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Effect of the Retardant "Dextril" on the Quality of Tomato Seedlings Grown at High Temperature Conditions

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Authors' contributions

This work was carried out in collaboration between all authors. Authors RZ and MB performed the experiences and participate in preparing this paper and statistical analysis. Author SS performed the literature and results discussion and the arrangement of the paper. All authors read and approved the final manuscript.

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ABSTRACT

The effect of different concentrations of growth retardant "Dextril" (C_{11} $H_{18}Cl_2O_7P$) on tomato (*Solanum lycopersicum* c.v Huda F1) seedlings quality was studied, at the Agriculture Faculty of Alexandria - Egypt, on 2010. Tomato seedlings were sprayed when the second true leaf was appeared with "Dextril" at (0.02 – 0.04 – 0.06 – 0.08 – 0.1%) levels, to promote seedlings tolerance to heat stress during summer – autumn period and limit stem growth and elongation. The results showed that, "Dextril" treatment of (0.02 - 0.04 – and 0.06%) levels improved seedlings quality and decreased stem height by 30, 32 and 35% respectively compared to the control, whereas, 0.08 and 0.1% levels showed toxic effects. Treatment with "Dextril" increased as well, stem diameter, fresh and dry weight of shoots but it did not affect leaf number compared to the control. The results indicate that the spraying with low concentrations of 'Dextril" is promising measure for improving the stress response and developmental characteristics of tomato seedlings grown under high temperature conditions.

Keywords: Tomato; seedling; growth retardants; dextril.

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1. INTRODUCTION

Tomato is the most important vegetable cultivated in greenhouses in the world. It is considered as a main crop in Syria and it occupies 75% of total greenhouses which count 129000. The technique of seedlings production is as important as crop production, because most tomato growers use plant seedling and prepare them under protected conditions.

Tomato seedlings are subjects during their production in summer, to a high temperature which cause stem elongation and diameter reduction and finally, bad seedling quality, they become less tolerant to environmental stress and die after planting.

Plant growth retardants are used to retard the shoot length of plants without changing developmental patterns or evoke phototoxic effects. This has been achieved not only by reducing cell elongation but also by lowering the rate of cell division and regulating the plant height physiologically [1,2]. Most plant growth retardants inhibit the formation of gibberellins (GAs) and can thus be used to reduce unwanted shoot elongation [3,4].

Plant growth retardants are synthetic substances, which inhibit, for a period of time, the elongation of stem and shoots, without irreversible blocking of vital metabolic and developmental processes in plants [5].

The inhibition effects of gibberellins biosynthesis, resulting in internodes shortening and long term growth suppression of many plants. The activity of growth retardants occur after stem penetration or root uptake following irrigation or rainfall. Flowering can be enhanced in some crops and intensified leaf greening with a little or no toxicity [6].

The effects of growth retardants vary with plant species, genotype, concentration used method of application, plant age and various other factors which influence the uptake and translocation of the chemicals [7].

Growth retardants have some other physiological effects; they could induce the more intense accumulation of compounds that influence taste, color and flavor, thus improving the quality and the commercial value of the products [5].

Growth retardants are used widely in agriculture, especially, on cereal crops, to prevent their lodging and decrease grain loss at ripening and enhance plant tolerance to environmental stress, without affecting positively growth and production [8,9,10].

Chlormequat and its related commercial compounds: Cycocel and Dextril are the most important growth retardants.

Other growth retardants like uniconazole and paclobutrazol improved cold resistance of Zoysia turfgrass and increased SOD activity and proline concentration [11].

Paclobutrazol and uniconazole-p, as well constrained the elongation rate of the leaves and reduced leaf length of young date palm seedling [12]. These results suggest the possible future use of growth retardants to reduce trunk height of date palm trees.

Plant height of *Erysimum marshallii* (ornamental plant) was decreased by the growth retardant Cycocel application, whereas B-nine application was not effective in decreasing

the plant height. The fresh and dry mass of roots, leaves and stem was decreased by the spray application of both Cycocel and B-nine [13].

Treatment of fruit trees and vegetable seedlings or plants with growth retardants, decreased stem height and increased its thickness [14,15,16].

