Chapter 4

Results

1. **Experiment 1 :** The concentration of potassium chlorate on flower induction of longan.

All plants treated with potassium chlorate were induced to flowering whereas there was no flower in untreated plants. However, the concentrations of potassium chlorate at 0.05, 0.10 g/pot, the flower buds were noticed about 14 days earlier than potassium chlorate at 0.15 g/pot (Figure 4.1). The lower concentration of potassium chlorate also had significantly higher percentage of flowering, 100% found in plants treated with 0.05 and 0.10 g of $KClO_3$ / pot while 52.78% found in plants treated with higher concentration. (Table 4.1). Number of female flowers was high at lower concentration of potassium chlorate. However, number of male flowers also high too, therefore, ratios of female and male flowers seem to be high. From this experiment, potassium chlorate at 0.05 and 0.10 g were appropriate concentration to induce flowering in longan. Potassium chlorate at the rate of 0.05 g was chose to apply to plants in the experiments 2, 3 and 4 to study its effect to longan plant compared with control.

Table 4.1 The concentration of potassium chlorate on flower induction of longan

$KClO_3$ (g / pot)	Days of flowering	Percentage of flowering	No. of female flowers	Female : male flower
0	0 c	-	-	-
0.05	29 b	100.00 a	61.33 a	1 : 19.32 ab
0.10	28 b	100.00 a	48.50 ab	1 : 14.12 b
0.15	42 a	52.78 b	17.33 b	1 : 30.55 a

a, b, c means in the same column followed with the same letter does not significant difference at $\alpha = 0.05$ by Lsd.

0 0.05 0.10 0.15

$KClO_3$ (g/plant)

Figure 4.1 The shoots of longan plants treated with potassium chlorate 0, 0.05, 0.10 and 0.15 g/pot, five weeks after treatments

2. Experiment 2: Root growth and development

The experiment was conducted in hydroponics. Potassium chlorate 0.05 g was dissolved in 4 litters of water (12.5 ppm) could not induced flowering and no difference in root growth and development were observed. Therefore, the higher concentration, 1 g of $KClO_3$ / 4 l of water (250 ppm) was applied. The flower buds were observed on the 5th week. The root relative growth rates of six weeks after treatment of treated plants tended to be higher than untreated plants (Figure 4.2), but there was not significant difference (Table 4.2), as shown on the picture of roots at 1, 3 and 5 weeks after treated with $KClO_3$ (Figure 4.3).

Table 4.2 Relative growth rate of longan roots treated with $KClO_3$ compared with untreated plants six weeks in hydroponics

Week(s) after treated	Root relative growth rate		Sign. Differ.
	- $KClO_3$	+ $KClO_3$	
1	0.892 ± 0.30	0.801 ± 0.04	NS
2	1.349 ± 0.39	1.450 ± 0.22	NS
3	1.399 ± 0.41	1.709 ± 0.31	NS
4	1.449 ± 0.43	1.768 ± 0.29	NS
5	1.449 ± 0.43	1.790 ± 0.28	NS
6	1.449 ± 0.43	1.881 ± 0.24	NS

NS means non significant difference

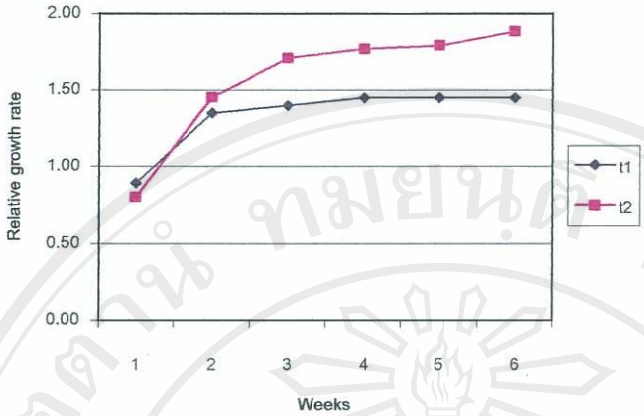


Figure 4.2 Root relative growth rate of untreated plants (T1) compared with plants treated with $KClO_3$ (T2)

