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Stimulation of Bulb Growth in Onion (*Allium cepa* L.) by N,N-diethyl-N-(2-hydroxyethyl)glycine

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Abstract. Both N,N-diethyl-N-(2-hydroxyethyl)glycine (DEHEG) and N,N-diethyl-2-oxo-morpholinium chloride (DEOMC) in an optimal dosage of 4×10 μmoles per seedling initially accelerated then retarded leaf growth in onion, and doubled the yield of bulbs in field conditions. Gibberellin and auxin nullified the latter effect. It is concluded that DEHEG represents a physiologically active form of DEOMC.

DEOMC (Witek *et al.* 1967) and some other plant growth retardants may stimulate the bulb growth in onion (Knypl 1977). Since DEOMC in the presence of water hydrolyzes to a betaine derivative DEHEG (Knypl 1979), this study was undertaken in order to test whether DEHEG represents a physiologically active form of DEOMC.

MATERIAL AND METHODS

Seeds of onion, *Allium cepa* L. cv. Wolska, were sown in a seed-bed under glass on April 12, 1978. Seedlings were planted in garden soil on April 29, in 5 m long rows with a spacing of 10 cm between plants. Treatments with growth regulators started when the plants were in a 2-leaf developmental stage; two rows of plants were used per each treatment. Five or 50 μl aliquots of 0.2 M solution of DEHEG or DEOMC in 0.05% Tween 20 were applied to the base of 2nd leaf sheath. The controls were treated with a similar vol. of the solute. Ten μg of GA_3 or IAA in 5 μl of 0.05% Tween 20 supplemented with 10% ethanol were applied when droplets of DEHEG or DEOMC had evaporated. Treatments with the growth retardants were repeated 4 times at weekly intervals (June 11, 18 and 25, and July 3). Bulbs were harvested when the leaves collapsed, *i.e.* at the end of September.

RESULTS

Both DEHEG and DEOMC stimulated growth of the 2nd leaf which was *ca.* 50 mm long at the time of the first treatment. The compounds accelerated also initial growth of the 3rd, 4th and 5th leaves which developed after 1st,

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TABLE 1

The effect of DEHEG and DEOMC on growth of leaves in onion. 10 μmol of DEHEG or DEOMC were applied 4 times in a week intervals (days 0, 7, 14 and 21). Mean length of the 1st and 2nd leaves at t_0 = 145 and 50 mm, respectively. Stimulation (s) or inhibition (i) of growth in comparison with the control value in the same column is significant at $P = 0.05$ (Student *t*-test)

Days since 1st treatment	Length [mm]						
	No. of leaf 1	2	3	4	5	6	7
	Control						
7	165	106	28	0			
14	170	161	143	42	0		
21	186	200	228	119	42	0	0
42		244	361	418	462	419	300
	DEHEG						
7	169	124	39s	0			
14	171	187	162	58s	0		
21	181	244s	235	172s	74s	0	0
42		390s	418s	364i	288i	190i	92i
	DEOMC						
7	165	111	53s	0			
14	171	181	166	76s	0		
21	179	225s	235	172s	70s	0	0
42		306s	370	372i	250i	170i	90i

2nd and 3rd treatments, respectively (Table 1). The stimulation of leaf growth was transient, as the length of the 4th and 5th leaves was strongly reduced in comparison with the untreated control when measured 42 days following the 1st treatment. The leaves were darker green and much thicker than the control ones, *i.e.* they showed symptoms typical of the action of

TABLE 2

Effects of DEHEG and DEOMC on bulb growth.

Bulbs were harvested 170 days after sowing the seeds. Figures in the same column followed by a different letter differ significantly at $P = 0.05$

Treatment and dosage	Fr. wt. [g]	Diameter [mm]	Volume [cm^3]
Control	61a	46a	62a
DEHEG, 2× 10 μmol	87b	56b	88b
DEHEG, 4× 10 μmol	120c	61c	126c
DEHEG, 2×100 μmol	60a	46a	61a
DEHEG, 4×100 μmol	84b	56b, c	86b
DEOMC, 2× 10 μmol	79b	52a, b	79b
DEOMC, 4× 10 μmol	118c	60c	120c
DEOMC, 2×100 μmol	64a	47a	65a
DEOMC, 4×100 μmol	80b	51a, b	81b

Abbreviations used: DEHEG: N,N-diethyl-N(2-hydroxyethyl)-glycine; DEOMC: N,N-diethyl-2-oxomorpholinium chloride; GA_3: gibberellic acid; IAA: indolyl-3-acetic acid.

growth retardants. Growth of the 6th and 7th leaves which developed after the last treatment with either DEHEG or DEOMC was severely reduced (Table 1).

