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Influence of different plant growth retardants in Mexican lawn grass (*Zoysia matrella*) for reducing the mowing frequency and better visual qualities

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Abstract

Mexican lawn grass (*Zoysia matrella*) is a perennial mat-forming species suited for the landscaping industry due to its versatile adaptability. The pleasing appearance of the lawn grasses can be achieved through mowing at regular intervals to avoid a shabby appearance, which requires skilled persons and ends up with expensive operation. Under these circumstances, the experiment was intended with the commonly available growth regulators for their efficiency in the reduction of the mowing cycle without losing or hampering their visual quality attributes. The application of 1.0% chlormequat chloride (T_4) produced a mean grass leaf length of 2.00 cm, which was remarkably lower than that of control (T_9), i.e., 4.87 cm. The same pattern of growth was exhibited during the 45th and 90th days after spraying. The mean turf shoot length (7.80 cm) and root length (13.40 cm) were observed in the control plots, while the application of 1.0% chlormequat chloride (T_4) produced 3.83 cm and 7.94 cm, respectively, determining its ability to hamper the growth of turf grass. The *Z. matrella* grass failed to produce flower heads by the application of 1.0% mepiquat chloride (T_2), 0.5% chlormequat chloride (T_3), 1.0% chlormequat chloride (T_4), 0.5% maleic hydrazide (T_7) and 1.0% maleic hydrazide (T_8). The control plots devoid of growth regulators initiate flower heads after 70 days. From the study, the application of 0.5% chlormequat chloride (T_3) and 1.0% chlormequat chloride (T_4) exerted a low level of thatch accumulation and no flower head formation was observed with maximal visual scoring, leading to the commercial expeditions for the turf industry.

Keywords

Growth retardants; mowing; thatch accumulation; turf shoot length; visual qualities; *Zoysia matrella*

Introduction

Lawn grass is the heart of the garden, which determines the aesthetic sense and brings pleasing effects to it. Lawn grasses are preferred mostly in residential gardens for relaxation, industrial gardens for mitigating pollution, educational institutions for pleasing effect and monetary value, etc. (1). Lawn grasses are a vital part of any landscaping garden. In addition to the above, grasses are mainly intended for sports activities, including golf, cricket and football grounds, which bring the cushioning effect during intensive sports activities. Grasses possess the innate attractive greenness that attracts and creates pleasure among visitors, as well as reducing the pollution load of the particular locality (2).

Zoysia matrella (syn: *Agrotis matrella, Zoysia tenuifolia*) is a perennial mat-forming species of grass commonly known as Manilla grass, Mexican grass and Manila temple grass. It has an extensive spreading habit, forming velvety green mats with stolons and sporadically with rhizomes. The leaves are finely textured and suited for warm and open sunny locations, often producing flower heads.

The pleasing nature of the lawn can be maintained properly through mowing at regular intervals. During the process of grass cutting (mowing), the leaf blades of grass leaves are partially or fully removed at regular intervals (mowing schedule), depending upon our choice and environmental conditions. The improper mowing schedule led to the unevenness of growth, frequently prone to pests and diseases, hiding place for rodents and snakes, which pose a threat to the visitors and also further leads to the formation of the flowering head, which detracts the overall appearance of the lawn. Mowing is a vital mechanical operation that varies according to the prevailing environmental conditions, *viz.,* the summer season requires frequent mowing at shorter intervals, while in winter, the mowing intervals will be longer as the grass exhibits slow growth rates. Under these circumstances, lawnmowers are operated at cyclic intervals to maintain the perfect look. Very frequent mower operations require skilled operators and well-maintained mowers, which led to a hike in the cost of maintenance. The accumulation of thatch is heavy under frequently mowed lawns. Besides the disposal of cut grass, it is also to be considered for the maintenance of lawn grass.

Plant growth regulators (PGRs) are synthetic or natural compounds (phytohormones) used to stimulate or inhibit plant growth and development or modify particular physiological or metabolic processes. For effective lawn grass maintenance, plant growth regulators, especially growth retardants, are used to suppress the growth of grass and are classified into five classes, *viz.,* Class A: inhibitor for cell elongation in late GA biosynthetic pathway, Class B: inhibitor for cell elongation in early GA biosynthetic pathway, Class C: inhibitors for cell division, Class D: herbicides with growth regulating activity and Class E: phytohormones. The major concern with the use of growth regulators in lawns is that it produces bronze coloration and drying of leaf blades (3, 4). In golf courses, GA inhibitors play a major role in reducing vertical growth and reducing the frequency of mowing without any negative functional effects (5, 6). Further, it has been proved that stunting of growth with dense root development, low water consumption, and hampered production of flowering heads (7-9).

