STUDIES ON NUTRIENT ABSORPTION OF RICE PLANTS IN TAIWAN (PART 3)

Nutrient Absorption of Rice Plants in Pingtung and Taipei Soils with and without Compost under Different Temperatures

by

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In our previous papers[1,2] we showed that under high temperatures straw yield, elongation of plants and heading date were promoted, but grain yield did not always increase. High temperatures increased absorption of fertilizer three elements especially for potassium. In an Indica variety, the increasing of nutrient absorption under high temperatures apperared to result in an increased transmission of nutrients to grains, but it was not true in a Japonica variety.

It seems that more detailed investigation of nutrient absorption is necessary for understanding the physiological aspect of grain production under different conditions. This study using glass-house pot culture was directed to the following three points, i. e. a) nutrient absorption in different soils, b) the effect of application of organic matter, and c) the effect of temperature.

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MATERIALS AND METHODS

1. Variety, soil and compost used

A Japonica rice variety, Taichung No. 65 was used. Two kinds of soils used in this study were Pingtung slate alluvial soil with a pH of 6.8, silt clay loam in texture and Taipei sandstone and shale alluvial soil with a pH of 5.1, silt loam in texture. Crude compost, made of straw, having C/N ratio of 20, was used as a sourse of organic matter.

2. Temperature treatment

Comparison was made between in two glass-houses, one with windows closed and the other with windows opend as same as used in previous studies.

3. Design

Two temperature plots, two kinds of soil (Pingtung and Taipei soils) and two different rates of compost (50 g and no application) were examined in an experiment of factorial design with five replications. Two levels of each treamental factor are represented in the following symbols and total of eight treatments is showed in Tabel 1.

Table 1. Experimental treatments

Symbol	Treatment
(1) HPM	High temperature plot, Pingtung soil, Compost application
(2) HPO	〃 〃 No compost
(3) HTM	〃 Taipei soil, Compost application
(4) HTO	〃 〃 No compost
(5) LPM	Low temperature plot, Pingtung soil, Compost application
(6) LPO	〃 〃 No compost
(7) LTM	〃 Taipei soil, Compost application
(8) LTO	〃 〃 No compost

4. Conditions of pot culture

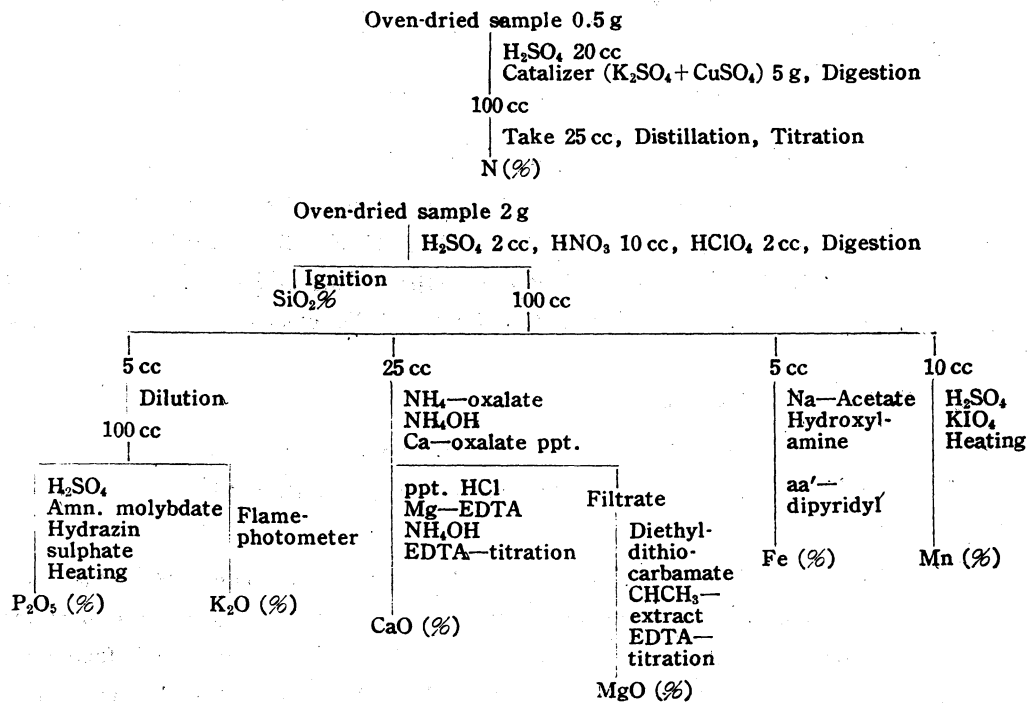
Each pot was filled with 12 kg of soils and was dressed with ammonium sulphate, calcium superphosphate, potassium sulphate at the rate of 1 g each of N, P_2O_5 and K_2O. In addition to the chemical fertilizer, 50 g of air-dried compost was added to the compost plot. Five rice seedlings were planted in each pot.

