ENFLUENCE OF 5-AMINOLEVULINIC ACID ON THE EFFICIENCY OF DRY-MATTER PRODUCTION IN VEGETABLE POT-SEEDLINGS

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ABSTRACT

Effect of 5-aminolevulinic acid (5-ALA) and foliar-fertilizer containing 5-ALA (Penta-keep) on the efficiency of dry-matter production in cabbage pot-seedlings were investigated. In Japan, the raising of good young seedlings is an important factor for high-yielding of cabbage. A significant increases in photosynthetic rate (Po), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) in cabbage young seeklings were observed in both 5-ALA-and Penta-keep A- treated plants. It should be noted that the excellent effect of both the compounds was controlled through the acceleration of nitrogen absorption and photosynthetic activity. From results obtained here, we wish to conclude that the dressing of 5-ALA or PKV to culture pot were very useful for the production of good young seedlings in cabbage.

INTRODUCTION

Five-aminolevulinic acid (5-ALA) is a key precursor in the biosynthesis of porphyrins, such as chlorophyll and heme. This compound acts as a herbicide at high concentration (>1,000ppm) and a growth promoter at low concentration (30-100ppm). We have previously reported that this compound has some beneficial effects on crops at low concentration (<30ppm), such as the promotive effect on photosynthetic activity and the inhibitory effect on respiration (Yoshida etal., 1996a, 1996b, 2003). Tanaka and Kuramochi (2001) also found that the application of 5-ALA 100ppm increased salt tolerance of young cotton seedlings.

On the other hand, in Japan, the raising of good young seedlings is an important factor for high-yielding of vegetables, especially of cabbage young seedling. In this experiment, therefore, we examined the effects of 5-ALA alone and PKV (penta keep-V) which contains microelements and 5-ALA on the dry-matter production of cabbage young seedlings.

MATERIALS AND METHODS

The cultivar of cabbage used was cv. Gokuwase Kanran. Two g of the compound fertilizer (N:15%, P_2O_5:15%, K_2O:15%) was dressed to each pot (φ80mm) before sowing and then the seedlings were grown in green house under natural condition. The planting density of pots was 196 per m^2.

When plants reached 2, 4 and 6 leaf-age, each testing liquid solution of 5-ALA (10, 30, 100ppm) or PKV (1000, 5000, 10000-fold dilutions) were applied to soil at the rate of 10ml per pot.

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Ammonium sulphate labeled with ^{15}N, 50mg as N, was also applied with each solution of 5-ALA or PKV.

The efficiency of dry-matter production and photosynthetic rate were mainly measured at 6 leaf-age. The CO_2 analyzer for measuring photosynthetic rate was Koito C1RAS-1. The leaf tissue of 6 leaf-age was used for Tris-HCl buffer soluble protein.

Growth analysis was done at 7 and 15 days after 5-ALA and PKV treatments. The equations for crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) are as follows :

$CGR=w_2-w_1 / t_2-t_1$
$RGR=2.30 (\log w_1-\log w_2) / t_2-t_1$
$NAR=2.30 (w_2-w_1) (\log A_2-\log A_1) / (t_2-t_1) (A_2-A_1)$
w_2, w_1 : dry weight
A_2, A_1 : leaf area
t_2, t_1 : growth period

RESULTS AND DISCUSSION

Effects of 5-ALA alone on dry-matter accumulation, photosynthetic activity, growth analysis and soluble protein content are shown in tables 1, 2, 3 and 4. As shown in Table 1, the dressing of 5-ALA increased both fresh and dry-weight of cabbage young seedlings, and this increase was more marked at 5-ALA 100ppm dressing. This concentration also increased the values of CGR, RGR and NAR (Table 2). However, the increasing rate of transpiration, stomatal conductance and photosynthesis was found in the case of 5-ALA 10 and 30ppm dressing (Table 3). The leaf tissues treated with 5-ALA 10 and 30ppm had highly content of soluble protein (Table 4). These results show that the increment of dry-matter accumulation in cabbage young seedlings treated with 5-ALA was supported by the increment of photosynthetic rate, CRG, RGR and NAR. The higher rate of photosynthesis seems to correlate the higher amount in leaf tissue treated with 5-ALA.

Comparative effects of PKV dilution and 5-ALA on the dry-matter accumulation and photosynthetic activity of cabbage young seedlings are shown in tables 5, 6 and 7. As shown in Table 5, the dressing of PKV at 5000-fold dilution and of 5-ALA at 10ppm caused dramatic increase in fresh and dry weights. These concentrations of both the compounds also increased the values of CGR, RGR and NAR (Table 6). As for the increment of transpiration rate, stomatal conductance and photosynthetic rate, the leaves treated with PKV at 1000-fold dilution or 5-ALA at 10ppm had the maximum values (Table 7). Thus, both the PKV dilution and 5-ALA alone at low concentration showed the stimulatory effect on dry-matter accumulation and each value of growth analysis. It should be noted that the dressing of PKV at 1000-fold and 5000-fold dilutions stimulated photosynthetic rate, and this stimulatory effect of PKV was similar to that of 5-ALA.

On the other hand, the dressing of PKV and 5-ALA increased the rate of nitrogen uptake in cabbage young seedlings (Table 8). This result shows that PKV and 5-ALA act as a stimulant for nitrogen absorption by cabbage young seedlings.

