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Effects of Di-(β-chloroethyl)-α-hydroxyethyl Phosphonate on Growth and Yield of Crops

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Abstract The organic phosphorous compound synthesized in our country increases yield of rice, maize and bean to 108～116%, vegetable to 118～133% respectively, when the rational concentration and times of regulator for leaf spraying is 3～4 times at 100 000 folds of diluted solution in grain crops, 4 times at 1 000 000 folds of diluted solution in vegetable crops including radish and cabbage.

Key words organophosphorous growth regulator, di-(β-chloroethyl)-α-hydroxyethyl phosphonate, growth, yield

Introduction

The great leader Comrade **Kim Il Sung** said as follows.

"The chemical industry should produce larger quantities of different kinds of agricultural chemicals such as highly effective weed killer and insecticide, growth stimulant and growth restraint."("**KIM IL SUNG** WORKS" Vol. 33 P. 29)

Application of plant growth regulators is significant to acceleration of crop growth and to increase in crop yield [2－5].

Recently there are many studies on plant growth regulators in our country [1].

We investigated the effects of organic phosphorous compound di-(β-chloroethyl)-α-hydroxyethyl phosphonate(DCHP), a new synthetic substance in our country, on growth and yield of crops.

1. Materials and Methods

1.1. Materials

Experimental crops were rice(var. "Pyongyang No. 50"), maize (var. "Chongun No. 3"), bean(var. "Sunchon No. 3"), cabbage(var. "cabbage No. 55") and radish(var. "second crop No. 4").

1.2. Methods

Germination rates of rice, maize and bean were measured 8 days and their germination powers were measured 4 days after soaking seeds in DCHP solution [2].

Germination powers were measured 3 days later, and germination rates of cabbage and radish were measured 6 days later [2].

For rice crop, leaf sprays were arranged for two occasions in seedling bed and at intervals of ten days two occasions after earing in paddy the yield was investigated.

For vegetable crops, leaf sprays were arranged for four occasions in field and the yield was investigated.

2. Results and Discussion

2.1. Effect of organic phosphorous regulator on germination of crops

First, we investigated the effect of organic phosphorous regulator (DCHP) on germination of rice, maize and bean, the result is as following (table 1).

Table 1. Effect of DCHP on germination of rice, maize and bean(%)

Group		Index					
		Rice		Maize		Bean	
		Germination power/%	Germination rate/%	1	2	1	2
Control	Water	31.1	95.6	42.5	95.8	46.7	96.0
DCHP	100 000 times DS	38.7	96.8	62.5	100	62.3	96.6
Difference	—	7.6	1.2	20.0	4.2	15.6	0.6

Temperature: 27～28℃

As shown in table 1, DCHP accelerated germination; germination power was 7.6% in rice, 20.0% in maize and 15.6% in bean higher than control.

Next, we investigated effect of DCHP on germination of cabbage (table 2).

Table 2. Effect of DCHP on germination of cabbage

Group		Index					
		Germination rate/%		Germination power/%		Average shoot length/mm	
		%	Difference from control	%	Difference from control	mm	Rate/%
Control		89.1	—	64.5	—	1.64	100
100 000	1h	96.6	7.5	74.3	9.8	1.74	106.1
	2h	98.7	9.6	75.9	11.4	1.88	114.6
	3h	97.8	8.7	75.2	10.7	1.82	110.9
1 000 000	1h	97.5	8.4	75.0	10.5	1.93	117.7
	2h	99.0	9.9	76.3	11.8	2.01	122.6
	3h	98.7	9.6	75.9	11.4	1.95	118.9
10 000 000	1h	97.0	7.9	67.6	3.1	1.79	109.1
	2h	98.8	9.7	68.0	3.5	1.93	117.7
	3h	98.3	9.2	69.6	5.1	1.82	110.9

Control soaking duration: 2h

As shown in table 2, germination rate and germination power were higher in DCHP-treated populations than control. In particular, cabbage population treated with 1 000 000 times DS for 2 hours showed germination rate of 99%, germination power of 76.3%, and average shoot length of 2.01mm which are 9.9, 11.8 and 22.6% higher, respectively, than control population.

