農業研究

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半矮稻遺傳之研究*

(Genetic study on Semi-dwarf Rice)

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一、緒　言

品種改良或作物育種，一般認爲是提高產量最有效之方法。爲適應本省氣候環境，水稻育種之目標側重於株型直立而矮，耐肥，豐產品種之各項條件上。目前台灣所育成之新品種，合乎上述條件者，有台中在來一號等。不過所有新品種中很難有超過現有標準品種產量5%以上者，其中原因固多，而對於親本遺傳組成之瞭解，以獲得所期待之遺傳型可能爲最有效途徑之一。

欲獲得適合於育種條件之雜交親本，本試驗乃就矮稻之特性，詳加研究，如耐肥性，外界因素對矮性因子之影響（植物生長素），正常稻與矮稻雜交F_2之分離情形及數量性狀之遺傳因子分析，遺傳率及相關等，俾供今後稻作育種之參考。

二、試驗材料與方法

以由放射線處理所得矮稻13種與其親本品種6種爲材料，其系統號及主要性狀列如表1：

Table 1. 試驗品種之來源及性狀

品種名種	來源	主要性狀
D-65-1	臺中65號	株高 51cm，密穗，谷粒中。
D-65-2	臺中65號	〃 55cm，短穗，穗軸扭曲。
D-65-3	臺中65號	D-65-1×D-65-2 後代中選出，株高 30cm。
M-65-5	臺中65號	株高 77cm，分蘖8～10支，細葉。
M-65-6	臺中65號	〃 81cm，分蘖10～20支，細葉。
D-8-1	嘉南8號	〃 30cm，分蘖較多，細葉。
D-8-7	嘉南8號	〃 60cm，中部節間2-3節特短。
D-27-9	高雄27號	〃 30cm，分蘖多，葉梢黃色。
D-155-5	臺中155號	〃 30cm，細葉。
D-155-8	臺中155號	〃 66cm，分蘖數多，谷粒大，穗較一般矮稻長。
D-155-43	臺中155號	〃 72cm，谷粒大，葉較穗長、葉直立。
C-2180	臺中155號	〃 60cm，細葉、分蘖多。
D-242-2	嘉農242號	〃 30cm，分蘖多，30～50支。
P-123	臺中65號代號	〃 104cm。
P126	臺中155號代號	〃 142cm。

* 本研究承國家科學委員會之補助，萬所長之指正，及謝主任順景多方面指教，謹此一併誌謝。

P128	臺中糯46號代號	〃 110cm。
P176	稗 稈 稻 代 號	正常株高，無葉舌。
7102	Nagao's 選 系	株高 112cm。
H106	稗稈稻 ×C2180	〃 54cm，分蘖多，細葉，無葉舌。

將以上所選用之材料，突變矮稻與未經處理之正常植株或親本雜交，或矮稻間相互雜交，經過F_1之 Screening test,選取適於此研究之組合爲F_2，F_2之田間同時種植雙親，單本植，行株距爲 25×25cm，雙親種植 100 株以上，F_2植株300株以上，田間管理依一般慣例進行。調查項目有株高、分蘖數、穗數、穗長、抽穗期、結實率等。

依據上述所調查之性狀，除採用 Mather 氏和 Powers氏之方法分析遺傳因子外，並用下列公式計算遺傳率及相關：

$$\text{Hertability}=\frac{V_{F_2}-V_E}{V_{F_2}}$$

V_{F_2}=Total F_2 Variance observed

$V_E=\frac{1}{2}(V_{P_1}+V_{P_2})$

r_P=Phenotypic correlation coefficient.

r_G=Genotypic correlation coefficient.

r_E=Environmental correlation coefficient.

$$r_P=\frac{\text{Cov. xy } F_2}{\sqrt{VxF_2 \cdot VyF_2}}$$

$$r_G=\frac{CovxyF_2-CovxyE}{\sqrt{(VxF_2-VxE)(VyF_2-VyE)}}$$

$$r_E=\frac{\text{Cov}\cdot xyE}{\sqrt{VxE \cdot VyE}}$$

三、試 驗 結 果

Ⅰ、水稻株高之遺傳因子分析

(1)突變矮稻與正常稻雜交後代之分離情形。

突變矮稻與正常稻雜交之後代，F_1植株高度正常，F_2爲 3 高：1 矮之分離比，因此可知支配矮稻之遺傳因子爲一對，且爲隱性因子。如表 2

(2)表 3 及圖 1 — 3 所示，係兩突變矮稻互交之結果，F_1 爲正常，F_2則分離爲 9 正常：3 矮-Ⅰ：3 矮-Ⅱ型：1 特矮型。故特矮型乃爲雙隱性矮稻（Double recessive dwarf），而D-65-1與D-65-2或D-65-3, D-65-2 與 D-8-5, D-8-7, D-8-8, D-8-16, La-8-25, D-155-5, D-242-2等所帶有的矮稻因子不同。假定-65-1 爲d_1則 D-65-2 及 D-65-3 爲d_2，而其餘各矮稻，因無彼此間的交配，故假定其亦爲d_2，但是否矮稻因子僅有d_1及d_2,則需作進一步之研究。

Table 2. Segregating ratios for dwarfness in F_2

Cross	Normal	Dwarf	Total	Expected ratio	X^2	P
P123 x D-65-1	201	72	273	3:1	0.202	0.5-0.7
P123 x D-65-2	122	43	165	3:1	0.009	0.7-0.8

P138 x C2180	238	62	300	3:1	3.004	0.05–0.10
P138 x D-242-2	242	65	307	3:1	2.199	0.10–0.20
P176 x D-155-5	236	61	297	3:1	3.153	0.05–0.10
P126 x C2180	241	74	315	3:1	0.382	0.5–0.7
P126 x M-155-5	220	80	300	3:1	0.444	0.5–0.7
7102 x D-155-5	228	70	298	3:1	0.362	0.5–0.7
7102 x D-8-9	297	101	398	3:1	0.030	0.8–0.9
7102 x M-8-7	217	78	295	3:1	0.327	0.5–0.7
D-65-2 x M-65-6	167	66	233	3:1	1.275	0.2–0.3
D-65-3 x D-65-1	179	60	239	3:1	0.002	0.9–0.95

Table 3. Segregating Ratios of Normal and Dwarf Types in F_2 Population of Crosses among Dwarf Mutants.

Crosses	Normal D_1–D_2–	Dwarf – I D_1–d_2d_2	Dwarf – II $d_1d_1D_2$–	Double dwarf $d_1d_1d_2d_2$	Total	Expected ratio	X^2	P
D-65-1 x D-65-2	166	42	50	24	282	9:3:3:1	5.042	0.1–0.2
D-65-1 x D-65-3	158	67	52	21	289	〃	3.338	0.3–0.5
D-65-2 x D-8-5	186	53	47	11	297	〃	6.713	0.05–0.10
D-65-2 x D-8-7	176	57	55	10	298	〃	4.446	0.2–0.3
D-65-2 x D-8-8	189	48	41	19	297	〃	7.920	0.02–0.03
D-65-2 x D-8-16	173	56	49	16	294	〃	1.353	0.7–0.8
D-65-2 x La-8-25	167	48	65	23	303	〃	3.457	0.3–0.5
D-65-2 x D-155-5	170	60	59	15	304	〃	1.076	0.7–0.8
D-8-1 x D-242-2	181	53	52	11	297	〃	4.617	0.2–0.3



Fig. 1. Two dwarf mutants derived from Taichung No. 65 and their F_1 plants. Left, D-65-1, middle F_1, right D-65-2

Fig. 2. Two grassy dwarf mutants and their F_1 plant. Left, D-8-1, middle F_1, right D-242-2.

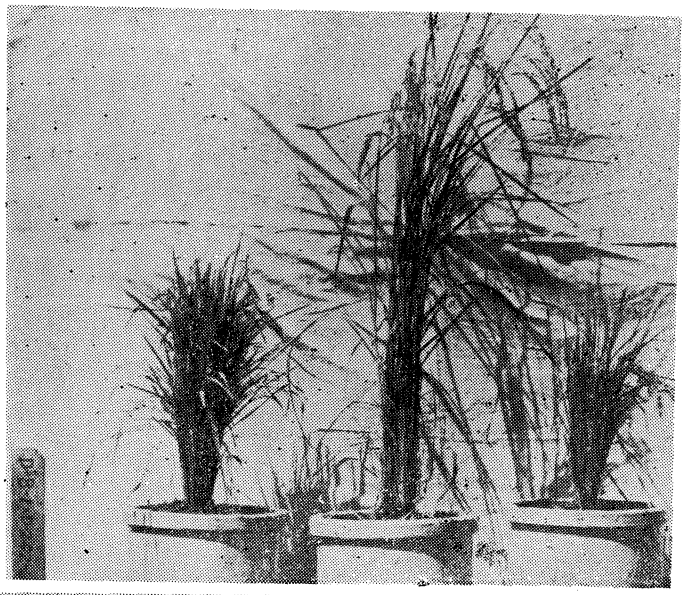




Fig. 3. Four segregates in F_2 from cross between two dwarf mutants. From left to right: Normal, D-65-1 type, D-65-2 type and new double recessive type.

Ⅱ、水稻數量性狀之遺傳因子分析

水稻之株高、分蘖數、穗長等農藝性狀，如何遺傳爲一有趣味的問題，爲明瞭此點，曾做不同之雜交組合，並觀察其在F_1及F_2之分離情形。玆將其結果示於表4—6。

表4．株高之遺傳因子分析

Table 4. Sgregation for plant height in F_2

Crosses	Variation of plant height in cm												Total	Segregation ratio	X^2	P
	140	130	120	110	100	90	80	70	60	50	40	30				
D-242-2										1	15	12	28			
D-27-9										2	15	3	20			
7102				4	12	11	3						30			
D-242-2 x 7102			1	4	30	105	64	8	7	5	32	29	3	298	3:1	0.441	0.5-0.7
						229 (223.5)						69 (74.5)				
D-242-2 x D-27-9					20	62	16	2	2	1	26	48	3	180	9:7	0.011	0.9-0.95
						102 (101.3)						78 (78.7)				

7102是正常系統，其高度爲100～110cm左右，當此系統與矮稻 D-242-2（約30～40cm高）雜交時，F_1爲正常高度（100～120cm）；F_2之株高分佈於40～140cm之間。株高之分佈成雙峯曲線，若將自雙峯之接聯處分爲高及矮二羣時，則適合於3：1之比例，表示 D-242-2受單一隱性矮性因子所控制，當 D-242-2與另一矮性系統 D-27-9 雜交時，在F_2 同樣表示雙峯曲線分佈，適合於9：7之分離比，株高值介於 70-110cm 之間，較雙親（介於30～50cm）爲高，表示由於兩個不同矮性互補因子之作用（Complementary effect）。今假定 D-242-2 之因子型爲 d_1 d_1 D_2 D_2，D-27-9 因子型爲D_1 D_1 d_2 d_2，則正常高度植株之因子型爲 D_1 D_1 D_2 D_2，矮株之遺傳型爲d_1 d_1 D_2，D_1 - d_2 d_2或 d_1 d_1 d_2 d_2，故造成分離比例爲9：7。

表5．分蘖數之遺傳因子分析

Table 5. Segregation for number of tillers in F_2

Crosses	Variation of number of tiller															Total	Segregation ratio	X^2	P
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75 80				
D-242-2					2	1	4	3	2	1	1	2	3	2		21			
D-27-9						1	1	1	1	2	3	1	2	1		13			
D-8-1					1	2	1	3	3	4	5	1	1			20			
7102	29	1														30			
D-242-2 x 7102	142	86	5	11	22	12	9	6	2	3	1					299	3:1	1.363	0.2-0.2
		233 (224.25)					66 (74.75)												

D-242-2 x 2-27-9	14 65 23 10 (112, 96.75) 9 10 10 10 15 3 2 1 (60, 75.25)	172	9:7	5.495	0.01-0.2
D-8-1 x D-242-2	33 117 17 7 (174, 156.4) 8 20 24 19 14 8 5 3 1 1 1 (104, 121.6)	278	9:7	4.538	0.02-0.05

7102之分蘖僅5支左右，但 D-242-2, D-27-9 及 D-8-1等突變矮稻之分蘖數非常多，介於25—70支之間。當分蘖少的7102與分蘖多的 D-242-2雜交時，在 F_1 分蘖數少，但在 F_2 則分離爲 3 分蘖少：1 分蘖多之比例。雖然分蘖爲一數量性狀，但在本研究範圍內僅由一對遺傳因子所支配，分蘖少爲顯性因子，當二多分蘖之矮稻相互雜交時（如 D-242-2×D-27-9）及（D-8-1×D-242-2），F_1正常（圖 2）分蘖數10—14支間，其F_2則分離爲 9 少分蘖及 7 多分蘖之比例，表示支配各矮性系統分蘖數之遺傳因子不同，彼此之間有互補作用。

表 6． 穗長之遺傳因子分析

Table 6. Segregation for panicle length in F_2

Crosses	Variation of panicle length in cm (28 26 24 22 20 18 16 14 12 10 8 6 4 2)	Total	Segregation ratio	X^2	P
D-8-1	6 5 10 2 2 1	26			
D-242-2	1 15 6 4 2 1	29			
D-27-9	3 10 7	20			
D-8-1 x D-242-2	1 5 28 60 42 13 (149, 150.8) 6 3 9 51 38 10 2 (119, 117.2)	268	9:7	0.049	0.8-0.9
D-242-2 x D-27-9	1 13 24 32 16 6 (92, 91.1) 5 16 32 16 1 (70, 70.9)	162	9:7	0.020	0.9-0.95

穗長的情形在本研究中與株高相同，當二短穗之突變系統雜交時，F_1爲正常穗長，且有超越親本的現象（圖 2），F_2則分離爲正常穗長與短穗二羣，其比例爲 9 ： 7 ，表示同樣受兩對有互補作用之遺傳因子所支配。

Ⅲ、 矮稻與正常稻雜交，雜種第二代數量性狀遺傳及相關之研究

爲明瞭矮稻各數量性狀之遺傳率及遺傳相關，乃進行雜交，將双親，F_2之資料用上述方法求遺傳率（Heritabililty）及遺傳相關（genetic correlation）。茲將統計結果示於表 7 — 9 。

表 7． P_1, P_2, F_2 各農藝性狀之平均值

Table 7. Means of five agronomic characters of the parents and their coresponding F_2 populations in eight rice crosses.

Parents	P123	P176	H106	D-65-2	M-65-5	M-65-6	D-155-5	D-155-8	D-155-48
Heading date (days)	98	88	103	98	103	92	88	98	92
Plant of height (cm)	104	111.9	54.9	71.4	77.9	81.2	67.2	66.2	72.9

Number of tillers	12	9.2	19.7	13.8	11.9	16.5	16.3	22.2	13.6
Number of panicles	10.2	8.4	12.8	12.8	10.9	14.6	13.4	16.9	11.4
Length of panicle (cm)	19.5	23.1	14.2	12.9	17.2	14.9	14.3	15.2	13.2

Crosses (F_2)	P123 x D-65-2	H106 x D-65-2	D-65-2 x M-65-5	D-65-2 x M-65-6	P176 x D-155-5	D-155-5 x D-155-8	P126 x D-155-48	D-155-48 x D-155-5
Heading date (days)	88	80	82	88	88	86	84	82
Plant of height (cm)	94.8	81.3	81.2	83.6	80.5	89.5	82.9	83.3
Number of tillers	11.5	13.0	13.1	11.6	11.4	11.5	10.1	11.5
Number of panicles	10.0	10.9	11.7	10.3	8.9	9.6	9.1	10.9
Length of panicle (cm)	18.1	17.0	16.4	17.8	19.3	19.0	19.0	17.2

本試驗之親本各農藝性狀（如生育日數、株高、分蘖數、穗數、穗長等），隨品種之不同而變異很大，但雜交後各組合 F_2 之平均值變異較少。例如親本之生育日數介於 88～103 天，但在 F_2 則介於 82—86天，其他各性狀亦有相同的傾向。

表 8．各數量性狀之遺傳率

Table 8. Heritability estimates for five agronomic characters in various crosses

Crosses	D-65-2 x H106	D-65-2 x P123	D-65-2 x M-65-5	M-65-5 x M-65-6	P176 x D-155-5	P176 x D-155-8	P176 x D-155-48	D-155-48 x D-155-5
Heading date (days)	62.3	60.6	65.3	68.1	67.5	64.3	62.8	66.4
Plant height (cm)	85.0	78.0	48.0	95.8	86.3	80.5	84.0	89.0
Number of tillers	0	35.3	35.0	4.1	0	26.7	41.2	43.0
Number of panicles	48.0	0	55.0	0.8	13.1	40.1	0	0
Length of panicles (cm)	38.3	79.5	72.3	54.1	46.0	85.7	78.8	71.2

表 8 之八個雜交組合中，生育期間之遺傳率甚高，介於62.3～68%，株高則介於48～96%，分蘖數變異較大，介於4～43%，穗數則介於0.8～54%，穗長則介於38～86%可知除分蘖數，穗數較低外，其他各性狀之遺傳率均甚高。

表 9．各性狀間之遺傳相關與環境相關

Table 9. Phenotypic, genotypic, and environmental correlation coefficients between Characters of F_2 populations.