5. Chemical analysis

Plants after harvesting were dried in an electric oven and pulverized for chemical analysis. Inorganic constituents in grain and straw parts were determined respectively. The method is showed in below:

a) N—Semi-micro Kjeldahl method.

b) P—Mo-blue method using hydrazin sulphate as reducing reagent.[3]



c) K—Flame photometric method.

d) Ca, Mg—Chelate titration, EDTA-method.[4]

e) Si—Gravimetric determination.

f) Fe—Colorimetric method using aa'-dipyridyl.[3]

g) Mn—Colorimetric method using KIO_4.[3]

RESULTS AND OBSERVATION

1. Agronomic characters of plants

The average temperatures during the growing period in the glass-houses are showed in Table 2. The high temperature plot had always 2°–3°C higher than the low temperature plot.

Table 2. Average temperatures

	1st crop, 1961 (Mar. 3–July 3)			2nd crop, 1961 (July 25–Nov. 17)		
	Max.	Min.	Mean	Max.	Min.	Mean
High-temp. glass-house	33.6°C	19.8°C	25.7°C	37.9°C	23.3°C	30.6°C
Low-temp. glass-house	29.8°C	18.9°C	24.2°C	34.6°C	22.4°C	28°5°C
Difference	3.8°C	1.2°C	2.5°C	3.3°C	0.9°C	2.1°C

Plant length, tiller number, plant weight, heading date and other characters were measured at successive growing stages. The results are shown in the following tables.

Table 3. Measurements at maturity

Season	Treatment	Total yield (g/pot)	Grain yield (g/pot)	Straw yield (g/pot)	Plant length (cm)	Tiller number
1st crop	(1) HPM	71.9	33.0	38.9	125.8	16.2
	(2) HPO	83.4	38.6	44.8	126.8	19.5
	(3) HTM	87.8	35.6	52.2	125.0	25.0
	(4) HTO	73.7	32.1	41.6	121.5	21.8
	(5) LPM	71.4	33.0	38.4	120.2	18.8
	(6) LPO	83.7	40.3	43.4	124.2	20.5
	(7) LTM	87.7	40.3	47.4	117.2	24.8
	(8) LTO	70.3	30.5	39.8	121.8	23.0
	L.S.D. 5%	10.62	8.48	6.89	6.99	2.52
	L.S.D. 1%	14.39	11.47	9.33	9.48	3.42
2nd crop	(1) HPM	71.9	25.6	46.3	117.6	18.6
	(2) HPO	83.9	34.8	49.1	129.8	21.6
	(3) HTM	91.1	35.6	55.5	135.0	25.2
	(4) HTO	78.1	34.4	53.7	136.8	24.0
	(5) LPM	64.5	19.1	45.5	120.2	23.0
	(6) LPO	74.8	24.8	50.1	123.8	19.2

(7) LTM	63.7	22.7	41.0	130.0	22.0
(8) LTO	66.5	26.1	40.4	127.6	22.4
L.S.D. 5%	4.17	7.44	6.62	7.30	3.87
L.S.D. 1%	7.56	10.01	8.81	9.80	5.21

Note: 1. The data were average of 5 replications.
2. The yields were measured after oven-drying.