Ethephon is primarily used in turf grass management to prevent the development of floral stems or floral heads. In *Cynodon dactylon* (Bermuda grass), the application of ethephon resulted in leaf discoloration, impaired quality, etc. (10, 11). In spite of routine maintenance activities, the application of fertilizer, and irrigation water, the lawn grass should be healthy without any leaf discolorations to have better visual quality. Leaf color, texture, uniform spreading behavior (ground cover), and softness are the key features that decide the aesthetic quality and best indicator for the nutritional status of soil and water (12). The leaf color of lawn grass was rated visually from 1 to 9; scale one signifies pale yellow-colored leaves, and scale nine depicts lawn grass with dark green colored leaves (13). In *Poa annua* and other cool and warm season grasses, turf growth regulars are commonly used to control or hinder the seed head formation as well as their growth and other developmental processes. The plant growth regulator application to lawn grass enhances the visual quality and tolerance to salt and droughtiness and can adjust under meager light conditions. The scarcity of skilled and technical persons with well-maintained machinery is a great concern in lawn maintenance operations. Under these circumstances, the experiment was intended with the commonly available growth regulators for their efficiency in the reduction of the mowing cycle without losing or hampering their visual quality attributes.

Materials and Methods

The experiment was carried out in four lawn areas of the Botanical Garden, Department of Floriculture and Landscape Architecture, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, which is situated at an altitude of 426.72 m above mean sea level. The experimental site was backfilled with 75% red loamy soil, sand 20%, coir compost and a leaf mound with 5%. The growth retardants were tested in Mexican grass (*Zoysia matrella*) one year after the established period through the instantaneous sodding method. The lawn grass was mowed using walk-behind, self-propelled lawn mowers (Toro brand heavy duty-Irrigation Products International PVT Ltd.). The treatments were replicated thrice at a plot size of 2 × 2 ft in a Randomized Block Design (RBD) design (Table 1).

Table.1. Details of different plant growth retardants used in Mexican lawn grass.

Treatments		
T_1	-	0.5 % Mepiquat Chloride
T_2	-	1.0% Mepiquat Chloride
T_3	-	0.5 % Chlormequat chloride
T_4	-	1.0% Chlormequat chloride
T_5	-	0.5 % Ethephon
T_6	-	1.0 % Ethephon
T_7	-	0.5 % Maleic Hydrazide
T_8	-	1.0 % Maleic Hydrazide
T_9	-	Control

The commercially available formulation of Chamatkar (Mepiquat chloride 5% aqueous solution), Lihocin (Chlormequat chloride 50% SL), Ethrel (Ethephon 39% SL) and Maleic hydrazide (laboratory grade) was used for imposing the treatments. The growth regulators were applied ten days after mowing between 8.00 and 10 A.M. on a rainless day with bright sunshine using the battery-operated sprayer with uniform spray volume and dispersal chemicals to each and every demarked plot without any spillover to neighboring plots. Each plot was maintained with an isolation distance of one foot to avoid the residual effects on adjacent plots. The lawns were irrigated through a rain hose system on the day before the application for maximum absorption and efficacy.

At 45, 90, and 135 days after the application of growth retardants, the morphological parameters *viz.,* leaf length (cm), leaf width (cm), internodal length (cm), and turf shoot length (cm) (14) and the physiological parameters *viz.,* fresh and dry weight of root (g) (15), fresh and dry weight of shoot (g) of the grass was calculated according to the previously described method (16). The total chlorophyll content was estimated following the procedures (17) and expressed in mg g^{-1}. The observations, such as visual color change, were assessed based on the visual scoring involving a nine-point scale suggested by (18, 19) as furnished in table 2.

Table 2. Visual assessment of turf grass.