Characters correlated	Correlation coefficients								
	D-65-2x P123			P126 x D-155-5			P176 x D-155-8		
	r_P	r_G	r_E	r_P	r_G	r_E	r_P	r_G	r_E
Plant height and number of tillers	0.7191**	0.1017	0.0299	-0.4232	0.9586**	0.2467	-0.4177	-	-
number of panicles	0.0199	-	0.2813	0.3973*	-	0.1188	-0.1506	-	-

length of panicle	0.4139*	0.4719*	0.2007	0.9443**	0.7133**	0.0638	0.5001**	0.5456**	0.3342*
Number of tillers and number of panicles	0.8648**	-0.6405	0.8147**	0.7651**	- -	0.1241	0.4809*	-	-
length of panicle	0.0441	0.3422*	0.2079	-0.3680	-	0.2220	-0.2395	-	-
Number of panicles and length of panicle	-0.4478	-	0.2228	0.00298	-	0.2813	-0.0288	-0.1951	0.2002

* Significant at 5% level

** Significant at 1% level

D-65-2×P123組合內，株高與分蘖數之表現型相關（r_P）甚高，$r_P=0.79$，但遺傳相關（r_G）爲0.1017，與環境相關（r_E）爲0.0299甚低。但在 P176×D-155-5，則 $r_P=0.423$，$r_E=0.246$，而 $r_G=0.958$，增高甚多，可知三種相關係數因雜交組合不同及受環境之影響很大，分蘖數與穗數、穗長等之情形亦同。

四、討　　論

本研究中所用矮稻突變體，與正常親本雜交後，其F_1爲正常，在F_2則分離爲3正常：1矮之比例，若將此互交時則 F_2 呈9：3：3：1之比例，表示各矮稻由各不相同的一對隱性遺傳因子所支配。本研究中共有14種矮稻，除 H106 之矮性，遺傳因子爲 d_{12}（謝、嚴，1966）之外，其他各系統之遺傳因子（d）在染色體上之位置及其在遺傳因子間之關係尚不明瞭。H106 所帶 d_{12} 已知在第二連鎖羣（Linkage group），且已知與無葉舌因子lg與石炭酸反應因子 ph 等有連鎖關係，本研究中之其他矮性遺傳因子，假如與 d_{12}，lg 及 pi 之間未找到連鎖關係時，一定位在其他連鎖羣上。Nagao and Takahashi（1967）已報告水稻中存d_1……d_8等八個矮稻遺傳因子，其在 Linkage map的位置亦已明瞭。本研究中之各 d 遺傳因子應與日本的 gene marker 雜交，以檢定本試驗中之矮性遺傳因子是否與 Nagao and Takahashi（1967）的相同，關於此點正在研究中。

本研究中曾將二矮稻互交，觀察其 F_1 及 F_2 各數量性狀之分離情形，在兩個組合 D-242-2×D-27-9，與 D-8-1×D-242-2 內，F_2株高之分離爲9：7，其他性狀如分蘖數、穗長、結實率等均同樣呈9：7之分離比，此等分離比表示支配此等性狀之二對因子間有互補作用（Complementary effect）之影響。此等遺傳因子表現之情形與矮性因子完全相同，可能受了d因子之多種效果（Pleiotropic effect）影響所致。即矮稻株高變爲正常稻時，穗長、分蘖數、穗數等亦隨之受影響而表現相同的遺傳行爲。數量性狀是否如上述之假說，受d因子多種效果之影響或其他生理上之影響，尚待進一步的研究。

又株高、穗長之遺傳率甚高，介於40—95%，分蘖數及穗數之遺傳率較低（介於0—55%），分蘖數及穗數可能較容易受環境的影響。此與張（1964）之試驗結果相似。株高之遺傳率較高一事，表示對目前所提倡的矮性抗倒伏品種育種過程中選拔較容易，故在育種選拔上可善用此結果。又在本研究中注意到各性狀間之環境相關，因環境不同而變異很大，遺傳相關亦因雜交組合不同而有差異，因此在育種選拔上要特別注意。

五、摘　　要

爲分析半矮稻之遺傳因子及有關問題以作實際育種之依據，乃利用由放射線誘致的矮稻計14系統及未處理之新品種6種作爲雜交親本。14種矮稻品種與正常品種雜交後F_1均爲正常，F_2則顯示3正常

：1矮之比率，當兩種矮稻互交時，F_1爲正常，F_2則分離爲9正常：3矮—Ⅰ型：3矮—Ⅱ型：1特矮稻型」，故特矮稻型爲雙隱性矮稻（Double recessive dwarf）其遺傳因子型爲d_1 d_2。各矮稻遺傳因子與其他因子間之連鎖關係，除 H106 爲 d_{42} 而外，其他 d 各系統之連鎖關係尚未明瞭。

當矮稻系統間（D-242-2×D-27-9, D-8-1×D-242-2）彼此雜交時，株高、穗數、分蘖數、穗長等數量性狀在 F_2 呈雙峯曲線（Bimodal Curve）之分離，若由二峯之間分開時，則呈9：7之分離比，表示由於兩對遺傳因子之互補作用之結果。就分離比及相關關係來看，認爲此等數量性狀之遺傳可能更受矮稻遺傳因子之多種效果之影響。

經計算結果，株高、穗長之遺傳率甚高，介於40～95%，但分蘖數及穗數則較低，介於0—55%，因雜交組合而不同；遺傳相關亦因雜交組合不同而異；環境相關受環境之影響很大。本研究所得環境及遺傳相關及各性狀之遺傳率資料，可作爲矮稻育種選拔時之依據。

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GENETIC STUDIES ON SEMI-DWARF RICE

by

Te-mei Chang

Summary

Sixteen semi-dwarf mutants of rice induced by irradiation were analyzed regarding number and types of genes involved. It was found that each dwarf strain is controlled by a single recessive gene. When two dwarf strains were crossed, F_1 was normal, F_2 segregated into 9 normal: 3 dwarf-I: 3 dwarf-II: 1 new dwarf. It is suggested that different semi-dwarf strains carry different dwarf genes which have cumulative effect on plant height, so that the new dwarf is considered to be double recessive.

Agronomic characters such as plant height, panicle number, number of tiller, panicle length etc. were studied with the F_2 segregating populations. A 9:7 ratio regarding the above characters were found. Based on the segregation ratios and correlation coefficients between characters, it was assumed that dwarf gene d may have pleiotropic effect on above mentioned characters. Heritability of these characters was high ranging from 40 to 95%, indicating that selection for these characters is effective. Lower heritability value for tiller and panicle number ranging from 0-55% were estimated. Since the number of tiller and panicle are contributing factors to yielding ability selection must be very careful for these two characters in breeding high yielding rice varieties.

水稻世代促進法繁殖之F_3雜交集團主要農藝性狀變異性之研究

楊　遜　謙

一、前　言

水稻之品種改良工作因農業環境之改變或因客觀條件之需要而需隨時調整其目標。按照目前本省慣行之水稻育種程序，一年只能繁殖兩世代，以如此緩慢之育種方法勢必難應付今後對育種目標之快速改變。故如何縮短育種年限之問題，不但爲目前本省水稻育種人員所關心，同時亦爲世界各地水稻或其他穀類作物育種工作者所重視（Grafius. 1965, Okabe. 1967）。在本省有關水稻世代促進法之試驗，係在嘉義農業試驗分所進行，初步結果顯示若利用世代促進法時一年之內可完成三世代之繁殖（楊、1969），並發現在世代促進法繁殖之F_2集團內，其生育日數之遺傳力相當高，有利於該性狀之選拔（楊、1970）。

世代促進法係在溫室內以極端密植及少肥狀態下栽培，不利於個別稻株之生長發育。故在世代促進法栽培環境下培育之稻株，當與在田間正常栽培環境下培育之稻株有極顯著之差別。故在這種特殊環境下繁殖之水稻什種集團，其主要農藝性狀之變異性是否與在田間栽培之什種集團相同？這一點是決定世代促進法是否值得採用之一重要關鍵，實有加以探討之必要。

本研究之目的在於明瞭同一什交組合之F_2集團在世代促進法及一般慣行法經過一世代繁殖之F_3集團，分別在室內以世代促進法及在田間以慣行法栽培時，與將兩種來源不同之F_3集團同時在田間栽培時，其主要農藝性狀變異性之異同，以供今後採用水稻世代促進法進行實際育種時之參考。

二、試驗材料與方法

本研究係利用秈型稻×秈型稻，台中在來1號× CP231 ；粳型稻×秈型稻，嘉農 242×IRP — 60；與粳型稻×粳型稻；C223×Piro4 等三種不同什交組合之 F_2 種子，將F_2種子分成兩半，一部份採用世代促進法在溫室內繁殖，另一半則以慣行法在田間栽培。世代促進法部份係將 F_2種子於58年第一期作在溫室內栽培F_2集團並繁殖F_2種子，F_3 種子分成A、B兩部份，A種子在58年第二期作繼續在溫室內依世代促進法繁殖F_3集團。B種子則將其晒乾後存放在冷藏庫內，至59年第一期作時在田間栽培。世代促進法係在溫室內以直播法種在30×60× 5 公分之鉛盤內，該盤內盛放砂及耕土各一半，充分混合攪拌後播種，行距5公分，株距1.5公分，每行種植20個體，每盤種植親本各兩行，各40個體，$F_2$11行，220個體，每組合各重複4次，播種後鉛盤放置溫室內，妥爲管理。

慣行法部份則依本分所標準耕種方法在田間栽培，58年第一期作栽培F_2集團，並繁殖F_3種子，F_3種子並依世代促進法同樣分成A、B兩部份，A部份繼續在58年第二期作種植F_3集團，而B部份則晒乾後存放在冷藏庫內，至59年第一期作與世代促進法繁殖之F_3種子一起種在田間，田間試驗部份每集團種植100～200株，單本植、親本亦同。

調查項目世代促進部份包括生育日數、株高、一穗粒數及穗長，田間部份則包括生育日數、株高、穗數與每株谷重等性狀。調查個體數世代促進部份每重複調查20株計調查80株，田間試驗部份則從每集團隨機選取80株供爲調查之用。各性狀調查所得資料則以變方分析方法估算每集團有關性狀之變

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方與變異係數，以比較其變異性。

三、試驗結果與討論

1. F_3主要農藝性狀之平均值

F_2集團以世代促進法繁殖之 F_3 種子再以世代促進法栽培 F_3 集團時，其主要農藝性狀之平均值列如表一。F_2 集團以慣行法在田間繁殖之 F_3 種子再以慣行法栽培時，其主要農藝特性列如表二。F_2 集團分別以世代促進法及慣行法栽培而其 F_3 集團同時在田間以慣行法栽培時，其主要農藝性狀之平均值列如表三。由表一及表二可以看出，以世代促進法栽培之水稻個體，其生長發育顯然受到很大之限制，尤以株高、穗長及一穗粒數爲然。以世代促進法栽培之水稻，其平均株高約爲以慣行法栽培之三分之一。前者之穗長亦短，一穗粒數極少，平均只有 3 ～12粒。本試驗結果與官崎等（1961）秋作試驗結果及筆者（1969、1970）前試驗結果頗相吻合。

表一、 以世代促進法栽培時，F_3 集團主要農藝性狀之平均值

農藝性狀	臺中在來 1 號×CP231			嘉農242號×IRP-60			C223×Piro4		
	P_1	P_2	F_3	P_1	P_2	F_3	P_1	P_2	F_3
株高（公分）	34.1	34.4	38.0	39.5	30.2	37.4	42.2	34.1	35.9
生育日數（日）	81.0	90.0	84.6	83.7	88.5	84.8	90.2	90.8	89.7
穗長（公分）	10.2	5.1	8.5	6.4	8.4	7.5	7.1	6.7	6.4
一穗粒數（粒）	12.7	3.4	9.3	5.3	9.0	8.1	8.9	9.0	7.7

表二、 以慣行法栽培時，F_3 集團主要農藝性狀之平均值

農藝性狀	臺中在來 1 號×CP231			嘉農242號×IRP-60			C223×Piro4		
	P_1	P_2	F_3	P_1	P_2	F_3	P_1	P_2	F_3
株高（公分）	84.0	110.6	105.8	105.9	74.6	99.0	110.4	72.4	81.8
生育日數（日）	60.8	61.2	60.7	57.4	65.4	58.1	56.5	43.5	50.5
每株穗數（支）	14.0	6.4	10.5	8.0	16.0	9.9	12.3	14.6	13.3
每株谷重（克）	23.5	12.1	15.4	20.1	24.0	15.9	25.3	11.3	14.3

由表一及表二可知以世代促進法栽培之 F_3 集團，其生育日數大於慣行法栽培集團。其原因可能爲前者之播種期較早（5 月20日播種），而後者移植較遲（7 月20日插秧）有關，因早植水稻，其生育日數多較晚植者爲長。再者，世代促進之栽培係採用直播方式，其生育日數之計算係自播種期計算，而慣行法係採用移植方式，其生育日數之計算係自插秧期計算。這可能亦爲導致世代促進法栽培集

團生育日數較慣行法爲大之原因。雖然如此，但是生育日數受世代促進法影響較小之事實則頗明顯。楊（1970）亦曾指出這一點。

F_3 集團平均生育日數，台中在來1號×CP231之世代促進法栽培集團，其平均生育日數位在雙親之中間，但慣行法者則較雙親爲早。嘉農242×IRP—60則兩種栽培方法不同之 F_3 集團，其平均生育日數均位在雙親之間，C223×Piro4 則以世代促進法栽培者其平均生育日數早於雙親。而慣行法者位在雙親之間。F_3 集團之平均株高，台中在來1號×CP231之世代促進法栽培集團其平均株高較雙親爲高，而慣行法者則位在雙親之間，嘉農242號×IRP-60與 C223×Piro4 兩組合之兩種栽培方法不同之 F_3 集團，其平均株高均位在雙親之間，由此可以看出不同組合之雜種集團，因其栽培方式之不同而使其若干農藝性狀有不同之表現，惟大致言之，F_3 集團之平均值無論是以世代促進法栽培或以慣行法栽培，其主要農藝性狀之表現有分佈在雙親中間之趨勢。

由表三可以看出，來源不同之 F_3 集團若同時栽培在田間時，其主要農藝性狀之表現亦因性狀及雜交組合而有不同之反應。就生育日數而言，來自世代促進法之 F_3 集團與來自慣行法之 F_3 集團，其平均值頗爲接近，顯示前者之 F_2 集團雖在世代促進栽培條件下經過，但該特殊環境顯然對雜種集團內控制生育日數之遺傳因子頻度並無特殊不良之影響，不同雜交組合間之平均生育日數，來源間之差異均甚微小，顯示不同組合之 F_2 集團，在世代促進條件下均具類似之反應。

表三、來源不同之 F_3 集團同時在田間栽培時其主要農藝性狀之平均值

農藝性狀	來源	臺中在來1號×CP231			嘉農242號×IRP-60			C223×Piro4		
		P_1	P_2	F_3	P_1	P_2	F_3	P_1	P_2	F_3
生育日數（日）	世代法	90.0	91.3	88.2	90.7	95.5	87.6	93.7	79.9	82.0
	慣行法			89.3			88.3			82.9
株高（公分）	世代法	88.5	135.3	121.7	126.4	85.5	107.7	123.6	97.6	115.6
	慣行法			122.7			116.5			110.4
每株穗數（支）	世代法	19.2	9.0	16.1	11.6	22.7	15.8	15.5	25.5	22.8
	慣行法			14.8			13.4			19.2
每株谷重（克）	世代法	40.5	22.9	29.4	40.9	42.6	36.6	38.8	27.5	48.8
	慣行法			27.1			32.4			33.7

台中在來1號×CP231之平均株高，來自世代促進法之 F_3 集團與來自慣行法者相似，惟嘉農242號×IRP—60與C223×Piro4等兩組合之 F_3 集團，其平均株高則因來源而稍異，且反應不一。就嘉農242號×IRP—60之 F_3 集團而言，來自世代促進法者其平均株高較來自慣行法者爲低，惟在C223×Piro4之 F_3 集團則來自世代促進法者其平均株高較來自慣行法者爲高 。但後者之相差較前者爲小。由此設論，世代促進法之栽培條件似乎較有利於短稈個體之保存。

不同什交組合之 F_3 集團，其平均每株穗數及每株谷重均以來自世代促進法者爲大，顯示 F_2 集團若以慣行法在田間混合栽培時，穗數型高產個體出現之機會較低。換言之，世代促進法雖然是一種極端密植而少肥之特殊栽培方式，但是對什種集團內若干主要農藝性狀之表現不但未具不良之影響，反而較具有利之作用。西尾等（1966）亦曾比較經過世代促進處理次數不同之雜種集團若干農藝性狀之表現，結果發現不同世代什種集團間，若干農藝性狀之平均值並無很大之差別，由此可知世代促進法頗具實用價值。

2. F_3主要農藝性狀之變異性

F_2集團以世代促進法繁殖之 F_3 種子再以世代促進法栽培 F_3 集團時，其主要農藝性狀之變異性大小，以變方及變異係數表示，如表四。F_2集團以慣行法在田間繁殖之F_2種子再以慣行法栽培時，其主要農藝性狀之變異性大小，以變方及變異係數表示，如表五。F_2集團分別以世代促進法及慣行法栽培而其F_3集團同時在田間以慣行法栽培時，其主要農藝性狀之變異性大小，以變方及變異係數表示，如表六。由表四及表五可以看出，以世代促進栽培法栽培之水稻什種集團，其主要農藝性狀之變方以株高及生育日數較大，穗長及一穗粒數較小，以慣行法栽培之水稻什種集團，其主要農藝性狀之變方以株高最大，每株谷重次之，其餘每株穗數及生育日數較小。由此可知，以世代促進法栽培之水稻F_3集團及以慣行法在田間栽培之水稻 F_3 集團，其主要農藝性狀之變異性，在本質上並無太大之差別。以世代促進法栽培之三種不同什交組合之 F_3 集團，其生育日數之變方均大於以慣行法栽培之 F_3 集團，其株高變方亦與慣行法相似，顯示世代促進法之栽培條件有利於此兩性狀變異性之維持，故在此什種集團內，對此兩性狀之選拔當屬有效。楊（1970）亦曾就世代促進法栽培之F_2集團求得若干農藝性狀之遺傳力，發現生育日數與株高之遺傳力較其他性狀者爲高。可見 F_2 與 F_3 集團之變異性頗爲一致。