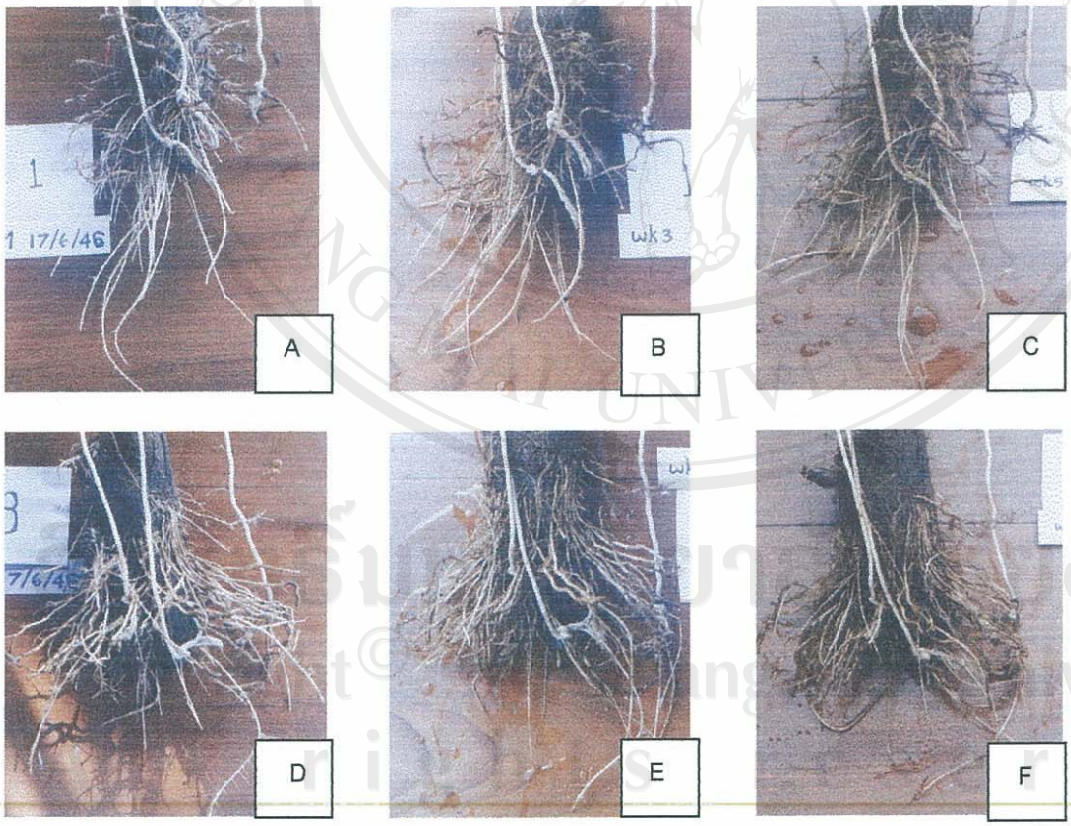


Figure 4.3 Roots of controlled plants (A-C) compared with plants treated with 250 ppm of $KClO_3$ (D-F) at 1, 3 and 5 weeks after treatments

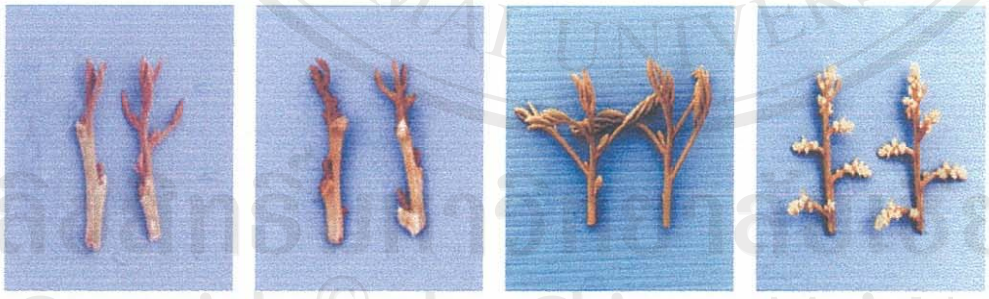
3. Experiment 3 : Root respiration

The experiment 3 was conducted in March and April, the temperature was higher than in November and December when the experiment 1 was conducted. Therefore, flower buds induced by potassium chlorate were noticed earlier from 29 to 18 days after treatments. However, flower initiation was detected under microscope on day 16 (Figure 4.4).

Day 14 Day 16 Day 18

Figure 4.4 The terminal bud of longan 14,16 and 18 days after treated with 0.05 g $KClO_3$

Flower buds of treated plants could obviously observed on the 3rd week and flower inflorescence on the 4th week (Figure 4.5).



Week 1 Week 2 Week 3 Week 4

Figure 4.5 Shoots of longan four weeks after treated with $KClO_3$

The root respiration of treated plants was not significant difference from the control, however, it was lower at the first and second week after treatments (Table 4.3).

Table 4.3 The root respiration rate of plants treated with $KClO_3$ (+$KClO_3$) compared with control, - $KClO_3$ ([a] = mean ± SE)

Week(s) after treatments	Respiration rate (µl CO_2 Kg^{-1} hr^{-1})		Sign. Differ.
	- $KClO_3$	+ $KClO_3$	
1	5.95 ± 1.43[a]	3.45 ± 0.50	NS
2	2.95 ± 0.45	2.03 ± 0.58	NS
3	2.52 ± 0.56	3.27 ± 0.62	NS
4	5.53 ± 1.06	4.87 ± 0.47	NS

NS means non significant difference

4. **Experiment 4:** Changes of the physiological aspects and some essential substances of roots, leaves and shoots.

4.1 The physiological aspects

4.1.1 Photosynthesis and stomatal conductance

The photosynthetic rates during the day of potassium chlorate treated and controlled plants were measured every two hours from 8.00 a.m. to 4.00 p.m. Photosynthetic rates and stomatal conductance were high at 8.00 am and decreased until 4.00 pm. The photosynthetic rates were calculated when carbon dioxide concentration in detective chamber decreased due to its used as a photosynthetic substrate. However, during midday and afternoon, high temperatures caused partially stomatal closure and high respiration. Therefore, photosynthetic rates took a long time to measure and some minus values were observed (Table 4.4).

4.1.2 Stomatal behaviors

Longan has very small and sunken stomata pore and guard cell were unclearly appeared. Any focusing could be seen either opening or closing stomata, so it is hard to see the actual situation of stomatal behaviors during the daytime (Figure 4.6).

Table 4.4 The photosynthetic rate (μmol CO_2 m^{-2} s^{-1}) and stomatal conductance (μmol CO_2 m^{-2} s^{-1}) of longan leaves during the day for four weeks (Wk) after applied $KClO_3$ (+ $KClO_3$) compared with control (- $KClO_3$).

Week/Time	Photosynthetic rate		Stomatal conductance	
	- $KClO_3$	+ $KClO_3$	- $KClO_3$	+ $KClO_3$
Wk1 08.00	2.574	2.713	0.354	0.391
10.00	2.543	2.661	0.065	0.065
12.00	1.975	1.700	0.088	0.088
14.00	1.883	1.363	0.102	0.096
16.00	2.572	1.540	0.095	0.102
Wk2 08.00	3.294	3.142	0.204	0.209
10.00	1.765	1.327	0.284	0.240
12.00	0.544	0.307	0.242	0.239
14.00	0.451	0.269	0.233	0.226
16.00	0.561	0.699	0.195	0.183
Wk3 08.00	2.768	2.333	0.452	0.439
10.00	1.301	1.010	0.347	0.341
12.00	-0.107	-0.171	0.112	0.011
14.00	0.106	0.289	0.166	0.162
16.00	-0.061	-0.243	0.199	0.215
Wk4 08.00	1.029	1.056	0.340	0.346
10.00	0.489	0.379	0.277	0.276
12.00	0.371	0.482	0.304	0.282
14.00	-0.076	-0.003	0.173	0.211
16.00	0.329	0.501	0.213	0.222

