transpiration ratio which in turn might have helped the crop growth. Hydrogels reduces the requirement of irrigation for crops and delay the permanent wilting point. The findings are in accordance with the earlier findings of Anupama *et al.* (2007) [4] and Thumar *et al.* (2020) [17] in chrysanthemum, Kumar *et al.* (2016) [9] in pot mums, Abdul *et al.* (2018) [1] in coleus, Deenavarman *et al.* (2018) [7] in Arrowhead and Madhu Bala (2018) [10] in philodendron.

Conclusion

It can be concluded that *Nephrolepis cordifolia* 'Duffii' grown in potting media Cocopeat + Vermicompost (2:1 v/v) amended with Pusa hydrogel @ 50 g enhanced vigorous growth with the highest yield of cut foliage as well as it reduced irrigation frequency and minimize the consumptive water use.

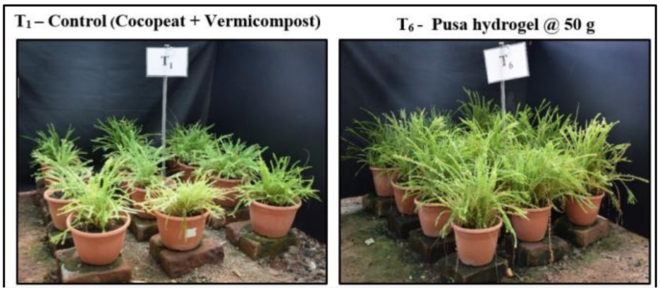

Fig 1: Effect of Pusa hydrogel application in potting media on overall growth of *Nephrolepis cordifolia* 'Duffii'

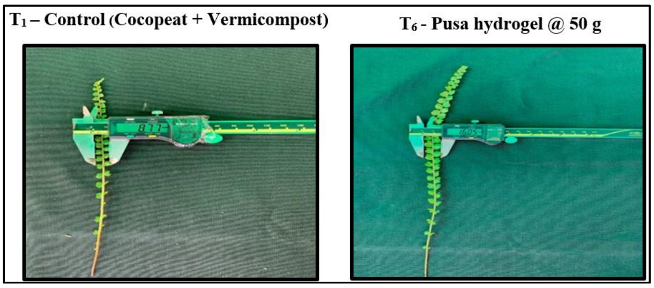

Fig 2: Effect of Pusa hydrogel application in potting media on blade width (mm) of *Nephrolepis cordifolia* 'Duffii'

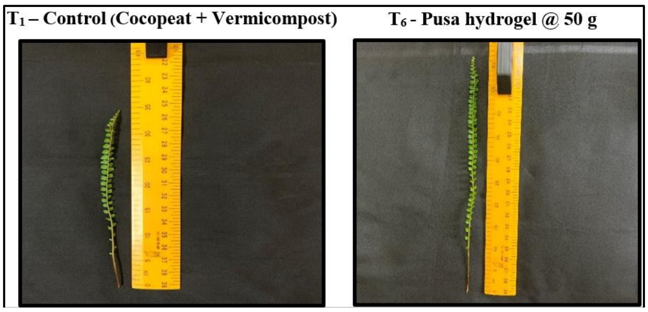

Fig 3: Effect of Pusa hydrogel application in potting media on frond length (cm) of *Nephrolepis cordifolia* 'Duffii'

Table 2: Effect of Pusa hydrogel application in potting media on different parameters of *Nephrolepis cordifolia* 'Duffii'

Treatments	Plant height (cm)			Plant Spread (cm)						Blade length (cm)			Blade width (mm)		
	At 60 days	At 120 days	At 180 days	At 60 days		At 120 days		At 180 days		At 60 days	At 120 days	At 180 days	At 60 days	At 120 days	At 180 days
				E-W	N-S	E-W	N-S	E-W	N-S						
T_1: Control	31.00	34.63	39.02	30.09	29.13	33.20	31.19	40.14	38.43	18.76	22.08	26.54	7.55	7.90	8.44
T_2: Pusa hydrogel @ 10 g	34.28	37.55	41.88	31.19	30.55	34.09	32.78	42.32	40.64	23.23	26.79	31.27	11.43	12.27	12.93
T_3: Pusa hydrogel @ 20 g	38.12	41.92	45.27	32.16	31.76	36.16	33.91	44.30	43.71	26.44	30.04	34.04	12.44	13.29	13.71
T_4: Pusa hydrogel @ 30 g	38.76	43.35	46.28	32.90	32.20	37.09	35.48	48.06	47.28	28.95	31.92	35.97	13.89	14.51	14.69
T_5: Pusa hydrogel @ 40 g	41.78	46.42	50.86	33.65	33.45	38.66	37.81	53.25	51.25	30.65	34.07	38.29	15.27	15.66	15.81
T_6: Pusa hydrogel @ 50 g	44.34	48.73	53.20	34.73	34.48	40.34	39.28	55.35	53.88	33.19	36.54	40.41	15.96	16.37	16.66
SEm ±	0.91	0.86	0.79	0.57	0.72	0.59	0.58	0.74	0.93	0.94	0.89	0.74	0.28	0.30	0.38
CD @ 5 %	2.71	2.55	2.36	1.68	2.14	1.75	1.72	2.19	2.76	2.80	2.65	2.20	0.82	0.89	1.12
CV %	4.80	4.07	3.45	3.49	4.51	3.22	3.30	3.13	4.05	7.02	5.90	4.30	4.34	4.47	5.49