表四、以世代促進法栽培時，F_3 集團主要農藝性狀之變異性

雜交組合	生育日數		株高		穗長		一穗粒數	
	變方	變異係數%	變方	變異係數%	變方	變異係數%	變方	變異係數%
臺中在來 1 號×CP231	90.38	11.24	69.53	21.96	4.21	24.11	20.21	48.34
嘉　農242號×IRP-60	63.25	9.38	111.02	28.19	8.40	38.87	24.29	61.17
C223號×Piro4	108.86	11.64	117.58	70.18	5.94	38.03	27.75	68.20

表五、以慣行法栽培時，F_3 集團主要農藝性狀之變異性

雜交組合	生育日數		株高		每株穗數		每株谷重	
	變方	變異係數%	變方	變異係數%	變方	變異係數%	變方	變異係數%
臺中在來 1 號×CP231	31.25	9.22	264.89	15.39	13.29	34.69	57.07	49.18
嘉　農242號×IRP-60	44.45	11.47	113.94	10.78	10.26	32.28	67.49	51.69
C223號×Piro4	14.25	7.48	48.35	8.50	9.78	23.49	33.49	40.37

以世代促進法栽培之 F_3 集團，其主要農藝性狀之變異係數以一穗粒數最大，穗長次之，株高及生育日數者較小。以慣行法栽培之 F_3 集團，其主要農藝性狀之變異係數則以每株谷重最大，每株穗數次之，株高及生育日數較小。由此可知，主要農藝性狀之變異係數，以世代促進法栽培之F_3集團及以慣行法栽培之F_3集團，所得結果頗爲一致。變方大之性狀，其變異係數較小，而變方小之性狀則其變異係數較大，由表一及表二可知變方大之性狀如株高與生育日數其平均值均較變方小之性狀如穗長及一穗粒數（世代促進法）或每株穗數及每株谷重（慣行法）爲大，故求得變異係數平均值大者當相

對變小。

由表六可以看出來源不同之 F_3 集團若同時栽培在田間時，其主要農藝性狀之變異性，亦因性狀及什交組合而有不同之反應。就本試驗所調查之性狀而言，顯然以株高之變方最大，每株谷重次之，每株穗數與生育日數之變方較小。就什交組合而言，各種農藝性狀之變方以秈粳稻雜交組合、嘉農242號×IRP—60 及秈型稻組合、台中在來1號×CP231 者較大，而粳型稻組合 C223×Piro4者較小。就 F_3集團之來源而言，在嘉農242號×IRP—60，則各性狀之變方均以來自世代促進法者較來自慣行法者爲大。而台中在來1號×CP231則均以來自慣行法者較來自世代促進法者爲大。C223×Piro4 則在生育日數及株高兩性狀，來自慣行法者大於來自世代促進法者，但在每株穗數與每株谷重，則以來自世代促進法者大於來自慣行法者。惟來源不同之F_3集團間變方之差異，一般言之均相差有限，顯示來源不同之F_3集團內，其農藝性狀均具有類似之變異性，就變異係數而言，每株谷重與每株穗數之變異係數較大，株高與生育日數者較小，組合間及來源間之差異不大。

六、來源不同之 F_3 集團同時在田間栽培時其主要農藝性狀之變異性

雜交組合	來源	生育日數		株高		每株穗數		每株谷重	
		變方	變異係數%	變方	變異係數%	變方	變異係數%	變方	變異係數%
臺中在來1號×CP231	世代法	24.84	5.65	222.46	12.25	26.82	32.14	149.68	41.61
	慣行法	28.63	5.99	267.37	13.23	28.15	35.75	182.67	49.91
嘉農242號×IRP-60	世代法	47.28	7.68	286.89	15.72	40.94	40.51	229.07	41.37
	慣行法	37.36	6.78	183.72	11.64	13.53	27.40	160.85	39.17
C223號×Piro4	世代法	11.00	4.04	36.80	5.25	34.70	25.84	258.50	32.92
	慣行法	16.37	4.88	40.71	5.78	17.88	22.03	126.53	33.37

由本試驗所得初步結果，可知水稻雜種集團若施以世代促進法處理時，不但可以縮短育種年限，並可維持什種集團內主要農藝性狀之正常變異性，與慣行法在田間栽培者並無差別，值得採用。

四、摘　　要：

本試驗係將台中在來1號×CP231、嘉農242號×IRP—60與 C223×Piro4 等三種雜交組合之 F_2集團分別以世代促進法及一般慣行法繁殖，所得 F_3 集團則一方面再以世代促進法及慣行法分別在室內及田間栽培，另一方面則將此兩種來源不同之 F_3 集團同時按慣行法在田間栽培，以觀察其主要農藝性狀如生育日數、株高、穗長、一穗粒數、每株穗數及每株谷重之變異性。

以世代促進法栽培之 F_3 集團，因受空間及養料之限制，致其主要農藝性狀之平均值均較以慣行法栽培者爲小，而生育日數受世代促進法栽培條件之影響顯然較其他性狀爲輕。兩種來源不同之 F_3 集團同時以一般慣行法在田間栽培時，兩者之生育日數頗爲相似，惟來自世代促進法之 F_3 集團，其平均株高似較來自慣行法者爲小，而前者之平均每株穗數及每株谷重則較後者爲大。

主要農藝性狀之變方及變異係數，以世代促進法栽培之 F_3 集團與以慣行法栽培者，雖因雜交組合之不同而有大小之別，但兩者之間差異不大，兩種來源不同之F_3集團以慣行法栽培時，來自世代促進法者其有關性狀之變方及變異係數在台中在來 1 號×CP231什交組合均較來自慣行法者爲小，而在嘉農242號×IRP—60則均較來自慣行法者爲大，C223×Piro4則因性狀而不同，惟來源不同之F_3集團間之差異不大，由此可知水稻雜種集團若以世代促進法繁殖時，亦可保持該集團內有關性狀之正常變

異性。

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VARIABILITY OF SOME AGRONOMIC TRAITS IN THE F_3 POPULATIONS GROWN BY GENERATION ACCELERATION METHOD OF RICE

S. C. Yang

SUMMARY

F_2 generation of the crosses, Taichung native 1 x CP 231, Chianung 242 x IR 9-60, and C 223 x Pi No.4 were raised by both "Generation Acceleration Method" and conventional one, and F_3 populations were continuously grown by the same method as their respective F_3 populations. At the same time, F_3 populations derived from different methods were grown together in the field by the conventional method. The general performance as well as variability of some agronomic characters in the above mentioned F_3 populations were investigated.

The growing conditions of the "Generation Acceleration Method" greatly reduced the means of all characters except that of heading date when compared with those grown by the conventional method. When two F_3 populations of different origin were grown together in the field, they appeared to have similar heading date but the plants from the "Generation Acceleration Method" were slightly shorter with more panicles per hill and heavier grain weight per hill in comparison with those of from conventional method.

Variance and coefficient of variation for agronomic traits differed slightly with growing conditions. For example, variance associated with heading date in the F_3 populations grown by "Generation Acceleration Method" was considerably greater than those of conventional method. When two F_3 populations of different origin were grown together in the field, it was observed that in the cross of Taichung native 1 x CP 231, variance and coefficient of variation of agronomic traits were larger in the F_3 population derived from "Generation Acceleration Method" than those from the conventional method, whereas in the cross of Chianung 242 x IR 9-60, the opposite situation prevailed. In the cross of C 223 x Pi No. 4, however, F_3 population of "Generation Acceleration Method" had smaller variance and coefficient of variance and coefficient of variation in heading date and plant height but had larger variance and coefficient of variation in number of panicles per hill and weight of grains per hill than F_3 population from conventional method. The difference in variance and coefficient of variance between two F_3 populations of different origin was generally small, indicating that hybrid population treated with "Generation Acceleration Method" may have the same variability for the agronomic traits as that handled by the conventional method.

THE EFFECT OF WEEDS ON RICE IN PADDY FIELD

1. WEED SPECIES AND POPULATION DENSITY

W. L. Chang

Introduction

Weeds in transplanted rice are customarily controlled by hands in Taiwan. Recently, however, due largely to the rapid industrial development, farm labors needed for hand weeding are becoming increasingly scarce. As a result, interest in controlling weeds with herbicides in transplanted rice has greatly increased among rice farmers. The understanding of the factors affecting the degree of damage caused by different weed species in transplanted rice is necessary if chemical weed control is to be practiced effectively and economically. For this reason, a series of experiments were conducted at the Chiayi Agricultural Experiment Station to obtain the necessary information. This paper presents results of the first experiment which evaluates the effect of population density of several major weeds in transplanted rice.

Materials And Methods

The experiment was conducted on the clay pots in the screen house of the Chiayi Agricultural Experiment Station in the first and second crops of 1968. The variables included two levels of fertility, five species of weeds, and three population densities for for each weed species. Two levels of fertility were low and high by applying 80, 40, 40, and 160, 80, 80, kg per ha of N, P_2O_5, and K_2O, respectively. Five species of weeds used in this experiment were *Echinochloa crusgalli, Monochoria vaginalis, Cyperus difformis, Marsilea quadrifolia,* and *Spirodela polyrhiza.* Three population densities of weeds were 0, 3 weeds per pot or about 100 weeds per m^2, and 6 weeds per pot or about 200 weeds per m^2.

One Seedling of the japonica rice variety, Chianung 242 was transplanted in each clay pot with surface area of 314 cm^2 Weeds were planted around rice seedling right after the transplanting of rice. For *Echinochloa crusgalli, Monochoria vaginalis,* and *Cyperus difformis* weeds with four to five leaves were used whereas cutting with one node was used for *Marsilea quadrifolia.* For *Spirodela polyrhiza,* fully developed weeds were used.

The experiment was laid out in a randomized complete block design with three replications. The plots were represented by individual pots. Data for grain yield and components of yield were recorded for the evaluation of the damage of rice caused by weeds which was expressed in the percentage of weed-free check treatment.

The first crop was transplanted in March 14, 1968 and harvested in July 9, 1968. The second crop was transplanted in July 19, 1968 and harvested in October 28, 1968. The climatic data of the station for 1968 are presented in Table 1.

Table 1. Climatic data of the Chiayi Agricultural Experiment Station.

Month	Rainfall (mm)	Number of rainy day	Relative humidity (%)	Number of sunshine hours (hrs/month)	Solar radiation gr-cal/cm² /month	Temperature (°C)		
						Maximum	Minimum	Mean
January	11.1	5	76	77.6	7,084.0	21.0	12.3	16.6
February	161.0	20	87	38.3	4,822.9	16.7	11.4	14.1
March	178.4	9	70	116.2	8,092.2	24.4	15.6	20.0
April	19.6	6	71	88.6	10,722.1	26.4	18.1	22.3
May	245.4	9	69	58.6	9,208.5	30.1	22.3	26.4
June	589.2	18	70	70.3	8,294.5	30.8	23.4	27.1
July	292.8	13	68	132.0	9,809.3	32.2	25.4	28.8
August	244.4	15	68	77.8	9,562.5	32.1	25.7	28.9
September	227.6	9	74	85.4	8,186.5	30.6	24.2	27.4
October	127.2	6	70	122.8	8,544.6	27.9	19.8	23.9
November	0	0	61	115.1	7,677.4	27.0	16.8	21.9
December	0	0	63	112.7	6,686.1	26.0	15.9	20.9

Results And Discussion

The effect of Weed on Rice Yield

The grain yield of rice in the plots infested with different weed species and population densities was expressed in percentage of weed-free treatments (Table 2). It was observed that *Echinochloa crusgalli* reduced the grain yield of rice by 84.9%. A yield damage of 90% was also reported for this weed (IRRI, 1968). *Cyperus difformis, Marsilea quadrifolia, Monochoria vaginalis,* and *Spirodela polyrhiza* reduced the grain yield of rice by 71.7, 62.0, 61.7, and 9.0%, respectively. Difference in grain yield of rice among five species of weeds was highly significant (Table 3). As *Echinochloa crusgalli* and *Cyperus difformis* usually grow as tall as rice plants, it appears that effective competition of these weeds with rice for solar energy may have resulted in the significant yield reduction of rice. Black *et al.* (1969) proposed that competitive ability depends on the net capacity of a plant to assimilate carbon dioxide and use the photosynthate to extend its foliage or increase its size. They also reported that the so-called "efficient" plants possess the ability to fix CO_2 at higher rates and become relatively more competitive as light intensity increases. Since rice was found to be a "non- efficient" plant whereas *Echinochloa crugalli,* an "efficient" one, it is not surprising to note that rice suffered a great loss of yield when it was grown with *Echinochloa crusgalli.*

Table 2. Yield performance of rice in percentage of weed-free treatment

Weed species	Crop season	High fertility (%)			Low fertility (%)			Average (%)		
		100 weeds /m²	200 weeds /m²	Mean	100 weeds /m²	200 weeds /m²	Mean	100 weeds /m²	200 weeds /m²	Mean
Echinochloa Crusgalli	First	14.5	8.2	11.4	23.1	9.8	16.5	18.8	9.0	13.9
	Second	13.0	9.4	11.2	28.6	13.9	21.3	20.0	11.7	15.9
	Mean	13.8	8.8	11.3	25.9	11.9	18.9	19.8	10.4	15.1
Monochoria vaginalis	First	68.8	64.3	66.6	74.6	34.7	54.7	71.7	49.5	60.6
	Second	16.0	15.5	15.8	18.8	13.5	16.2	17.4	14.5	16.0
	Mean	42.4	39.9	41.2	46.7	24.1	35.4	44.6	32.0	38.3
Cyperus difformis	First	26.4	18.6	22.5	50.9	42.2	46.6	38.7	30.4	34.6
	Second	19.1	12.4	15.8	46.5	9.8	28.2	32.8	11.1	22.0
	Mean	22.8	15.5	19.2	48.7	26.0	37.4	35.8	20.8	28.3
Marsilea quadrifolia	First	43.5	38.3	40.9	54.9	12.7	33.8	49.2	25.5	37.4
	Second	47.8	25.7	36.8	45.3	35.5	40.4	46.6	30.6	38.6
	Mean	45.7	32.0	38.9	50.1	24.1	37.1	47.9	28.1	38.0
Spirodela polyrhiza	First	91.5	89.6	90.6	89.6	73.4	81.5	90.6	81.5	86.1
	Second	94.8	96.7	95.8	104.9	86.5	95.7	99.9	91.6	95.8
	Mean	93.2	93.2	93.2	97.3	80.0	88.7	95.3	86.6	91.0
Average	First	48.9	43.8	46.4	58.6	34.6	46.6	53.8	39.2	46.5
	Second	38.1	31.9	35.0	48.8	31.8	40.3	43.5	31.9	37.7
	Mean	43.5	37.9	40.7	53.7	33.2	43.5	48.7	35.6	42.2

Marsilea quadrifolia and *Monochoria vaginalis* never grow too tall and they compete for light with rice only during the early stage of rice growth. Therefore, the effect of these weeds on rice may come largely from competing the utilization of soil nutrients with rice plants. An investigation conducted by the International Rice Research Institute also indicate that the nitrogen content of *Monochoria vaginalis* was higher than that of *Echinocnloa crusgalli*(IRRI, 1968). *Spirodela polyrhiza*, a floating weed commonly found in the paddy field, caused very slight damage to rice and treatments infested with this weed did not differ significantly with weed-free treatment in their grain yield of rice. Although this weed is not easily killed by chemicals, the control of this weed is probably of minor importance from the practical standpoint.

Table 3. Combined analysis of variance for grain yield of rice in the first and second crops of 1968.

Source of variation	D.F.	S.S.	M.S.	F.	L.S.D. 5%	L.S.D. 1%
Treatment	59	21,746.44	368.58	21.19**	1.21	1.32
Crop seasons (CS)	(1)	529.76	529.76	30.46**	3.92	6.84
Fertility levels (FL)	(1)	1,593.70	1,593.70	91.64**	3.92	6.84
Weed species (WS)	(4)	3,248.52	812.13	46.70**	2.44	3.47
Population densities (PD)	(2)	9,789.28	4,894.64	281.46**	3.07	4.78
CS x FL	(1)	1.61	1.61	0.09	3.92	6.84
CS x WS	(4)	1,190.66	297.67	17.12**	2.44	3.47
CS x PD	(2)	524.75	262.38	15.09**	3.07	4.78
FL x WS	(4)	441.59	110.40	6.35**	2.44	3.47
FL x PD	(2)	536.93	268.47	15.44**	3.07	4.78
WS x PD	(8)	3,112.28	389.04	22.37**	2.01	2.66
CS x FL x WS	(4)	102.69	25.67	1.48	2.44	3.47
CS x FL x PD	(2)	35.06	17.53	1.01	3.07	4.78
CS x WS x PD	(8)	160.13	20.02	1.15	2.01	2.66
FL x WS x PD	(8)	346.91	43.36	2.49*	2.01	2.66
CS x FL x WS x PD	(8)	132.57	16.57	0.95	2.01	2.66
Error	116	2,017.53	17.39			

* Significant at 5% level. ** Significant at 1% level

Population density of 100 and 200 weeds per m^2 reduced 51.3 and 64.4% of grain yield respectively when compared with weed-free plots, showing that weed population of higher than 100 weeds per m^2 was capable of causing drastic reduction in grain yield of rice. Population density of higher than 100 weeds per m^2 may occur frequently for broadleaved and sedge weeds but is rarely found for grassy weeds even in the heavily infested paddy field. For example, 480, 200, and 80 weeds per m^2 were counted in the unweeded plots for broadleaves, sedges, and grasses (Chang, 1969). This situation makes the selection of herbicides highly important. It is necessary that herbicides should be selected on the actual infestation of weeds in the paddy field to insure best control of weeds. It also appears useful for more expensive grass-controlling herbicides to be combined with cheaper phenoxy herbicides to obtain a better control of weeds in rice fields of Taiwan.