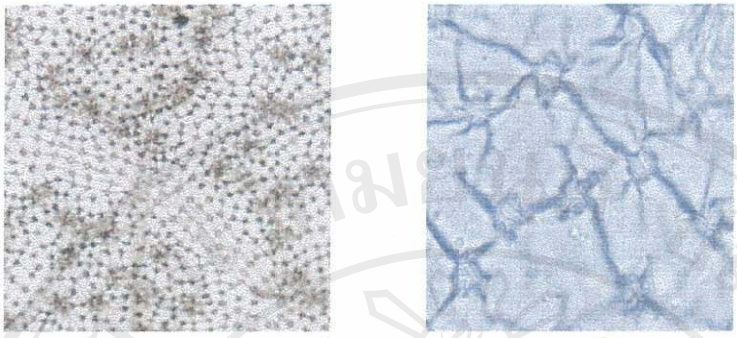


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Figure 4.6 The stomata of longan

4.1.3 Electrolyte leakage

There was no effect of $KClO_3$ on electrolyte leakage of leaves and roots (Table 4.5 and 4.6).

Table 4.5 Electrolyte leakage of longan leaves treated with $KClO_3$ (+ $KClO_3$) compared with control (- $KClO_3$)

Week(s) after treatments	Electrolyte leakage (%)		Sign. Differ.
	- $KClO_3$	+ $KClO_3$	
1	12.64 ± 1.34	13.52 ± 2.69	NS
2	15.74 ± 3.51	12.28 ± 0.07	NS
3	12.51 ± 0.30	16.57 ± 2.01	NS
4	13.11 ± 0.87	14.03 ± 0.99	NS

NS means non significant difference

Table 4.6 Electrolyte leakage of longan roots treated with $KClO_3$ (+$KClO_3$) compared with control (- $KClO_3$)

Week(s) after treatments	Electrolyte leakage (%)		Sign. Differ.
	- $KClO_3$	+ $KClO_3$	
1	22.87 ± 4.41	25.18 ± 2.85	NS
2	24.72 ± 3.22	28.20 ± 2.04	NS
3	20.48 ± 0.48	17.03 ± 2.92	NS
4	27.66 ± 6.96	23.32 ± 1.04	NS

NS means non significant difference

4.2 Changes of some essential substances and mineral nutrients

4.2.1 The chlorophyll content and degradation

Chlorophyll content was measured to assure the result of photosynthetic rate of longan leaves after treated with $KClO_3$. Chlorophyll a and b and total chlorophyll of treated plants were not significant difference from untreated plants (Table 4.7, 4.8 and 4.9).

Table 4.7 The chlorophyll a content of longan leaves treated with $KClO_3$ ($+KClO_3$) compared with control ($-KClO_3$)

Week(s) after treatments	Chlorophyll a (mg/g fresh wt.)		Sign. Differ.
	$-KClO_3$	$+KClO_3$	
1	.669 ± .040	.633 ± .023	NS
2	.462 ± .050	.506 ± .003	NS
3	.455 ± .021	.458 ± .018	NS
4	.508 ± .040	.538 ± .013	NS

NS means non significant difference

Table 4.8 The chlorophyll b content of longan leaves treated with $KClO_3$ ($+KClO_3$) compared with control ($-KClO_3$)

Week(s) after treatments	Chlorophyll b (mg/g fresh wt.)		Sign. Differ.
	$-KClO_3$	$+KClO_3$	
1	.444 ± .036	.402 ± .014	NS
2	.319 ± .037	.348 ± .004	NS
3	.280 ± .017	.291 ± .014	NS
4	.339 ± .023	.362 ± .011	NS

NS means non significant difference

The total chlorophyll degradation was determined every week for four weeks after treatments. Each week, total chlorophyll from detached leaves was determined for three consecutive days for chlorophyll degradation. On second and third day total

chlorophyll were increased due to leaf dehydration. There was highly significant difference between the treatments on day three of the first week (table 4.9).

Table 4.9 Total chlorophyll and chlorophyll degradation three consecutive days after treatments

Week(s) after treatments	Chlorophyll (mg/g fresh wt.)					
	Day 1		Day 2		Day 3	
	- $KClO_3$	+ $KClO_3$	- $KClO_3$	+ $KClO_3$	- $KClO_3$	+ $KClO_3$
1	1.113	1.035	1.281	1.201	1.622 **a**	1.475 **b**
2	0.779	0.854	0.726	0.884	1.073	1.075
3	0.726	0.750	0.772	0.744	1.026	0.865
4	0.847	0.899	0.722	0.689	1.047	1.042

a, b means in the same row followed with the same letter does not significant difference at $\alpha = 0.05$ by Lsd.

4.2.2 Peroxidase activity

Peroxidase activity of leaves was greater than of roots. Significant difference of peroxidase activity was found four weeks after treated with potassium chlorate, whereas there was no significant difference in root (Table 4.10 and 4.11).

Table 4.10 Peroxidase activity (μM/min) of longan leaves treated with $KClO_3$ (+ $KClO_3$) compared with control (- $KClO_3$)

Week(s) after treatments	Peroxidase activity		Sign. Differ.
	- $KClO_3$	+ $KClO_3$	
1	4.66 ± 1.23	5.58 ± 0.72	NS
2	3.81 ± 0.62	3.49 ± 0.38	NS
3	2.89 ± 0.62	3.72 ± 0.83	NS
4	1.79 ± 0.31	3.46 ± 0.39	*

* means treatments have significant difference at $\alpha = 0.05$ by Lsd.

