BA Serves as a Stimulant for Improving Rice Seedling Growth

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ABSTRACT

Effects of benzyladenine (BA), dissolved in Hoagland solutions at various low concentrations (10^{-9}; to 10^{-12} M), on rice seedling shoot and root growth of three rice cultivars (*Oryza sativa* L. cv. Taichung 189; cv. Tai-Keng 3; Tai-Nung 67) were investigated. The results showed that BA solution is effective in promoting shoot growth at 10^{-10}; M for Taichung 189, at 10^{-10} to 10^{-11} M for Tai-Keng 3 and at 10^{-10} to 10^{-12} M for Tai-Nung 67. However, BA solution at 10^{-11} M was effective in promoting root growth of Taichung 189 only. In contrast, BA treatment at 10^{-12} M resulted in a slight inhibition of root growth of Tai-Keng 3.

Key words: benzyladenine, Hoagland solution, rice, seedling growth.

Introduction

Cytokinins are a group of plant hormone with adenine moiety and have been found to regulate plant cell division of callus systems[7,8,10,11,12,14,15,17] and shoot formation from callus[3,19], intact seedlings[9], leaf axils[16], detached leaves[12] and cultured seeds[17]. Cytokinins also increased frond growth of *Spirodella* [8].

Although these results have demonstrated that cytokinins work as regulators for plant cell division and shoot differentiation, they have not been extensively applied to practical purposes in nature except tissue culture systems. In this report, benzyladenine (BA), a type of cytokinin, was mixed with Hoagland solutions at various low concentrations and tested on rice seedling shoot and root growth of three rice cultivars.

Materials and Methods

Three Taiwan rice cultivars (*Oryza sativa* L. cv. Taichung 189; cv. Tai-Keng 3; Tai-Nung 67) were used as experimental materials. Rice seeds of these cultivars were kindly provided by Taichung District Agricultural Improvement Station, Changhua. Benzyladenine (BA) and other general chemicals were purchased from Sigma and Wako Pure Chemical Industries Ltd., respectively. Experiments were carried out between Apr. 25 and June 2 of 1995.

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Rice seeds were surface-sterilized with 70% ethanol for 10 min, rinsed with distilled water a few times, immersed in fresh distilled water and placed under white fluorescent lamps (19.0 μ mol m^{-2} s^{-1}) for germination. Distilled water was daily replaced. The temperature in the growth space was regulated at 25℃. Germinated rice seedlings (5-day-old) were transferred to culture solutions which include Hoagland solution [Ca $(NO_3)_2$, 5.0×10^{-3} mol L^{-1}; KNO_3, 5.0×10^{-3} mol L^{-1}; $MgSO_4$, 2.0×10^{-3} mol L^{-1} ; KH_2PO_4, 1.0×10^{-3} mol L^{-1}; Fe-EDTA, 1.18×10^{-5} mol L^{-1} and micronutrient solution consisting of H_3BO_3, 4.6×10^{-5} mol L^{-1} ; $MnCl_2 \cdot 4H_20$, 9.14×10^{-6} mol L^{-1}; $ZnSO_4 \cdot 7H_2O$, 7.65×10^{-7} mol L^{-1}; $CuSO_4$, 7.0×10^{-7} mol L^{-1} and H_2MoO_4, 1.24×10^{-7} mol L^{-1}; pH 5.0] and Hoagland solution to which BA was added to provide concentrations of 10^{-9}, 10^{-10}, 10^{-11} and 10^{-12} M, respectively. Each tested solution (pH 5.0) was contained in plastic trays (diameter, 11.5 cm; depth, 3.5 cm) with two filter papers each (Advantec, Toyo; No. 1; diameter, 90 mm). Each tested solution included four replicates with seven seedlings each.

Germinating rice seedlings in each culture tray were grown under white fluorescent lamps (19.0 μ mol m^{-2} s^{-1}) for 18 days at 25℃. The tested solution in each tray was maintained at a sufficient level for seedlings to absorb enough nutrients during the experimental period. At the final stage of harvest, the seedlings from each tray were washed with water (mainly for roots) and blot-dried with paper towels. Seed was cut off from each seedling. Then, shoots were separated from roots and each portion was dried in an oven (at 70℃; 24 h). Dried shoots and roots of each tray were weighed to provide a unit of dry mass (mg $plant^{-1}$), separately. The results of each measured parameter were finally analyzed by Duncan's multiple range test at the 5% level.

Results and Discussion

The results in Fig 1 showed that BA dissolved in Hoagland solutions was effective in promoting shoot growth of rice seedling at 10^{-10} M for Taichung 189, at 10^{-10} to 10^{-11} M for Tai-Keng 3 and at 10^{-10} to 10^{-12} M for Tai-Nung 67. BA solution at 10^{-11} M promoted root growth of Taichung 189 and none of BA solutions were effective for Tai-Nung 67. In contrast, BA treatment at 10^{-12} M resulted in an inhibition of Tai-Keng 3 root growth.

The results shown above indicate that effects of BA solutions on shoot and root growth of these three rice cultivars are variable, mainly depending on the type of rice cultivar. The reasons for these variable responses to BA solutions are not clear at present. One of the possibilities may be related to the involvement of cytokinin oxidases, which have been reported to exist widely in plant tissues(4). In a feeding experiment of ^{14}C-BA in moss protonemata, ^{14}C-BA was found to be degraded into ^{14}C-adenine(1). Laloue and Fox(6) ever reported that a cytokinin oxidase isolated from wheat embryoes was capable of cleaving BA side chain to a small extent. Thus, it seems that plant cytokinin oxidase activity is higher in roots than in shoots, which in turn results in differential responses of root and shoot to BA application.