Branch growth of apple (*Malus sylvestris*), peach (*Prunus persica*) and bear (*Pyrus communis*) trees when treated with growth retardants (200 - 400 ppm) after 2 weeks of blooming, were reduced [17,18].

Several studies demonstrated that spraying tomato plants with growth retardants improved their capacity to tolerate low temperatures and increased early and total yield [19,20,21,22]. Treatment of two cultivars (No-14 and Riana) of pot grown alstroemeria (cut flower) with different growth retardants (Alar Daminozide), Chlormequat (Cycocel) and Paclobutrazol (Cultar) resulted in growth reduction and cultivar No-14 took minimum days to bud formation and produced a greater number of cymes by inflorescence [23].

Treating of tomato, potato (*Solanum tuberosum*), cauliflower (*Brassica oleracea* botrytis), and cabbage (*B. oleracea capitata*) seedlings with growth retardants at (250-1000 mg/l) two alternative times, with 7-10 days intervals resulted in stem shortening and thickness, intensifying leaf greening, improve root system which promote seedling quality without any residual effects in tomato fruits, potato tubers, cauliflower head and cabbage leaves [24,25,26,27].

Purpose of the present investigation was to examine the retarding effects of Dextril on tomato seedlings quality and their tolerance to after planting shock.

2. MATERIALS AND METHODS

Tomato seeds (*Solanum lycopersicum* c.v Huda F1) were sown in trays containing 50 holes of 65 cm^3 volume filled with peat moss and were allowed to germinate in the greenhouse at 25±4ºC.

When the second leaf was emerged, seedlings were treated with growth retardant "Dextril" at five levels, as following:

1- seedling sprayed with distilled water (control).
2- seedling sprayed with "Dextril" 0.02%.
3- seedling sprayed with "Dextril" 0.04%.
4- seedling sprayed with "Dextril" 0.06%.
5- seedling sprayed with "Dextril" 0.08%.
6- seedling sprayed with "Dextril" 0. 1%.

A completely randomized design was employed for the experimental design, which consists of 6 treatments with 4 repetitions and 20 seedlings for each replicate.

Seedlings were fertilized twice during growth period with (delta spray) TE+ 20:20:20, (1g/ L of water). They were treated as well with fungicide Previcur – N (Propamocarb hydrochloride) and insecticide lentrek 4 EC (Chlorpyrifos 48% w/v), to prevent infection with fungal diseases and insects.

When seedlings are 40 days old, plant quality was determined by measuring:

1- Seedling height / cm.
2- Seedling stem diameter / mm.
3- Number of leaves by plant.
4- Leaf area (cm^2 / plant).
5- Fresh and dry weight of shoots and roots (g / plant).
6- Degree of adaptation after planting, defined by [28]:

$$K = \frac{\text{No.of survival seedlings}}{\text{Total No.of seedlings}}$$, Where: K= the degree of adaptation.

- Scanning electron microscopy, SEM. Trans section of epidermal and cortical cells of tomato control, and tomato treated with Dextril realized by technicians at electron microscopy center- Faculty of Sciences- University of Alexandria- Egypt.

- Statistical analysis realized by using Genstat 5 program.

Temperature degrees (minimal and maximal) were registered during growth period in the greenhouse (Table 1).

Table 1. Maximal and minimal temperatures during growth period

Date / Cº	1st week	2ed week	3ed week	4th week	5th week	6th week
Maximal	34.6	34.8	34.4	35.4	35.6	35.8
Minimal	20.4	20.8	21.2	21	22.2	22.6

Table 1 showed that the mean of maximal temperature (34.4- 35.8) was greater by 6 to 8ºC than the maximum optimal degrees needed for growth, and the minimal temperature was greater as well by 3 to 4ºC than the minimal optimal degrees for growth.

3. RESULTS AND DISCUSSION

3.1 Effect of "Dextril" on Seedling Height, Stem Diameter, Number of Leaves and Leaf Area

Treatment with different concentrations of Dextril significantly affect seedlings quality (Table 2). Lower concentrations of Dextril (0.02 – 0.04 – 0.06%) improved standard characters of seedlings. Plant height was decreased, while stem diameter and leaf area were increased compared to the control (Fig. 2). The number of leaves was affected only with high concentrations (0.06- 0.08- 0.1%).