In conclusion, the dressing of PKV dilution and 5-ALA markedly stimulated the dry-matter accumulation of cabbage young seedlings, and this excellent effect was supported by the results of growth analysis, photosynthetic activity and nitrogen uptake. From all results obtained here, we wish to emphasize that 5000-fold dilution of PKV and 10ppm concentration of 5-ALA are very useful for improving the dry-matter accumulation of cabbage plants during nursing seedling.

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Table 1. Effects of 5-ALA on fresh and dry weight of cabbage young seedlings.

Treatment	Fresh weight (g/3 plants)	Dry weight (g/3 plants)	Percentage dry-matter (%)
Control(H_2O)	18.03±2.70(100.0)	1.36(100.0)	7.57(100.0)
5-ALA 10 ppm	22.61±2.07(125.4)	1.65(121.3)	7.31 (96.5)
5-ALA 30 ppm	19.63±2.73(108.8)	1.51(111.0)	7.68(101.4)
5-ALA 100 ppm	21.62±3.60(119.9)	1.79(131.6)	8.27(109.2)

Table 2. Growth analysis of cabbage young seedlings treated with 5-ALA.

Treatment	CGR ($g/m^2/day$)	RGR (g/g/day)	NAR ($g/m^2/day$)
Control(H_2O)	8.77	0.15	8.77
5-ALA 10 ppm	9.99	0.16	14.90
5-ALA 30 ppm	8.40	0.14	18.82
5-ALA 100 ppm	11.85	0.18	24.76

* 7 days after 5-ALA application

Table 3. Effects of 5-ALA on photosynthetic activity of the leaves in cabbage young seedlings.

Treatment	Transpiration rate ($mmol/m^2/s$)	Stomatal condactance ($mmol/m^2/s$)	Photosynthetic rate ($\mu mol/m^2/s$)
Control(H_2O)	4.18	227.0	10.34
5-ALA 10 ppm	6.70	443.4	13.34
5-ALA 30 ppm	6.97	498.2	12.98
5-ALA 100 ppm	5.62	338.4	11.64

Table 4. Effects of 5-ALA on the soluble protein in leaves of cabbage young seedlings.

Treatment	Soluble protein content (mg/g FW)
Control(H_2O)	3.58
5-ALA 10 ppm	4.61
5-ALA 30 ppm	4.28
5-ALA 100 ppm	3.85

Table 5. Effects of 5-ALA and PKV on fresh and dry weight of cabbage young seedlings.

Treatment	Fresh weight (g/3 plants)	Dry wieght (g/3 plants)	Percentage dry matter (%)
Control(H_2O)	25.71±7.62(100.0)	2.38(100.0)	9.29(100.0)
PKV 1000-fold dilution	28.65±7.56(111.4)	2.60(109.2)	9.10 (97.9)
PKV 5000-fold dilution	32.64±7.38(126.9)	3.12(131.0)	9.57(103.0)
PKV 10000-fold dilution	24.72±2.22 (96.1)	2.17 (91.1)	8.79 (94.6)
5-ALA 10 ppm	34.65±3.45(134.7)	3.47(145.7)	10.02(107.8)
5-ALA 30 ppm	27.09±6.63(105.3)	2.76(115.9)	10.19(109.6)
5-ALA 100 ppm	31.29±6.69(121.7)	3.25(136.5)	10.39(111.8)

Table 6. Growth analysis of cabbage young seedlings treated with 5-ALA and PKV.

Treatment	CGR ($g/m^2/day$)	RGR (g/g/day)	NAR ($g/m^2/day$)
Control(H_2O)	6.77	0.071	20.84
PKV 1000-fold dilution	7.73	0.076	32.44
PKV 5000-fold dilution	10.00	0.089	37.98
PKV 10000-fold dilution	5.86	0.064	31.86
5-ALA 10 ppm	11.52	0.096	52.38
5-ALA 30 ppm	8.43	0.080	32.32
5-ALA 100 ppm	10.56	0.091	57.20

* 15 days after 5-ALA or PKV applicaton

Table 7. Effects of 5-ALA and PKV on photosynthetic activity of the leaves in cabbage young seedlings.

Treatment	Transpiration rate (mmol/m^2/s)	Stomatal conductance (mmol/m^2/s)	Photosynthetic rate (μmol/m^2/s)
Control(H_2O)	3.50	146.6	8.92
PKV 1000-fold dilution	6.41	364.8	10.00
PKV 5000-fold dilution	5.29	268.8	10.86
PKV 10000-fold dilution	6.05	337.0	9.08
5-ALA 10 ppm	7.47	505.6	12.98
5-ALA 30 ppm	5.20	257.8	10.06
5-ALA 100 ppm	4.80	231.0	11.06

Table 8. Effects of 5-ALA and PKV on nitrogen uptake in cabbage young seedlings.

Treatment	Dry weight (g/plant)	Nitrogen cotent (%)	Nitrogen uptake (mg/plant)
Control(H_2O)	1.42±0.04	5.06	71.85
PKV 5000-fold dilution	1.55±0.09	5.09	78.90
5-ALA 10 ppm	1.89±0.10	4.69	88.64
5-ALA 30 ppm	1.76±0.13	4.90	86.24
5-ALA 100 ppm	1.77±0.06	4.94	87.44