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APPLICATION OF GROWTH INHIBITORS FOR DECREASING LAWN GRASS GROWTH

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Abstract

For decreasing the shoot growth of lawn grasses solutions of maleic hydrazide (MH), ethrel and CCC of a concentration of 500, 1000, 2500 and 5000 ppm were tested as sprayings.

The shoot growth and mass increase of grasses which were sprayed once, twice and thrice gradually decreased with the increase of the concentration of the applied chemical agents and of the number of treatments. Growth was inhibited by MH to the greatest extent whereas the shortening of shoots induced by ethrel and CCC was in all cases weaker. In the majority of cases the growth decrease due to MH was about twice stronger than the effect of CCC as the least effective agent.

On applying the growth inhibitors in higher concentrations and repeatedly, the leaves suffered damages of smaller or greater extent. The phytotoxicity of the tested compounds proved to rise parallel with their growth inhibitor activity.

On applying MH and ethrel in higher concentrations and repeatedly, the contents of chlorophylls and carotenoids of the leaves were decreased significantly, and the degradation of chlorophylls was greater than that of yellow components. CCC in turn, increased in the majority of cases the amount of leaf pigments.

The concentrations of chemical agents and the ways of their application were established by means of which the growth decrease of lawn grasses can be attained without any damage of the leaves. For this purpose MH proved to be the most efficient of the three inhibitors tested. However, owing to its higher toxicity the hazards of its application are greater than those of ethrel or CCC whose effects are more moderate but their toxicity is lower.

Introduction

The maintenance of a nice and even green lawn in the parks and gardens is one of the most labour-intensive and cost-intensive operations of horticulture. Namely, the growth of the lawn must be continuously limited by regular mowing. However, the use of mowing machines requires expensive labour, motor fuels and much time. In addition to these, owing to frequent mowings the lawn consumes great amounts of nutrients. Therefore it appears to be expedient to find a simpler and more economical procedure for the decrease of grass growth.

In the knowledge of substances controlling plant growth the idea emerges that this problem might be solved by the application of adequate growth inhibitors in a chemical way. The chemical method is more up-to-date, quicker and much cheaper than the traditional methods, and thus it is of an immense practical importance.

Experiments in this direction have been carried out very sparsely throughout the world, and up to the present no experiments of this type were performed at all in Hungary (VARGA, 1976; SURÁNYI, 1978; FÜLEP, 1979). For the decrease of the growth of lawn grasses theoretically any synthetic growth inhibitor would be suitable e.g. the antiauxin-type TIBA and maleic hydrazide (MH); the antigibberellin-type growth retardants such as CCC, Phosfon-D, Amo-1618; furthermore the Alar (B_9), the ethrel and the morphactins. According to WEAVER (1972) the few inhibitors tested thus far did not give satisfactory results in case of lawn grasses. MADISON et al. (1969) applied morphactin as a growth inhibitor in case of blue grass, Bermuda grass and creeping bent grass but besides the inhibition of shoot elongation also an undesirable yellowing and phytotoxic effects occurred. It has been reported that MH inhibited the growth of pasture grasses with relatively good results (RUELKE, 1961) and thus this compound appears to be promising also for the limitation of lawn grass growth. The effect of other available inhibitors has been, in turn, not investigated thus far from this aspect.

Our experiments concerning the growth retardation of lawn grasses were started with MH, CCC and ethrel. MH is a general inhibitor of meristematic activity and is used since 1950 for the inhibition of the growth of trees, shrubs, stored potatoes and onions. CCC/ (2-chloroethyl)-trimethyl-ammonium chloride, chlorocholine chloride, Cycocel/ is applied since 1960 extensively for various practical purposes. CCC is considered generally as an antigibberellin i.e. a compound blocking in plant tissues the biosynthesis of gibberellins. It is probable however, that besides influencing the gibberellin level also other processes of metabolism are affected by CCC and its growth-inhibiting activity is correlated with the metabolism of other phytohormones as well (LETHAM et al., 1978). The ethylene generator ethrel /(2-chloroethyl)-phosphonic acid, CEPA/ is used in the practice since 1970. Quite a number of growth-physiological processes can be influenced by ethrel and, respectively, by ethylene liberated from it in the plant tissues; according to our investigations (VARGA and NIKL, 1981) it exerts a dwarfing effect when applied in higher concentrations and thus it is suitable also for the limitation of vegetative growth.