Table 4. The interaction of soil and compost on grain yield of the 1st crop (g/pot)

Soil \ Compost	M	O	Diff.
P	33.0	38.6	− 5.6
T	39.4	31.3	8.1
Diff.	− 6.4	7.3	− 13.7
L.S.D. 5%	6.0		
L.S.D. 1%	8.1		

Note: 1. The interaction of soil and compost was significant at 1% level.
2. The data were average of 10 replications.

Table 5. The interaction of soil and compost on straw yield of the 1st crop (g/pot)

Soil \ Compost	M	O	Diff.
P	38.6	44.1	− 5.5
T	49.8	40.7	9.1
Diff.	− 11.2	3.4	− 14.6
L.S.D. 5%	4.9		
L.S.D. 1%	6.6		

Note: 1. The interaction of soil and compost was significant at 1% level.
2. The data were average of 10 replications.

Table 6. Effects of temperature and compost on grain yield of the 2nd crop (g/pot)

Treatment	Grain yield	Treatment	Grainyield
Temperature H	32.6	Compost M	25.8
Temperature L	23.2	Compost O	30.0
L.S.D. 5%	3.7		
L.S.D. 1%	5.0		

Note: 1. Temperature and compost treatments were significant at 1% and 5% levels respectively.
2. The data were average of 20 replications.

Table 7. The interaction of temperature and soil on straw yield of the 2nd crop (g/pot)

Temperature \ Soil	P	T	Diff.
H	47.7	54.9	− 6.9
L	47.8	40.7	7.1
Diff.	− 0.1	13.9	− 14.0
L.S.D. {5%	5.3		
L.S.D. {1%	7.1		

Note: 1. The interaction of temperature and soil was significant at 1% level.
2. The data were average of 10 replications.

Table 8. Heading dete

	1st crop, 1961		2nd crop, 1961	
	Taipei soil	Pingtung soil	Taipei soil	Pingtung soil
High-temp. plot	7/VI-12/VI	1/VI- 4/VI	7/X-14/X	6/X-12/X
Low-temp. Plot	14/VI-19/VI	7/VI-10/VI	9/X-16/X	3/X-10/X

Note: The data were average of 10 replications.

Elongation of plants was apparently promoted by the high temperatures during growth period. Plant length of Pingtung soil was longer than that of Taipei soil, and with application of compost plant length of Pingtung soil was generally retarded while that of Taipei soil was increased. More tiller number was found in Taipei soil than in Pingtung soil.

In the first crop, application of compost gave detrimental effect to rice yields in Pingtung soil while Taipei soil was benifited by it. In the second crop, the high temperature increased grain yield in both soils and increased straw yield in Taipei soil. Application of compost was obseved detrimental to grain yield especially in Pingtung soil.

Plants in the high temperature plot headed seven days earlier in the first crop than those in the low temperature plot and two days earlier in the second crop. Kinds of soils also showed difference in heading date. Plants grown in Pingtung soil generally headed earlier than in Taipei soil. The difference of plant length, tiller number and heading date between these two soils may be due to their difference in plant nutrition caused by different fertilities.

2. Nutrient absorption

As shown in Table 9 and 10, soil effected greatly on nutrient contents of plants especially in straw, but temperature and compost appeared to have less effect on nutrient contents. As for straw, plants grown in Pingtung soil generally had higher contents of K, Si, Mn and lower contents of N, P and Fe than Taipei soil. It seemed that Taipei soil was deficient in available Si and Mn. Temperature effected mostly

on K contents. The high temperature significantly increased K contents and decreased N contents.

As shown in Table 11 and 12, the high temperature somewhat increased potassium absorption. Kind of soil effected mostly on nutrient absorption, e.g. plants absorbed more amounts of N, P and Fe but less of Si and Mn in Taipei soil than in Pingtung soil. It was also shown that application of compost generally gave a decrease of nutrient absorption especially in Pingtung soil. It is considered that different effect of compost in these two soils on plant growth and nutrient absorption is due to its different decomposition process in the two soils.