Visual scoring	
Scale 1	Plots without any grass
Scale 2	Weak grass, poor quality with shabby look
Scale 3	Grass with yellow to brown colouration having <20% grass cover
Scale 4	Turf grass with discolouration having <45% coverage
Scale 5	Grey to brown coloured grass leaves with <60% coverage
Scale 6	Grass with green to blue coloured leaves having >60% coverage
Scale 7	Grass with light green with dense coverage (80%)
Scale 8	Grass with green coloured leaves with dense coverage of nearing 100%
Scale 9	Grass with dense coverage with dark green coloured leaves

The data obtained during the course of observation was statistically analyzed to compute the level of probability at 5% (0.05) level following the steps outlined by (20); R Core Team version R.4.2.2 (21).

Results

Effect of growth retardants on growth parameters

The growth retardant application in Mexican grass (*Zoysia matrella*) lawn grass exerted remarkable differences in the growth pattern and physiological parameters. The application of 1.0% chlormequat chloride (T_4) produced a mean grass leaf length of 2.00 cm, which was remarkably lower than that of control (T_9), i.e., 4.87 cm. The same pattern of growth was exhibited during 45th and 90th days after spraying. The maximum mean leaf width was observed in 0.5% ethephon (0.47 cm) (T_5) followed by 0.5% mepiquat chloride (0.40 cm) (T_1) and the minimum leaf width (0.26 cm) was recorded in 1.0% chlormequat chloride (T_4). The pronounced variation in internodal length after the spraying of growth retardants was registered (1.30 cm and 1.56 cm) in 1.0% chlormequat chloride (T_4) on the 45th and 135th days after the application. The unsprayed control (T_9) has well-elongated internodes, such as 2.50 cm and 3.22 cm, in the same period of time. The mean turf shoot length (7.80 cm) and root length (13.40 cm) were observed in the control plots, while the application of 1.0% chlormequat chloride (T_4) produced 3.83 cm and 7.94 cm, respectively, determining its ability to hamper the growth of turf grass (Table 3 and Fig. 1).

Effect of growth retardants on physiological parameters

The highest accrued fresh weight of root (13.06 g) and dry weight of root (2.70 g) was recorded in control, and the lowest mean fresh weight of root (8.01 g) and dry weight of root (1.64 g) was noticed in 1.0% chlormequat chloride (T_4). A similar trend was observed for the parameters, *viz.,* fresh weight of shoot and dry weight of shoot. The proficiency in the activity of 0.5% ethephon (T_5) pertinent to the fresh weight of the shoot was on par (6.22 g) with 0.5% maleic hydrazide (5.90 g) and control (6.47 g). Notified and significant variation in total chlorophyll content was observed on all the stages of observations, particularly the highest (4.82 mg g^{-1} fresh weight) and lowest (2.52) mean of total chlorophyll content of turf grass was registered in untreated control and 1.0% mepiquat chloride (T_2). The weight of biomass after mowing 135 days after the application of growth retardants expressed significant differences among the treatments, and the maximum (2.82 kg m^{-2}) and minimum (1.22 kg m^{-2}) were recorded in 1.0% chlormequat chloride (T_4) and control (T_9), respectively (Table 4 and Fig. 1).

Effect of growth retardants on visual qualities

The Mexican grass (*Zoysia matrella*), after the application of growth retardant, produced substantiative results on visual qualities, advocating the commercial implications on turf grass and the landscape industry. On the 45th day after the application of 1.0% ethephon (T_6) exerted the lowest visual score of 3.0. The effects of 0.5% mepiquat chloride (T_1), 0.5% ethephon (T_5) and 1.0% maleic hydrazide (T_8) were the same, producing a score of 5.0, while the control showed the highest score of 9.0. Subsequently, the recovery was observed 90 days after the application of growth retardants with visual scores of 8.0, 7.0 and 7.0, respectively. But on the 135th day after the application, the visual qualities of the treatments, *viz.,* 0.5% chlormequat chloride (T_3) and 1.0% chlormequat chloride (T_4) were the same with a maximum score of 9.0. The visual qualities of untreated control (T_9) showed a decline in visual qualities such as yellowing and puffy growth, shading and physiological suppression mechanisms. The results of 0.5% mepiquat chloride (T_1), 0.5% ethephon (T_5), 0.5% maleic hydrazide (T_7) and 1.0% maleic hydrazide (T_8) were similar to the visual score of 8.0.

