Benzyladenine dissolved in Hoagland solution promotes plant seedling growth

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Summary

This research was designed to study the effect of BA-made Hoagland solutions at various low concentrations from 10^{-7} to 10^{-12} M on seedling growth of lettuce, water convolvulus and rice. The results show that BA solution at 10^{-9} M is suitable for enhancing lettuce seedling growth, while at 10^{-8} M and 10^{-10} to 10^{-11} M are efficient in promoting water convolvulus and rice seedling shoot growth, respectively. Rice seedlings are the most sensitive to BA response. Also, BA-made Hongland solutions at 10^{-10} to 10^{-11} M can be suggested as potential agents for promoting rice seedling growth.

Key words: Benzyladenine, Hoagland solution, plant seedling growth.

Introduction

Benzyladenine(AB), a type of synthetic cytokinin, is known as a promoter in enhancing growth in several tested systems. BA was ever found to increase the level of DNA, RNA, protein, chlorophyll, dry weight and fresh weight when applied to intact young bean leaves and detached cucumber cotyledons (Naito et al, 1978; Haru et al., 1982). BA increased total fatty acids and phospholipids in Lemna plants (Berube at al., 1982). Shoots in the leaf axil of Stellaria media L., direct shoot formation in intact seedlings of Phaseolus vulgaris L. and shoot-forming callus from seeds of two Poa pratensis cultivars were initiated by BA treatment (Tepper, 1992; Malik and Saxena, 1992; Van der Valk et al., 1995). Thus, these studies strongly suggest that BA is an enhancer for promoting plant growth, especially young tissues. In this report, BA-prepared Hoagland nutrient solutions were found to be effectively in promoting plant seedling growth of several species.

Materials and Methods

Three plant species were used in this study: lettuce (Lactuca sativa L. cv. Grand Rapids and cv. Celtuce), water convolvulus (Ipomoea aquatica Forsk L. cv. Large leaf)

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and rice (Oryza sativa L. cv. Tai-Keng 3). Seeds of lettuce and water convolvulus were purchased from Known-You Seed Co. Ltd., Taichung. Rice seeds were kindly provided by Taichung District Agricultural Improvement Station, Chunghua. BA and other general chemicals were bought from Sigma and Wako Pure Chemical Industries Ltd., respectively.

Letture and water convolvulus seeds were distriduted in petri dishes (each contains a filter paper moistened with some didtilled water) and germinated under white fluorescent lamps (16.8 μ mol m^{-2} s^{-1} for lettuce; 19.9 μ mol m^{-2} s^{-1} for water convolvulus for two days. Rice seeds were surface-sterilized with 70% ethanol for 10 mins, rinsed with distilled water a few times, immersed in fresh distilled water and placed under white light (19.0 μ mol m^{-2} s^{-1}) for 5 days' germination. Distilled water was daily replaced. The temperature in the growth space was regulated at 22 °C for lettuce grown from Dec. to Feb. and at 25 °C for water convolvulus and rice grown from May to Sept. Germinated seedlings 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}; $MnCl_2 \cdot 4H_2O$, 9.14×10^{-6} mol L^{-1}; $ZnSO_4 \cdot 7H_2O$, 7.65×10^{-7}mon L^{-1}; $CuSO_4$, 7.0×10^{-7} mol L^{-1} and H_2MoO_4, 1.24×10^{-7} mol L^{-1}; pH5.0] and Hoagland solution to which BA was added to make concentrations of 10^{-7}, 10^{-8}, 10^{-9}, 10^{-10}, 10^{-11} and 10^{-12} M. Each test solution was placed in plastic trays (diameter, 11.5cm; deepth, 4cm) with two filter papers (Advantec, Toyo; No.1; diameter, 90mm) each. Each test solution involved four replicates with a certain number of seedlings each (a detailed description is included in each table).