NS means non significant difference

Table 4.11 Peroxidase activity (μM/min) of longan root treated with $KClO_3$ (+ $KClO_3$) compared with control (- $KClO_3$)

Week(s) after treatments	Peroxidase activity		Sign. Differ.
	- $KClO_3$	+ $KClO_3$	
1	0.185 ±0.038	0.155 ±0.019	NS
2	0.775 ±0.255	0.885 ±0.143	NS
3	0.507 ±0.108	0.426 ±0.186	NS
4	0.279 ±0.076	0.257 ±0.056	NS

4.2.3 Total non structural carbohydrate (TNC)

The percentage of TNC concentration of roots, leaves and shoots dry matter four weeks after treated with potassium chlorate found that root TNC in treated plants was significantly higher than untreated plants, one week after treatment(Table 4.12)

Table 4.12 Total non structural carbohydrate of roots, leaves and shoots of plants treated with $KClO_3$ (+$KClO_3$) compared with control (-$KClO_3$)

Plant organs	Week(s) after treatments	TNC (mg g^{-1}FW)		Sign. Differ.
		- $KClO_3$	+ $KClO_3$	
Roots	1	115.06 b	145.75 a	*
	2	143.74	167.63	NS
	3	136.49	149.02	NS
	4	110.75	127.88	NS
Leaves	1	91.71	80.58	NS
	2	88.14	79.73	NS
	3	80.07	65.97	NS
	4	86.22	70.22	NS
Shoots	1	148.47	148.49	NS
	2	140.11 b	153.00 a	**
	3	147.34 b	180.81 a	*
	4	172.77	174.49	NS

*, ** means treatments have significant difference at α = 0.05 and 0.01 by Lsd., NS means non significant difference

It was not significant difference in leaves TNC, but shoots TNC of treated plants has significantly higher on the 2nd and 3rd weeks (Figure 4.7).

4.2.4 Reducing Sugar (RS)

Reducing sugar content of treated roots were significantly lower than controlled plants in the first week as same as RS content of leaves at the 4th week. Nevertheless, RS contents of the shoot at the 2nd, 3rd and 4th week in treated plants were higher than controlled plants (Table 4.13 and Figure 4.7).

Table 4.13 The reducing sugar (RS) content of roots, leaves and shoots of plants treated with $KClO_3$ and untreated plants, four weeks after treatments

Plant organs	Week(s) after treatments	RS (mg/g DW)		Sign. Differ.
		-$KClO_3$	+$KClO_3$	
Roots	1	31.02 a	27.78 b	**
	2	33.99	35.29	NS
	3	31.30	27.42	NS
	4	14.86	13.63	NS
Leaves	1	46.00	50.51	NS
	2	51.31	45.42	NS
	3	49.05	44.86	NS
	4	43.87 a	38.19 b	*
Shoots	1	82.93	78.90	NS
	2	76.75 b	87.45 a	*
	3	88.94 b	129.34 a	**
	4	98.53 b	115.39 a	*

*, ** means treatments have significant difference at $\alpha = 0.05$ and 0.01 by Lsd.,
NS means non significant difference

4.2.5 Total nitrogen, nitrate and C: N ratio

Total nitrogen (TN) of shoots of treated plants at the fourth week after treatments were higher than controlled plants, while TN of roots and leaves were not difference (Table 4.14 and Figure 4.7).

Table 4.14 The percentage of nitrogen (%) of roots, leaves and shoots of treated plants (+$KClO_3$) compared with control (-$KClO_3$)

Plant organs	Weeks	Total nitrogen (%)		Sign.
		- $KClO_3$	+ $KClO_3$	Differ.
Roots	1	2.49	2.46	NS
	2	2.42	2.51	NS
	3	2.43	2.37	NS
	4	2.06	2.07	NS
Leaves	1	5.00	5.07	NS
	2	5.84	5.37	NS
	3	3.63	3.41	NS
	4	3.26	3.54	NS
Shoots	1	3.01	2.95	NS
	2	2.71	2.43	NS
	3	3.13	3.43	NS
	4	2.33	3.76	**