Table 3. Effect of growth retardants on growth parameters of *Zoysia matrella.*

Treatments	Leaf length (cm)				Leaf width (cm)				Internodal length (cm)				Shoot length (cm)				Root length (cm)			
	45 days	90 days	135 days	Mean	45 days	90 days	135 days	Mean	45 days	90 days	135 days	Mean	45 days	90 days	135 days	Mean	45 days	90 days	135 days	Mean
0.5% mepiquat chloride (T_1)	2.80^{abc}	3.40^{bc}	4.90^{ab}	3.70^{ab}	0.31^{abc}	0.44	0.46	0.40^{ab}	1.90^{abcd}	2.15	2.28^{ab}	2.11	4.80^{cd}	5.70^{c}	7.50^{bc}	6.00^{ab}	8.20^{b}	12.10^{abc}	15.27^{b}	11.86^{bc}
1.0% mepiquat chloride (T_2)	2.10^{bcd}	3.20^{bc}	4.20^{abc}	3.17^{bc}	0.23^{bcd}	0.41	0.42	0.35^{bc}	1.50^{cd}	1.70	1.97^{b}	1.72	4.00^{ef}	4.70^{e}	6.40^{cd}	5.03^{bc}	7.00^{cd}	10.30^{c}	12.98^{c}	10.09^{c}
0.5% chlormequat chloride (T_3)	1.90^{cd}	2.30^{cd}	3.30^{bc}	2.50^{bc}	0.21^{cd}	0.42	0.44	0.36^{b}	1.70^{bcd}	1.85	1.92^{b}	1.82	4.20^{ef}	5.00^{de}	6.90^{bcd}	5.37^{bc}	7.60^{bc}	11.00^{bc}	13.20^{c}	10.60^{c}
1.0% chlormequat chloride (T_4)	1.40^{d}	1.90^{d}	2.70^{d}	2.00^{c}	0.14^{d}	0.31	0.32	0.26^{c}	1.30^{d}	1.50	1.56^{b}	1.45	2.90^{g}	3.50^{f}	5.10^{d}	3.83^{c}	5.50^{d}	8.10^{d}	10.21^{d}	7.94^{d}
0.5% ethephon (T_5)	3.20^{ab}	3.80^{ab}	5.60^{a}	4.20^{a}	0.39^{a}	0.49	0.51	0.46^{a}	2.30^{ab}	2.40	2.49^{ab}	2.40	5.00^{bc}	6.40^{b}	9.00^{ab}	6.80^{ab}	7.48^{bc}	12.90^{ab}	15.13^{b}	11.84^{abc}
1.0% ethephon (T_6)	2.90^{abc}	3.20^{bc}	4.70^{abc}	3.60^{abc}	0.31^{abc}	0.40	0.41	0.37^{ab}	2.00^{abc}	2.10	2.18^{ab}	2.09	3.90^{f}	5.00^{de}	7.30^{bc}	5.40^{bc}	8.00^{bc}	10.70^{c}	12.90^{c}	10.53^{c}
0.5% maleic hydrazide (T_7)	3.00^{ab}	3.50^{bc}	4.90^{ab}	3.80^{ab}	0.33^{ab}	0.40	0.42	0.38^{ab}	2.10^{abc}	2.20	2.31^{ab}	2.20	5.30^{ab}	6.60^{b}	8.60^{ab}	6.83^{ab}	8.30^{ab}	13.20^{a}	16.70^{a}	12.73^{ab}
1.0% maleic hydrazide (T_8)	2.60^{abc}	3.20^{bc}	4.30^{abc}	3.37^{abc}	0.22^{bcd}	0.35	0.36	0.31^{bc}	1.80^{bcd}	1.90	2.00^{b}	1.90	4.40^{de}	5.50^{cd}	7.30^{bc}	5.73^{bc}	8.00^{bc}	11.14^{bc}	13.61^{c}	10.92^{bc}
Control (T_9)	3.60^{ab}	4.80^{a}	6.20^{a}	4.87^{a}	0.30^{abc}	0.40	0.48	0.39^{ab}	2.50^{a}	2.70	3.22^{a}	2.81	5.70^{a}	7.30^{a}	10.40^{a}	7.80^{a}	9.40^{a}	13.70^{a}	17.10^{a}	13.40^{a}
SEd	0.56	0.59	1.02	0.81	0.06			0.04	0.31		0.51		0.23	0.34	0.93	0.98	0.57	0.95	0.65	0.99
CD (p=0.05)	1.12	1.20	2.05	1.63	0.11	NS	NS	0.09	0.63	NS	1.04	NS	0.46	0.68	1.87	1.96	1.14	1.91	1.33	1.98