Table 9. Inorganic nutrient contents of plants (percentage on oven-dry basis)

Season	Treatment	Part	N (%)	P_2O_5 (%)	K_2O (%)	CaO (%)	MgO (%)	SiO_2 (%)	Fe (%)	Mn (%)
1st crop	(1) HPM	Grain	1.38	0.674	0.468	0.04	0.23	3.48	0.0031	0.0027
		Straw	0.89	0.336	2.784	0.51	0.32	12.71	0.0171	0.0458
	(2) HPO	Grain	1.38	0.702	0.504	0.03	0.18	3.57	0.0042	0.0027
		Straw	0.84	0.292	3.246	0.37	0.48	12.67	0.0211	0.0872
	(3) HTM	Grain	1.38	0.659	0.480	0.06	0.21	2.15	0.0040	0.0016
		Straw	1.12	0.488	2.924	0.60	0.37	4.22	0.0475	0.0264
	(4) HTO	Grain	1.43	0.616	0.492	0.05	0.19	2.18	0.0044	0.0015
		Straw	1.30	0.503	2.862	0.53	0.37	3.79	0.0385	0.0202
	(5) LPM	Grain	1.34	0.655	0.432	0.07	0.17	3.14	0.0053	0.0010
		Straw	1.18	0.240	3.320	0.56	0.31	13.57	0.0208	0.0470
	(6) LPO	Grain	1.35	0.727	0.444	0.03	0.21	2.97	0.0050	0.0028
		Straw	0.85	0.336	3.024	0.51	0.40	12.28	0.0212	0.0787
	(7) LTM	Grain	1.33	0.693	0.492	0.03	0.20	2.11	0.0047	0.0016
		Straw	0.98	0.402	2.614	0.52	0.49	4.90	0.0438	0.0206
	(8) LTO	Grain	1.59	0.718	0.522	0.03	0.24	1.78	0.0047	0.0014
		Straw	1.24	0.483	2.100	0.64	0.46	4.25	0.0414	0.0251
2nd crop	(1) HPM	Grain	1.45	0.679	0.456	0.08	0.20	3.23	0.0045	0.0054
		Straw	1.13	0.350	3.072	0.54	0.38	9.43	0.0306	0.0370
	(2) HPO	Grain	1.39	0.717	0.432	0.07	0.20	2.58	0.0061	0.0046
		Straw	1.00	0.363	3.072	0.56	0.43	7.07	0.0354	0.0458
	(3) HTM	Grain	1.55	0.761	0.444	0.08	0.20	2.24	0.0060	0.0027
		Straw	1.26	0.486	2.712	0.45	0.48	4.34	0.0388	0.0206
	(4) HTO	Grain	1.56	0.657	0.450	0.07	0.21	1.79	0.0043	0.0017
		Straw	1.20	0.480	2.688	0.46	0.50	4.10	0.0459	0.0140
	(5) LPM	Grain	1.73	0.906	0.426	0.08	0.23	3.65	0.0123	0.0087
		Straw	1.21	0.482	2.400	0.40	0.43	8.32	0.0333	0.0427
	(6) LPO	Grain	1.48	0.710	0.450	0.06	0.23	3.51	0.0210	0.0069
		Straw	1.21	0.411	2.640	0.51	0.46	6.37	0.0388	0.0674
	(7) LTM	Grain	1.48	0.656	0.492	0.08	0.20	1.94	0.0115	0.0043
		Straw	1.36	0.413	2.748	0.57	0.51	5.21	0.0848	0.0371

(8) LTO	Grain	1.49	0.720	0.468	0.05	0.24	2.02	0.0148	0.0037
	Straw	1.34	0.447	2.448	0.42	0.61	5.06	0.1080	0.0276

Note: The data were average of duplication.