The inhibitory effect of Dextril on plant height may be due to the inhibition of cell division of stem apex as it was demonstrated for other growth retardants like: Chlorocholine Chloride (CCC) on sunflower (*Helianthus annuus)* [29] and 2,3,5- triiodobenzoic acid (TIBA), on sorghum (*Sorghum sp.*) [30].

The effect of Dextril may be due as well to its effect on gibberellins biosynthesis like other growth retardants which is responsible on stem elongation [3,4].

Table 2. Effect of "Dextril" on seedling height, stem diameter, number of leaves and leaf area

Treatments	Seedling height/cm	Stem diameter/mm	Number of leaves	Leaf area/cm^2/plant
Control	18.5^a	3.3a	4.3^a	167^a
Dextril 0.02%	13^b	4.5^b	4.3^a	244^b
Dextril 0.04%	12.5^b	4.5^b	4.2^a	213^c
Dextril 0.06%	12^b	4^c	3.9^b	206^d
Dextril 0.08%	6.7^c	2.5^d	3^c	96^e
Dextril 0.1%	6.5^c	2.5^d	3^c	87^e
LSD 5%	3.5	0.194	0.43	21.4

** Values indicated with same letters are not significantly different*

Dextril effect on stem diameter may be due to the inhibition of longitudinal cell growth and the stimulation of cell width when used in low concentrations [16].

Many works showed that application of growth retardants like MH (Maleic hydrazid) and CCC on sorghum during flower initiation and 7 days after, resulted in the reduction of plant height and leaf area [31], while, foliar application of CCC (500 ppm), significantly increased leaf area per plant as compared to the control.

Foliar application of growth retardant daminozide (400 – 800 ppm) on sunflower genotypes, significantly decrease plant height over control [32], while stem diameter was not significantly different among treatments. Other authors demonstrated that foliar application of mepiquat chloride (1000 ppm) and lihocin (1000 ppm), significantly decreased plant height and increased the number of leaves and leaf area in cluster bean (*Cyamopsis tetragonoloba*) [33,34].

Fig. 1 showed that cell sizes of plant control are larger than cells of treated plants with Dextril. The mechanism of reduction in plant height due to application of growth retardants appears to be due to slowing down of cell division and reduction in cell expansion. It has been suggested that, TIBA, cycocel and mepiquat chloride are anti-gibberellin dwarfing agents, leading to a deficiency of gibberellin in the plant and reduce the growth by blocking the conversion of geranyl pyrophosphate to copalyl pyrophosphate which is the first step of gibberellin synthesis [35]. Thus, reduction in plant height is due to retardation of transverse cell division particularly in cambium which is the zone of meristimatic activity at the base of the internodes [36].

It was mentioned above that the increase of stem diameter resulted of Dextril treatment may be due to the inhibition of longitudinal cell growth and the stimulation of cell width when used in low concentrations [16]. Fig. 1 showed that Cell sizes of plant control were larger than cells of plants treated with Dextril, the Fig. 1 showed as well that the number of cells in control are less than these treated with Dextril, it's possible that cell division was inhibited in stem apex but not at epidermal and cortical cells, this may explain the thickness of plant stems treated with growth retardant Dextril.