The reduction of grain yield caused by *Echinochloa crusgalli* and *Cyperus difformis* was greater in high fertility treatments while *Monochoria vaginalis*, and *Spirodela polyrhiza* reduced more yield in low fertility treatments. The fertility levels x weed species interaction was also highly significant (Table 3), indicating that the degree of damage caused by weeds differed with levels of fertility. It appears that weeds such as *Echinochloa crusgalli* and *Cyperus difformis*, which compete highly with rice for light are likely to

comete more severely with rice in the paddy field applied with high rate of fertilizers. In the paddy field applied with low rate of fertilizers, however, weeds such as *Monochoria vaginalis* and *Marsilea quadrifolia,* which compete more for soil nutrients may have more Profound effect on rice.

The effect of weeds on rice also varied with crop seasons as reflected by a highly significant crop seasons x weed species interaction. *Echinochloa crusgalli* and *Marsilea quadrifolia* reduced yield more or less similarly in both crops but *Monochoria vaginalis* and *Cyperus difformis* were found to cause heavier demage to rice in the second crop than in the first one. Since temperature during the early stage of rice growth varies greatly with crop seasons (Table 1), difference in weed damage to rice with crop seasons may be related to the response of weed growth to temperature. *Echimochloa crusgalli* grows equally well under both cold and warm growing conditions but *Monochoria vaginalis* apparently requires high temperature for its good establishment. In the first crop, *Monochoria vaginalis* grows poorly because of low temperature and is not likely to have severe competition with rice. However, in the second crop when high temperature becomes available for its growth, it competes vigorously with rice for essential growth factors. As shown in Table 2, *Monochoria vaginalis* caused only 39.4% yield reduction in the first crop but in the second one, it raised the percentage of yield reduction to as high as 84.0% which was comparable to that of *Echinochloa crusgalli,* the most destructive weed of rice. As *Monochoria vaginalis* is the most predominant weed of transplanted rice in Taiwan, its potentiality as a serious weed in the second crop can not be underestimated.

The Effect of Weeds on Yield Components of Rice

The average performance of the four components of grain yield of rice in the percentage of weed-free treatment is shown in Figure 1. The number of panicles per plant suffered the greatest damage which was followed by the number of grains per panicle but the100-grain weight and the fertility percentage were only slightly affected, indicating that the reducton of grain yield of rice caused by weeds may be largely attributable to the decrease in the number of panicles per plant and the number of grains per panicle. Since weed competition with rice was reported to be most serious during the first 30 days after emergence of weeds (Show and Danielson, 1961), and this period also corresponds to the active tillering stage of rice plants, it is quite understandable that the number of panicles per plant was most susceptible to the attack of weeds among four components of yield.

The number of panicles per plant was most severely affected by *Echinochloa crusgalli* while *Spirodela polyrhiza* showed only slight suppression of rice tillering in both crop seasons. *Cyperus difformis, Marsilea quadrifolia,* and *Monochoria vaginalis* reduced more tillers in the second crop than in the first one, suggesting that competition was more serious in the second crop when high temperature was available for weed growth during the tillering stage of rice. The significant difference in the reduction of the number of panicles per plant in different crop seasons for *Monochoria vaginalis* agreed closely with that of the reduction of rice yield. This observation appears sufficient to emphasize the importance of this weed in the second crop of rice. Population density of 100 weeds per m^2

caused a drastic reduction in the number of panicles per plant for most weed species but difference between 100 and 200 weeds per m^2 was rather small except that of *Marsilea quadrifolia* under low fertility level. *Echinochloa crusgalli* and *Cyperus difformis* reduced more tillers in high fertility while *Marsilea quadrifolia* and *Monochoria vaginalis* caused more reduction of tillers in low fertility level.

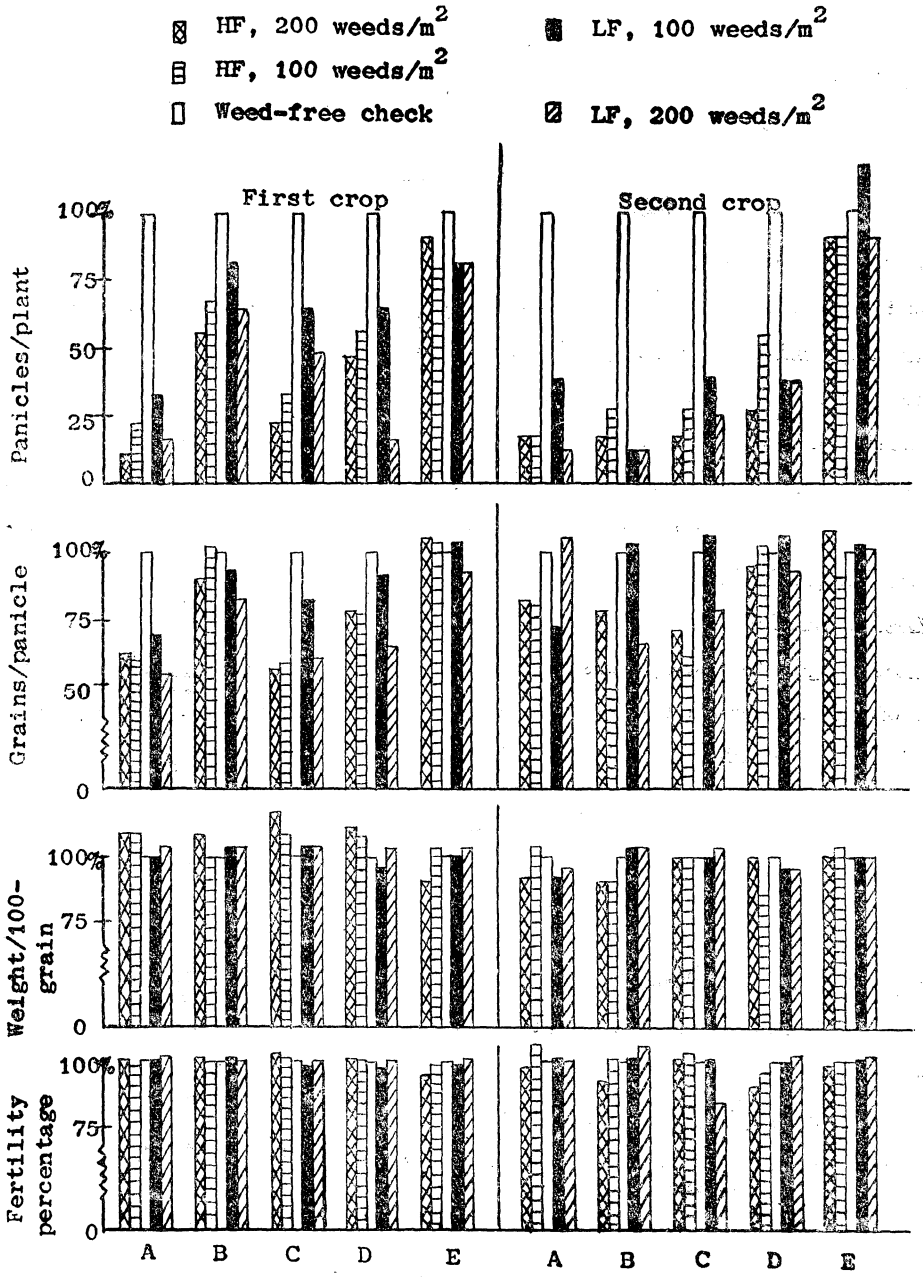


Figure 1. Average performance of yield components in the percentage of weed-free check.

A: *E. crusgalli*, B: *M. vaginalis*, C: *C. difformis*, D: *M. quadrifolia* E: *S. polyrhiza*. HL: High fertility, LF: Low Fertility.

The effect of weeds on the number of grains per panicle was similar to that of the number of panicles per plant in the first crop. The response of this trait was rather irregular in the second crop simply because plants with less tillers produced more grains on each panicle. Thus, the number of grains per panicle may not be a clear indication of the real damage of weeds when the number of panicles per plant or hill has been greatly affected. There was practically no trace of weed damage on 100-grain weight and the percentage of fertility. Apparently, the wave of weed competition was too weak to hit these two characters which develop at relativey late growing stage of rice.

Summary

The effect of weeds on rice was evaluated on five species of weeds at 3 population densities and two fertility levels in the first and second crops of 1968. *Echinochloa crusgalli*, *Cyperus difformis*, *Marsilea quadrifolia*, *Monochoria vaginalis*, and *Spirodela polyrhiza* reduced grain yield of rice by 84.9, 71.7, 62.0, 61.7, and 9.0%, respectively, Population density of 100 and 200 weeds per m^2 reduced 51.3 and 64.4% of grain yields, respectively when compared with weed-free treatment. *Echinochloa crusgalli* and *Cyperus difformis* reduced more grain yield of rice at high fertility level while *Monochoria vaginalis* and *Marsilea quadrifolia* caused more damage at less fertilized field. *Echinochloa crusgalli* and *Marsilea quadrifolia* reduced grain yield of rice more or less similarly in both crops but *Monochoria vaginalis* and *Cyperus difformis* caused heavier damage in the second crop. The number of panicles per plant suffered the greatest damage, followed by the number of grains per panicle but the 100-grain weight and the fertility percentage were only slightly affected.

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水田雜草對水稻之影響

I. 雜草種類與雜草密度

張　萬　來

摘　要

嘉義農業試驗分所曾於民國57年第1、2期作在網室內舉行盆栽試驗，調查不同密度之主要水田雜草在不同肥力下對水稻爲害之程度，初步結果顯示稗草、三角草、田字草、鴨舌草及浮萍分別減產84.9、71.7、62.0、61.7 與9.0%。雜草密度每平方公尺100支與200支者較無草之對照處理分別減產51.3及64.4%，稗草與三角草在重肥區爲害情形勝於輕肥區，惟鴨舌草與田字草則恰恰相反。稗草與田子草之爲害情形，第1期作與第2期作相若，但鴨舌草與三角草之爲害情形則以第2期作較爲嚴重。產量構成因素中以每株穗數爲害最重，每穗粒數次之，而百粒重與稔實率則未見其害。

THE EFFECT OF WEEDS ON RICE IN PADDY FIELD

II. STAGE OF WEED EMERGENCE

W. L. Chang

Introduction

In the first experiment conducted in 1968, it was observed that the degree of damage caused by weeds in transplanted rice varied with weed species, population density, crop season and fertility level (Chang, 1970). In this experiment, weeds were planted right after the transplanting of rice with assumption that weeds emerged at the same time of rice transplanting. However, weed damage to rice may differ if weeds emerge at different rice growing stage. Early-emerging weeds are likely to cause more damage to rice when rice plants are still small, whereas late-emerging weeds may not have such heavy competition with rice because rice plants at that time are already well established. The understanding of the damage caused by weeds emerged at different rice growing stage may provide usefu information for the planning of an effective and economical weed control practice. This paper summarizes the results obtained from the second experiment which measures the effect of stages of emergence of some major weeds in transplanted rice.

Materials and Method

The experiment was conducted on the clay pots in the screen house of the Chiayi Agricultural Experiment Station in the first and second crops of 1969. Two levels of fertility, three weed species, and five stages of weed emergence were arranged in a randomized complete block design experiment with three replications. The plots were represented by individual clay pots with surface area of 314 cm^2. Low and high levels of fertility were represented by the application of 80, 40, 40, and 160, 80, 80, kg per ha of N, P_2O_5, and K_2O, respectively. Three weed species, *Echinochloa crusgalli*, *Monochoria vaginalis* and *Cyperus difformis* were employed to represent grassy, broadleaved and sedge weeds, respectively. Five stages of weed emergence were 15, 30, 45, and 60 days after rice transplanting in the first crop and 10, 20, 30 and 40 days after rice transplanting in the second crop, respectively, by planting four to five-leaf stage weeds at the given rice growing stages. A standand weed-free check treatment was included for comparison. Population density of weeds was three weeds per pot or about 100 weeds per m^2.

A japonica rice variety, Chianung 242 was used to evaluate weed damage on rice. One rice seedling was transplanted to each pot. The first crop was transplanted on January 31, 1969 and harvested on June 19, 1969. The second crop was transplanted on July 27, 1969 and harvested on November 2, 1969. Data for grain yield and components of grain yields were recorded for the evaluation of weed damage to rice which was expressed in percentage of weed-

free check treatment.

Results and Discussion

The Effect of Weed on Rice Yield

The average performance of rice yield in percentage of weed-free treatment is presented in Table 1. It was found that average yield of rice corresponded inversely with stages of weed emergence. Difference in rice yield among stages of weed emergence was significant at 1% level (Table 2). The percentages of yield reduction were 60.5, 29.5, 13.5, and 1.9% for the first, second, third, and fourth dates of weed emergence or at 15 (10), 30 (20), 45 (30), and 60 (45) days after rice transplanting, respectively. In the previous experiment, 72.8% reduction of yield was recorded for the same weeds emerged right after the transplanting of rice (Chang, 1970). These observations clearly indicated that early-emerging weeds tend to cause more damage to rice than that of late-emerging ones. The control of the early emerging weeds appears, therefore, more important than that of the late emerging ones.

Table 1. Yield performance of rice in the percentage of weed-free treatment.

Crop season	Stage of weed emergence (DAT) *	*Echinochloa crusgalli*			*Monochoria vaginalis*			*Cyperus difformis*			Average		
		HF* (%)	LF* (%)	Mean (%)	HF (%)	LF (%)	Mean (%)	HF (%)	LF (%)	Mean (%)	HF (%)	LF (%)	Mean (%)
First	15	13.8	15.9	14.9	49.7	57.4	53.6	30.8	20.0	25.4	31.4	31.1	31.3
	30	30.5	26.3	28.4	74.6	89.3	82.0	63.8	35.2	49.5	56.3	50.3	53.3
	45	61.1	55.9	58.5	83.8	95.2	89.5	62.9	72.6	67.8	69.3	74.6	71.9
	60	75.5	89.3	82.4	105.1	98.9	102.0	87.1	77.8	82.5	89.2	88.7	89.0
Second	10	35.3	33.9	34.6	54.5	61.7	58.1	59.4	40.3	49.9	49.7	45.3	47.5
	20	69.2	79.4	74.3	87.2	101.6	94.4	94.0	89.0	92.0	83.5	90.3	86.9
	30	103.8	106.9	105.4	91.0	108.5	96.8	98.1	96.8	97.5	97.6	104.1	100.9
	40	110.5	104.4	107.5	113.5	106.1	109.8	104.1	104.4	104.3	109.4	105.0	107.2
Average	15 (10)	24.6	24.9	24.8	52.1	59.6	55.9	45.1	30.2	37.7	40.6	38.2	39.5
	30 (20)	49.0	52.9	51.4	80.9	95.5	88.2	78.9	62.6	70.8	69.9	70.3	70.1
	45 (30)	82.5	81.4	82.0	87.4	101.9	94.7	80.5	84.7	82.7	83.5	89.3	86.5
	60 (40)	93.0	66.9	95.0	109.3	102.5	105.9	95.6	91.1	93.4	99.3	96.8	98.1

* DAT=Days after transplanting. HF=High fertility. LF=Low fertility.

The damage of rice caused by weeds varied with stage of emergence as reflected by a highly significant weed species x stage of weed emergence interaction (Table 2). Early-emerging grassy and sedge weeds found to offer more serious competition to rice than that of broad-leaved one. For example, *Echinochloa crusgalli* and *Cyperus difformis* emerging at 15 and 10 days after rice transplanting in the first and second crops, reduced grain yield of rice by 75.2, and 62.3% respectively, while only 44.1% yield reduction was observed for *Monochoria vaginalis* emerging at the same stage of rice growing (Table 1). *Echinochloa crus-*

galli and *Cyperus difformis* emerged at late tillering stage of rice 60 and 40 days after transplanting in the first and second crops were still capable of competing with rice, although the degree of weed influence was considerably smaller in comparison with that caused by weeds emerging earlier. Grain yield of rice was not affected by *Monochoria vaginalis* when it emerged at late tillering stage of rice. Significantly lower mean yields of rice were also reported for early and late competition by grasses (IRRI, 1969). Apparently, grasses and sedges can grow tall and compete highly with rice for height even they emerge late but the growth of late-emerging broadleaves tends to be suppressed by the well established rice plants. It appears therefore, that the control of grassy and sedge weeds such as *Echinochloa crusgalli* and *Cyperus difformis* should be continued up to the late-tillering stage of rice while the control of late-emerging broadleaves such as *Monochoria vaginalis* may be of no practical importance.

Table 2. Combined analysis of variance for grain yield of rice in the first and second crops of 1969.