** means treatments have significant difference at $\alpha = 0.01$ by Lsd.

NS means non significant difference

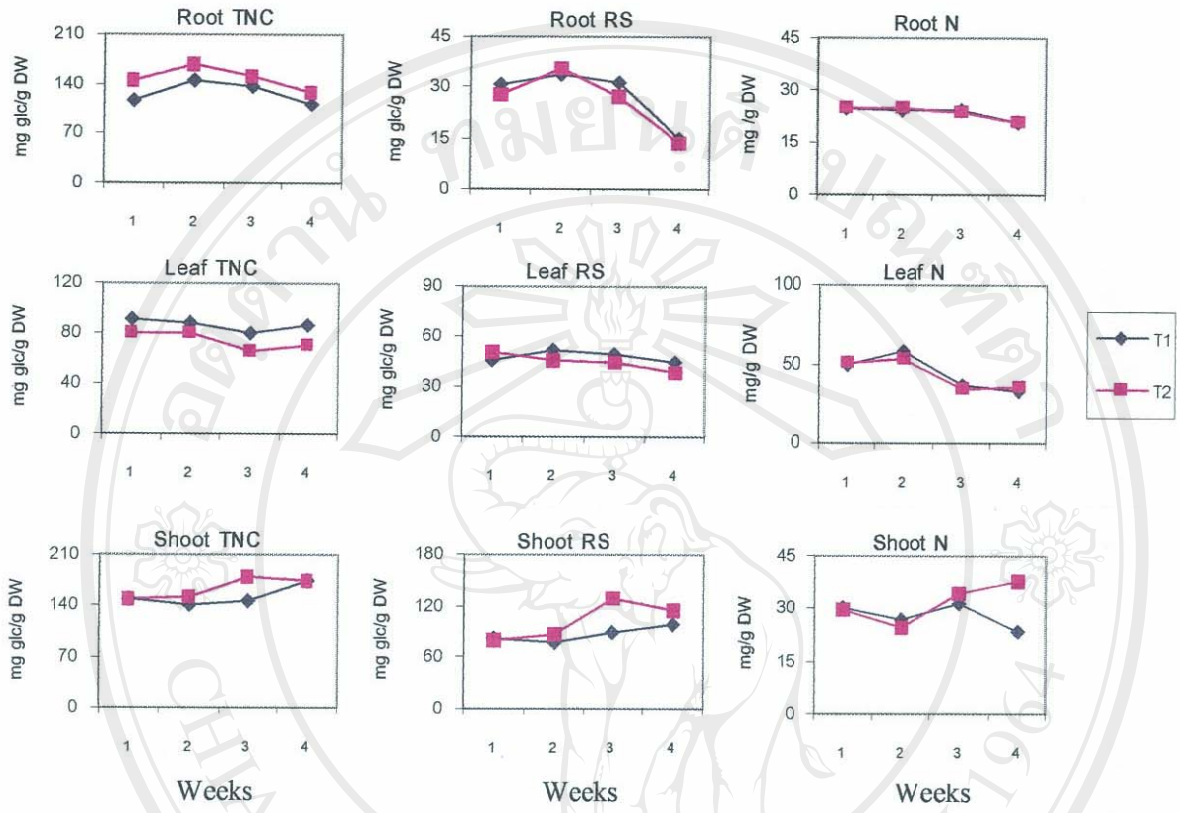

Figure 4.7 The TNC, RS and TN content of roots, leaves and shoots after applied potassium chlorate (T2) compared with control (T1)

The similar concentration of nitrate was found in the leaves and shoots, but in roots, it was shown significantly higher in treated plants on the second week of treatments (Table 4.15).

Table 4.15 Percentage of nitrate content of roots, leaves and shoots of untreated ($-KClO_3$) and treated plants ($+KClO_3$)

Plant organ	Week(s) after treatements	NO_3^- (%) - $KClO_3$	NO_3^- (%) + $KClO_3$	Sign. Differ.
Roots	1	2.16 ± 0.34	2.44 ± 0.17	NS
	2	2.62 ± 0.08 b	2.82 ± 0.09 a	*
	3	2.82 ± 0.16	3.18 ± 0.04	NS
	4	2.65 ± 0.06	2.96 ± 0.21	NS
Leaves	1	3.54 ± 0.23	3.85 ± 0.28	NS
	2	3.50 ± 0.05	3.40 ± 0.02	NS
	3	4.48 ± 0.26	4.51 ± 0.28	NS
	4	3.44 ± 0.15	3.46 ± 0.12	NS
Shoots	1	2.16 ± 0.05	2.15 ± 0.19	NS
	2	2.65 ± 0.07	2.65 ± 0.12	NS
	3	2.64 ± 0.12	2.67 ± 0.11	NS
	4	2.87 ± 0.12 b	3.24 ± 0.66 a	*

* means treatments have significant difference at $\alpha = 0.05$ by Lsd.

NS means non significant difference

The C: N ratio of shoots of treated plants on the 2nd week was higher than the controlled but lower on the 4th week, while there was not significant difference in C: N ratio of roots and leaves (Table 4.16).

Table 4.16 The C: N ratio of roots, leaves and shoots in treated ($+KClO_3$) and Untreated plants ($-KClO_3$)

Week(s)	Roots		Leaves		Shoots	
after treatments	- $KClO_3$	+ $KClO_3$	-$KClO_3$	+$KClO_3$	-$KClO_3$	+$KClO_3$
1	4.73	5.91	1.85	1.58	4.94	5.04
2	5.79	6.73	1.67	1.71	5.19 b	6.31 a
3	5.68	6.34	2.25	1.92	4.78	5.37
4	5.61	6.20	2.64	1.99	7.44 a	6.50 b

a, b means treatments have significant difference at $\alpha = 0.05$ by Lsd.

4.2.6 Phosphorus

Potassium chlorate did not affect phosphorus content of roots, leaves and shoots (Table 4.17).

Table 4.17 The percentage of phosphorus of roots, leaves and shoots treated with $KClO_3$ (+$KClO_3$) compared with control (-$KClO_3$)

Plant organs	Week(s) after treatments	Phosphorus (%)		Sign. Differ.
		- $KClO_3$	+ $KClO_3$	
Roots	1	0.32	0.33	NS
	2	0.21	0.19	NS
	3	0.24	0.18	NS
	4	0.17	0.17	NS
Leaves	1	0.20	0.19	NS
	2	0.22	0.20	NS
	3	0.16	0.16	NS
	4	0.17	0.20	NS
Shoots	1	0.25	0.25	NS
	2	0.24	0.26	NS
	3	0.21	0.20	NS
	4	0.29	0.21	NS

NS means non significant difference

4.2.7 Potassium

There was not significant difference on potassium content of roots and leaves except shoots, at the fourth week of treatments (Table 4.18).

Table 4.18 Potassium content of roots, leaves and shoots treated with $KClO_3$ ($+KClO_3$) compared with control ($-KClO_3$)

Plant organs	Week(s) after treatments	Potassium (%)		Sign. Differ.
		$-KClO_3$	$+KClO_3$	
Roots	1	0.71	0.60	NS
	2	0.60	0.64	NS
	3	0.62	0.56	NS
	4	0.54	0.54	NS
Leaves	1	0.89	0.86	NS
	2	0.85	0.83	NS
	3	0,86	0.96	NS
	4	0.90	0.87	NS
Shoots	1	0.77	0.77	NS
	2	0.76	0.70	NS
	3	0.74	0.71	NS
	4	0.67 b	0.88 a	*

* means treatments have significant difference at $\alpha = 0.05$ by Lsd.

NS means non significant difference

4.2.8 Root hormones

IAA and auxin-like substances content of roots of treated plants measured by bioassay method was high on the 1st and 2nd weeks but declined on the 3rd and 4th weeks after treatments. The auxin content was found significant difference on the 2nd week (Table 4.19 and Figure 4.8). The same pattern of IAA content was found when measured by spectrophotometer (Table 4.20).

Table 4.19 IAA and auxin-like substances content (μ g g^{-1}FW) of root of plants treated with $KClO_3$ (+$KClO_3$) compared with control (-$KClO_3$) by IAA bioassay

Week(s) after treatments	IAA (μ g g^{-1}FW) - $KClO_3$	IAA (μ g g^{-1}FW) + $KClO_3$	Sign. Differ.
1	13.05 ± 1.31	20.53 ± 1.85	NS
2	9.90 ± 0.63	18.83 ± 1.47	*
3	15.14 ± 2.08	16.43 ± 2.27	NS
4	8.64 ± 2.57	6.98 ± 1.72	NS

* means treatments have significant difference at α = 0.05 by Lsd.