The aim of the present work was to test the suitability of the mentioned three, relatively cheap compounds for the decrease of the shoot growth of lawn grasses and to analyze the positive and negative reactions which deviated from those of the control plants. We set us the task to establish the concentrations and ways of treatment by which a growth reduction of lawn grasses to an extent desirable from practical aspects can be attained without the damage of the leaves.

Materials and Methods

Experiments were carried out with a seed sample denoted as "Grass mixture" which was suitable for grassing parks and domestic gardens. The seed mixture originated from the 1980 collection of the Vetőmagtermeltető és Értékesítő Vállalat (Enterprise for Producing and Marketing Seedgrains), Budapest. Of the components of this "Grass mixture", *Lolium perenne, Poa pratensis, Festuca rubra* and *Agrostis alba (stolonifera)* were present in the mixture in the greatest amounts.

Maleic hydrazide (MH) was prepared in the Department of Plant Physiology of the Attila József University, Szeged, in a crystalline form, its purity degree was 97.3%. CCC was a powdered product of Sigma Chemical Co. (U.S.A.), and ethrel was a liquid product of the Chinoin Factory Ltd. (Budapest) containing 40% of active substance and marketed under the name Rol-Fruct.

The seeds were sown into 10×10 cm plastics dishes filled with garden mould soil. The seedgrain requirement was 5 g/dm^2, the depth of sowing 0.5 cm. The plants were grown in a greenhouse

at a daily illumination rhytm of 16/8 hours at a temperature of 24±1 °C. A stable soil water content was maintained by irrigation with tap water controlled by weighing.

At an age of ten days the grasses were cut evenly to 4 cm and their spraying was started with an aqueous solution of the growth inhibitors of a concentration of 500, 1000, 2500 and 5000 ppm, respectively. The polyglycol derivative Citowett (BASF AG, BRD) served as wetting agent. A part of the grasses was sprayed once whereas another part of them obtained leaf spraying twice and thrice in weekly periods. The control plants were treated with tapwater containing wetting agent. Spraying was carried out in every dish with a manual sprayer device, on using equal amounts of solutions.

Prior to the first treatment and subsequently in ten-day periods samples were withdrawn from the plants and the lenght, the fresh and dry mass, and the leaf pigment content of the shoots, the mars increase of the roots were measured, furthermore the eventual leaf damages and their extent wese recorded.

The extraction of leaf pigments was carried out according to DÁNIEL (1963) in the presence of $MgCO_3$ with a 1:1 mixture of acetone: ethylether. Then acetone was washed off the extract with water and the pigments were shaken over into ethylether. The absorption of the ethereal pigment extracts was measured by a UV/VIS spectrophotometer at the wavelengths 430 nm (carotenoids), 625 nm (protochlorophyll), 645 nm (chlorophyll-a) and 665 nm (chlorophyll-b). At the calculation of the concentration of chlorophylls (μg/g fresh mass) the formula given by WITHROW et al. (1953) was used. The total carotenoid content is expressed by the values A_{430}.

Each investigation was carried out in triplicates.

Results and discussion

On investigating the growth inhibition of the lawn grass mixture it must be taken into account that the plant stand is heterogeneous i.e. it consists of various grasses. Though the individual components are affected by the growth inhibitors separately to various extents (SUM, 1978), in our experiments the total effect of these compounds on the grass mixture i.e. the average reaction of the various species is actually observed. Thus, our task was to find ways of treatment and concentrations of chemical agents which ensure for all the components the best result obtainable from the aspect of both growth inhibition and toxicity.

Effect of growth inhibitors on shoot growth

For the decrease of shoot growth of the lawn grass mixture four various concentrations of MH, ethrel and CCC were tested in the interval from 500 to 5000 ppm, and sprayings carried out once or twice or thrice. The shoot lengths observed at the end of the 30-day experimental period are shown in Figs. 1, 2 and 3 whereas the percentages of growth decrease are summarized in Table 1. According to the experimental data the shoot growth was inhibited by all the three inhibitors tested, proportionally to the increase of the concentration of chemicals and of the number of sprayings, to a gradually increasing extent. However, on comparing the results obtained with the investigated three compounds it appears that their growth-inhibiting activity and the reaction of lawn grasses induced by them is rather different.

