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A DRAMATIC EFFECT OF STEREOCHEMISTRY ON THE PLANT GROWTH ACTIVITY OF THE CADINANE GROUP OF TERPENOIDS

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Key Word Index—*Phaseolus aureus*; Leguminosae; cadinanes; terpenoids; plant growth regulators; root formation.

Abstract—Seven cadinane terpenoids have been tested as plant growth regulators. Khusinoloxide and epikhusinol acetate greatly stimulated root initiation with hypocotyl cuttings of *Phaseolus aureus* seedlings.

INTRODUCTION

Earlier reports from our laboratory record the plant growth activity of a variety of terpenoids [1–4] and indicated a relation between the structure of a terpenoid and its potential as a plant growth regulator. We have carried out an extensive screening of a large number of terpenoids for this purpose. The data (P. S. Kalsi, unpublished results) from this screening have provided ample evidence that the root-forming potential of a terpenoid is dependent on its overall structure. A large variation occurs among the physiologically active α-methylene-γ-lactones in stimulating rooting of hypocotyl cuttings of mung beans (*Phaseolus aureus*) [5]. The α-methylene-γ-lactones from the guaianolide and germacranolide series both induce root formation, but to different extents. Therefore, it appears more reasonable to assign structure reactivity relationships to terpenoids having the same basic carbon skeleton. The present paper reports on this aspect in the case of some terpenoids from the cadinane group. Significantly, it was observed that in this series of compounds the root-forming activity of a cadinane showed a remarkable dependence on minor structural and stereochemical changes.

The present work investigated the effects of five naturally occurring sesquiterpenes, including a hydrocarbon (−)-γ-cadinene (**1**) [6], two isomeric alcohols khusinol (**2**) [6, 7] and khusol (**3**) [8], two epoxy alcohols khusinoloxide (**4**) [9] and *iso*-khusinoloxide (**5**) [10], and the two derived acetates khusinol acetate (**6**) and *epi*-khusinol acetate (**7**) [11].

RESULTS AND DISCUSSION

(−)-γ-Cadinene (**1**) was only slightly more active than the control in causing root formation (Table 1), whilst it was rather more active than the control as far as the length of the roots was concerned (Table 2). Similar effects were observed with the isomeric primary and secondary alcohols khusinol (**2**) and khusol (**3**), which are the hydroxy derivatives of (−)-γ-cadinene, the only difference being that with **2** and **3** the numbers of roots produced were slightly more at higher concentrations. This was also found to occur with khusinol acetate (**6**) and *iso*-khusinoloxide (**5**).

Very interestingly, it was found that *epi*-khusinol acetate (**7**), which is the C-5 epimer of khusinol acetate (**6**), showed a tremendous increase in root formation which

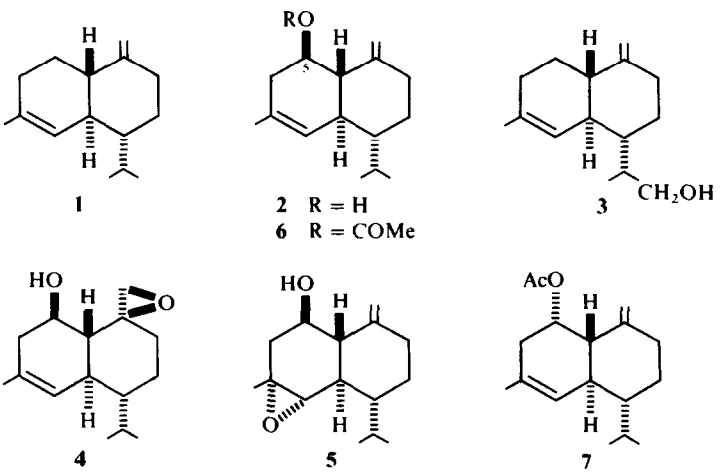

Table 1. Effect of different terpenoid concentrations on the number of roots per rooted segment produced on hypocotyl cuttings of *Phaseolus aureus* after 8 days