Seedlings in each culture tray were grown under white fluorescent lamps (intensity as mentioned above) for a certain numbers of days (an exact number is described in each Table) at 22 °C (for lettuce) and at 25 °C (for water convolvulus and rice). The solution in each tray was maintained at a sufficient level for seedlings to uptake enough nutrients during the experimental period. At the final stage of harvest, lettuce and water convolvulus seedlings were blot-dried with paper towels. Shoots were separated from roots and each portion was then weighed. In some cases, water convolvulus seedlings were dried in an oven (at 70 °C ; 24 hr) and weighed. For rice, seedlings from each tray were washed with water (mainly for roots) and blot-bried with paper tissues. Seed was cut off from each seedling. Then, shoots were separated from roots and each portion was dried in an oven (70 °C ; 24hr). Dry shoots and roots of each tray were separately weighed to provide a unit of dry mass (mg $plant^{-1}$). The results of each measured parameter were finall analyzed Duncan's multiple range test at the 5% level.

Results and Disucssion

Results in Table 1 and Table 2 show that when young lettuce seedlings (cv. Grand Rapids and cv. Celtuce) were cultured in BA-made Hoagland solutions at 10^{-7} to 10^{-10} M,

their growth yields in terms of fresh seedling weight, fresh shoot weight and fresh root weight were found only to be increased by AB solution at 10^{-9} M. BA solution at 10^{-7} M reduced seedling growth of both varieties and other concentrations at 10^{-8} M and 10^{-10} M were ineffective. Table 3 indicates that BA solution at 10^{-8} M is the only one for the promotion of water convolvulus seedling growth while other concentrations such as 10^{-7}, 10^{-9} and 10^{-10} M were ineffective. An extended experiment showed that this 10^{-8} M BA solution also increased seedling shoot and root growth (Table 4). In rice (cv. Tai-Keng 3), results in Table 5 indicate that BA solutions from 10^{-10} to 10^{-11} M were good in promoting seedling shoot growth, but none of BA solutions were effective in promoting root growth.

These results clearly show that three plant species responding to the appropriate concentrations of BA-made Hoagland solutions for growth promotion: lettuce, at 10^{-7} M; water convolvalus, at 10^{-8} M and rice, at 10^{-10} to 10^{-11} M. Interestingly, each species only requires a specific range of BA concentrations. The reasons for this are still unknown. On the practical point of view, these BA solutions of low concentrations can be considered as potential agents for the promotion of rice seedling growth.

Table 1. Effect of BA-prepared Hoagland solutions on the growth of 16-day-old lettuce (cv. Grand Rapids) seedlings. Each value is the mean of four replicates with eight plants each. Values with the same letter are not significantly different.

Treatment	Fresh seedling wt. (mg plant^{-1})	Fresh shoot wt. (mg plant^{-1})	Fresh root wt. (mg plant^{-1})
Hoagland solution	$99.4 \pm 11.2^{(b)}$	$86.9 \pm 8.6^{(b)}$	$12.4 \pm 1.7^{(b)}$
Hoagland solution +BA (10^{-7} M)	$57.0 \pm 2.1^{(c)}$	$50.9 \pm 2.6^{(c)}$	$6.1 \pm 0.7^{(c)}$
Hoagland solution +BA (10^{-8} M)	$99.0 \pm 1.6^{(b)}$	$85.5 \pm 1.2^{(b)}$	$13.4 \pm 0.8^{(a)(b)}$
Hoagland solution +BA (10^{-9} M)	$120.7 \pm 4.9^{(a)}$	$105.1 \pm 4.9^{(a)}$	$15.6 \pm 0.7^{(a)}$
Hoagland solution +BA (10^{-10} M)	$98.4 \pm 4.1^{(b)}$	$85.9 \pm 3.7^{(b)}$	$12.5 \pm 0.6^{(b)}$

Table 2. Effect of BA-prepared Hoagland solutions on the growth of 14-day-old lettuce (cv. Celtuce) seedlings. Each value is the mean of four replicates with eight plants each. Values with the same letter are not significantly different.