Both compounds on an optimal dosage of 4×10 μmoles per plant doubled the weight and volume of mature bulbs in comparison with the control

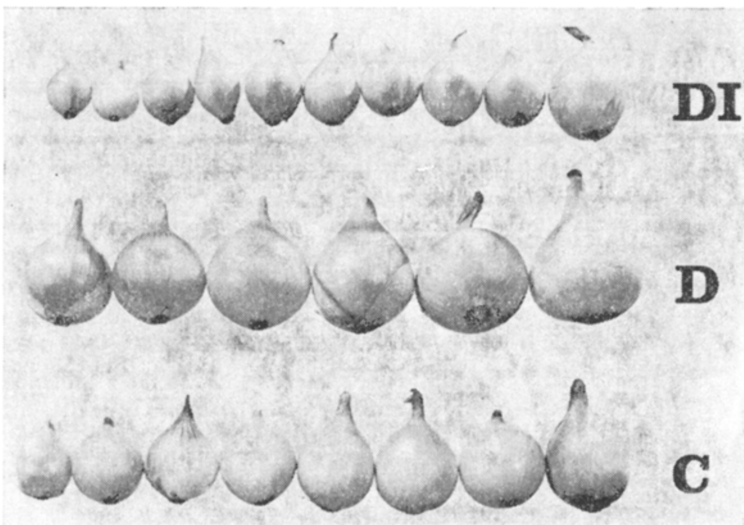

Fig. 1. The effect of IAA and DEHEG on growth of onion bulbs. DI = DEHEG (4×10 μmol) and IAA (3×10 μg); D = DEHEG (4×10 μmol); C = untreated control. Other details as in Tables 1 and 2.

(Table 2). The optimal dosage of each of the compounds was rather narrow as evidenced by the fact that the retardants on a dosage of 2×100 μmoles did not affect the weight of bulbs whereas a dosage of 4×100 μmoles was as effective as the suboptimal one of 2×10 μmoles.

IAA and GA_3 halved the weight of bulbs at maturity (Table 3). Of these phytohormones IAA produced morphological malformations of the leaves

TABLE 3

The inhibitory effect of IAA and GA_3 on growth of onion bulbs in the absence and in the presence of DEHEG or DEOMC.
10 μmol of DEHEG or DEOMC were applied 4 times; 3×10 μg of IAA applied at t_0, t_7 and t_{14}; 2×10 μg of GA_3 applied at t_0 and t_7. The data followed by unlike letters differ significantly at $P = 0.05$

Growth retardant	Fresh weight of bulb [g]		
	O	IAA	GA_3
None (control)	60a	32b	34b
DEHEG	116c	36b	65a
DEOMC	108c	39b	60a

(*cf.* SIPRA GUHA *et al.* 1966) whereas GA_3 stimulated the top growth (*cf.* LIPE 1975). IAA antagonized the stimulatory effect of either DEHEG or DEOMC on the bulb growth (Fig. 1). The plants treated with GA_3 in combination with any of the two growth retardants produced bulbs as large as the control plants did (Table 3). This means that GA_3 at a dosage of 2×10 μg applied at t_0 and t_7 simply nullified the effects brought about by the growth retardants (*cf.* KNYPL 1979).

DISCUSSION

Physiological activity of DEHEG is equal to the activity of DEOMC per a mole basis. It is thus justified to conclude that DEHEG in fact represents a physiologically active form of DEOMC, because the morpholinium ring of the latter compound undergoes a spontaneous hydrolysis in water solutions (KNYPL 1979). On the basis of the facts that [1] GA_3 competitively interacts with DEOMC in the control of elongation of cucumber hypocotyl (KNYPL 1977) and [2] DEHEG nullifies the visible symptoms of GA_3 action on the development of onion plants, it can be suggested that this betaine analogue: $(C_2H_5)_2N^+(C_2H_4OH) . (CH_2COO^-)$ acts as an inhibitor of biosynthesis of some gibberellin fractions in the onion (*cf.* LANG 1970).

