FLOODING RESISTANCE AND ETHYLENE. I. AN ECOPHYSIOLOGICAL APPROACH WITH *RUMEX* AS A MODEL

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As an ecophysiological research group, we are concerned with the occurrence and distribution of plant species in riparian areas of the Rhine delta in the Netherlands. The downstream flood plains are characterized by differences in elevation, leading to a distinct flooding gradient and a typical plant zonation. In order to elucidate this zonation, investigations are in progress with different species of the genus *Rumex*, each having a specific growth location within the flooding gradient. *Rumex maritimus*, and *R. palustris* occur at the lowest elevation level in the river foreland. *R. thyrsiflorus* and *R. acetosa* are found on higher and rarely flooded grounds while *R. crispus* and *R. obtusifolius* take an intermediate position. The central hypothesis is that the observed *Rumex* zonation is mainly determined by the degree of resistance to flooding [2].

Adaptations of *Rumex* species towards waterlogging and submergence are: (i) the development of new adventitious roots, (ii) aerenchyma formation [2,4] and (iii) enhanced shoot elongation [1,5]. Ethylene plays a central role in the initiation and regulation of these adaptive responses. An example of the petiole elongation upon total submergence of four *Rumex* species is given in fig. 1. Petioles of the flooding-tolerant *R. maritimus* and *R. palustris* elongate most, *R. crispus* shows moderate elongation, while *R. acetosa* shows no elongation.

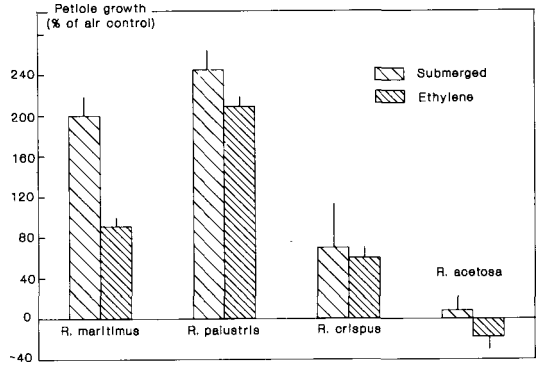

Fig. 1. The elongation of the youngest petioles of four *Rumex* species, as percentage of the growth in air (± 1 SE; n=10/12). Plants were submerged in tap water or exposed to 0.5 Pa ethylene for 4 days. Mean actual length (cm) in air and leaf number (between brackets): *R. maritimus*=2.1 (6) *R. palustris*=2.2 (5); *R. crispus*=2.5 (4); *R. acetosa*=7.6 (4).

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The submergence response can be mimicked by treatment with 0.5 Pa ethylene (fig. 1). The reduction in response to ethylene treatment compared with submergence, is most likely due to an absence of CO_2 in the ethylene/air mixture. All *Rumex* species in fig. 1 show an elevated internal ethylene concentration during submergence compared to the air control.

Experiments, both in the field and under laboratory situation, are conducted in all life stages of the plants. Upon submergence during the vegetative stage, the petioles of the rosette leaves of the flooding resistant species elongate the most. When submerged at the fullgrown rosette stage, plants of *R. palustris* postpone their flowering and elongate the petioles of the rosette leaves, while *R. maritimus* plants commence bolting and elongate the stem internodes, appearing to be obligated to flower once fullgrown [3]. Differences in response not only occur between species or life stages but even within the development of the individual leaf. Petioles of young, furled leaves of *R. palustris* elongate more than petioles of fully expanded leaves.

These results indicate an ethylene response, regulated by sensitivity towards this hormone, whether direct or via other plant growth substances.

Tabel 1. Length (mm) of *Rumex palustris* petioles after 96 h treatment with or without paclobutrazol. Plants where watered four days in advance with 1.0 μM and submerged in 0.1 μM paclobutrazol (± 1 SE; n=9/14).

treatment	paclobutrazol -	paclobutrazol +
shoot in air	11.1 (0.8)	11.8 (0.9)
submerged	39.1 (0.7)	29.8 (0.6)
0.5 Pa ethylene	31.5 (2.1)	23.9 (1.0)
submerged + 5 μM GA_3	-	39.8 (0.9)

Present research is focussed on the involvement and timing of action of auxin and gibberellin in the elongation of the rosette petioles. The elongation of petioles of *R. palustris* upon submergence reduces when plants are treated with paclobutrazol, a inhibitor of gibberellin synthesis, and can be restored by supplementation of 5 μM GA_3 (tabel 1). In addition, investigations with respect to the kinetics of the ethylene production [1] and the formation of adventitious roots and aerenchyma are in progress [4].

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