It is concluded from the results of this study that BA mixed with Hoagland solutions at certain low concentrations are effective at promoting shoot growth of rice seedling of these tested cultivars. Besides BA, other chemicals ever have also been found to improve rice seedling growth. These chemicals include Triacontanol (TRIA) and L(+) adenosine, which were proved to be efficient at nanomolar concentrations[13]. But these concentrations are still higher than BA solutions (10^{-10} to 10^{-12} M) adopted in this study. Hopefully, BA and other cytokinins can be used as stimulants for upgrading rice seedling growth in the near future.

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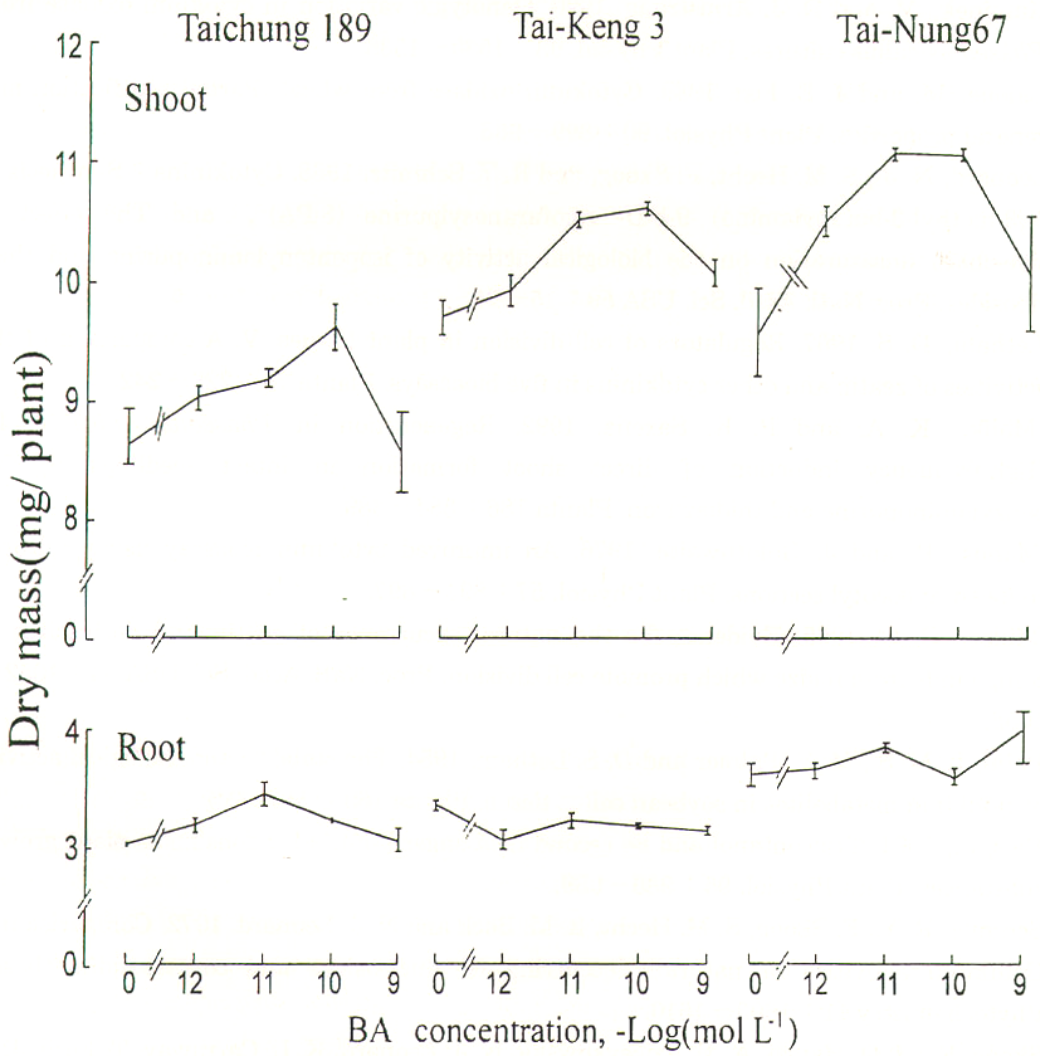

Fig. 1. Effects of benzyladenine (BA), dissolved in Hoagland solutions at various concentrations, on 18-day-old rice seedling shoot and root growth of three Taiwan cultivars. Each value is the mean ±sd of four replicates (p=0.05).

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BA為栽培稻幼苗生長的有效促進劑

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摘　要

本題研究的目的主要是在探討BA溶入Hoagland營養液內(10^{-9}至10^{-12} M)對於三種栽培稻(台中189；台粳3號；台農67號)幼苗的shoot及根生長有何不同的影響力。結果顯示BA溶液在10^{-10} M；10^{-10}至10^{-11} M；10^{-10}至10^{-12} M分別對台中189；台粳3號；台農67號的shoot生長有助益。BA溶液在10^{-11} M可促進台中189幼苗根的生長，但是BA溶液在10^{-12} M卻抑制台粳3號幼苗根的生長。

關鍵字：benzyladenine, Hoagland溶液、水稻、幼苗生長。

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