It seems to be improbable that DEHEG specifically interacts with the auxin system in onion as [1] DEOMC did not interact competitively with IAA in the control of cucumber growth (KNYPL 1977) and [2] DEHEG did not decrease the inhibitory effect of IAA on the bulb growth (Table 3). Auxin content increases during the first week following the long day (LD) induction period, then it falls off below the original level (CLARK and HEATH 1962, LERCARI *et al.* 1977). High auxin level is seemingly required for the induction of bulbing in onion, whereas low auxin content is necessary for growth of the bulbs. This fact explains why exogenous IAA inhibited bulb growth in this study (Fig. 1). LERCARI *et al.* (1977) extracted from LD induced plants a neutral growth inhibitor which decreased the growth of leaves and stimulated the growth of bulbs. Since the bulb growth is inversely correlated with the growth of leaves (HEATH and HOLDSWORTH 1948), DEHEG may cooperate with this natural inhibitor in retarding the top growth (Table 1) and determining the site of the sink for assimilates in the bulb (*cf.* HALEVY and BIRAN 1975, LOWE and WILSON 1974).

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BOOK REVIEW

HALLÉ, F., OLDEMAN, R. A. A., TOMLINSON, P. B.: TROPICAL TREES AND FORESTS. AN ARCHITECTURAL ANALYSIS. — Springer-Verlag, Berlin—Heidelberg—New York 1978. Pp. 441. Figs. 111. Cloth DM 125,—; US $ 62.50.

Not seldom has it be stated that if a botanist is eager to learn the potential ability of the plant kingdom, he has to concentrate on the tropical ecotopes, tropical rain forests in particular. No matter if he is an ecologist, physiologist or is fond of systematics, there he will see what the plant kingdom is able to perform. This statement is true in many respects, for not only the stress strategy in extreme ecotopes is to be admired and thoroughly studied. A similar interest is to be paid to the most favorable habitats, where most luxurious development of the genetic richness and physiological productivity is to be encountured.

The main topic of the book is the descriptive and adaptive geometry of tropical trees; the potential morphological models of the overground parts of tropical trees are discussed step by step starting with their genotypically induced features and ending with their morphology as it is controlled in the stand conditions of competition.

The book stands at the edge between describing forms and strategies of the overground growth of tropical trees and explaining them. Not too much attention is paid to the physiological morphology from the physiological point of view. On the other hand a tremendous amount of forms and (especially) their development is described and classified from point of view of comparative morphology, adaptive geometry and developmental strategy.

In introductory chapters, on what is a tree and what is a tree in the tropics, the tree architecture elements (apical meristems, seedling morphology, growth, phyllotaxis, branching, generative growth, radial growth) are discussed from the stand point of the developmental morphology. As too little is known about the root systems morphology, not enough attention is paid to roots.

The most extensive third chapter is devoted to the description of architectural tree models of more or less solitary tree individuals. These models are confined to different types encountered in the floristic realm of tropical trees. A very interesting chapter is devoted to what is called the opportunistic tree architecture: The behaviour of trees is described under different stress modifying their architecture such as pest attack, competition, damage, environmental stress and supraoptimal conditions. Here problems concerning the energetics of trees (*e.g.* the surface: volume ratio), their productivity and growth potential are discussed.

The last fifth chapter deals with the behaviour of individual trees in a stand: the architecture of forests is discussed from the point of view of homeostatic behaviour of tree stands. Selected cases of tree architecture are exemplified and attempt has been made to explain them both in causal and silvigenetic way.

A glossary, list of references, fairly detailed indexes of plant and model names and subject indexes are included.

On the whole, the book brings a very good review of the morphological richness of tropical trees stimulating the creative fantasy of botanists. As this fantasy represents undoubtedly a rich source for the scientific progress, the book contributes excellently to further development of many branches of botany.

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