Source of variation	D.F.	S.S.	M.S.	F	L.S.D.	
					5%	1%
Treatment	59	10,522.52	178.35	11.40*	1.21	1.32
Crop seasons (CS)	(1)	35.37	35.37	2.26	3.92	6.84
Fertility levels (FL)	(1)	556.16	556.16	35.56**	2.92	6.86
Weed species (WS)	(2)	1,002.95	501.48	32.06**	3.07	4.78
Stage of weed emergence (SWE)	(4)	6,270.47	1,567.62	100.23**	2.44	3.47
CS x FL	(1)	46.62	46.62	2.98	3.92	6.84
CS x WS	(2)	326.24	163.12	10.43**	3.07	4.78
CS x SWE	(4)	810.29	202.57	12.95**	2.24	3.47
FL x WS	(2)	53.19	26.60	1.70	3.27	4.78
FL x SWE	(4)	289.81	72.45	4.63**	2.24	3.47
WS x SWE	(8)	501.02	62.63	4.00**	2.01	2.66
CS x FL x WS	(2)	14.64	7.32	0.47	3.07	4.78
CS x FL x SWE	(4)	136.79	34.20	2.19	2.24	3.47
CS x WS x SWE	(8)	216.12	27.02	1.73	2.01	2.66
FL x WS x SWE	(8)	182.12	22.77	1.46	2.01	2.66
CS x FL x WS x SWE	(8)	80.73	10.09	0.65	2.01	2.66
Error	116	1,814.78	15.64			

** Significant at 1% level.

It was observed that weeds emerging at 15, 30, 45, and 60 days after rice transplanting reduced grain yield of rice by 68.7, 46.7, 28.1, and 11.0%, respectively in the first crop. In the second crop, however, yield reduction was recorded only for early-emerging ones. weeds emerging at 10 and 20 days after rice transplanting reduced grain yield of rice by 52.5 and 13.1% respectively, but weeds emerging at 30 and 40 days after rice transplanting did not cause any damage to

rice in the second crop. The crop seasons x stage of weed emergence was highly significant (Table 3), indicating that damage caused by weeds emerging at different stages varied with crop seasons. In the first crop, because of low temperature, the growth of rice plant is generally slow which enables late-emerging weeds to compete favorably with rice. In second crop, however, rice growth is generally stimulated by high temperature prevailing during the early growing stage which may inhibit the growth of late-emerging weeds. The degree of damage caused by weeds emerging at different stages appeared to be more or less similar under different fertility levels.

In Taiwan, it is a general pratice by hand weeding 3 to 4 times in the first crop and 2 to 3 times in the second one for transplanted rice. The first weeding usually begins at about 15 days after transplanting in the first crop and 10 days in the second one, then the second and later weeding will be done with 10- and 7-days intervals for the first and second crops of rice, respectively. This means that hand weeding ends at about 35 to 45 days after rice transplanting in the first crop and at about 17 to 24 days in the second one. Since grassy and sedge weeds emerging as late as 60 days after transplanting were found to be still capable of causing considerable damage to rice in the first crop, one more hand weeding after the fourth weeding or 45 days after transplanting may prove useful if the paddy is infested with heavy grassy and sedge weeds. In the second crop, however, the third weeding may be unnecessary as long as early-emerging weeds are properly controlled. In the case of chemical weed control, most granular herbicides such as Nitrofen or TOK, the most popular herbicide currently in use in Taiwan (Chang, 1969), are applied at 7 days after transplanting in the first crop, and 4 days in the second one, they are able to provide good control of weeds for only one month, and weeds are likely to emerge at about 37 days after transplanting in the first crop and at about 34 days in the second one. One application of chemicals or one hand weeding at the time of maximum tillering stage appears, therefore, necessary for the control of late emerging weeds in the first crop.

The Effect of Weeds on Yield Components of Rice

The average performance of the four yield components of rice expressed in the percentage of weed-free treatment is presented in Table 3. It was observed that the number of panicles per plant suffered the greatest damage, followed by the number of grains per panicle but the 100 grain-weight and the fertility percentage were not affected by weed competition, indicating that the reduction of grain yield of rice caused by weeds may be due largely to the decrease in the number of panicles per plant and the number of grains per panicle. The degree of weed damage to the number of panicles per plant and the number of grains per panicle was also found to be negatively associated with the stage of weed emergence. In the first crop, substantial damage was found for these two characters from competition of both early- and late-emerging weeds but they were affected only by early-emerging weeds in the second crop. As in the case of grain yield, both early- and late-emerging grassy and sedge weeds caused more damage to these two components than those of broadleaved one. The degree of damage caused by weeds emerged at different stages was not affected by levels of fertility.

Table 3. Average performance of yield components in the percentage of weed-free treatment.

Yield component	Weed species	Fertility level*	Stage of weed emergence, first crop				Stage of weed emergence, second crop			
			15 DAA*	30 DAA	45 DAA	60 DAA	10 DAA	20 DAA	30 DAA	40 DAA
Number of panicles per plant	*Echinochloa crusgalli*	HF	22.6	36.3	73.5	88.2	36.7	85.6	103.3	111.1
		LF	24.1	44.6	72.3	84.3	41.7	87.5	106.9	106.9
	Monochoria vaginalis	HE	61.8	68.6	98.0	98.0	52.2	92.2	107.8	107.8
		LF	60.2	84.3	96.4	100.0	69.4	90.3	97.2	97.2
	Cyperus difformis	HF	46.1	68.6	68.6	81.4	58.9	88.9	92.2	100.0
		LF	32.5	60.2	75.9	84.3	59.7	83.3	90.3	97.2
Number of grains per panicle	*Echinochloa crusgalli*	HF	53.0	58.3	84.6	86.1	71.5	88.8	99.5	100.9
		LF	63.8	63.4	74.2	103.8	65.3	95.4	110.6	101.3
	Monochoria vaginalis	HF	67.9	91.7	92.6	107.6	81.6	99.4	103.0	111.0
		LF	86.4	90.1	91.6	100.3	80.5	97.0	108.0	105.3
	Cyperus difformis	HF	55.0	80.1	87.6	94.6	77.3	105.6	105.6	104.7
		LF	63.9	70.7	88.8	87.5	62.9	100.8	102.1	102.4
Weight of 100-grain	*Echinochloa crusgalli*	HF	100.0	107.4	100.0	103.7	103.7	100.0	103.7	100.0
		LF	93.9	97.5	97.5	100.1	96.2	96.2	96.2	100.0
	Monochoria vaginalis	HF	100.0	103.7	103.7	103.7	103.7	96.3	103.7	103.7
		LF	97.5	93.9	93.9	104.7	107.7	107.7	107.7	103.9
	Cyperus difformis	HF	96.3	107.4	107.4	103.7	107.4	103.7	103.7	103.7
		LF	101.1	97.5	97.5	97.5	103.9	100.0	103.9	107.8
Percentage of fertility	*Echinochloa crusgalli*	HF	101.9	102.4	99.2	100.1	103.3	100.3	97.0	102.6
		LF	99.7	99.8	100.4	100.5	100.6	96.5	99.8	102.9
	Monochoria vaginalis	HF	102.0	100.8	101.8	100.7	100.7	98.0	100.8	101.0
		LF	99.6	99.8	101.4	100.3	103.9	103.3	100.4	103.9
	Cyperus difformis	HF	102.8	102.0	100.3	102.2	106.0	100.7	98.1	98.0
		LF	101.0	100.0	99.1	101.7	103.4	102.7	102.0	105.5

* HF=High fertility. LF=Low fertility. DAA=Days after transplanting.

Summary

The effect of weeds emerged at different stages on transplanted rice was investigated in both crops of 1969. Weeds emerged at 15, 30, 45, and 60 days after rice transplanting reduced grain yield of rice by 68.7, 46.7, 28.1, and 11.0% respectively in the first crop. In the second crop, weeds emerging at 10 and 20 days after transplanting caused yield reduction of 52.5 and 13.1% respectively, but weeds emerging at 30 and 40 days after tansplanting did not affect the grain yield of rice. Early- and late-emerging *Echinochlor crusgalli* and *Cyperus difformis* reduced more grain yield of rice than those of *Monochoria vaginalis.* The degree of damage caused by weeds emerging at different rice growing stages was not affected by fertility levels. Among components of yield, weeds affected only the number of panicles per plant and the number of grains per panicle, but not the 100-grain weight and the fertility percentage.

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水田雜草對水稻之影響

Ⅱ雜草之發生時期

張　萬　來

摘　要

嘉義農業試驗分所於民國58年第1、2期作在網室內調查三種主要水田雜草在不同時期發生時，對水稻爲害之情形。初步結果顯示在第1期作水稻，雜草若在插秧後15、30、45與60日發生時可分別減產68.7、46.7、28.1與11.0%，第2期作水稻，其產量只因插秧後10與20日發生之雜草而減產52.5與13.1%，但其產量却不受在30與40日萌發雜草之影響。早期與後期萌發之稗草與三角草影響水稻產量之程度較鴨舌草爲大。不同時期萌發之雜草在不同肥力條件下減低稻谷產量之程度相若，稻谷產量構成因素中每株穗數與每穗粒數受雜草爲害之程度最爲嚴重，而百粒重與稔實率則不受影響。

本省水稻田土壤之生成研究[1]

——紅棕壤水稻田土壤生成之研究——

黎 靜 韻[2]　梁 鉅 榮[3]

一、緣起及目的

稻米爲本省之首要糧食作物，生產稻米之水田占全省耕地三分之二以上。水田由來已久，歷經年代，對該類土壤之生成，無從稽考。最大多數之水由，係冲積平原兼有水利之便者，水利稱便而無缺水者每年用爲兩期作，水利不便者年僅單期作，或至三年輪作水稻一次，故一般水田應爲冲積土之用爲水稻栽培，部分由於栽植水稻悠久，感受浸水影響，或地下水位高，更經長期栽培水稻，而生成特殊之土壤剖面，有稱之爲水稻土 Paddy Soils。本省過去土壤調查，發現確實受水稻栽植生成特殊剖面之土壤尚鮮，一般仍多保存其原有冲積之層次，因仍視其原始物質而歸類。近二十年來，日本對於水稻田土壤研究頗多，分類方案亦有八案之多（1.2），學術之研究甚盛。本省北部桃園、中壢、新竹一帶，台地發達，土壤多屬紅棕壤，由於地位略高至一、二百公尺，水利未便，向多旱作栽培，自石門水庫完成後，水源充沛，灌溉區內，旱作地多改爲水田。筆者爲明瞭水稻田土壤之生成，卽於民國五十三年起，就中壢紅棕壤改作水稻栽培之旱田，逐年按一、二期作採取土壤樣本，研究其理化性狀，及其形態上之變異，以推論其化育之經過，及闡釋水稻土之生成，換言之，本研究之目的，在瞭解水稻栽培於紅棕壤上，經每年兩期淹水狀態下，對該紅棕壤理化性質之影響，及其形態之變遷，以闡釋其土壤化育之趨勢及水稻土之生成。

二、研究之內容

筆者於民國五十三年夏，在桃園縣、中壢、南勢附近石門水庫灌水幹線之南，選一茶園，原係紅棕壤，在開成梯田利用爲水稻栽培前，採集剖面樣本五層，復於民國五十四年夏，就原田於栽植水稻一年兩期作後，採集第二次土壤樣本，以後每年夏、春於水稻收穫後，均前往研討其剖面性態，並採集剖面樣本，提供理化性分析，自始迄今，忽將五載。茲將主要代表剖面性態摘錄於下：

㈠ 原紅棕壤旱作茶園之剖面性態

採集地點：桃園縣中壢、南勢附近灌水幹線之南。

地面狀況：平坦梯級田，原爲茶園。

0—13公分：紅黃色（5YR$^{6}/_{6}$乾）至紅棕色（5YR$^{4}/_{4}$潤）之粘土，構造粒狀結構鬆脆，通透性適中，有機質少（1.36%），pH4.4。

13—30公分：黃紅色（5YR$^{5}/_{6}$乾）至黃紅色（5YR$^{4}/_{6}$潤）之粘土，構造段狀，結構脆而易碎，通透性不佳，有機質（0.59%），pH4.6。

30—46公分：黃紅色（5YR$^{5}/_{6}$乾）至黃紅色（5YR$^{4}/_{6}$潤）之粘土，構造及結構與上層同，有機質更少（0.5%），pH 5.1。

46—60公分：黃紅色（5YR$^{5}/_{6}$乾）至黃紅色（5YR$^{4}/_{8}$潤）之粘土，構造段狀，結構較上層易碎，通透性不良，有機質含量極少（0.24%），pH5.2。

1.本研究之完成，得國家長期發展科學委員會之補助。

2.台灣省農業試驗所技士。　3.台灣省農業試驗所技正。

60—80公分：黃紅色（5YR$^{5}/_{8}$乾）至紅棕色（5YR$^{4}/_{4}$潤）之粘土，除有機質含量爲最少外，餘皆與上層相同，pH 5.0。

㈡ 民國五十四年第一期作收穫後之水田土壤剖面形態：

0—13公分：紅黃色（7.5YR$^{6}/_{6}$乾）至深棕色（7.5YR$^{4}/_{4}$潤）之粘土，構造團粒狀，結構鬆脆，有機質少（1.41%），通透性適中，pH 4.7。

13—30公分：紅黃色（5YR$^{6}/_{6}$乾）至黃紅色（5YR$^{4}/_{6}$潤）之粘土，構造段狀，結構脆，有機質少（0.78%），pH 4.8。

其餘三層底土與原旱田形態相同，仍依原厚度分三層採樣。

㈢ 民國五十六年七月水稻收穫後，開掘之土壤剖面性態：

0—18公分：强棕色（7.5YR$^{5}/_{8}$乾）至暗棕色（7.5YR$^{4}/_{4}$潤）之粘土，無構造，結構潤時脆性，通透性中等，有機質少（1.8%），pH 5.3。

18—33公分：强棕色（7.5YR$^{5}/_{8}$乾，7.5YR$^{5}/_{6}$潤），粘土，無構造，結構潤時微實，通透性不良，有機質仍少（1.3%），pH5.4。

33—58公分：黃紅色（5YR$^{5}/_{6}$乾）至紅棕色（5YR$^{4}/_{4}$潤）粘土，段狀構造，結構極實，難通透，有機質亦少（0.67%），pH 4.9。

58—73公分：黃紅色（5YR$^{5}/_{8}$乾）至紅棕色（5YR$^{4}/_{4}$潤）粘土，有機質僅有0.34%，pH5.2，餘與上層同。

73—90公分：顏色與質地同上層，無構造，結構潤時極實，濕時板滯狀，極難通透，有機質含量與上層同，pH 5.1。

㈣ 民國五十七年一月水稻第二期作收穫後採集之土壤剖面性態：

0—18公分：紅黃色（7.5YR$^{6}/_{6}$乾）至强棕色（7.5YR$^{5}/_{6}$潤）粘土，團粒狀構造，潤時結構鬆脆，通透性尙好，富稻根，有機質中等（1.8%），pH 5.4。

18—33公分：强棕色（7.5YR$^{5}/_{6}$乾）至黃紅色（5YR$^{4}/_{6}$潤）之粘土，無構造，結構微實，通透性不良，有機質少（1.10%），pH 5.5。

33—68公分：黃紅色（5YR$^{4}/_{8}$乾）至暗棕色（5YR$^{4}/_{4}$潤）粘土，段狀構造，結構更實，通透性不良，有機質少（0.67%），pH 4.9。

68—73公分：顏色、質地均與上層相同，濕時無構造，結構爲粘結狀，難於通透，有機質缺乏（0.57%），pH 5.2。

73—90公分：顏色、質地、構造均與上層同，結構濕時板滯狀，通透更難，有機質更爲缺乏（0.45%），pH 5.2。

三、理化性之分析

㈠ 分析項目及方法

1. 機械組成：浮秤法(8)
2. 有效矽(SiO_2)：用醋酸鈉（pH4）浸出法(9)
3. 有效磷)P_2O_5)：白雷氏磷第一法(5)
4. 有效鉀(K_2O)：孟立克氏法(6)
5. 二氧化錳(mnO_2)：用强鹽酸抽出後，經過碘酸鉀處理後比色（10,11）
6. 全鐵量（Fe_2O_3）：用强鹽酸抽出發，用Barshed法（10,12）
7. 游離鐵（Fe_2O_3）：Barshed法(12)
8. 有機質含量：Walkley Black法(11)
9. 全氮量：擴散法(17)

10. 陽離子置換性質：用醋酸鹽法(11)，抽出液pH7.0，置換性鉀與鈉用焰光光電計測定，置換性鈣與鎂用Versene法。

(二) 分析結果

1. 物理性方面

本研究就四年半分期作採集樣本，進行分析。茲將每年一、二期作之代表土壤分析結果列於表1-a與1-b，並分述於下：

自表1-a及表1-b中觀之，機械組成不論在第一期作，或第二期作後所採之土壤剖面各層成分變化均甚微，或因同一田丘間之輕微差異。至於土色方面，僅改變表土與亞表土之顏色，底土幾無變更其色澤。

表 1-a 第一期作收穫後代表土壤剖面之主要物理性質

Table 1-a. Major physical properties of representative soil profiles after harvest of first crop