The means followed by the same letter do not differ statistically among themselves by Ducann's test ($p \leq 0.05$)

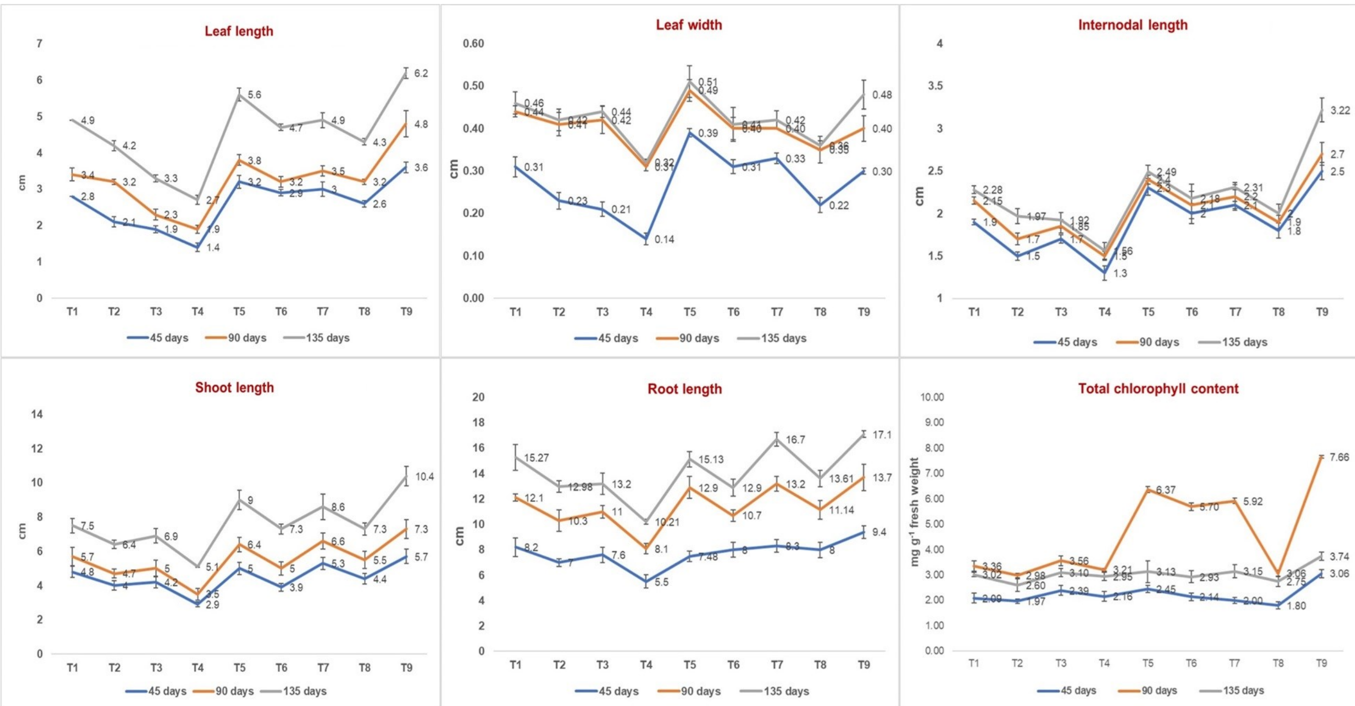

Fig. 1. Effect of growth retardants on growth parameters of *Zoysia matrella.*

Table 4. Effect of growth retardants on physiological parameters of *Zoysia matrella*.