NS means non significant difference

Table 4.20 IAA and auxin-like substances (μ g g^{-1}FW) of roots treated with $KClO_3$ (+$KClO_3$) compared with control (-$KClO_3$), measured by spectrophotometer

Week(s) after treatments	IAA (μ g g^{-1}FW) - $KClO_3$	IAA (μ g g^{-1}FW) + $KClO_3$	Sign. Differ.
1	24.77 ± 3.08	40.39 ± 4.97	*
2	39.16 ± 6.72	53.30 ± 3.40	*
3	35.36 ± 3.29	38.82 ± 9.18	NS
4	46.15 ± 6.84	38.71 ± 2.99	NS

* means treatments have significant difference at α = 0.05 by Lsd.

NS means non significant difference

Gibberellins and GA-like substances content of treated and untreated plants were low at the first week, gradually high on the 2nd and 3rd week, but root GA of untreated plants tended to decline on the 4th week after treatments (Table 4.21 and Figure 4.8).

Table 4.21 Gibberellin and GA-like substances content (μ g g^{-1}FW) of roots treated with $KClO_3$ (+$KClO_3$) compared with control (-$KClO_3$)

Week(s) after treatments	GA (μ g g^{-1}FW)		Sign. Differ.
	- $KClO_3$	+ $KClO_3$	
1	0.119 ± 0.03	0.146 ± 0.04	NS
2	0.271 ± 0.03	0.250 ± 0.06	NS
3	0.321 ± 0.06	0.302 ± 0.03	NS
4	0.271 ± 0.07	0.323 ± 0.09	NS

NS means non significant difference

Cytokinin and cytokinin-like substances concentration of treated plants on the 2nd weeks of treatments found significantly higher than controlled plants (Table 4.22 and Figure 4.8). Root cytokinin on the 3rd week tended to be low but increased on the 4th week.

Table 4.22 Cytokinin and cytokinin-like substances content (ng g^{-1} FW) of roots treated with $KClO_3$ (+$KClO_3$) compare with control (-$KClO_3$)

Week(s) after treatments	Cytokinin (ng g^{-1}FW)		Sign. Differ.
	- $KClO_3$	+ $KClO_3$	
1	0.060 ± 0.006	0.041 ± 0.009	NS
2	0.057 ± 0.004	0.108 ± 0.014	*
3	0.114 ± 0.003	0.088 ± 0.011	NS
4	0.121 ± 0.010	0.123 ± 0.010	NS

* means treatments have significant difference at α = 0.05 by Lsd.

NS means non significant difference

Ethylene concentration of roots of treated and untreated plants increased during four weeks of treatments. However, there was significantly difference on the 2nd and 3rd week of treatments (Table 4.23 and Figure 4.8).

Table 4.23 Ethylene content (ppm) of root treated with $KClO_3$ (+$KClO_3$) compared with control (-$KClO_3$)

Week(s) after treatments	Ethylene (ppm) - $KClO_3$	Ethylene (ppm) + $KClO_3$	Sign. Differ.
1	0.114 ± 0.02	0.124 ± 0.03	NS
2	0.105 ± 0.03	0.137 ± 0.03	*
3	0.160 ± 0.02	0.220 ± 0.01	*
4	0.277 ± 0.02	0.333 ± 0.04	NS

* means treatments have significant difference at α = 0.05 by Lsd.

NS means non significant difference

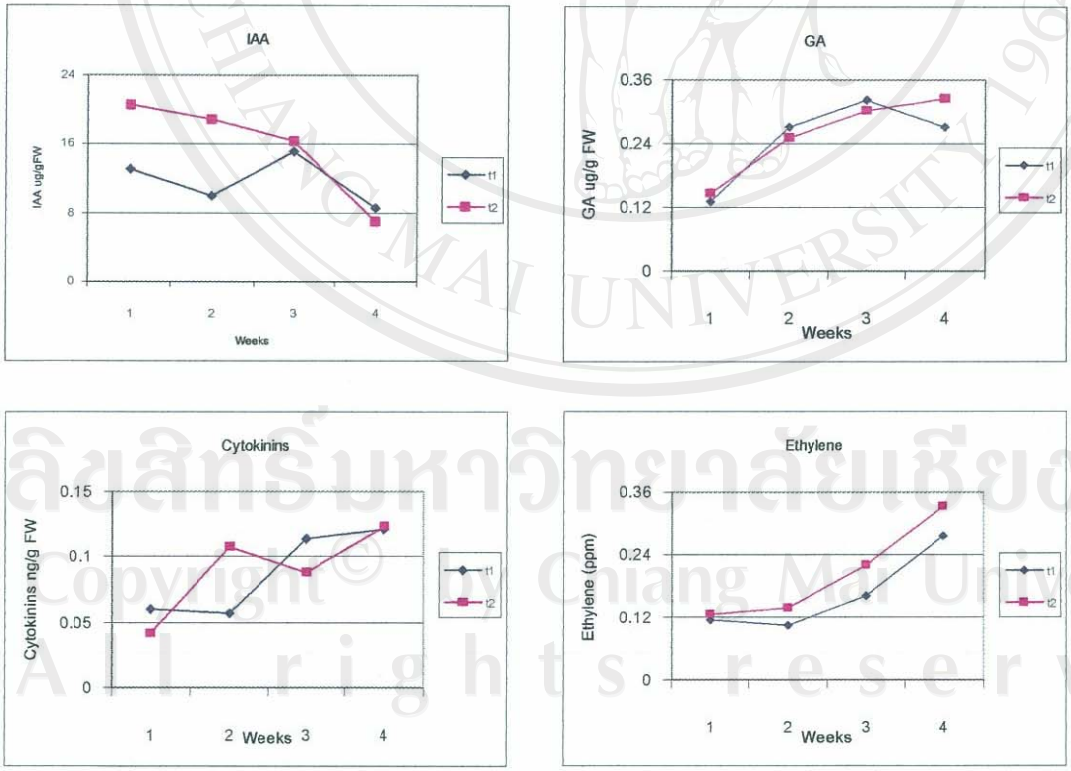

Figure 4.8 Hormones content of longan root treated with $KClO_3$ (T2) compared with control (T1)