採集期 Sampling date	剖面號 Profiles No.	土號 Soil No.	厚度(公分) Depth cm	機械組成 Mechanical composition % 砂粒 Sand 0–0.02 mm	坋粒 Silt 0.02–0.002 mm	粘粒 Clay <0.002 mm	質地名稱 texture name	土色 Soil color 乾 Dry 色譜 Hue	色值/色度 Value/Chroma	名稱 Name *	濕 Moist 色譜 Hue	色值/色度 Value/Chroma	名稱 Name *
	1	8	0–13	16.06	31.52	52.42	Clay	5YR	6/6	紅黃色R.Y.	5YR	4/4	紅棕色R.B.
1964		9	13–30	21.06	22.52	56.42	〃	〃	5/6	黃紅色Y.R.	〃	4/6	黃紅色Y.R.
July		10	30–46	7.06	32.52	60.42	〃	〃	〃	〃 〃 〃	〃	〃	〃 〃 〃
Dry		11	46–60	11.06	32.52	56.42	〃	〃	〃	〃 〃 〃	〃	4/8	〃 〃 〃
field		12	60–80	5.06	32.52	62.42	〃	〃	5/8	〃 〃 〃	〃	4/4	紅棕色R.B.
	2	13	0–13	16.06	35.52	48.42	Clay	7.5YR	6/6	紅黃色R.Y.	7.5YR	4/4	深棕色D.B.
1965		14	13–30	7.06	24.52	58.42	〃	5YR	〃	〃 Y.R.	5YR	4/6	黃紅色Y.R.
July		10	30–46	7.06	32.52	60.42	〃	〃	5/6	黃紅色R.Y.	〃	〃	〃 〃 〃
Paddy		11	46–60	11.06	32.52	56.42	〃	〃	〃	〃 〃 〃	〃	4/8	〃 〃 〃
field		12	60–80	5.06	32.52	62.42	〃	〃	5/8	〃 〃 〃	〃	4/4	紅棕色R.B.
	4	26	0–13	11.76	37,82	50.42	〃	7.5YR	5/6	强棕色S.B.	5YR	4/4	紅棕色R.B.
1966		27	13–20	17.76	29.82	52,42	〃	〃	6/6	紅黃色R.Y.	〃	4/6	黃棕色Y.R.
July		28	20–30	5.76	33.82	60.42	〃	5YR	5/6	黃紅色Y.R.	〃	4/4	紅棕色R.B.
Paddy		29	30–68	7.76	33.82	58,42	〃	〃	5/8	〃 〃 〃	〃	〃	〃 〃 〃
field		30	68–90	9.96	31.82	58.42	〃	〃	〃	〃 〃 〃	〃	〃	〃 〃 〃
		31	90–100	6.58	35.26	58.16	〃	〃	〃	〃 〃 〃	〃	〃	〃 〃 〃
	6	51	0–18	12.48	39.34	48.18	Clay	7.5YR	5/8	强紅色S.B.	7.5YR	4/4	深棕色D.B.
1967		52	18–33	12,48	37.44	50.08	〃	〃	〃	〃 〃 〃	〃	5/6	强棕色S.B.
July		53	33–58	10.48	33.44	56.08	〃	5YR	5/6	黃棕色Y.R.	5YR	4/4	紅棕色R.B.
Paddy		54	58–73	13.14	30.09	56.82	〃	〃	5/8	〃 〃 〃	〃	〃	〃 〃 〃
field		55	73–90	13.14	29.04	57.82	〃	〃	〃	〃 〃 〃	〃	〃	〃 〃 〃

1968	8	121	0–18	12.96	38.94	48.10	Clay	7.5YR	5/8	强棕色S.B.	7.5YR	4/4	深棕色D.B.
July		122	18–33	13.06	37.12	49.82	〃	〃	5/6	〃 〃 〃	5YR	4/6	黃紅色Y.R.
Paddy		123	33–58	13.12	36.06	50.82	〃	5YR	4/6	黃紅色Y.R.	〃	4/4	紅棕色R.B.
field		124	58–90	13.12	33.06	53.82	〃	〃	4/8	〃 〃 〃	〃	〃	〃 〃 〃

*R.Y.—Reddish Yellow, Y.R.—Yellowish Red, D.B.—Dark Brown, S.B.—Strong Brown, R.B.—Reddish Brown.

表 1-b 第二期作收穫後代表土壤剖面之主要物理性質

Table 1-b Major physical properties of representative soil profiles after harvest of second crop

採集期	剖面號	土號	厚度(公分)	機械組成 Mechanical composition %				土色 Soil Color					
								乾 Dry			潤 Moist		
Sampling date	Profiles No.	Soil No.	Depth cm.	砂粒 Sand 2–0.02 mm	坋粒 Silt 0.02–0.002 mm	粘粒 Clay <0.002 mm	質地名稱 Texture name	色譜 Hue	色值/色度 Value/Chroma	名稱 Name *	色譜 Hue	色值/色度 Value/Chroma	名稱 Name *
1966	3	15	0–13	13.06	37.52	49.42	Clay	7.5YR	5/6	强棕色S.B.	7.5YR	4/4	暗棕色D.B.
Jan.		16	13–20	15.35	32.26	52.42	〃	〃	6/6	紅黃色R.Y.	5YR	4/6	黃紅色Y.R.
Paddy		17	20–30	13.76	30.82	55.42	〃	〃	5/8	强棕色S.B.	〃	〃	〃 〃 〃
field		18	30–68	9.79	29.82	60.42	〃	5YR	5/6	黃紅色Y.R.	〃	4/8	〃 〃 〃
		19	68–90	11.76	29.82	58.42	〃	〃	5/8	〃 〃 〃	〃	4/4	暗棕色D.B.
	5	37	0–18	12.58	37.34	50.08	Clay	7.5YR	6/6	紅黃色R.Y.	7.5YR	4/4	暗棕色D.B.
		38	18–33	10.58	33.34	56.08	〃	〃	6/8	〃 〃 〃	5YR	4/6	黃紅色Y.R.
1967		39	33–48	12.58	28.34	57.08	〃	〃	〃	〃 〃 〃	〃	4/4	暗棕色D.B.
Jan.		40	48–63	10.58	30.34	59.08	〃	5YR	5/8	黃紅色Y.R.	〃	〃	〃 〃 〃
Paddy		41	63–78	12.58	28.34	59.08	〃	〃	〃	〃 〃 〃	〃	〃	〃 〃 〃
field		42	78–100	10.58	31.34	58.08	〃	〃	〃	〃 〃 〃	〃	〃	〃 〃 〃
	7	64	0–18	12.96	30.22	47.82	Clay	7.5YR	6/6	紅黃色R.Y.	7.5YR	5/6	强棕色S.B.
1968		65	18–33	13.96	32.36	53.68	〃	〃	5/6	强棕色S.B.	5YR	4/6	紅黃色Y.R.
Jan.		66	33–68	12.96	28.36	58.68	〃	5YR	4/8	黃紅色Y.R.	〃	4/4	暗棕色D.B.
Paddy		67	38–73	11.96	30.36	57.68	〃	〃	〃	〃 〃 〃	〃	〃	〃 〃 〃
field		68	73–90	10.96	31.36	57.68	〃	〃	〃	〃 〃 〃	〃	〃	〃 〃 〃
1969	9	166	0–15	10.68	39.50	49.82	Clay	10YR	5/6	黃棕色Y.B.	10YR	4/4	暗黃棕色D.Y.B.
Jan.		167	15–30	10.68	33.50	55.82	〃	7.5YR	5/8	强棕色S.B.	5YR	4/6	黃紅色Y.R.
Paddy		168	30–48	6.80	29.38	63.82	〃	5YR	〃	黃紅色Y.R.	〃	5/6	〃 〃 〃
field		169	48–90	6.68	29.50	63.82	〃	〃	〃	〃 〃 〃	〃	〃	〃 〃 〃

* R. Y. — Reddish Yellow, Y. R. — Yellowish red, Y. B. — Yellowish Brown. D. Y. B.— Dark Yellowish Brown.
D. B. — Dark Brown, S. B,— Strong Brown, R. B. — Reddish Brown.

2. 化學性方面

可分主要化學性質及陽離子交換性質，每年亦分別以一、二期作後所採之代表土壤分析結果列於表2-a，2-b，3-a及表3-b。

表 2-a 第一期作收穫後代表土壤剖面之主要化學性質

Table 2-a Major chemical properties of representative soil profiles after harvest of first crop

採樣期 Sampling date	剖面號 Profiles	土號 Soil No.	厚度 Depth cm	有效養分 Available nutrition SiO_2 mg/100g	P_2O_5 ppm	K_2O ppm	二氧化錳 MnO_2 %	游離鐵 Free Fe_2O_3 %	全鐵 Total Fe_2O_3 %	游離鐵/全鐵 Free Fe_2O_3 / Total Fe_2O_3	有機質 Organic matter %	全氮量 Total Nitrogen %	炭氮比 C/N
		8	0–13	6.00	6.0	13.3	0.08	4.34	5.74	0.76	1.36	0.06	13.2
1964 July		6	13–30	8.25	8.3	6.4	0.09	4.53	5.96	0.76	0.59	0.05	11.8
Dry	1	10	30–46	24.63	6.0	17.0	0.14	5.28	6.95	0.76	0.50	0.04	7.5
field		11	46–60	30.75	5.0	14.0	0.15	5.01	7.03	0.71	0.24	0.04	3.5
		12	60–80	31.00	7.4	13.0	0.17	4.93	7.49	0.66	0.04	0.01	2.0
		13	0–13	7.25	6.0	17.0	0.12	4.12	5.28	0.78	1.41	0.08	10.0
1965 July		14	13–30	14.13	6.0	11.0	0.13	4.70	6.08	0.77	0.78	0.05	9.0
Paddy	2	10	30–46	24.63	6.0	17.0	0.14	5.28	6.95	0.76	0.05	0.04	7.5
field		11	46–60	30.75	5.0	14.0	0.15	5.01	7.03	0.71	0.24	0.04	3.5
		12	60–80	31.00	7.4	13.0	0.17	4.93	7.49	0.66	0.04	0.01	2.0
		26	0–12	10.00	20.0	44.0	0.15	4.50	5.72	0.79	1.73	0.08	12.6
		27	13–20	12.50	6.5	20.0	0.12	4.60	5.82	0.79	1.54	0.10	8.9
1966 July		28	20–30	14.44	11.0	20.0	0.13	5.11	6.85	0.74	0.96	0.09	5.9
Paddy	4	25	30–68	19.44	5.0	11.0	0.14	5.11	6.62	0.77	0.72	0.08	5.2
field		30	68–90	27.64	6.5	13.0	0.15	5.11	6.95	0.73	0.42	0.06	4.0
		31	90–100	32.64	5.2	13.0	0.16	5.08	6.45	0.68	0.49	0.05	5.9
		15	0–18	10.52	23.8	40.0	0.09	4.12	5.17	0.79	1.79	0.11	9.5
1967 July		52	18–33	12.20	9.2	11.0	0.10	4.68	6.08	0.77	1.36	0.08	10.2
Paddy	6	53	33–58	19.16	6.8	17.0	0.21	5.01	6.54	0.77	0.67	0.05	7.7
field		54	58–73	25.84	6.8	34.0	0.14	5.18	6.79	0.76	0.34	0.04	5.0
		55	78–90	34.52	9.2	24.0	0.14	5.36	7.06	0.75	0.34	0.04	5.4
		121	0–18	18.31	25.3	42.0	0.10	3.96	4.88	0.80	1.77	0.09	11.4
1968 July		122	18–33	20,70	9.8	17.0	0.13	4.14	5.40	0.77	1.30	0.07	107
Paddy	8	123	33–58	19.7	7.1	15.0	0.16	4.43	6.40	0.70	0.82	0.04	12.0
field		124	58–90	23.86	6.2	16.0	0.16	5.21	6.82	0.78	0.69	0.04	10.0

表 2- b第二期作收穫後代表土壤剖面之主要化學性質

Table 2-b Major chemical properties of representative soil profiles after harvest of second crop

採樣期 Sampling date	剖面號 Profiles	土號 Soil No.	厚度 Depth cm	有效養分 Available nvtrition 矽 SiO_2 mg/100g	磷 P_2O_5 ppm	鉀 K_2O ppm	二氧化錳 MnO_2 %	游離鐵 Free Fe_2O_3 %	全鐵 Total Fe_2O_3 %	游離鐵/全鐵 Free Fe_2O_3 / Total Fe_2O_3	有機質 Organic matter %	全氮量 Total Nitrogen %	炭氮比 C/N
		15	0–13	9.35	24.0	38.0	0.12	4.29	5.49	0.78	1.81	0.09	11.7
1966 Jan.		16	13–20	10.81	10.8	20.6	0.14	4.36	5.64	0.77	1.62	0.07	13.4
Paddy	3	17	20–30	10.84	11.8	18.0	0.13	4.72	6.57	0.72	1.23	0.07	10.2
field		18	30–68	24.60	7.4	14.0	0.12	5.29	6.92	0.76	0.34	0.06	3.3
		19	64–90	32.07	5.6	17.0	0.13	5.11	6.65	0.76	0.34	0.06	3.3
		37	0–18	12.89	23.1	45.0	0.12	4.19	5.44	0.77	1.55	0.08	10.7
		38	18–33	13.82	14.2	20.0	0.13	5.08	6.61	0.77	0.84	0.06	8.1
1967 Jan.		39	33–48	20.45	8.8	17.0	0.15	5.26	6.99	0.75	0.60	0.06	6.0
Paddy	5	40	48–63	26,82	7.6	23.0	0.13	5.18	6.69	0.77	0.38	0.05	4.4
field		41	63–78	30.22	9.6	20.0	0.14	5.11	6.72	0.76	0.38	0.05	4.4
		42	78–100	35.25	8,8	20.0	0.15	4.93	6.99	0.76	0.38	0.04	5.5
		64	0–18	16.92	25.2	46.0	0.12	4.00	5.30	0.75	1.80	0.11	9.4
1968 Jan.		65	18–33	18.45	15.0	25.0	0.15	4.60	5.84	0.79	1.10	0.05	10.6
Paddy	7	66	33–68	19.89	9.0	18.0	0.18	5.13	6.76	0.76	0.67	0.06	6.5
field		67	68–73	27,33	8.6	24.0	0.19	5.08	6.87	0.74	0.57	0.07	4.7
		68	73–100	32.31	7.4	22.0	0.18	5.08	6.50	0.78	0.45	0.07	3.8
1969 Jan.		166	0–15	20.32	25.6	46.0	0.11	4.22	5.35	0.75	1.56	0.14	6.5
Paddy	9	137	15–30	25.88	5.3	19.0	0.14	4.80	6.23	0.77	1.29	0.11	6.8
field		168	30–48	26.48	4.0	17.0	0.15	5.60	7.36	0.76	0.90	0.10	5.2
		169	48–90	36.72	13.3	16.0	0.16	5.55	7.06	0.78	0.55	0.09	3.6

表 3-a 第一期作收穫後代表土壤剖面之陽離子置換性質及pH

Table 3-a Cation exchange properties and pH of representative soil profiles after harvest of first crop

採樣期 Sampling date	剖面號 Profiles No.	土號 Soil No.	厚度 Depth cm	陽離子置換性 Cation exchange properties m. e./100 g. K	Na	Ca	Mg	Ex.H	C.E.C.	飽和度 Base saturation %	pH
1964 July Dry field	1	8	0–13	0.20	0.07	0.21	o.06	8.73	9.27	5.82	4.4
		9	13–30	0.14	0.08	0.26	0.11	9.22	9.81	6.01	4.6
		10	30–46	0.09	0.12	0.79	0.37	10.74	12,11	11.31	5.1
		11	46–60	0.10	0.13	0.23	0.12	9.91	10.49	5.52	5.2
		12	60–80	0.11	0.11	0.40	0.35	9.41	10.38	9.34	5.0
1965 July Paddy field	2	13	0–13	0.11	0.11	0.78	0.31	8.84	10.15	12.90	4.7
		14	23–30	0.09	0.12	0.77	0.33	10.16	11.47	11.42	4.8
		10	30–46	0.09	0.12	0.79	0.37	10.74	12.11	11.31	5.1
		11	46–60	0.10	0.13	0.23	0.12	9.91	10.49	5.52	5.2
		12	60–80	0.11	0.11	0.40	0.35	9.41	10.38	9.34	5.0
1966 July Paddy field	4	26	0–13	0.23	0.14	1.60	0.60	7.98	10.56	24.36	5.2
		27	13–20	0.11	0.09	0.68	0.29	9.37	10.54	11.10	5.0
		28	20–30	0.12	0.13	0.96	0.50	9.29	11.00	15.54	5.1
		29	30–68	0.10	0.13	0.76	0.50	9.91	11.40	13.07	5.1
		30	68–90	0.10	0.17	0.42	0.42	8.74	9.85	11.26	5.3
		31	90–100	0.10	0.19	0.35	0.44	9.29	10.37	10.41	5.3
1967 July Paddy field	6	51	0–18	0.16	0.14	1.24	0.45	7.90	9.86	20.12	5.3
		52	18–33	0.09	0.11	0.91	0.48	8.62	10.21	15.57	5.4
		53	33–58	0.10	0.14	0.92	0.40	9.74	11.30	13.80	4.9
		54	58–73	0.13	0.18	1.26	0.62	8.79	10.98	19.94	5.2
		55	73–90	0.13	0.20	1.15	0.49	8.29	10.26	19.20	5.1
1968 July Paddy field	8	121	0–18	0.15	0.22	1.89	0.75	7.29	10.30	29.22	5.5
		122	18–33	0.26	0.15	1.79	0.68	8.47	11.35	25.37	5.6
		132	33–58	0.14	0.16	1.56	0.59	10.00	12.45	19.67	5.2
		124	58–90	0.11	0.20	1.14	0.66	11.72	13.83	15.25	5.1