Treatments	Fresh weight of root (g)				Dry weight of root (g)				Fresh weight of shoot (g)				Dry weight of shoot (g)				Total chlorophyll content (mg g^{-1} fresh weight)				Weight of biomass after mowing on 135 days (kg m^{-2})
	45 days	90 days	135 days	Mean	45 days	90 days	135 days	Mean	45 days	90 days	135 days	Mean	45 days	90 days	135 days	Mean	45 days	90 days	135 days	Mean	
0.5% mepiquat chloride (T_1)	8.47^{cd}	12.11^{ab}	14.88^{ab}	11.82^{ab}	1.80^{bcd}	2.44^{b}	3.19^{a}	2.48^{ab}	4.91^{bc}	6.08^{ab}	6.22^{ab}	5.74^{abc}	1.99^{bc}	3.40^{c}	4.55^{b}	3.31^{bc}	2.09^{c}	3.36de	3.02^{bc}	2.82^{cde}	1.78^{b}
1.0% mepiquat chloride (T_2)	7.29^{e}	10.04^{c}	12.74^{bcd}	10.02^{b}	1.50^{d}	1.99^{d}	2.69^{b}	2.06^{c}	4.02^{d}	4.78^{cd}	4.80^{d}	4.53^{d}	1.71^{d}	2.84^{e}	3.76^{d}	2.77^{d}	1.97^{cd}	2.98e	2.60^{d}	2.52^{e}	1.53^{cd}
0.5% chlormequat chloride (T_3)	7.70^{de}	10.09^{c}	12.43^{cd}	10.07^{b}	1.67^{cd}	2.05^{cd}	2.54^{b}	2.09^{c}	4.10^{d}	4.56^{d}	4.71^{d}	4.46^{de}	1.60^{cd}	2.90^{de}	3.61^{d}	2.70^{d}	2.39^{b}	3.56d	3.10^{bc}	3.02^{cde}	1.39^{de}
1.0% chlormequat chloride (T_4)	5.81^{f}	8.04^{d}	10.19^{d}	8.01^{c}	1.19^{e}	1.61^{e}	2.12^{c}	1.64^{d}	3.19^{c}	4.01^{e}	4.09^{c}	3.76^{e}	1.26^{e}	2.41^{f}	3.08^{e}	2.25^{e}	2.16^{c}	3.21de	2.95^{bcd}	2.77^{de}	1.22^{e}
0.5% ethephon (T_5)	10.25^{a}	12.64^{ab}	14.89^{a}	12.59^{a}	2.21^{a}	2.50^{ab}	3.13^{a}	2.61^{a}	5.11^{bc}	6.75^{a}	6.81^{ab}	6.22^{ab}	2.06^{b}	3.45^{c}	4.46^{bc}	3.32^{bc}	2.45^{b}	6.37b	3.13^{b}	3.99^{ab}	1.42^{d}
1.0% ethephon (T_6)	8.30^{cde}	10.33^{c}	12.18^{d}	10.27^{b}	1.79^{bcd}	2.07^{cd}	2.58^{b}	2.15^{c}	4.89^{bc}	5.30^{c}	5.44^{cd}	5.21^{c}	1.93^{bc}	3.14^{cde}	4.04^{cd}	3.04^{cd}	2.14^{c}	5.70c	2.93^{bcd}	3.59^{bcd}	1.38^{de}
0.5% maleic hydrazide (T_7)	8.91^{bc}	12.54^{ab}	16.04^{a}	12.50^{a}	1.92^{abc}	2.49^{b}	3.34^{a}	2.58^{ab}	5.20^{b}	6.21^{ab}	6.30^{ab}	5.90^{ab}	2.07^{b}	3.66^{b}	4.46^{bc}	3.40^{b}	2.00^{cd}	5.92bc	3.15^{b}	3.69^{bc}	1.47^{d}
1.0% maleic hydrazide (T_8)	8.10^{cde}	11.40^{bc}	14.51^{abc}	11.34^{ab}	1.73^{cd}	2.21^{c}	3.07^{a}	2.3^{4bc}	4.70^{c}	5.94^{abc}	6.01^{abc}	5.55^{abc}	1.81^{cd}	3.18^{cd}	4.02^{cd}	3.00^{cd}	1.80^{d}	3.06de	2.75^{b}	2.54^{e}	1.69^{bc}
Control (T_9)	9.68ab	13.43^{a}	16.08^{a}	13.06^{a}	2.08^{ab}	2.70^{a}	3.32^{a}	2.70^{a}	5.80^{a}	6.70^{ab}	6.90^{a}	6.47^{a}	2.32^{a}	4.24^{a}	5.23^{a}	3.93^{a}	3.06^{a}	7.66a	3.74^{a}	4.82a	2.82^{a}
SEd	0.54	0.89	1.06	0.99	0.14	0.10	0.17	0.12	0.24	0.33	0.29	0.30	0.10	0.15	0.23	0.19	0.11	0.27	0.18	0.43	0.09
CD (p=0.05)	1.09	1.77	2.13	1.98	0.29	0.20	0.34	0.25	0.49	0.67	0.58	0.60	0.21	0.31	0.46	0.39	0.22	0.54	0.36	0.89	0.19