4.3 The correlation of chemicals content between roots, leaves and shoots

4.3.1 The correlation between nitrogen, reducing sugar and total non structural carbohydrate

The correlation between N, RS and TNC of roots, leaaves and shoots four weeks after treated with $KClO_3$ compared with control were calculated by bivariate correlation of SPSS program. In untreated plants, high positive correlation found between roots N and shoots N (r = .8897), roots N and root RS (r = .9570), but high negative correlation with shoots RS (r = -.8154) and shoots TNC (r = -.9210). Roots RS had high negative correlation with shoots RS (r = -.9018) and shoot TNC (r = -.9940). The relation showed that whenever high N of root was found, there was high root RS, leaf N and shoot N, but low in shoot TNC and RS (Table 4.24 and Figure 4.8).

Table 4.24 The correlation coefficients (r) of TN, RS and TNC between roots, leaves and shoots of untreated plants

	Leaf N	Root N	Shoot N	Leaf RS	Root RS	Shoot RS	Leaf TNC	Root TNC	Shoot TNC
Leaf N	1.0000	.6336	.2109	.6357	.7270	-.9516	.6136	.4766	-.7667
		p= .336	p= .789	p= .364	p= .273	p= .048	p= .386	p= .523	p= .233
Root N		1.0000	.8897	.6340	.9570	-.8154	.1395	.5222	-.9210
			p= .110	p= .366	p= .043	p= .185	p= .860	p= .478	p= .079
Shoot N			1.0000	.4413	.7855	-.4721	-.2008	.3964	-.7181
				p= .559	p= .214	p= .528	p= .799	p= .604	p= .282
Leaf RS				1.0000	.8280	-.7853	-.2193	.9800	-.9940
					p= .172	p= .215	p= .781	p= .020	p= .006
Root RS					1.0000	-.9018	.0631	.7326	-.9940
						p= .098	p= .937	p= .267	p= .006
Shoot RS						1.0000	-.3959	-.6466	.9268
							p= .604	p= .353	p= .073
Leaf TNC							1.0000	-.3988	-.0662
								p= .601	p= .934
Root TNC								1.0000	-.7829
									p= .217
Shoot TNC									1.0000

Plants treated with $KClO_3$, there were significantly positive correlation between roots N and roots RS (r = .9672) and high correlation to roots TNC (r = .8837) and leaves RS (r = .8683). Roots TNC also was significantly positive correlation with roots RS (r = .9721) and high correlation with roots N (r = .8837), but negative correlation with shoot N (r = -. 9059). Root RS has high negative correlation with shoot N too (r = .9042). The correlation pattern of treated plants was different from the untreated. Shoot was a strong sink, when concentrations of shoot N, TNC and RS were high, low concentration of N, TNC and RS were observed to leaves and roots (Table 4.25 and Figure 4.9).

Table 4.25 The correlation coefficients (r) of TNC, RS and TN between roots, leaves and shoots of treated plants

	Leaf N	**Root N**	**Shoot N**	**Leaf RS**	**Root RS**	**Shoot RS**	**Leaf TNC**	**Root TNC**	**Shoot TNC**
Leaf N	1.0000	.7495 p= .251	-.9272 p= .073	.6533 p= .346	.7089 p= .291	-.9448 p= .055	.9669 p= .033	.6817 p= .318	-.9638 p= .036
Root N		1.0000	-.8797 p= .120	.8683 p= .132	.9672 p= .033	-.5787 p= .421	.5958 p= .404	.8837 p= .116	-.6383 p= .362
Shoot N			1.0000	-.6416 p= .358	-.9042 p= .096	.7558 p= .244	-.8009 p= .199	-.9059 p= .094	.7997 p= .200
Leaf RS				1.0000	.7142 p= .286	-.6362 p= .364	.6026 p= .397	.5356 p= .464	-.6734 p= .327
Root RS					1.0000	-.4745 p= .525	.5154 p= .485	.9721 p= .028	-.5403 p= .460
Shoot RS						1.0000	-.9950 p= .005	-.4111 p= .589	.9971 p= .003
Leaf TNC							1.0000	.4723 p= .528	-.9953 p= .005
Root TNC								1.0000	-.4761 p= .524
Shoot TNC									1.0000

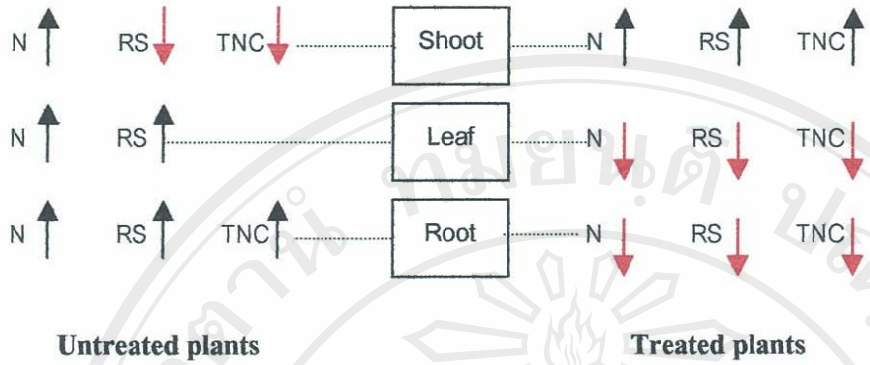

Figure 4.9 Model of N, RS and TNC content of plant treated and untreated with $KClO_3$ four weeks after treatments, ↑ : high concentration ; ↓ : low concentration

4.3.2 The correlation between nitrogen, phosphorus and potassium

In untreated plants, the correlation between root N and shoot N were higher than root N and leaf N (r = .8897 and .6336 respectively). High positive correlation also found between root K and shoot K (r = .8563), while there was no correlation of P between the plant organs. Significantly positive correlation between root K and root P were found (r = .9926). There was negative correlation between shoot N and P (r = -. 8861).

