Growth promotive effects of 5-aminolevulinic acid in the presence of micro elements on yield in Komatsuna, *Brassica campestris* var.*perviridis* under alkaline soil conditions

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Abstract

Growth promotive effects of 5-aminolevulinic acid (5-ALA) on the yield of Komatsuna were studied under alkaline soil conditions in the presence of micronutrients. The low yield of Komatsuna on alkaline soil was reduced by the foliar application of 5-ALA or pentakeep-V (PKV) alone or of the 5-ALA- chelating iron mixture. In conclusions, these chemicals were very useful for the production of vegetables under alkaline soil conditions.

Media summary

Five ALA, chelating iron and PKV were able to alter the yield and nitrogen uptake of vegetable crops under alkaline soil conditions.

Key words

5-Aminolevulinic acid(5-ALA) Alkaline,soil,Chelating iron,Komatsuna, Pentakeep-V(PKV) Yield

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 concentrations (>1,000 ppm). On the other hand, we have previously reported that this compound has some beneficial effects on crops at low concentrations (30-100 ppm), such as improvements in dry matter yield, promotive effects on photosynthetic activity and inhibitory effects on respiration (Yoshida et al., 1996a, 1996b, 2003). Recently, Tanaka and Kuramochi (2001) found that application of a low concentration (100 ppm) of 5-ALA increased salt tolerance of young cotton seedlings. Thus, these results suggest that a low concentration of 5-ALA is very useful in increasing yield and salt tolerance of crops. However, the physiological function of 5-ALA or microelements containing chelating iron are not well understood for crops growing on alkaline soils. In this experiment, we examined the effects of 5-ALA alone and in the presence of chelating iron or microelements (pentakeep-V, PKV) on the yield and nitrogen uptake of Komatsuna (*Brassica compestris*, var. *perviridis*) under alkaline soil conditions.

Materials and Methods

Alkaline soil (pH 8.5) was prepared by an addition of natural calcium carbonate (Kaikaseki shellfish fossil:CaO 42%, alkaline percent 52%) at two rates – 10g and 100g applied to Wagner pots. The alkaline soil prepared here was used in both Experiments of 1 and 2. Experiments were conducted in 2001 and 2002.

Experiment 1

The cultivar of Komatsuna used was cv.Tokijiro. Ten g of the compound fertilizer (N:15;P_2O_5:15;K_2O:15%) was applied to each pot before sowing. The concentrations of 5-ALA and chelating iron applied were 30ppm and 55ppm as a foliar spray, respectively, both singly and in combination. These solutions were sprayed only once onto foliage at 14 days before the harvesting time. The volume sprayed was 20ml per pot. The foliar spray solution also contained 0.1% wetting agent.

Experiment 2

The growth conditions were identical to Experiment 1, but the chemical used was pentakeep-V (PKV) instead of chelating iron. The foliar spray solutions of 5-ALA (30ppm) and PKV (0.01%) were applied only once to foliage at 14 days before the harvesting time.

Yield, total nitrogen (micro-kjeldahl distillation method) and nitrate nitrogen (HPLC-UV method) were determined at harvest.

Result and Discussion

Table 1 shows the effect of 5-ALA in the presence of chelating iron on fresh and dry weight of Komatsuna. When 10g of shellfish fossil was applied to soil, 5-ALA, chelating iron and the mixture of 5-ALA and chelating iron significantly increased the fresh weight of plants, but had no effect on plant dry weights. Application of the higher rate of shellfish fossil decreased both fresh and dry weight of control plants (by 40% and 50%, respectively), but foliar application of 5-ALA alone and in the mixture with chelating iron again significantly increased both fresh and dry weight of plants.

Table 1. Effect of 5-ALA on fresh and dry weight of Komatsuna.

Application of shellfish fossil (g/ pot)	Treatment	Soil pH	Fresh weight (g/ pot)	Dry weight (g/ pot)	Dry matter ratio (%)
10	Cont.(water)	6.5~7.0	61.38±14.8(100.0) b*	6.97±0.5 (100.0)	11.36
10	5-ALA	6.5~7.0	83.16±14.5 (135.5) a	6.79±0.5 (97.4)	8.16
10	Chelating iron	6.5~7.0	83.16±14.2 (135.5) a	6.45±1.3 (92.5)	7.76
10	5-ALA+chelating iron	6.5~7.0	76.74±13.2 (125.5) a	6.37±1.6 (91.4)	8.30
100	Water(control)	7.6~8.3	37.26±18.1 (60.7) d	3.52±1.4 (50.5)	9.45
100	5-ALA	7.6~8.3	62.22±17.2 (101.4) b	5.25±0.9 (75.3)	8.44
100	Chelating iron	7.6~8.3	43.62±16.5 (71.1) d	4.95±1.4 (71.0)	11.35
100	5-ALA+chelating iron	7.6~8.3	56.94±12.3(92.8) c	6.38±1.4 (91.5)	11.21

Concentrations: 5-ALA:30ppm, chelating iron:55ppm.
*Means followed by the same letter within a column are not significantly different using Duncan's multiple test at the 5% level.