Table 10. Variance analysis on nutrient contents of plants

Season	Source of variace	N		P_2O_5		K_2O		CaO		MgO		SiO_2		Fe		Mn	
		Str.	Gr.	Str.	Gr.	Str.	Gr.	Str.	Gr.	Str.	Gr.	Str.	Gr.	Str.	Gr.	Str.	Gr.
1st crop	Temperature	N	N	*	N	*	N	**	N	N	N	N	N	N	**	N	N
	Soil	N	*	**	N	**	N	**	N	N	*	**	**	**	N	**	*
	Temp.×Soil	N	N	N	N	**	**	*	N	*	**	N	N	N	N	N	N
	Compost	N	**	*	N	N	**	*	N	*	N	N	N	N	N	**	N
	Temp.×Compost	N	*	*	N	**	N	**	N	N	**	N	**	N	N	N	N
	Soil×Compost	N	**	N	N	*	N	**	N	*	*	N	N	N	N	**	N
	Temp.×Soil×Compost	N	*	N	N	N	N	N	N	N	N	N	N	N	N	N	N
2nc crop	Temperature	*	*	N	N	**	N	N	N	**	N	N	N	*	**	**	**
	Soil	**	N	N	N	*	N	N	N	**	N	**	**	*	N	**	**
	Temp.×Soil	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Compost	N	*	N	N	N	N	N	N	**	N	**	N	N	*	N	N
	Temp.×Compost	N	N	N	N	N	N	N	N	N	N	N	N	N	*	N	N
	Soil×Compost	N	**	N	N	N	N	N	N	N	N	**	N	N	N	**	N
	Temp.×Soil×Compost	N	*	N	**	N	N	N	N	N	N	*	N	N	N	N	N

Note: 1. Symbols *, **, and N represent significant at 5% level, 1% level and no significant.
2. Theoretical F values are 5.32 and 11.26 at 5% and 1% levels respectively.

Table 11. Amounts of nutrients absorbed by rice plants (mg/pot)

Season	Treatment	N	P_2O_5	K_2O	CaO	MgO	SiO_2	Fe	Mn
1st crop	(1) HPM	801	353	1,237	211	200	6,092	7.7	18.7
	(2) HPO	909	402	1,649	178	284	7,054	11.1	40.0
	(3) HTM	1,076	490	1,697	334	268	2,968	26.4	14.6
	(4) HTO	1,000	407	1,349	236	215	2,277	17.4	8.9
	(5) LPM	895	308	1,418	236	175	6,247	9.7	18.3
	(6) LPO	913	439	1,491	233	259	6,527	11.2	35.1
	(7) LTM	997	468	1,439	259	313	3,172	21.9	10.4
	(8) LTO	979	411	995	264	256	2,235	17.9	10.4
2nd crop	(1) HPM	894	336	1,539	271	227	5,193	15.3	18.5
	(2) HPO	975	427	1,658	299	281	4,369	19.5	24.1
	(3) HTM	1,251	541	1,663	279	337	3,206	23.6	12.4
	(4) HTO	1,181	484	1,598	271	340	2,818	26.2	8.1
	(5) LPM	881	392	1,173	197	240	4,483	17.5	21.1
	(6) LPO	973	382	1,435	270	287	4,011	24.6	35.5

(7) LTM	894	318	1,239	252	254	2,576	37.4	16.2
(8) LTO	930	369	1,111	183	309	2,571	47.5	12.1

Table 12. Amounts of nutrients absorbed as influenced by main treatments (mg/pot)

Season	Treatment		N	P_2O_5	K_2O	CaO	MgO	SiO_2	Fe	Mn
1st crop	Temperature	H	947	438	1,483	215	242	4,598	15.7	20.6
		L	946	407	1,336	249	251	4,545	15.2	18.6
	Soil	P	880	376	1,449	215	230	6,480	9.9	28.0
		T	1,013	469	1,370	248	263	2,663	20.9	11.1
	Compost	M	942	430	1,448	236	239	4,620	16.4	15.5
		O	950	415	1,371	228	253	4,523	14.4	23.6
2nd crop	Temperature	H	1,075	447	1,615	280	296	3,897	21.2	15.8
		L	920	365	1,240	226	273	3,410	31.8	21.3
	Soil	P	931	384	1,451	259	259	4,514	19.2	24.8
		T	1,064	428	1,403	246	310	2,793	33.7	12.2
	Compost	M	980	397	1,404	250	265	3,865	23.5	17.1
		O	1,015	416	1,451	256	304	3,442	29.5	19.9

SUMMARY

Agronomic characters and nutrient absorption of rice plants, Taichung No. 65, under the following treatments were investigated using pot culture. Two temperature plots (different temperatures in two glass-house), two kinds of soils (Pingtung slate and Taipei sandstone and shale alluvial soils) and two different rates of compost (50 g per pot and no application of crude compost), thus total of eight treatments were examined in an experiment of factorial design.