The shoot growth of grasses was decreased by MH to the greatest extent (Table 1, and Fig. 4) whereas the inhibition of growth induced by ethrel and CCC was in all cases weaker than that which could be obtained with MH of identical concentration. In the majority of samples MH caused about twice as great growth decrease, expressed in percentages, than CCC which proved to be the least efficient as an inhibitor of shoot growth of grasses (Table 1). Consequently, lawn grasses are more sensitively reacting to MH than to ethrel and CCC.

Table 1. Decreasing effect of growth inhibitors on the shoot growth of lawn grasses
Degree of growth decrease observed on the thirtieth day, expressed as percentages of the control plants

Number of sprayings	Growth inhibitor	Concentration, ppm			
		500	1000	2500	5000
1	MH	23%	45%	50%	62%
	Ethrel	18	22	29	45
	CCC	15	20	24	32
2	MH	32	49	55	63
	Ethrel	21	26	36	52
	CCC	16	25	30	40
3	MH	42	52	56	67
	Ethrel	27	30	41	59
	CCC	26	29	43	51

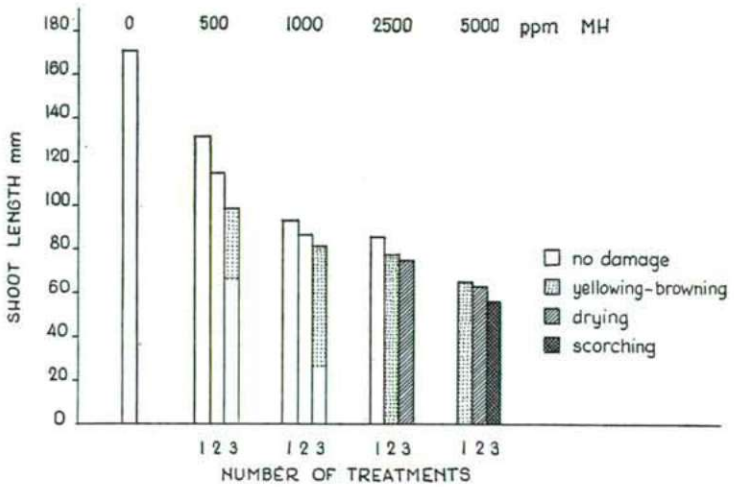

Fig. 1. Shoot growth and leaf damages of lawn grasses on the effect of sprayings with MH, on the thirtieth day after the first treatment

On evaluating the leaf damages due to sprayings it appears that the phytotoxicity of the compounds increases parallel with their growth-inhibiting activity and, respectively, with the sensitivity of lawn grasses to the compounds. MH as the growth inhibitor which proved to be the most efficient caused, when applied in a concentration of 500 to 1000 ppm consecutively thrice, yellowing and browning of a part of the leaves. With the increase of concentration the toxic symptoms became stronger, and the plants treated thrice with a 5000 ppm MH solution were destroyed on the 30th day due to drying (withering) and scorching (Fig. 1). Ethrel caused only in a concentration of 2500—5000 ppm leaf damages whose extent was smaller or greater accord-

ing to number of the applied sprayings (Fig. 2) whereas CCC caused observable leaf damages only in the case when it was applied in the highest concentration and repeatedly (Fig. 3).

It must be noted that in case of grass samples which did not suffer any damages the decrease of apical growth resulted in a more compact form, higher resistance to lodging and stronger stooling than those observed in the control plants. This is particularly valid in case of plants sprayed with CCC.