This means 1 000 000 times DCHP-treatment of 2h is the most suitable to cabbage crop.

Changes in activities of some enzymes were analyzed to identify the mechanism for

DCHP acceleration of rice seed germination (table 3).

Table 3. Effect of DCHP on activities of enzymes in rice seed

Treatment	Amylase activity /(mg·g^{-1}·h^{-1})	Peroxidase activity /(mg·g^{-1}·h^{-1})	Catalase activity /(μmol·g^{-1}·h^{-1})
Control	2.13±0.12	1.61±0.12	6.75±0.54
Test	2.55±0.17	1.98±0.10	9.12±0.78
Difference	0.42	0.37	2.37

Concentration: 100 000 times DS, soaking duration: 30h, measurement: after germination

As shown in the table 3, DCHP treatment of rice seed increased activity of catalase to 125.1%, activity of peroxydase to 122.9% and activity of amylase to 119.9% in contrast with control.

Activities of amylase and catalase were measured to identify biochemical mechanism of accelerating germination in cabbage and radish seeds treated with DCHP (table 4).

Table 4. Effect of DCHP on activities of enzymes in cabbage and radish

Crop	Treatment	Amylase activity		Catalase activity	
		Activity /(mg·g^{-1}·h^{-1})	Rate/%	Activity /(μmol·g^{-1}·h^{-1})	Rate/%
Cabbage	Control	1.42	100	5.50	100
	Test	1.86	130.9	6.74	122.5
Radish	1	1.40	100	4.49	100
	2	1.68	120.0	5.18	115.4

Concentration: 1 000 000 times DS, soaking duration: 2h, measurement: 36h after treatment

As shown in the table 4, 1 000 000 times DS of DCHP treatment for 2 hours increased activities of amylase by 30.9% and catalase by 22.5% in cabbage, amylase by 20.0% and catalase by 15.4% in radish. It shows that DCHP treatment for seeds of Brassicaceae accelerates germination by increasing activities of hydrolases and oxydoreductases.

Nucleic acid content was measured in rice and maize after seed treatment of DCHP (table 5).

Table 5. Effect of DCHP on nucleic acid content(μg/L) of rice and maize

Division		Time/h				
		10	20	30	40	50
Rice	Control	1.65	3.95	2.65	4.18	6.10
	Test	3.10	4.40	3.95	5.61	7.55
	Difference	1.45	0.45	1.3	1.43	1.45
Maize	1	5.95	6.56	4.65	5.95	6.05
	2	7.05	8.30	4.85	7.65	8.20
	3	1.10	1.74	0.2	1.7	2.15

Measurement wavelength: 260nm

Table 5 shows that total nucleic acid content between test population and control population is different clearly.

Generally, DNA content of plant doesn't differ because it is a hereditary character of its plant, but m-RNA content differs according to seed vitality.

It shows that total nucleic acid content increases 0.45～1.45μg/L in rice, 0.2～2.15μg/L in maize more than control.

This means that germination rate and germination power are increased because the synthesis of m-RNA coding transcription of hydrolases and oxydoreductases is enhanced.

2.2. Effect of DCHP leaf spray on growth of vegetable crops

Firstly, we investigated the effect of DCHP leaf spray on growth of cabbage, the result is as following (table 6).

Table 6. Effect of DCHP leaf spray on growth of cabbage

Division		Leaf growth			Root growth		Total weight /(g·plant^{-1})	T/R
		Number of leaf	Length of leaf/cm	Width of leaf/cm	Number of root	Length of root/cm		
Control		22.0	42.0	27.7	37.4	7.1	689.7	31.97
100 000	2 times	22.9	44.3	32.1	76.7	12.0	743.2	30.14
	3 times	24.2	45.4	34.8	78.1	12.9	748.7	29.07
	4 times	24.7	45.7	34.6	78.9	13.1	750.1	28.93
1 000 000	2 times	22.8	44.1	30.8	76.0	11.8	732.8	27.91
	3 times	24.6	45.7	35.1	79.3	12.7	762.9	26.04
	4 times	24.9	46.3	34.9	80.4	12.4	754.1	26.01
10 000 000	2 times	22.3	43.7	30.1	73.2	11.6	632.1	29.31
	3 times	23.6	45.3	33.3	76.9	12.1	639.8	28.52
	4 times	23.7	45.5	33.6	77.7	12.4	641.0	27.64

As shown in the table 6, DCHP leaf spray has a good effect on the growth of cabbage. Especially, in case of the regulator 3～4 times witht 1 000 000 folds DS, the best effects appeared.