表 3-b 第二期作收穫後代表土壤剖面之陽離子置換性質及pH

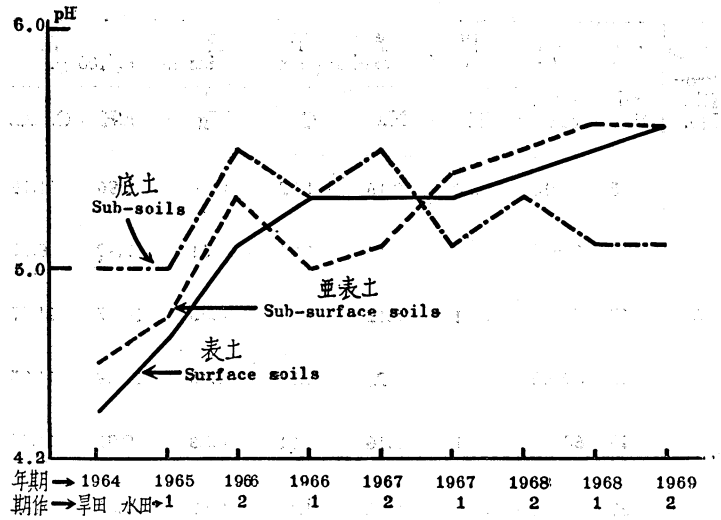
Table 3-b Cation exchange properties and pH of representative soil profiles after harvest of second crop

採樣期 Sampling date	剖面號 Profiles No.	土號 soil No.	厚度 Depth cm	陽離子置換性 Cation exchange properties m. e./100 g.						飽和度 Base saturation %	pH
				K	Na	Ca	Mg	Ex.H	C.E.C.		
		15	0–13	0.20	0.16	1.32	0.54	8.96	11.18	11.00	5.1
1966 Jan.		16	13–20	0.17	0.15	1.24	0.51	7.90	9.97	20.76	5.3
Paddy	3	17	20–30	0.11	0.12	0.74	0.33	10.67	11.97	10.86	4.9
field		18	30–68	0.10	0.22	0.71	0.43	10.49	11.95	12.22	5.3
		19	68–90	0.11	0.16	0.81	0.58	9.96	11.62	14.28	5.5
		37	0–18	0.19	0.15	1.18	0.52	7.49	9.53	21.41	5.3
		38	18–33	0.09	0.09	0.63	0.32	9.67	10.80	10.45	5.1
1967 Jan.		39	33–48	0.10	0.14	0.85	0.45	9.79	11.33	13.59	5.0
Paddy	5	40	48–63	0.12	0.12	0.92	0.61	9.36	11.13	15.93	5.1
field		41	63–78	0.11	0.13	0.46	0.63	9.44	10.77	12.34	5.4
		42	78–100	0.10	0.12	0.53	0.53	9.11	10.39	12.32	5.5
		64	0–18	0.30	0.22	1.49	0.63	7.34	9.98	26.45	5.4
1968 Jan.		65	18–33	0.12	0.26	2.62	0.98	8.13	12.11	32.86	5.5
Paddy	7	66	33–68	0.11	0.21	1.48	0.97	9.50	12.27	22.57	4.9
field		67	68–73	0.12	0.22	1.58	1.02	18.78	11.72	25.08	5.2
		68	73–90	0.12	0.20	1.67	1.02	9.06	12.07	24.93	5.3
		166	0–15	0.20	0.25	1.89	0.86	8.97	11.87	25.95	5.6
1969 Jan.		167	15–30	0.17	0.18	1.88	0.89	7.14	10.26	30.40	5.6
Paddy	9	167	30–48	0.14	0.25	1.05	0.59	9.69	11.72	17.32	4.9
field		169	48–90	0.13	0.48	1.13	0.73	9.69	12.16	20.31	5.1

爲便於以上各項化學成分之說明，逐項養分按其年期之變遷，繪成各圖，以曲線顯示其間之變化，並分別說明各圖於後。

圖1，紅棕壤旱田改作水田四年半內pH值之比較

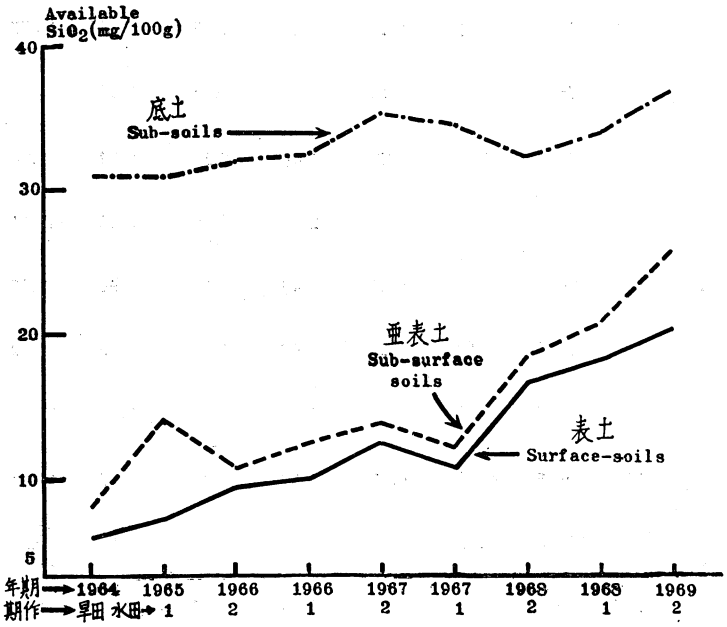
Fig. 1. The comparison of pH of the paddy field which alter from the dry field of reddish brown latosol for 4.5 years。



由上圖知土壤潛水後，導致 pH 逐漸上昇，尤以表土爲顯，初一、二年內表土上昇較快，其後較緩，四年半內表土 pH 值自4.4升至5.6，亞表土p H 值亦向上昇，底土之 pH 值在第一期作後上昇，第二期作後下降，變動輕微，亦卽紅棕壤潛水在四年半內，底層 pH 值之影響較輕。

圖2. 紅棕壤旱田改作水稻田四年半內之有效矽（SiO_2）含量比較

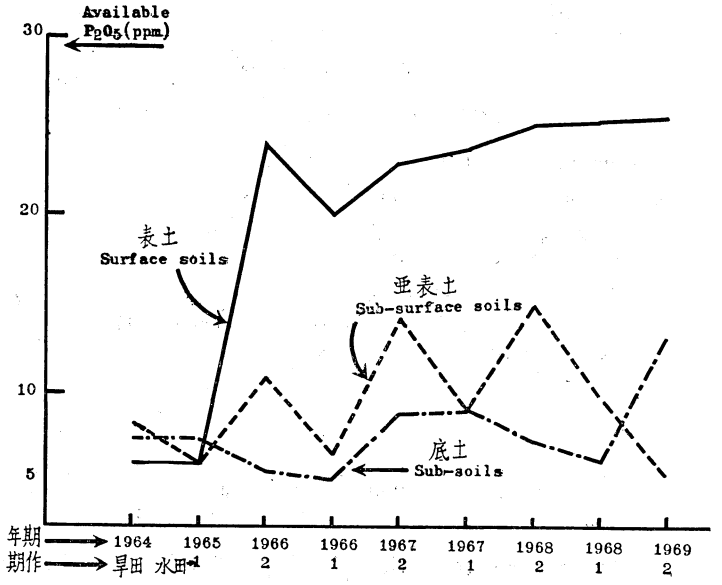
Fig. 2. The comparison of available silica content of the paddy field which alter from the dry field of reddish brown latosol for 4.5 years.



自上圖知紅棕壤有效矽含量，一般言之，表土含量較低，亞表土次之，底土含量較高，較表土多達四倍，四年半內矽之含量除第一年半外，其餘三年表土與亞表土之含矽量至爲接近，且趨向相同，逐年增加，而與底土漸趨接近，四年半內各層含矽量之差異，以亞表土變動最大(17.8mg/100g)，表土次之 (14.3mg/100g)，底土變動輕微 (6mg/100g)

圖3. 紅棕壤旱田改作水稻田四年半內有效磷（P_2O_5）含量之比較

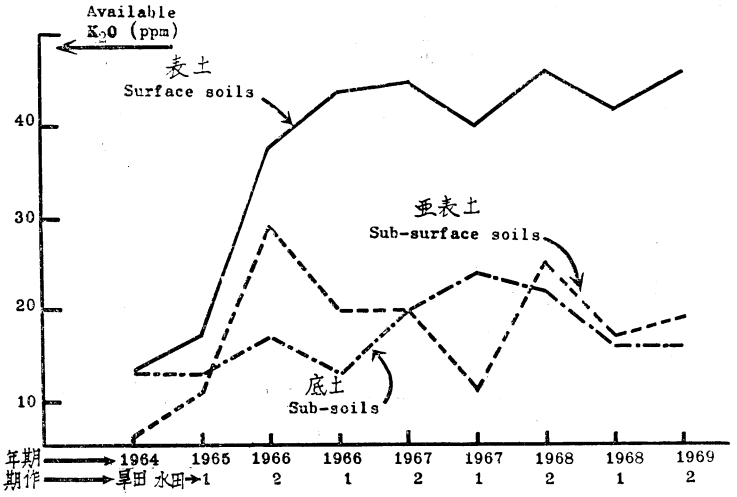
Fig. 3. The comparison of available P_2O_5 content of the paddy field which alter from the dry field of reddish brown latosol for 4.5 years。



有效磷（如上圖）含量，改作水田後表土含量增加，至1966年二期作後稍爲減少，至1967年一期作後迄今繼續緩慢上昇，較原旱田增達四倍餘，故由旱田改作水田，潛水種植水稻四年餘，有加强表土磷酸之有效性。亞表土之升降較爲頻繁，卽一期作後上升，二期後下降，但幅度不大。底土之升降則較微，四年半仍有增加。以上情形或與肥料應用有關。

圖4. 紅棕壤旱田改作水稻田四年半內之有效鉀（K_2O）含量之比較

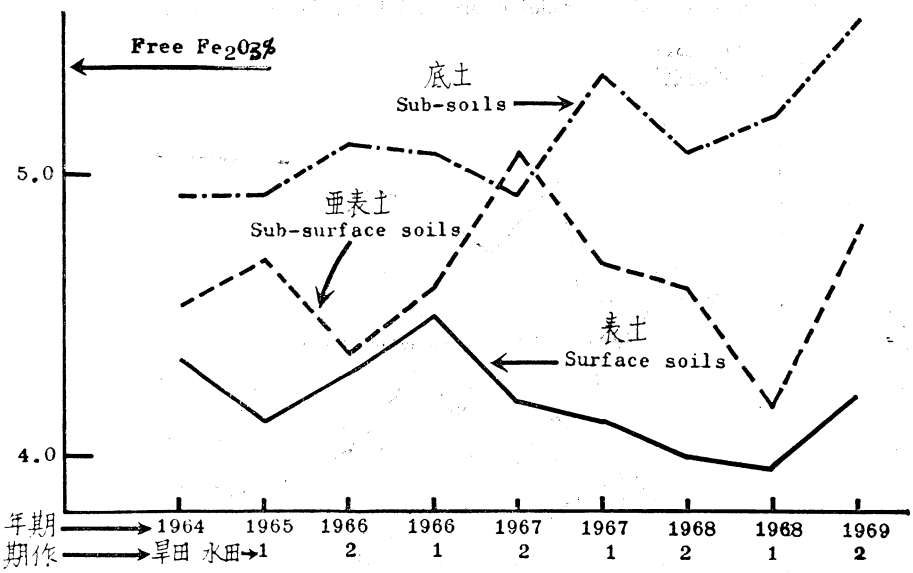
Fig. 4. The comparison of available K_2O content of the paddy field which alter from the dry field of reddish brown latosol for 4.5 years.



自上圖知有效鉀含量之趨勢，大致與有效磷相同，卽表土之有效鉀含量較高，亞表土次之，底土更次之，四年半內之變化，表土亦於一年後上昇頗高，至二年半後（1967）二期作下降，一期作後上昇，如是繼續升降，迄今較原旱田高約三倍餘，亞表土及底土有效鉀含量，升降不定，但仍較旱田爲高。

圖5. 紅棕壤旱田改作水稻田四年半內之游離鐵含量之比較

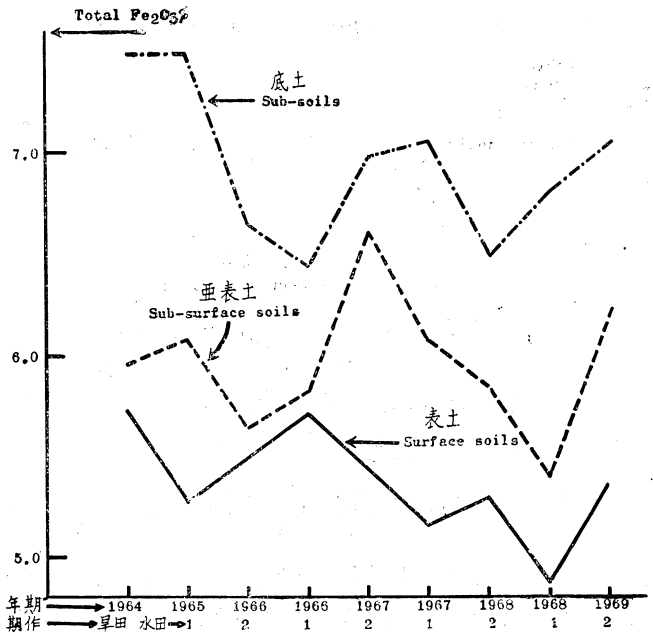
Fig. 5. The comparison of free iron content of the paddy field which alter from the dry field of reddish brown latosol for 4.5 years.



游離鐵之含量（如上圖），土壤中之游離鐵係屬還原鐵，其含量高低，反映還原性物料之多寡。本研究四年半內，各期作後之還原性物質之移動在上圖中示之，表土及亞表土游離鐵之含量在四年半內轉變趨向尙稱一致，底土則於第二年後一期作減低，二期作後復升，此後兩年情形相同，四年半後表土游離鐵含量較原旱田略爲減低，亞表土及底土均提高其含量，顯示還原性物質有趨向積聚於亞表土或底土之可能。

圖6. 紅棕壤旱田改作水稻田四年半內全鐵量之比較

Fig. 6. The comparison of total iron content of the paddy field which alter from the dry field of reddish brown latosol for 4.5 years.

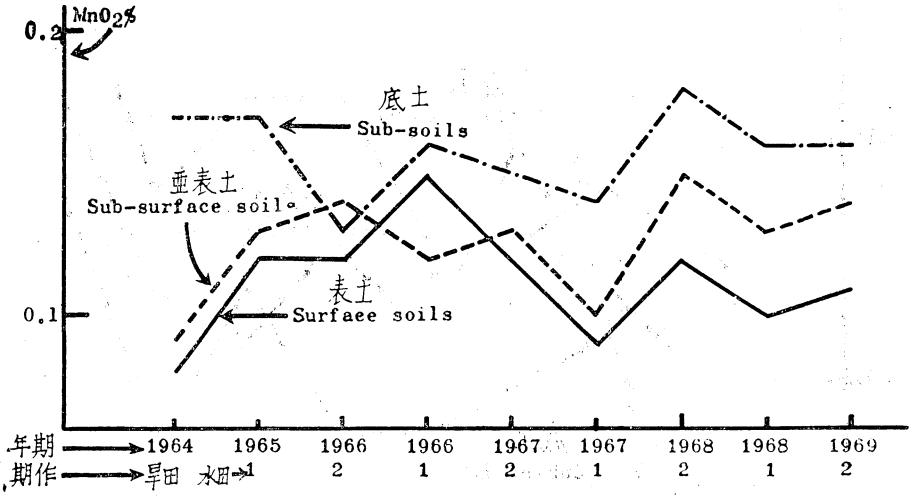


自上圖知紅棕壤之全鐵量含量，全鐵量包括還原鐵及氧化鐵之總量，故在各年期之升降可反映鐵之積聚或淋洗，在四年半後之轉變言之，鐵有積聚於亞表土之現象呈顯，爲量至微(0.3%)。在各年期

間之關係，表土與底土均較原旱田低，僅亞表土則除第一年二期，二年一期，第三年二期與四年一期較原旱田低外，其餘各期均較高，故亦有積聚，其中以二年二期爲較多，但查其實際含量，僅 0.6%，此僅能視爲有積聚之趨向而已。

圖7. 紅棕壤旱田改作水稻田四年半內之全錳（MnO_2）量比較

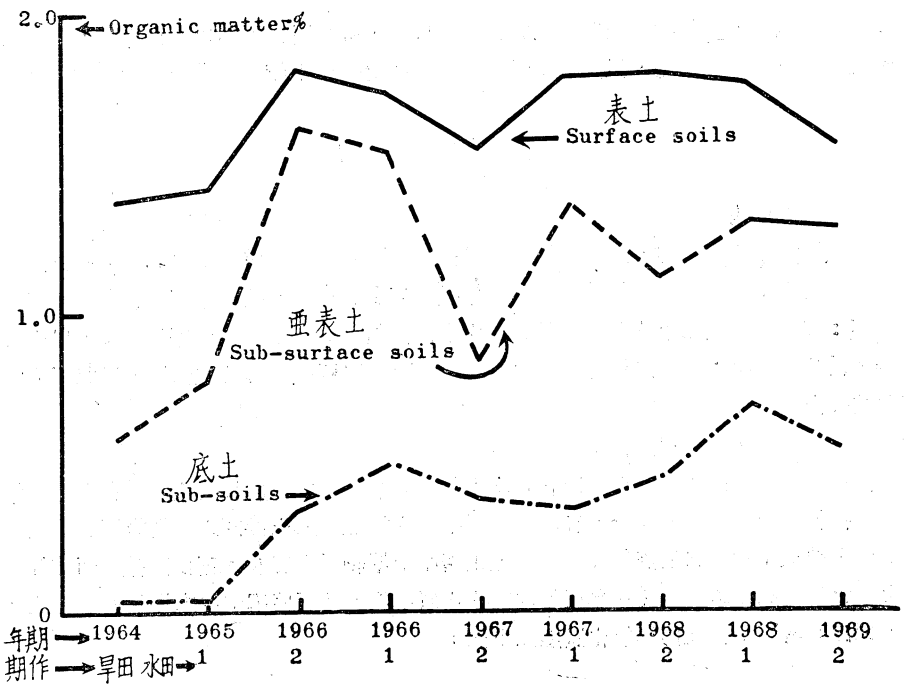
Fig. 7. The comparison of MnO_2 content of the paddy field which alter from the dry field of reddish brown latosol for 4.5 years.