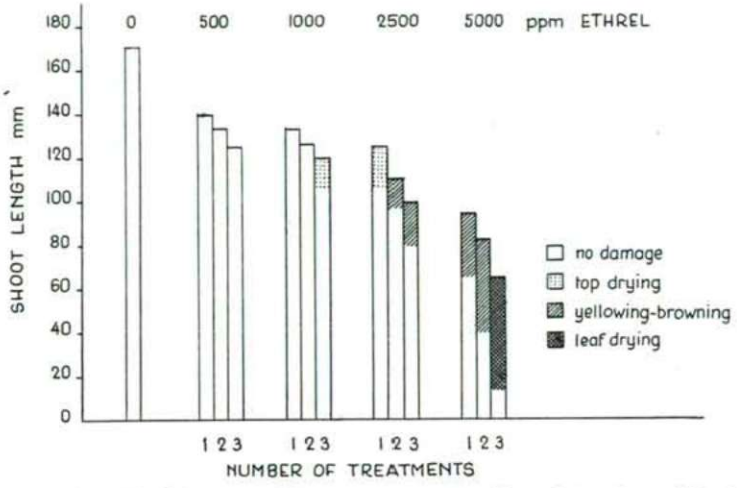

Fig. 2. Shoot growth and leaf damages of lawn grasses on the effect of sprayings with ethrel, on the thirtieth day after the first treeatment.

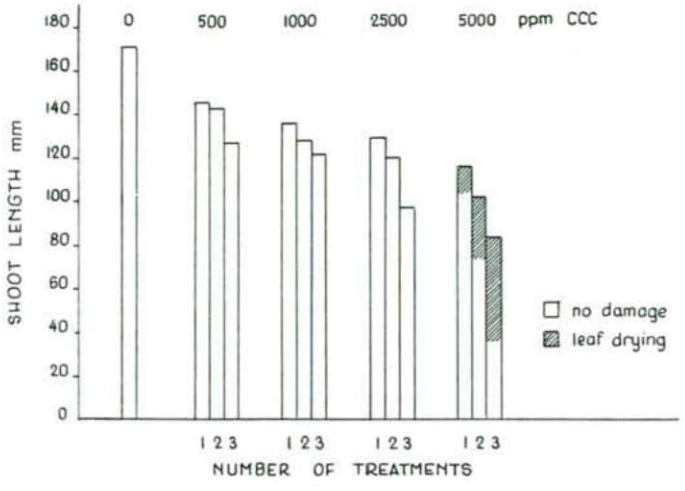

Fig. 3. Shoot growth and leaf damages of lawn grasses on the effect of sprayings with CCC, on the thirtieth day after the first treatment.

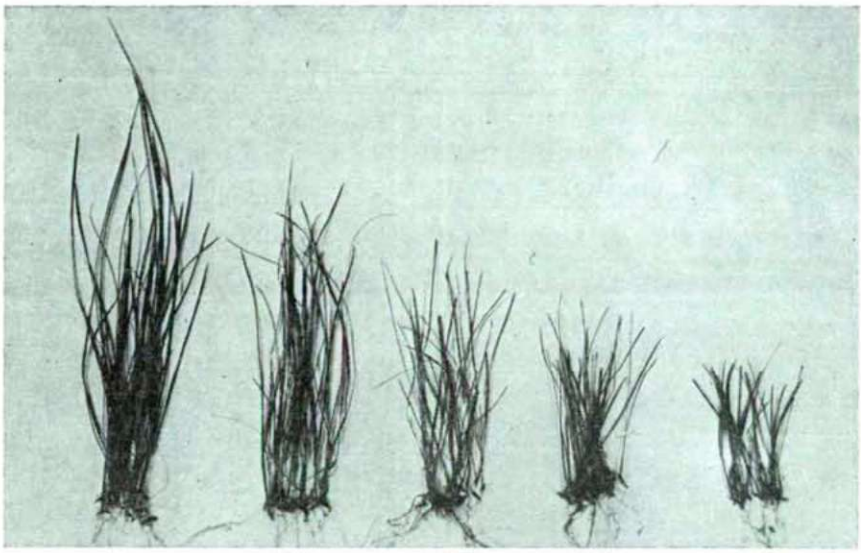

Fig. 4. Shoots of lawn grasses sprayed once with various concentrations of MH, on the thirtieth day after the treatment.