Next, effect of DCHP leaf spray on growth of radish was investigated (table 7).

Table 7. Effect of DCHP leaf spray on growth of radish

Division		Leaf growth		Root growth		Total weight /(g·plant^{-1})
		Number of leaves	Length of leaf/cm	Number of roots	Diameter of root/cm	
Control		13.1	20.6	13.5	5.2	542.7
100 000	2 times	15.0	21.4	14.9	6.0	579.0
	3 times	15.3	22.1	15.2	6.3	581.5
	4 times	15.7	23.0	16.7	6.5	590.1
1 000 000	2 times	14.7	21.7	14.6	5.9	573.4
	3 times	17.4	24.9	16.8	7.0	694.1
	4 times	18.1	25.3	17.2	6.8	703.6
10 000 000	2 times	14.9	20.7	14.4	5.7	570.1
	3 times	16.1	23.6	16.2	6.5	621.9
	4 times	16.4	23.9	16.6	6.8	623.2

As shown in table 7, the tendency was very similar to that of cabbage crop in radish crop. It shows that leaf spray 3～4 times with 1 000 000 folds DS is optimal for acceleration of vegetative growth.

2.3. Effect of DCHP on the yield of crops

Firstly, effect of DCHP on the yield of rice was found (table 8).

Table 8. Effect of DCHP on yield of rice

Group	Index						
	Number of ear per m^2	Number of grain per ear	Maturity /%	1 000 grain weight/g	Yield /(t·ha^{-1})	Difference /(kg·ha^{-1})	Rate /%
Control	245	117	80.3	29.0	6.68	—	100
Test	247	121	82.9	29.4	7.28	600	108.9

* $LSD_{0.01}$=430kg/ha

As shown in table 8, the yield components were increased number of ear by 2 per m^2, number of grain by 4 per ear, maturity by 2.6%. yeild per ha 7.28t, by 8.9% higher than control. It shows that DCHP has a positive effect on yield of rice.

Next, effect of DCHP on yield of radish was investigated.(table 9)

Table 9. Effect of DCHP on yield of radish

Group	Weight per plant/kg	Yield per m^2/kg	Yield /(t·ha^{-1})	Difference /(t·ha^{-1})	Rate /%
Control	0.62	4.8	48	—	100
Test	0.77	6.0	60	12*	124.5

* $LSD_{0.01}$=5.6t/ha

Table 9 shows that weight of a radish is increased 150g; yield of radish is increased 12t per ha higher than control.

Last, we found the effect of DCHP on yield of cabbage.(table 10)

Table 10. Effect of DCHP on yield of cabbage

Group	Index					
	Height /cm	Diameter /cm	Weight per plant /kg	Yield /(t·ha^{-1})	Difference /(t·ha^{-1})	Rate /%
Control	41.7	17.2	2.12	95.4	-	100
Test	44.4	20.0	2.78	125.1	29.7*	131.1

* $LSD_{0.01}$=6.5t/ha

As shown in table 10, in case of DCHP leaf spray-treatment 4 times with 1 000 000 folds DS, yield increased 31.1% more than control.

Above results mean that DCHP newly synthesized in our country is a good organic phosphorous growth regulator which contribute to increasing crop and vegetable yields with lowest concentration.

Conclusion

1) The seed treatment of rice, maize, bean, cabbage and radish by 100 000 to 1 000 000 times DS of di-(β-chloroethyl)-α-hydroxyethyl phosphonate(DCHP) increases activities of hydrolases and oxydoreductases and germination power to 7.6～20%

2) The leaf spray with 100 000 times DS for grain crop and 1 000 000 times DS for vegetable accelerates their growth, and increases the yield of grain to 108～116%, vegetable to 118～133%.

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