The means followed by the same letter do not differ statistically among themselves by Ducann's test ($p<0.05$)

The application of growth retardants in the treatments, *viz*., 0.5% mepiquat chloride (T_1), 0.5% chlormequat chloride (T_3), 1.0% chlormequat chloride (T_4), 0.5% ethephon (T_5), 0.5% maleic hydrazide (T_7) produced a low level of thatch accumulation. The medium level of thatch accumulation was noticed in 1.0% mepiquat chloride (T_2), 1.0% ethephon (T_6) and 1.0% maleic hydrazide (T_8); however, the control was prone to the high level of thatch accumulation. The *Zoysia matrella* grass failed to produce flower heads by the application of 1.0% mepiquat chloride (T_2), 0.5% chlormequat chloride (T_3), 1.0% chlormequat chloride (T_4), 0.5% maleic hydrazide (T_7) and 1.0% maleic hydrazide (T_8). The control plots devoid of growth regulators initiate flower heads after 70 days (Table 5). The application of 1.0% ethephon (T_6) produces the flower heads after 135 days. The application of 0.5% chlormequat chloride (T_3) and 1.0% chlormequat chloride (T_4) exerted a low level of thatch accumulation and no flower head formation was observed with maximal visual scoring of turf grass (Fig. 2). Flower head formation occurs after 90 days by the application of 0.5% ethephon (T_5) and application of 1.0% ethephon (T_6) produced flower head occurs after 135 days.

Discussion

Mepiquat chloride application reduces the plant height, leaf area and leaf size and it blocks gibberellin activity, which results in shorter internodes and reduced stem elongation. The physiological role of PGR's in turf grasses varies according to the prevailing temperatures of the locality (22). Subsequently, Zhang *et al.* (23) reported that root biomass increased from 17% to 29% by the application of natural plant growth regulators in creeping bent grass (*Agrostis stolonifera* L). Chlormequat chloride is one of the pronounced inhibitors of gibberellin biosynthesis and inhibits cell elongation in plants. In the present study, spraying of ethephone suppresses the process of growth and development by the ethylene liberation, besides promoting the opening of stomata and flowering, accelerating sterility of pollens and interfering with secondary metabolite biosynthetic pathways. The assessment of the quality and color of turf grass showed a decreasing trend with the application of ethephone. The results of the present investigation are in line with the opinion of (10, 24). Further, (25) also found that the application of ethephon led to a slight reduction of the hue of turf leaves without compromising the quality of the turf.

During frequent mowing operations, the organic matter that gathers around the base of grass plants forms loose, slack, or intermixed layers, which obstruct the penetration of water and other applied nutrients to the grass. This is formed due to poor nutrition, improper watering cycles, over-deposition of cut or mowed pieces of grass, or deprived dethatching operations for longer periods of time. Similar results were recorded by (26) with 95% in the suppression of flower heads in annual bluegrass. Several research findings brought out incongruous results on the effect of PGRs on leaf color and quality of turf grass (27). The effects are governed by the type of grass species, application time, weather conditions *etc*. In the present study, the application of chlormequat chloride exerted a hampering effect on the growth of turf grass, low level of thatch accumulation and no flower head formation was visualized with maximal visual scoring, leading to the commercial expeditions for the turf industry.

Table 5. Effect of growth retardants on visual qualities of *Zoysia matrella*.

Treatments	Visual scoring of grass			Thatch accumulation	Flower head formation
	45 days	90 days	135 days		
0.5% mepiquat chloride (T_1)	5	8	8	Low level of thatch accumulation	Flower head formation occurs after 90 days
1.0% mepiquat chloride (T_2)	4	5	7	Medium level of thatch accumulation	No flower head formation
0.5% chlormequat chloride (T_3)	8	9	9	Low level of thatch accumulation	No flower head formation
1.0% chlormequat chloride (T_4)	8	8	9	Low level of thatch accumulation	No flower head formation
0.5% ethephon (T_5)	5	7	8	Low level of thatch accumulation	Flower head formation occurs after 90 days
1.0% ethephon (T_6)	3	5	6	Medium level of thatch accumulation	Flower head formation occurs after 135 days
0.5% maleic hydrazide (T_7)	7	8	8	Low level of thatch accumulation	No flower head formation
1.0% maleic hydrazide (T_8)	5	7	8	Medium level of thatch accumulation	No flower head formation
Control (T_9)	9	9	7	High level of thatch accumulation	Flower head formation occurs after 70 days

