Herbicidal Potential of Microbiologically-Produced 5-Aminolevulinic Acid

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Objective : The present study was conducted to determine herbicidal effect of 5-Aminolevulinic Acid (ALA) on several crop and weed species, and to examine the accumulation of tetrapyrroles, metabolic intermediates of the chlorophyll and heme metabolic pathway in darkness. When ALA-treated plants are exposed to sunlight, excess tetrapyrroles absorb the energy that is normally used for photochemical reactions and use it instead to photosensitize the production of $^1O_2$. The $^1O_2$ oxidizes unsaturated membrane lipids, generating free radicals, which damage the membrane system and lead to the death of the plant.

Materials and Methods : ALA produced by chemical synthesis (synthetic-ALA) was purchased from Sigma Chemical Co. (St. Louis, MO, USA), and another type ALA produced by overexpressing the *hemA* gene isolated from *Bradyrhizobium japonicum* (Choi *et al.*, 1999) was supported from Environgen Co., Korea (Bio-ALA). Imbibed seeds of corn, soybean and barnyard grasswere seeded in small horticulture pot (10x10x5cm) filled with silt-loam soil. Germinated seedlings were grown for 20 days under greenhouse conditions. Then ALA at 0, 2, 4, 6, and 8 mM mixed with Tween 80 was foliar applied at 6:00 PM. At the time of application, leaf stage of test plants was about 2-leaves. After application, post-spray dark incubation period was kept for 16 hrs, and next morning exposed to the natural sunlight ranged from 1000 to 1500 mol photons m^{-2} s^{-1} to elicit photodynamic damage. Shoot length, root length and fresh weight were measured on all seedlings 6 days after exposure to sunlight. Chlorophyll concentration was measured spectrophotometrically by the method of Lichtenthaler (1987). After post-spray dark incubation period for 16 hrs, leaves from each plant species were collected for tetrapyrrole assay by means of HPLC Analysis

Results : ALA effect on early plant growth was greatly concentration dependant, suggesting that it promotes plant growth at very low concentration and inhibits at high concentration. With post-emergence application, ALA at 2 to 8mM reduced shoot growth of barnyard grass much more than that of corn and soybean. Chlorophyll a content of each plant species was decreased with increase of treated ALA concentration. Proto IX and Pchlide accumulated significantly in ALA-treated plants, especially Proto IX with much greater levels in barnyard grass than in corn or soybean. However, only trace amounts of Proto IX-ME were detected in all plant species with ALA application.

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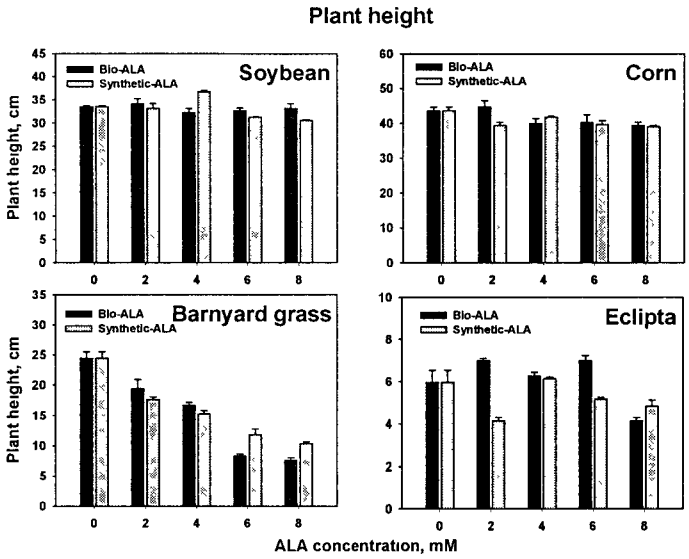

Fig. 1. Effects of ALA-foliar application of two types on plant height of soybean, corn, barnyard grass and eclipta as affected by different ALA concentrations.

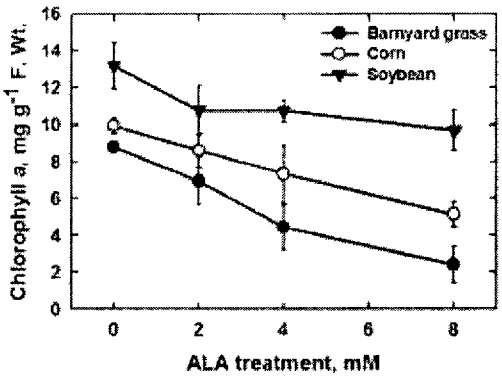

Fig 2. Effects of ALA-foliar application on chlorophyll a content of barnyard grass, corn and soybean plant as affected by different ALA concentrations.

Table 1. Intermediates of chlorophyll biosynthesis in plant species treated with 8mM-ALA.

Plant Species	Application Con., mM	Proto IX	Proto IX-ME (nmol g^{-1} fresh wt.)	Pchlide
Barnyard grass	0	0.34 ± 0.07	0.31 ± 0.04	0.86 ± 0.31
	8	238.50 ± 6.21	0.44 ± 0.04	10.95 ± 1.21
Corn	0	0.90 ± 0.45	0.52 ± 0.06	0.48 ± 0.09
	8	1.38 ± 0.24	0.55 ± 0.02	0.93 ± 0.02
Soybean	0	0.37 ± 0.12	0.93 ± 0.03	1.51 ± 0.42
	8	2.58 ± 0.70	0.95 ± 0.07	4.39 ± 0.55

* Values are mean ± SE of three replications.