Effect of growth inhibitors on the increase of the fresh and dry mass of shoots

The growth-inhibiting effect of spraying with growth inhibitors carried out once, twice and thrice can be established also by observing the fresh mass of shoots (Table 2). In case of MH and ethrel the fresh mass decreased more and more with the increase of the concentrations and with the increase of the number of treatments. Consequently, mass accumulation is in concordance with the apical growth. In contrast to that, the increase of the fresh mass of shoots of lawn grasses sprayed with CCC did not

Table 2. Effect of growth inhibitors on the fresh mass increase of the shoots of lawn grasses Fresh mass (g) on an area of 10×10 cm, on the thirtieth day

Number of sprayings	Growth inhibitor	Concentration, ppm				
		0 (control)	500	1000	2500	5000
1	MH	10.13	6.98	5.97	5.06	2.73
	Ethrel		9.86	9.04	6.65	6.12
	CCC		10.84	10.43	9.62	8.10
2	MH	10.13	5.47	5.06	3.74	2.43
	Ethrel		9.62	8.12	7.30	5.39
	CCC		10.53	9.52	8.91	7.49
3	MH	10.13	4.96	4.92	2.93	2.23
	Ethrel		7.95	7.26	6.67	4.63
	CCC		10.10	9.21	8.30	6.88

show any parallelism with growth intensity. Namely, lower concentrations of CCC despite their certain growth-inhibiting effect rather increased the fresh mass instead of decreasing it. Though the fresh mass of shoots treated with higher CCC concentrations indicated some decrease when compared to that of the control plants, the degree of this decrease was not proportional to the inhibition of apical growth. This points to the more compact form, thicker foliage and higher water content of grasses treated with CCC.

The dry matter content of shoots does not show any parallelism with the degree of decrease of fresh mass caused by any of the growth inhibitors tested. Moreover, the percentage of dry mass in grasses sprayed repeatedly by higher MH concentrations exhibited even some rise when compared with that of the control (Table 3). This can be attributed certainly to the water loss due to the drying of leaves caused by the compunds.

Table 3. Effect of growht inhibitors on the dry mass increase of the shoots of lawn grasses expressed as percentages of dry mass

Number of sprayings	Growth inhibitor	Concentration, ppm				
		0 (control)	500	1000	2500	5000
1	MH	16.5	16.2	16.1	16.0	16.8
	Ethrel		15.8	14.3	14.5	14.8
	CCC		16.0	15.1	15.3	15.5
2	MH	16.5	15.5	16.1	16.6	16.8
	Ethrel		14.1	13.4	14.4	15.0
	CCC		15.0	13.5	15.0	16.2
3	MH	16.5	14.6	16.0	16.8	17.0
	Ethrel		13.4	14.2	15.3	15.8
	CCC		14.0	14.6	15.7	16.0

Effect of growth inhibitors on the content of leaf pigments

The growth decrease of lawn grasses induced by chemical agents can be successful only if the green colour and exterior look of the lawn is not affected adversely by the treatment with chemicals. Therefore it was necessary to measure in every sample the effect of sprayings on the content of leaf pigments.

The content of chlorophyll a + b (Fig. 5) was not affected appreciably by a single treatment with the 500, 1000 and 2500 ppm solutions of MH, nor by single or thrice repeated treatments with a 500 ppm solution of ethrel or a single or repeated treatment with a 1000 ppm solution of ethrel. In all the aforementioned cases the deviations from the control values were within the 10% error limit. In all other samples the amount of chlorophylls was significantly decreased by both compounds with the rise of the concentration and of the number of spryaings. The degradation of chlorophylls is of a particularly high degree (42 and 38%, 55 and 50%, 58 and 57%, respectively) in the leaves of grasses treated thrice with 2500 ppm solutions of MH and ethrel,

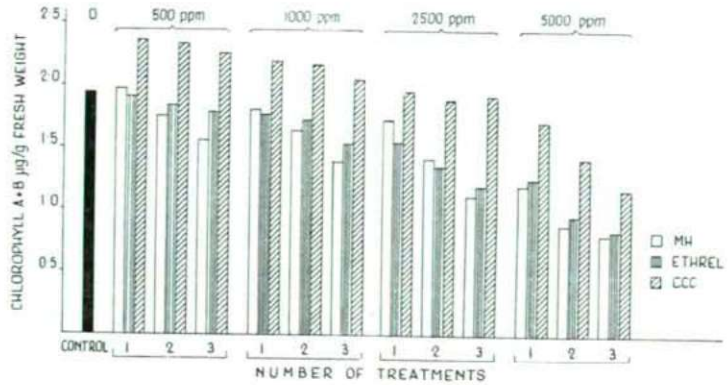

Fig. 5. Effect of MH, ethrel and CCC on the total chlorophyll content of the leaves of lawn grasses (on the thirtieht day).

and treated twice and thrice with 5000 pm solutions of MH and ethrel. The effect of MH and threl on the chlorophyll content proved to be about the same whereas CCC disclosed an effect differing from that of both other compounds. Namely, lower concentrations of CCC definitely raised the total chlorophyll concentration of the shoots which manifested itself by a darker colour observable also visibly. The amount of chlorophylls was decreased significantly by this compound only in lawn grasses repeatedly sprayed with its highest concentrations. The higher chlorophyll level obtained with non-toxic concentrations of CCC and its effect increasing the net photosynthetic production was observed by a number of authors in various plants (LETHAM et al., 1978).