The high temperatures promoted plant length and heading date and increased the yields in the second crop. The high temperature also increased K contents and decreased N contents of straw. Total amounts of K absorption were generally increased by high temperatures.

Kind of soil gave distinctly different characters on plant growth. Plant length was longer and tiller number was less in Pingtung soil than in Taipei soil. Plants grown in Pingtung soil had more absorption of K, Si, Mn and less of N, P and Fe than in Taipei soil. It seems that Taipei soil is deficient in available Si and Mn.

Effect of compost shown a significant interaction with soil on rice yield especially in the first crop. Application of crude compost shown detrimental effect to the yield in Pingtung soil while Taipei soil was beneifited by it. It is considered that some specific characters of these two soil caused different decomposition process of compost which in turn effect on crop yields.

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臺灣水稻之養分吸收之研究(第三報)

在屏東與臺北土壤，施用與不施堆肥及不同溫度之下水稻之養分吸收

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摘　要

以水稻臺中65號舉行玻璃室盆栽試驗，比較在屏東粘板岩冲積土及臺北砂岩頁岩冲積土，施用與不施堆肥，並在不同溫度處理下之水稻生育性狀和養分吸收。試驗仍如前報，於兩玻璃室內進行，其一係玻璃窗開啓，另一則關閉以做爲比較上之高低溫區。如此水稻生育期間，高溫區平均溫度高於低溫度約 2.1°C～2.5°C。所施用之堆肥爲碳氮比率20之半熟稻藁堆肥，其結果如下：

(1) 溫度之影響：高溫均促進株高，抽穗期及增加第二期作之收量。高溫也增加稻藁之鉀含有率而減低氮含有率並使鉀之吸收量增加。

(2) 土壤之影響：土壤種類對水稻生育及養分吸收之影響有顯著的差異。屏東土壤之水稻比臺北土壤者，其株高長，分蘗數少及對鉀、矽、錳之吸收量較多而氮、磷、鐵之吸收量較少。臺北土壤表示有缺乏有效型態矽及錳。

(3) 堆肥之影響：堆肥之施用與土壤對第一期作穀藁收量有顯著的交感作用，即堆肥之施用對屏東土壤之水稻生育有阻害而減少收量，對臺北土壤反而增加收量。此可推想爲此種半熟堆肥在兩種土壤中之分解過程不同而所生成之分解產物有異以致對水稻生育有不同影響。

各主要處理對收穫時稻藁之無機成分含有率之影響如下表。

主要處理對稻藁無機成分含有率之影響（烘乾物百分率）

期作	處理		N (%)	P_2O_5 (%)	K_2O (%)	CaO (%)	MgO (%)	SiO_2 (%)	Fe (%)	Mn (%)
第一期	溫度	高溫	1,04	0.405	2,954	0.50	0.39	8,35	0.0311	0.0449
		低溫	1.06	0.365	2.765	0.56	0.42	8.75	0.0318	0.0429
	土壤	屏東	0.94	0.301	3.094	0.49	0.38	12.81	0.0201	0.0648
		臺北	1.16	0.469	2.625	0.57	0.42	4.29	0.0428	0.0231
	堆肥	施用	1.04	0.367	2.911	0.55	0.37	8.85	0.0323	0.0350
		不施	1.06	0.404	2.808	0.51	0.43	8.25	0.0306	0.0528
	平均		1.05	0.385	2.860	0.53	0.40	8.55	0.0315	0.0439
第二期	溫度	高溫	1.15	0.420	2.886	0.50	0.45	6.24	0.0377	0.0294
		低溫	1.28	0.438	2.559	0.48	0.50	6.24	0.0662	0.0437
	土壤	屏東	1.14	0.402	2.796	0.50	0.43	7.80	0.0345	0.0482
		臺北	1.29	0.457	2.649	0.48	0.53	4.68	0.0694	0.0248
	堆肥	施用	1.24	0.433	2.733	0.49	0.45	6.83	0.0469	0.0344
		不施	1.19	0.425	2.712	0.49	0.50	5.65	0.0570	0.0387
	平均		1.22	0.429	2.723	0.49	0.48	6.24	0.0520	0.0366