Treatment	Fresh seedling wt. (mg plant^{-1})	Fresh shoot wt. (mg plant^{-1})	Fresh root wt. (mg plant^{-1})
Hoagland solution	116.3 ± 4.1$^{(b)}$	103.4 ± 3.4$^{(b)}$	12.9 ± 0.5$^{(b)}$
Hoagland solution +BA (10^{-7} M)	44.5 ± 1.4$^{(c)}$	41.7 ± 1.3$^{(c)}$	2.8 ± 0.1$^{(c)}$
Hoagland solution +BA (10^{-8} M)	114.1 ± 2.8$^{(b)}$	101.7 ± 2.7$^{(b)}$	12.3 ± 0.5$^{(b)}$
Hoagland solution +BA (10^{-9} M)	129.2 ± 2.9$^{(a)}$	112.2 ± 4.1$^{(a)}$	16.9 ± 1.2$^{(a)}$
Hoagland solution +BA (10^{-10} M)	114.1 ± 1.4$^{(b)}$	91.9 ± 1.4$^{(b)}$	14.2 ± 0.3$^{(b)}$

Table 3. Effect of BA-made Hoagland solutions on the growth of 11-day-old water convolvulus seedlings. Each value is the mean of four replicates with vife plants each. Values with the same letter are not significantly different.

Treatment	Fresh seedling wt. (mg plant^{-1})
Hoagland solution	20.67 ± 0.87$^{(b)}$
Hoagland solution +BA (10^{-7} M)	22.22 ± 0.88$^{(b)}$
Hoagland solution +BA (10^{-8} M)	26.35 ± 0.84$^{(a)}$
Hoagland solution +BA (10^{-9} M)	22.87 ± 1.01$^{(b)}$
Hoagland solution +BA (10^{-10} M)	23.5 ± 1.35$^{(a)(b)}$

Table 4. Effect of BA-made Hoagland solutions at 10^{-8} M on the growth of 22-day-old water convolvulus seedlings. Each value is the mean of eight replicates with vife plants each. Values with the same letter are not significantly different.

Treatment	Fresh seedling wt. (mg plant^{-1})	Fresh shoot wt. (mg plant^{-1})	Fresh root wt. (mg plant^{-1})
Hoagland solution	$450.1 \pm 88.4^{(b)}$	$400.6 \pm 80.4^{(b)}$	$52.1 \pm 11.6^{(b)}$
Hoagland solution +BA (10^{-8} M)	$619.3 \pm 113.4^{(a)}$	$548.3 \pm 100.1^{(a)}$	$71.5 \pm 17.0^{(a)}$

Table 5. Effect of BA-made Hoagland solutions on the growth of 18-day-old rice seedling shoots and roots. Each value is the mean of four replicates with seven plants each. Values with the same letter are not significantly different.

Treatment	Fresh seedling wt. (mg plant^{-1})	Fresh root wt. (mg plant^{-1})
Hoagland solution	$9.72 \pm 0.24^{(b)}$	$3.49 \pm 0.08^{(a)}$
Hoagland solution +BA (10^{-9} M)	$10.12 \pm 0.18^{(a)(b)(c)}$	$3.24 \pm 0.07^{(a)(b)}$
Hoagland solution +BA (10^{-10} M)	$10.69 \pm 0.12^{(a)}$	$3.27 \pm 0.05^{(a)(b)}$
Hoagland solution +BA (10^{-11} M)	$10.50 \pm 0.13^{(a)}$	$3.31 \pm 0.13^{(a)(b)}$
Hoagland solution +BA (10^{-12} M)	$9.84 \pm 0.24^{(b)(c)}$	$3.09 \pm 0.16^{(b)}$

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Benzyladenine 配入 Hoagland 溶液促進植物幼苗生長的影響

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摘要：本篇研究的目的主要是在探討 BA 溶入 Hoagland 溶液內成不同低濃度溶液（ 10^{-7} 至 10^{-12}M ）對於萵苣，蘿菜及水稻等幼苗之生長有何不同的影響力。實驗結果顯示 BA 溶液僅在 10^{-9}M 能促進萵苣幼苗的生長，而唯在 10^{-8}M 及 10^{-10} 至 10^{-11}M 各對蘿菜，水稻幼苗生長有助益。由這些結果可知不同植物品種對於 BA 溶液的反應具有差異性。在這些被試驗的三種植物中，以水稻幼苗對 BA 的反應最爲敏感，且 BA-made Hoagland 溶液在 10^{-10} 至 10^{-11}M 可被考慮做爲水稻幼苗生長的助長液。

關鍵字：Benzyladenine, Hoagland 溶液，植物幼苗生長。

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