The total carotenoid content of the leaves showed a similar behaviour (Fig. 6) with the difference that the concentration dependent alteration of the amount

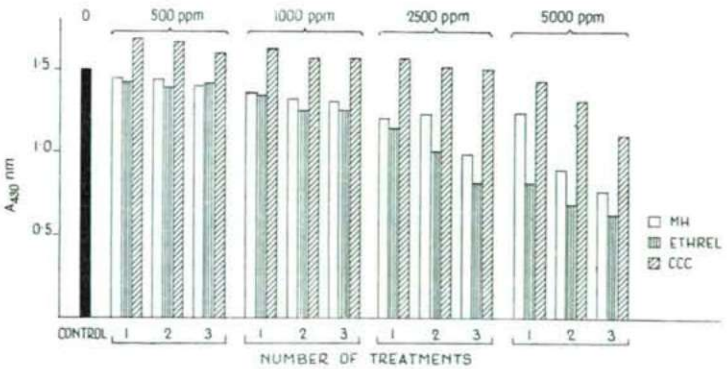

Fig. 6. Effect of MH, ethrel and CCC on the total carotenoid content of the leaves of lawn grasses (on the thirtieht day).

of yellow pigments was of a degree lower than that of the green components. Consequently, mainly on the effect of concentrated solutions of MH and ethrel, chlorophylls were degraded to a degree higher than that of carotenoids.

Successful ways of treatment for lawn grass mixture

On comparing the shoot growth inhibiting effect of sprayings with solutions of MH, ethrel and CCC of various concentrations and applied once or repeatedly with the damages of leaves observable visibly in their colour or in their other properties, it can be established which compounds and ways of treatment may be applied in practice for the successful and hazardless growth decrease of lawn grasses. Namely, in order to avoid a frequent lawn mowing the apical growth must be deceased by 45 to 50%.

According to our results a growth inhibition of this order of magnitude or higher can be obtained most of all with MH, of the compounds tested (Table 1). However, on taking into account the phytotoxic effect of treatments with higher concentrations of MH, practically only a single or repeated spraying with a 1000 ppm solution or a single spraying with a 2500 ppm solution can be applied. These types of treatment proved to result in a decrease of shoot elongation by 45, 49 and 50% without any visible damage of the leaves (Fig. 1) i.e. their effect is satisfactory from the aspect of the aim set by us.

Though a once to thrice applied spraying with a 500 ppm ethrel solution and a once or twice applied spraying with a 1000 ppm ethrel solution did not damage the leaves and leaf pigments (Figs. 2, 5 and 6), the observed decrease of shoot growth was unsatisfactory (only 18 to 27%).

CCC when applied repeatedly in both lower concentrations did not damage at all the grasses. Instead, it increased the pigment content, mass and resistance to lodging of the leaves (Figs. 3, 5 and 6). Still, CCC is not suitable for attaining the desired aim because the growth inhibition induced in this way is rather low (15 to 26%). A more significant growth decrease (up to 30—43%) without any phytotoxic symptoms can be obtained only by spraying with a 2500 ppm solution carried out twice or thrice. Thus, only these types of treatment can be taken into account in order to attain a rather moderate but hazardless result.

On summarizing our results it can be stated that of the three inhibitors tested MH proved to be the most efficient for the growth decrease of the lawn grass of parks and gardens. Namely, on applying MH twice as strong growth inhibition can be obtained without any damage of the leaves than that attainable with ethrel or CCC. Just therefore, MH can be applied with better results but at higher hazards (due its higher toxicity) than ethrel or CCC which have moderate effects but lower hazards.

Also experiments with other growth inhibitors are in progress under greenhouse and small-plot conditions.

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