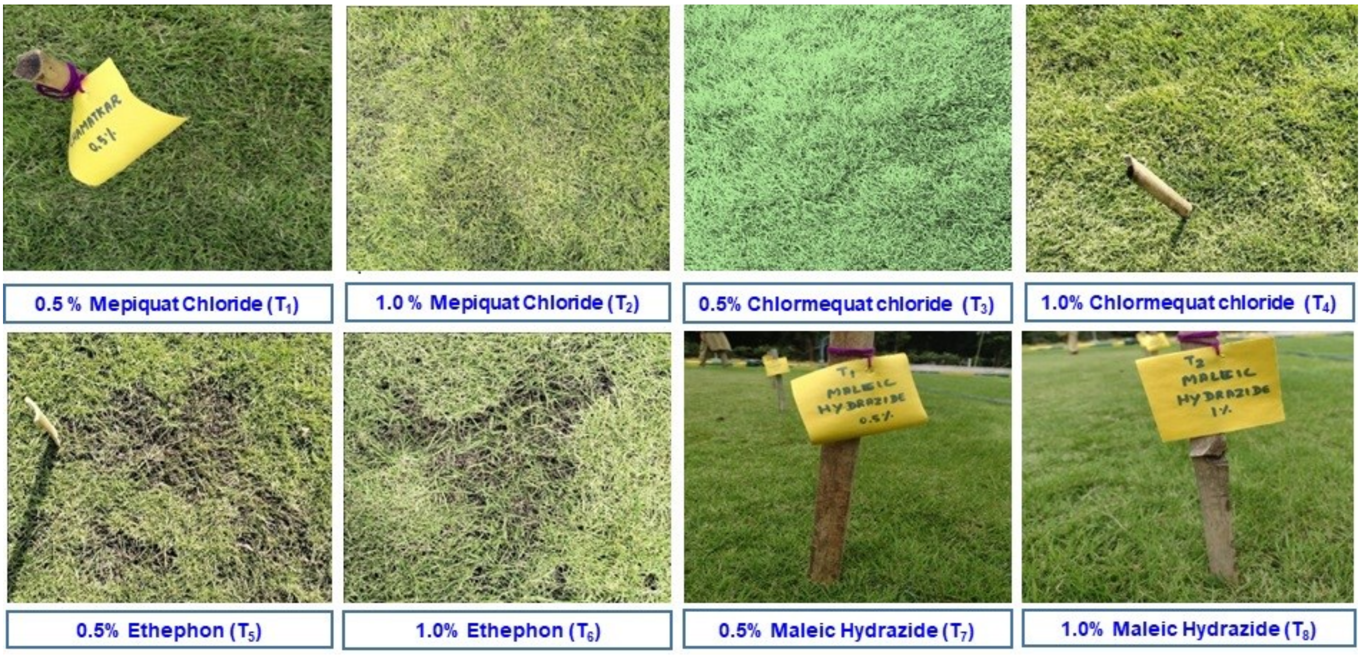

Fig. 2. Effect of growth retardants on visual qualities of *Zoysia matrella*.

Conclusion

From the study, the application of 1.0% chlormequat chloride (T_4) produced mean turf shoot length and root length of 3.83 cm and 7.94 cm, respectively, when compared to the control plots, influencing its ability to suppress the growth and low level of thatch accumulation and no flower head formation. In addition to the above, maximal visual scoring was observed in the same treatments, which paves the easy way of lawn maintenance, circumventing the shortage of skilled laborers and other resources, *viz.*, lawn mowers and fuel, *etc.,* which is a great boon to the turf industry.

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Authors' contributions

MV: Conceptualization, planning of experiment and manuscript writing; RT & VT: Literature collection and field work coordination; MA: Recording observation and statistical analysis; SS: Lab analysis; KR, LP & MKK: Supervision and Project Management; VR: Editing of tables and figures; SV & NM: Manuscript editing. All the authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The authors have declared that no conflict of interest exists.

Ethical issues: None.

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