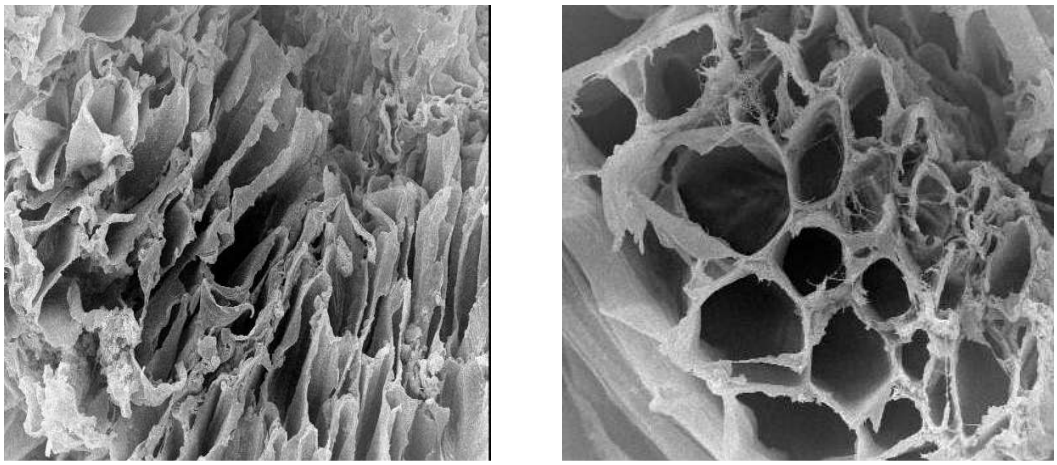

Fig. 1. Trans section of epidermal and cortical cells of tomato control (right) and tomato treated with Dextril 0.02% (left). Scanning electron microscopy, SEM

3.2 Effect of Dextril on Shoots and Roots Fresh and Dry Weight

Shoots fresh and dry weight significantly increased with low concentration (0.02%) of Dextril, while, 0.04% and 0.06% of Dextril had no significant effect compared to the control (Table 3).

Dextril (0.02 and 0.04%) enhanced fresh and dry weight of roots compared to the control, whereas, high concentrations had a negative effects as shown in Table 3.

Table 3. Effect of Dextril on shoots and roots fresh and dry weight

Treatments	Shoot weight /g / plant		Root weight /g / plant	
	Fresh	Dry	Fresh	Dry
Control	3.9^{a}	0.64^{a}	1.15^{a}	0.11^{a}
Dextril 0.02%	4.4^{b}	0.93^{b}	1.67^{b}	0.16^{b}
Dextril 0.04%	4.2^{ab}	0.81^{ab}	1.51^{b}	0.15^{b}
Dextril 0.06%	3.7^{ac}	0.77^{abc}	1.23^{c}	0.11^{a}
Dextril 0.08%	1.8^{d}	o.38^{d}	0.45^{d}	0.06^{c}
Dextril 0.1%	1.6^{d}	0.33^{d}	0.36^{d}	0.05^{c}
LSD 5%	0.42	0.22	0.27	0.032

** Values indicated with same letters are not significantly different*

The stimulatory effect of low concentration of Dextril on roots fresh and dry weight may be due to the enhancement of root system growth, so, mineral absorption will be stimulated and this will reflects on shoot growth [37].

Also, many studies reported that application of growth retardants like cycocel, significantly increased chlorophyll content compared to the control in groundnut (*Arachis hypogaea*) genotypes [38]. Foliar application of TIBA (50 and 100 ppm), Mepiquat chloride (500 – 100 ppm) and lihocin (500 – 1000 ppm) at 45 days after planting, resulted in increased chlorophyll *a, b* and total chlorophyll [39].

Fig. 2. Effects of spraying tomato seedlings with Dextril on plant height. 1. Control. 2- Dextril 0.02%. 3- Dextril 0.04%. 4- Dextril 0.06%. 5- Dextril 0.08%. 6- Dextril 0. 1%

[37] reported that foliar application of cycocel (500 and 1000 ppm) in sunflower increased chlorophyll content significantly over control, this stimulation of chlorophyll content by growth retardants may enhance photosynthesis and consequently, improve shoot and root fresh and dry weight.

3.3. Effect of Dextril on Adaptation Degree of Tomato Seedlings after Planting in Field

Tomato seedlings exhibited differences in their adapting capacity after planting in field. Treatment with Dextril (0.02 and 0.04%) increased seedlings adaptation to 100% compared to the control 90% (Table 4).

Table 4. Effect of Dextril on adaptation degree of tomato seedlings after planting in field

Treatments	Adapting degree %	N. of days after planting to form new leaf
Control	90	5
Dextril 0.02%	100	4
Dextril 0.04%	100	4
Dextril 0.06%	90	4
Dextril 0.08%	30	8
Dextril 0.1%	30	8

High concentrations of Dextril (0.08 and 0.1%) decreased seedlings adaptation to planting. Otherwise, new leaf was formed on the plant after 4 days of planting compared to the control (5 days).