There were correlation between N, P and K, where there was high N concentration of root, there was high concentration of K and P of roots and N and K of shoot too (Table 4.26 and Figure 4.10).

In treated plants, the correlation between shoots N and roots N were negative (r = -.8797) as well as the correlation between shoots N and leaves N (r = -.9272). There was average correlation between shoots P and leaves P. Negative correlation between shoots K and roots K was found (r = -. 7204). Among N, P and K of plant found highly significant negative correlation between shoots N and roots K (r = -1.0000). Where plant has high N and K of shoots, N and K of roots were low (Table 4.27 and Figure 4.10).

Table 4.26 The correlation coefficients (r) of N, P and K between roots, leaves and shoots of untreated plants

	Root N	Leaf N	Shoot N	Root P	Leaf P	Shoot P	Root K	Leaf K	Shoot K
Root N	1.0000	.6336	.8897	.7847	.3377	-.7978	.8512	- .5189	.9660
		p= .366	p= .110	p= .215	p= .662	p= .202	p= .149	p= .481	p= .034
Leaf N		1.0000	.2109	.3799	.9366	-.2239	.4597	- .4622	.7921
			p= .789	p= .620	p= .063	p= .779	p= .540	p= .538	p= .208
Shoot N			1.0000	.7545	-.1279	- .8861	.7933	- .4009	.7510
				p= .245	p= .872	p= .114	p= .207	p= .599	p= .249
Root P				1.0000	.1934	-.3924	.9929	.1222	.7904
					p= .807	p= .608	p= .007	p= .878	p= .210
Leaf P					1.0000	.1264	.2513	- .2389	.5567
						p= .874	p= .749	p= .761	p= .443
Shoot P						1.0000	-.4693	.7536	- .6319
							p= .531	p= .246	p= .368
Root K							1.0000	.0069	.8563
								p= .993	p= .144
Leaf K								1.0000	-.4471
									p= .553
Shoot K									1.0000

Table 4.27 The correlation coefficients (r) of N, P and K between roots, leaves and shoots of treated plants

	Root N	Leaf N	Shoot N	Root P	Leaf P	Shoot P	Root K	Leaf K	Shoot K
Root N	1.0000	.7495	-.8797	.4780	- .1059	.6691	.8796	- .1768	-.8970
		p= .251	p= .120	p= .522	p= .894	p= .331	p= .120	p= .823	p= .103
Leaf N		1.0000	- .9272	.5575	.5730	.9927	.9269	- .7747	-.4483
			p = .073	p= .442	p= .427	p= .007	p= .070	p= .225	p= .552
Shoot N			1.0000	-.3362	-.3389	- .8994	- 1.0000	. 5896	.7233
				p= .664	p= .661	p= .101	p= .000	p= .410	p= .277
Root P				1.0000	.1359	.5084	.3419	- .2392	-.0920
					p= .864	p= .492	p= .658	p= .761	p= .908
Leaf P					1.0000	.6659	.3417	- .9594	.3940
						p= .334	p= .658	p= .041	p= .610
Shoot P						1.0000	.9018	-.8451	- .3611
							p= .098	p= .155	p= .639
Root K							1.0000	- .5922	-.7204
								p= .408	p= .280
Leaf K								1.0000	-.1222
									p= .878
Shoot K									1.0000

Model of N, P and K content in root, leaf and shoot of plant treated with potassium chlorate compared with controlled is shown in Figure 4.10.

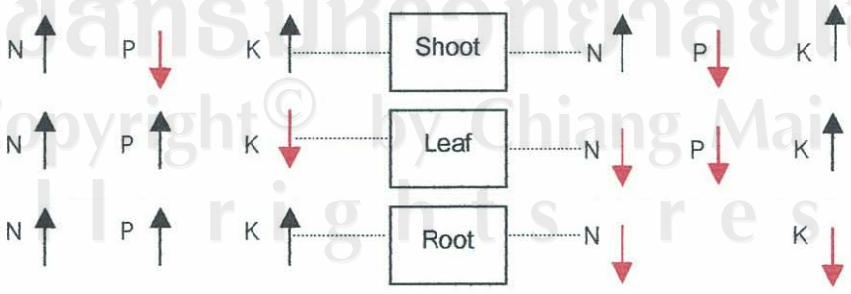

Figure 4.10 Model of N, P and K content of plant treated and untreated with $KClO_3$ four weeks after treatment, ↑ : high concentration ; ↓ : low concentration

4.3.3 The correlation between root hormones

The correlation between root hormones of controlled plants found high positive correlation between cytokinins and ethylene (r = .845), cytokinins and GA (r = .622) and negative correlation between IAA and ethylene (r = -.457) as shown on Table 4.28.

In treated plants found high correlation among root hormones. The correlation between IAA and the others were negative, particularly ethylene (r = -.978), while there were positive correlation between GA and cytokinins (r = .875) and ethylene (r = .814). The positive correlation also found between cytokinins and ethylene (r = .674), shown on Table 4.28.

Table 4.28 The correlation of root hormones of treated and untreated plants

Root hormones	Correlation	
	Untreated plants	Treated plants
IAA x GA	- .027	- .755
	p= .973	p= .245
IAA x Cytokinin	.022	- .712
	p= .978	p= .288
IAA x Ethylene	- .457	- .978
	p= .543	p= .022
GA x Cytokinin	.622	.875
	p= 378	p= .125
GA x Ethylene	.351	.814
	p= .649	p= .186
Cytokinin x Ethylene	.622	.875
	p= 378	p= .125

The pattern of hormones content of root of treated and untreated plants were almost the same. Once there was high concentration of IAA of root, low concentration of GA, cytokinins and ethylene were found. However, the correlation between hormones of root of treated plants was very much higher than the controlled.