Table 3: Effect of Pusa hydrogel application in potting media on different parameters of *Nephrolepis cordifolia* 'Duffii'

Treatments	Petiole (stipe) length (cm)			Pinna length (mm)			Pinna width (mm)			Frond length (cm)			Fresh weight of 10 fronds (g)	Number of cut foliage/ pot/year
	At 60 days	At 120 days	At 180 days	At 60 days	At 120 days	At 180 days	At 60 days	At 120 days	At 180 days	At 60 days	At 120 days	At 180 days		
T_1: Control	6.89	8.33	9.77	7.98	8.30	8.58	7.49	7.74	8.02	25.62	30.45	35.26	5.38	61.03
T_2: Pusa hydrogel @ 10 g	7.68	8.88	10.59	9.43	9.95	10.47	7.52	7.77	8.07	30.60	36.03	40.51	6.44	63.25
T_3: Pusa hydrogel @ 20 g	8.26	9.66	11.27	10.83	11.26	11.95	7.63	8.01	8.30	34.45	39.65	43.91	7.44	65.28
T_4: Pusa hydrogel @ 30 g	9.21	10.83	12.72	11.82	12.29	12.82	8.21	8.33	8.57	37.79	42.47	45.61	9.19	68.56
T_5: Pusa hydrogel @ 40 g	9.49	11.73	13.81	12.54	13.47	13.75	8.53	8.85	9.06	40.67	45.21	49.49	10.50	73.40
T_6: Pusa hydrogel @ 50 g	10.04	12.31	14.38	13.89	14.60	15.07	8.94	9.13	9.31	43.44	47.91	51.94	12.19	77.31
SEm ±	0.21	0.23	0.19	0.55	0.54	0.52	0.11	0.10	0.09	0.98	1.04	0.85	0.24	1.39
CD @ 5 %	0.61	0.67	0.57	1.63	1.60	1.53	0.32	0.29	0.27	2.91	3.10	2.53	0.72	4.12
CV %	4.78	4.38	3.20	9.92	9.26	8.54	2.68	2.34	2.16	5.53	5.17	3.83	5.70	4.07

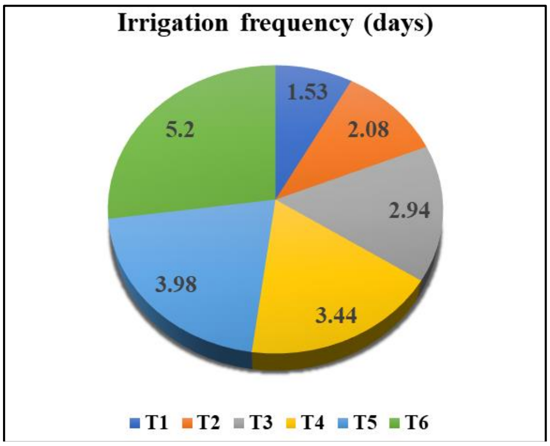

Fig 4: Effect of Pusa hydrogel application in potting media on Irrigation Frequency of *Nephrolepis cordifolia* 'Duffii'

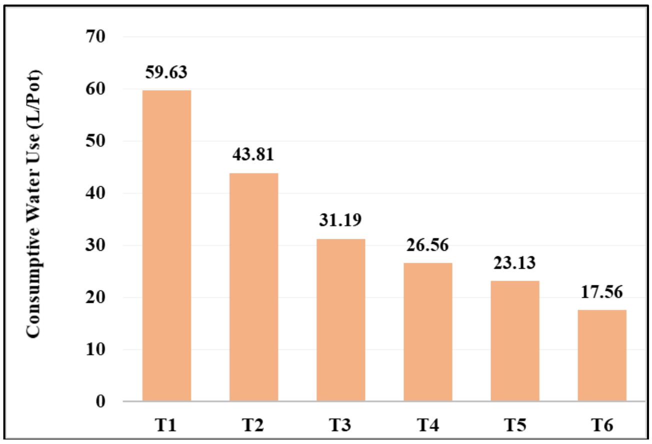

Fig 5: Effect of Pusa hydrogel application in potting media on Consumptive Water Use of *Nephrolepis cordifolia* 'Duffii'

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