The effect of growth retardants in decreasing stem height and increasing stem diameter may produce a vigor seedling more adaptable to field conditions. Otherwise, the stimulation of

root system by Dextril treatment may as well enforce the seedling stability in the soil and increase the adaptation to field environments.

It was demonstrated that treatments with growth retardant cycocel (1500 ppm) recorded higher total phenols after 60 days [40]; the enhancement of plant phenols may increase the lignifications of stem cell walls, and in consequence, improve the strength of seedlings to support field planting. [41] reported that phenols play a paramount role in reproductive development and growth of mung bean (*Vigna radiate*). Phenols play a very important role in host plant interactions and it also imparts disease resistance in the plant system.

4. CONCLUSION

This investigation has produced results suggesting that Dextril could be used for enhancing the tolerance of tomato seedlings to high temperature stress. Treatments with low concentrations (0.02 and 0.04%) of the retardant were found beneficial for controlling the growth and for improving the overall quality. The obtained data have strong potential for practical application at field conditions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rademacher W. Growth Retardants: Biochemical Feature and Applications in Horticultue. Acta Hortic. 1995;394:57-73.
2. Rademacher W. Growth Retardants: Effects on gibberellin biosynthesis and other metabolic pathways. Ann Rev Plant Physiol Mol Biol. 2000;51:501-531.
3. Singh AK. Response of pot marigold (*Calendula officinalis*) to plant regulators. Ind J Agric Sci. 2004;74:130–132.
4. Mansuroglu S, Karaguzel O, Ortacesme V, Sayan MS. Effect of paclobutrazol on flowering, leaf and flower colour of Consolida orientalis. Pak J Bot. 2009;41:2323-2332.
5. Caprita A, Rodica Caprita. Plant growth retardants for the treatment of vegetables used as row materials for the food industry. Scientifical Researches. Agro alimentary Processes and Technology. 2005;11(1):173-178.
6. Hafeez-ur-Rahman M, Asif Khan, Khalid Mahmood Khokhar. Effects of paclobutrazol on growth and yield of tomato. Pakistan J Agric Res. 1989;10(1).
7. Cathey HM. Physiology of growth retarding chemicals. Ann Rev Plant Physiol. 1964;15:271-302.
8. Likhotshirvo FN. The uses of growth retardants to resist lodges of Graminae crops. Plant protect J (In Russian). 2007;(2):31-34.
9. Matysiak K. Influence of trinexapac-ethyl on growth and development of winter J. of plant protection research/Inst. of plant protection, Polish acad. of science. – Poznan-Warsaw. 2006;46(2):133-143.