Table 2. Effect of 5-ALA on fresh and dry weight of Komatsuna.

Application of shellfish fossil (g/ pot)	Treatment	Soil pH	Fresh weight (g/ pot)		Dry weight (g/ pot)		Dry matter ratio (%)	
			leaf blade	petiole	leaf blade	petiole	leaf blade	petiole
10	Cont.(Water)	6.5~7.0	66.36±8.6(100.0) b*	40.11±5.9(100.0) d	6.75±0.5(100.0)	8.64±0.4(100.0)	10.17	7.18
10	5-ALA	6.5~7.0	74.67±8.5(112.5) a	65.97±7.3(164.5) a	6.51±0.5(96.4)	11.07±0.3(128.0)	8.72	5.59
10	PKV	6.5~7.0	73.05±7.0(110.1) a	57.06±7.4(142.7) b	6.42±0.4(95.4)	9.81±0.1(113.1)	8.79	5.73
100	Water(Cont.)	7.6~8.3	58.08±6.2(87.5) bc	35.25±4.0(87.8) d	6.06±0.3(89.8)	9.27±0.5(106.9)	10.43	8.77
100	5-ALA	7.6~8.3	52.50±4.2(79.1) c	37.29±3.3(92.9) d	5.58±0.0(82.6)	9.72±0.3(112.5)	10.63	8.69
100	PKV	7.6~8.3	62.91±6.7(94.8) b	48.30±6.8(120.4) c	6.63±0.7(98.4)	10.71±0.4(123.5)	10.54	7.39

Concentrations: 5-ALA: 30ppm Pentakeep V (PKV): 0.01%
*Means followed by the same letter within a column are not significantly different using Duncan's multiple test at the 5% level

Table 3. Effect of 5-ALA and PKV on nitrogen uptake and nitrate nitrogen content of Komatsuna.

Application of shellfish fossil (g/ pot)	Treatment	Total nitrogen(T-N,%)		Nitrate nitrogen(NO_3-N,%)		$\frac{NO_3\text{-}N}{T\text{-}N} \times 100$(%)		Nitrogen uptake(mg/ plant)	
		leaf blade	petiole	leaf blade	petiole	leaf blade	petiole	leaf blade	petiole
10	Water (Cont)	3.67	4.27	0.01	0.35	0.27	8.19	0.23	3.36
10	**5-ALA**	3.74	3.74	0.33	0.67	8.83	17.91	7.16	8.24
10	**PKV**	3.76	3.30	0.02	0.50	0.53	15.13	0.43	5.45
100	Water	3.38	5.22	0.01	0.59	0.30	11.31	0.20	6.08
100	**5-ALA**	3.49	4.76	0.46	1.09	13.19	22.89	8.56	11.77
100	**PKV**	3.67	3.71	0.01	0.73	0.27	19.66	0.22	8.69

These results show that 5-ALA alone and in the mixture with chelating iron can improve the yield of Komatsuna grown under alkaline soil conditions, and can mitigate the adverse effects of addition of liming materials.

In Experiment 2, PKV stimulated the fresh and dry weight in plants in soils treated with 10g or 100g of shellfish fossil, particularly for petiole fresh weights (Table 2). The dry matter ratio of the leaf blade and petiole in plants applied with 10g of shellfish fossil was slightly lower than those in control plants. Nitrogen uptake and the ratio of nitrate nitrogen per unit total nitrogen markedly increased in the leaf blade and petiole of plants treated with 5-ALA alone (Table 3). These results show that poor yields and nitrogen uptake in Komatsuna grown on alkaline soils can be improved by 5-ALA or PKV application.

In conclusion, we wish to emphasize that low concentrations (30～100ppm) of 5-ALA are very useful for improving vegetable production under alkaline soil conditions, and chelating iron and PKV also have yield benefits.

References

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