	Number of roots			
Treatment (mg/l.)	10	20	30	40
(−)-γ-Cadinene (**1**)	5.4 ± 1.4	4.8 ± 1.3	4.7 ± 0.8	4.6 ± 0.5
Khusinol (**2**)	5.8 ± 1.5	6.5 ± 0.3	7.6 ± 1.4	6.8 ± 1.2
Khusol (**3**)	5.1 ± 1.1	6.0 ± 1.3	6.0 ± 1.1	8.4 ± 1.8
Khusinoloxide (**4**)	6.7 ± 1.8	13.1 ± 1.6	17.0 ± 1.9	21.2 ± 1.9
Iso-khusinoloxide (**5**)	4.8 ± 1.1	5.9 ± 1.4	6.1 ± 1.0	7.1 ± 1.1
Khusinol acetate (**6**)	4.8 ± 0.7	6.2 ± 1.9	7.3 ± 1.7	6.9 ± 1.9
Epi-khusinol acetate (**7**)	18.4 ± 2.5	27.6 ± 4.6	26.0 ± 4.2	16.6 ± 2.2
	Control experiments: H_2O		4.3 ± 0.9	
	IAA (5 ppm):		7.7 ± 1.1	

Table 2. Effect of different terpenoid concentrations on the length of root (longest root per rooted segment) produced on hypocotyl cuttings of *Phaseolus aureus* after 8 days

	Length of root			
Treatment (mg/l.)	10	20	30	40
(−)-γ-Cadinene (**1**)	12.1 ± 1.5	12.9 ± 1.3	13.6 ± 1.5	12.1 ± 1.6
Khusinol (**2**)	11.0 ± 1.1	16.4 ± 1.7	12.6 ± 1.7	9.4 ± 1.4
Khusol (**3**)	22.0 ± 2.1	14.0 ± 0.2	12.7 ± 1.5	12.2 ± 1.1
Khusinoloxide (**4**)	14.4 ± 1.1	11.6 ± 1.7	9.0 ± 1.1	6.5 ± 1.1
Iso-khusinoloxide (**5**)	12.3 ± 1.6	10.9 ± 1.3	11.0 ± 0.3	10.8 ± 1.3
Khusinol acetate (**6**)	8.6 ± 1.2	10.0 ± 1.1	10.1 ± 1.1	7.3 ± 1.1
Epi-khusinol acetate (**7**)	10.3 ± 1.2	10.3 ± 1.6	13.2 ± 1.3	7.9 ± 1.2
	Control experiments: H_2O		7.4 ± 1.1	
	IAA (5 ppm)		2.8 ± 0.8	

was almost four times greater at 20 mg/l. when compared with khusinol acetate. It should be noted that the root-forming potential of epikhusinol acetate was higher than that of indole-3-acetic acid (IAA) at 5 ppm. Another dramatic observation in this series was that the presence of an epoxy group at the position of the methylenic double bond in khusinol produced an enhancement in the root-forming potential of the parent compound khusinol. However, this effect was not seen with the isomeric compound *iso*-khusinoloxide and other compounds.

These data, therefore, show that *epi*-khusinol acetate (**7**) and khusinoloxide (**4**) are two new plant growth regulators from the terpenoid group of natural products. The tremendous increase in the root-forming potential of epikhusinol acetate over its isomer khusinol acetate is reminiscent of similar changes in the biological activity of other compounds as a result of a change in their stereochemistry, as in the case of juvenile hormones, where activity is lost on isomerization of double bond(s).

EXPERIMENTAL

For the root initiation study on hypocotyl cuttings of *Phaseolus aureus*, seedlings were grown under continuous illumination. After 4 days when the hypocotyls were 4–5 cm long, cuttings were made by excision, 3 cm below the cotyledonary node leaving the cotyledonary leaves and apex intact. Seven compounds at four concns, viz. 10, 20, 30 and 40 mg/l., together with IAA at 5 ppm as standard and H_2O as control were tested. For all treatments ten replicates were cultured in vials containing 30 ml of test solns. All the solns were replaced with fresh ones after 4 days. The final observations were recorded on the eighth day of the experiment. The experiment was repeated three times at 26 ± 2°.

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