10. Maciorowski RM, Werwinska K, Nita Z, Stankowski. The reaction of naked and hulled oat on growth regulators treatment at different nitrogen Biuletyn Institute Hodowli i Aklimatyzaji Roslin. Warszawa. 2006;239:137-146.
11. Wang L, Ao D, Pan W, Wang K. The effect of plant growth retardants on cold resistance of Zoysia turfgrass. Journal: Food, Agriculture and Environment (JFAE). 2013;12(3-4):2372-2375.
12. Cohen Y, Aloni DD, Adur U, Hazon H, Klein JD. Characterization of growth- retardant effects on vegetative growth of date palm seedling. Journal of Plant Growth Regulation. 2013;32(3):533-541.
13. Bhat MA, Tahir I, Shahri W, Islam ST. Effect of cycocel and B-nine (growth retardants) on growth and flowering of *Erysimum marshallii* (Henfr.) Bois. Journal of Plant Sciences. 2011;6:95-101.
14. Jocov BC. The uses of growth stimuli and retardants on vegetables. Agric Bullet. 51. Moscow, (In Russian); 1990.
15. El Shahat NA. Plant hormones and their agricultural application. Cairo, Madbolli publ. (In Arabic). 1990;607.
16. Bezuglova OC. Fertilizers and Regulators. Rastov, Ed. Feniks. (In Russian). 2000;316.
17. Dicks J. Mode of action of growth retardants. In Recent development in the use of plant growth retardants -British plant Growth Regulator Group, Monograph N4, London. 1980;1-14.
18. Nagy, Tabi, Bezuglova OC. Fertilizers and Regulators. Rastov, Ed. Feniks. (In Russian). 1982;316.
19. Budekeyna NB, Temeco LF. The effect of Benycol substance on tomato plants in greenhouses. Agric J Moscow (In Russian). 2007;10:32-34.
20. Budekeyna NB. Studying the effect of CCC on tomato seedlings grown under greenhouse conditions. Plantprotect J Moscow (In Russian). 1998;2:45- 47.
21. El-Asdoudi AH. Incidence of tomato fruits with cracking and blossom-end rot and its relation to chlormequat (CCC) spraying Ann. Agr Sc. 1993;38:637-642.
22. Czapski J, Horbowicz M, Borkowski J. Effect of hlormequat (CCC) on the accumulation of ethephon in tomatoes and on ethephon-stimulated ripening Acta agrobot. Warszawa. 1990;41(1):39-45.
23. WAZIR JS. Response of plotted Alstroemeria to different growth retardants under protected conditions. Journal of Farm Sciences. 2011;1(1):27-36.
24. Malivania NN, Budekeyana NB, Alexiyafa TF. The effectiveness of Sercon on potato andcauliflower plants. Agric Chemist J Moscow (In Russian). 2007;9:32-37.
25. Avakyan AG. The effectiveness of the growth retardant on tomato plants under greenhouse conditions (long-term growth season). Vegetable Sci J (In Russian). 2000;(4):89–91.
26. Hickman GW, Perry EJ, Mullen RJ. Growth regulator controls tomato transplant height. Calif Agr. 1999;43(5):19 -20.
27. Genchew SK Miler. Effect of the retardant chlorcholinechloride (ccc) on plastid pigments content of tomatoes. Plant Growth Regulators. 1983;585-590.
28. Andreev UM. Production of vegetables. Ed. Scademia, Moscow, (In Russian). 2003;250.
29. Lovett GV, Orchard PW. Morphological and anatomical changes in sunflower by chloromepiquat and their possible significance. In: proceeding of the 6th International sunflower association, Newel and University Armidal, Astralia. 1981;323-331.
30. Hatley OE, Roth GW, Marshall HG, Jr RR. Effect of management practices on gran yirld test weight and lodging of sorghum. Agron J. 1985;76(3):379-383.

31. Mehetre SS, Lad SK. Effect of foliar application of growth substances on growth and yield. Soyabean genetics newsletter. 1995;22:132-134.
32. Saisankar S. Influence of plant growth regulators, chemicals and nutrients on productivity potential in green gram [*Vigna radiata* (L.) Wilczak]. M.Sc. (Agri.) Thesis, Univ. Agril Sci Dharwad, Karnataka, India; 2001.
33. Whipker BE, Mc Call I. Response of potted sunflower cultivars to damizonide foliar sprays and paclobutrazol drenches. Hort Technol. 2000;10(1):209-211.
34. Hanchinamath PV. Effect of plant growth regulators, organics and nutrients on growth physiology and yield in clusterbean (*Cyamopsis tetragonoloba* L. Taub). M.Sc. (Agri.) Thesis, Univ. Agril Sci Dharwad, Karnataka, India; 2005.
35. Moore TC. Biochemistry and Physiology of Plant Hormone, Narosja publishing house, New Delhi. 1980;107-131.
36. Grossman K. Plant retardants as tool in physiological research. Physiol. Plantarum 1990;78:642-648.
37. Kanade BC, Patil AJ, Zope RE, Kankal VY. Influence of foliar spray of cycocel on growth and yield attributes of safflower. J Maharashtra Agril Univ. 2002;27(1):49-51.
38. Chetti MB. Evaluation of Chamatkar on groundnut. Pestology. 1991;25:43-50.
39. Pravin Prakash, Chetti MB, Hosmani RM. Influence of plant growth regulators on physiological parameters and their relationship with yield IPS and tuber propagated potato. Ann Pl Physiol. 2001;14(1):16-20.
40. Kashid Dinesh A. Effect of growth retardants on growth, physiology and yield in sunflower (*Helianthus annuus* L.), Thesis submitted to the University of Agricultural Sciences, Dharwad; 2008.
41. Singh G, Kaur M. Effect of growth regulators on pudding and yield of mungbean (*Vigna radiata* L. Wilczek*).* Indian J Pl Physiol. 1980;23:366-370.

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