錳之含量（如上圖），數年內表土與亞表土之升降趨向尙一致，四年半後之變遷，亞表土較大，表土次之，底土變遷最少，顯示亞表土略有錳之澱積。

圖8. 紅棕壤旱田改作水稻田四年半內有機質含量比較

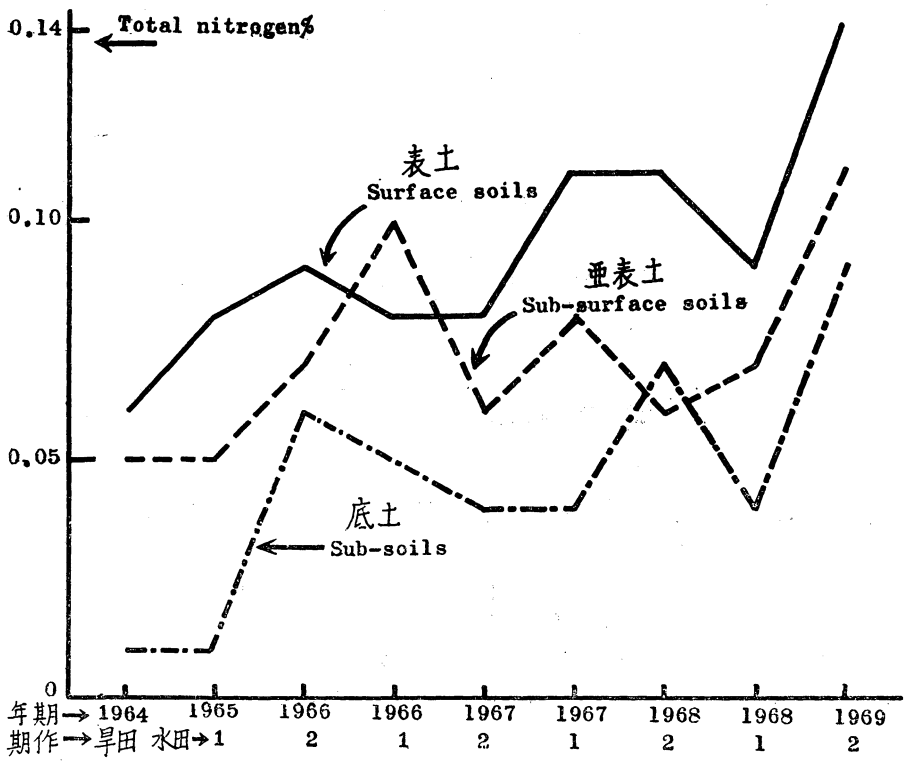
Fig. 8. The comparison of organic matter content of the paddy field which alter from the dry field of reddish brown latosol for 4.5 years.



有機質含量（如上圖），各年期土壤之有機質含量不高，均在 2 %以下，可稱缺乏。就各層言之，表土含量較高，亞表土次之，底土最低，四年半內之變化以亞表土較劇，表土次之，底土較輕。

圖9. 紅棕壤旱田改作水稻田四年半內之全氮量比較

Fig. 9. The comparison of total nitrogen content of the paddy field which alter from the dry field of reddish brown latosol for 4.5 years.



如上圖之全氮量，各年期之全氮量均在0.15%以下，就各層言，亦以表土略高，亞表土次之，底土含量最低，四年半內之變化，以亞表土最大，表土次之，底土較小，惟三者均有增加。

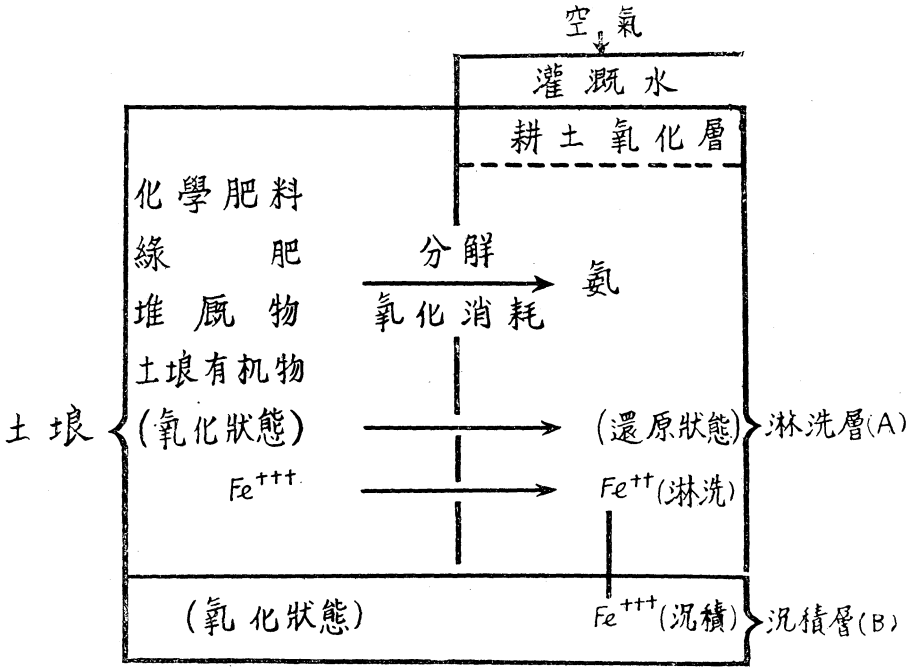
四、討　　論

㈠ 水稻土生成之理論

水稻向栽培於中國之南部，歷史最早，水稻土Paddy Soil之名稱，早載於中央地質調查所土壤學報(4)。近二十年來，日本對其稻田土壤之分類研究學者頗多，提出分類系統有八案(3)，亦可合併爲二類：卽一、以實用之施肥改良爲目的之小山案爲代表，根據土壤剖面形態，以土壤本身的區分特徵爲分類依據；一、以純碎土壤生成方式，及其影響程度爲分類依據，以鴨下或山崎之分類案爲其代表。

山崎氏之稻田土壤生成理論(1)：

1. 稻田土壤之淋洗作用——氏以爲在日本水稻每年有3—4個月之長期間內（在中國每年二期作時間更長）田面積水3—6公分，在瀦水狀態中，由於空氣與土壤間之接觸爲灌溉水遮斷，空氣中之氧所給與土壤之影響將無法產生，如土層中有機物料之存在，則由其分解而消耗原在土層中存在之氧，此時耕土層（耕犂層）卽陷入還原狀態，其下層因缺少有機物料，如地下水位低時，或田面有瀦水往往仍呈氧化狀態如下圖：



土壤若達成爲還原狀態時，還原性物質卽產生於土壤中，如在氧化狀態時，土層中之Fe^{++}化合物在土層達成還原狀態時卽變成Fe^{++}化合物，前者爲難溶性物質，不易移動，後者可溶，常隨滲透水移動至氧化狀態下層時，被氧化復成Fe^{+++}之化合物而積聚，因此地下水位低之稻田，其耕土層之Fe^{++}一般在灌水時，自該層淋失而在下層積聚，此種作用在長期間進行時，則土層將分化成爲兩層：一爲淋洗層（A層），一爲沉積層（B展），但某些稻田在灌水期中，其犂底層往往亦呈還原狀態，因而此犂底層亦可成爲淋洗層。

2. 稻田土壤剖面層分發育之經過——土壤母質物之堆積層稱爲C層，一般之冲積土其堆積後土壤母質物如未受土壤化作用時，其全土層亦可視作C層，冲積土如位於地下水之較高處者，其下層受地下水之影響進行灰粘化作用，土色呈藍綠灰色，稱爲G層，如地下水位極高時，則土層之全層亦可成爲G層，在地下水位較低處之冲積土，爲稻田利用時，因鐵之淋洗作用，土層分化爲淋洗層（A層）及積聚層（B層），山崎氏稱此作用爲稻田土壤化作用，而A層更可細分爲Ai層（受較弱之淋失作用所形成者），A_1層（受較强之淋失作用所形成者），A_2層（犂底層如有可分解性有機物多時，在排水期中呈現弱還原狀態時顯現之層）三層，G層亦分爲Gi層及Gr層，如下圖：

堆積當時之土層	堆積後受地下水影響之土層	作爲稻田利用後受淋失作用後之土壤	
C	C	A	稻田土壤作用
		B	
	G	G	灰粘化作用

3. 稻田土壤化作用之速度——土壤化作用，一般均認爲屬於一極緩慢作用，該作用雖與條件關係而有差異，但其作用力極强且速，以在日本富山縣東礪波郡上平村之旱田與改爲稻田後之土壤剖面進行觀察結果爲例，該土壤爲第三紀砂土，由旱田狀態開始至改爲稻田後1—7年止，依每年進行觀察其土壤剖面之變化，稻田經四年後，可認出有明顯的淋失層及沉積層之分化。
4. 鐵斑之形成——稻田層中之 Fe^{++} 化合物，經氧化後成 Fe^{+++} 化合物，沉積時普遍積聚於土層全面者甚少，而常形成爲鐵結核（iron concretion），鐵盤（iron pan）或是有鐵銹色之斑紋，鐵盤常出現於受有地下水及滲透水影響下之砂質土，然判別稻田土層時爲最有力之憑藉乃爲鐵斑，又還原層一般呈藍綠灰色，無鐵斑，受有强淋洗作用之淋洗層呈灰色，亦無鐵斑。綜合以上所見，用鐵斑之有無，形狀及土色之觀察，可以判別稻田土層之區分。
5. 稻田土壤之土層排列模式及各層之特徵——山崎氏將稻田土壤排列之模式以及各土層之特徵併記於下表：（表中O表示氧化狀態，WR表示弱還原狀態，SR表示强還原狀態）。

土層名	氧化還原狀態		特徵
	排水期	潛水期	
Ai 或 A_1	O	SR	接受淋失作用之結果，幾無鐵斑，或所受淋失作用較輕微時，則有管狀，膜狀之鐵斑出現。
A_2	O	WR 或 SR	土色呈灰白色，有微少之鐵斑，或缺欠之。
B	O	O	土色呈黃至棕色，有多量之管狀或絲狀，點狀等鐵斑。
Gi	WR	WR	土色呈藍綠灰色，見有暈管狀鐵斑。
Gr	SR	SR	土色呈藍綠灰色，但無鐵斑。

㈡ 本研究結果之說明

1. 根據土壤剖面形態言之，四年半期間內，潛水紅棕壤並栽植水稻田，僅改變表土及亞表土之顏色，色譜自5YR轉爲7.5YR，此因含鐵物質之水合作用影響較灌溉水之淋洗作用尤爲可能，至於各剖面之機械組成，則影響甚微，幾無改變，此與原旱田剖面質地粘重，而底土密實，滲透性緩慢，短期影響尚淺有關。
2. 就化學性質言之，不論全鐵、游離鐵、錳及有效矽含量均以底土含量最高，亞表土次之，表土較低，顯示諸項元素原紅棕壤卽具有相當量，經旱作潛水與稻作栽植均有影響。至於有機質與全氮量則相反之以表土較豐，亞表土次之，底土含量最低，顯示紅棕壤原具有該含量至微，旱作潛水與稻作栽培亦已受影響。
3. 從圖5.6及7中之游離鐵、全鐵及錳之含量，顯示潛水四年半後，有積聚鐵及錳於亞表土之趨向。
4. 土壤潛水栽稻後對表層之磷、鉀有效性有增加之效益，亞表土之矽含量亦然。
5. 自pH值圖1.觀之，紅棕壤潛水栽培稻田後，影響pH值最爲顯著，卽pH值逐年上昇，尤以表土爲高，四年半內 pH 值自4.4上昇至5.6，亞表土趨向相同，但較緩慢，底土昇降幅度不大，故四年半之潛水栽稻，並未影響紅棕壤底層 pH 值，此與該土壤質地粘重，透水困難有關。
6. 在圖8及表2-a，2-b中，知有機質含量一般均缺乏，中以表土含量較高，愈向下層而愈低，四年半內之變化，以亞表土較劇，顯示該層之氧化還原作用頻繁之有以致之。

7. 圖 9 與表2-a，2-b中，知全氮量亦缺乏，其趨向與有機質含量相同。
8. 就表3-a及3-b觀之，紅棕壤之pH 值雖自4.4升至5.6，但仍多屬强酸性（pH4—5.5）土壤，屬中酸性（pH5.5—6）者較少，陽離子置換性含量不高，鹽基飽和度%亦低，四年半內之變化甚爲輕微。

五、結　　論

㈠ 本研究紅棕壤旱田剖面之土壤質地粘重，底土密實，滲透性緩慢，表土有機質少，四年半栽稻，每年兩期潛水，對剖面影響不大，多仍保存原土壤剖面之底層形態，僅改變表土與亞表土之顏色，色譜自5YR轉爲7.5YR，係土壤本身含鐵物質之水合作用之結果，並非灌溉水之淋洗作用所影響而成。

㈡ 根據化學性質分析結果，鐵與錳有積聚於亞表土之趨向，惟並未呈顯於土壤形態之跡象，足知沉積仍輕或尚在初期，土壤之淋洗層或沉積層均未形成，故未能稱之爲有稻田土壤化作用之呈現。

㈢ 土壤潛水栽稻四年半，對紅棕壤之最大影響，爲表土酸度之減退，pH值按年期逐漸上昇，自4.4—5.6，亞表土之趨向相同，惟較緩慢，底土影響至微。

㈣ 土壤潛水栽稻四年半，有增加表土中磷與鉀有效性與表土及亞表土中矽之有效性之事實呈顯，對土壤有機質，全氮量與陽離子交換能量，則影響至微。

㈤ 就土壤剖面性態及化學性分析結果，說明紅棕壤旱田改爲水田，在短期間內（4.5年）尚難有明顯之化育或成土作用可言，該類水稻田土壤之生成仍有待長期之影響與繼續之研究。

六、摘　　要

㈠ 本研究之土壤，選自桃園縣、中壢鎮、南勢附近，包括原爲紅棕壤之旱作茶園，與改作水稻田後，逐年按期作於收穫後採集之土壤樣本，歷經四年半，研究其剖面形態，分析各層代表土壤之理化性質計有機械組成、pH 值、全鐵及游離鐵、二氧化錳、有效矽、磷及鉀、有機質、全氮量及陽離子交換性質等十一項。

㈡ 研究目的，在明瞭其土壤化育趨勢，以至水稻生成，研究結果詳列如表 1-a，1-b，2-a，2-b，3-a及3-b，圖1—9。

㈢ 原紅棕壤旱田剖面之土壤，質地粘重，底土密實，滲透性緩慢，表土有機質少，四年半栽稻潴水多仍保存原剖面之土壤底層之性態，僅改變表土與亞表土之顏色，自 5YR 轉爲 7.5YR，非灌溉水之淋洗作用影響，而係土壤本身含鐵物質之水合作用之結果。

㈣ 根據化學分析結果，鐵、錳有移積於亞表土之趨向（見圖5,6及7），惟土壤形態並無跡象，足見沉積尚輕，故土壤之淋洗層或沉積層均未形成，尚未能稱爲有稻田土壤化作用之呈現。

㈤ 土壤潴水栽稻四年半，對於紅棕壤之最大影響，爲表土酸度之減退，pH 值按年期逐漸上昇，自4.4—5.6，亞表土上昇較緩慢，底土影響至微。

㈥ 土壤潛水栽稻四年半，有增加表土磷、鉀有效性，與表土及亞表土矽之有效性之事實呈顯，對土壤有機質、全氮量與陽離子交換能量之影響甚輕微。

㈦ 就剖面形態，理化性分析結果，說明紅棕壤旱田改作水稻田，短期間內（4.5年），尚難有明顯之化育或成土作用可言，該類水稻土之生成，仍有待長期之影響與繼續之研究。

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GENESIS STUDIES ON THE PADDY SOILS OF TAIWAN

1. Studies on the genesis of paddy soils developed from reddish brown latosols

by

C. Y. Lai and K. W. Leung

Summary

1. Nine soil profiles were collected from the reddish brown latosols of Nam-she, Chungli, Taoyuan, including the original tea plantation dry field, and its altered paddy field which were sampled after the first crop and the second crop each year from 1964-1968 respectively. Soil morphology of those profiles and their physico-chemical properties were studied. Items of this experiment consist of mechanical analysis, pH value, total iron, free iron, manganese dioxide, available silica, available potash and phosphoric oxide, organic matter, total nitrogen and cation exchange capacity etc.
2. The purpose of this study is to want to know the trend of the development of reddish brown latosols which have altered to paddy field for 4.5 years and the genesis of the paddy soils. The results are showing on the Table 1-a, 1-b, 2-a, 2-b, 3-a, 3-b, and

the Fig. 1-9 etc.

3. Soil characteristics of the original dry field of latosols are as follow, The soil texture is heavy, the consistancy of the sub-soil is campact and firm, the permeability is low, the organic matter content is low. It is still reserved the original properties of the subsoil after the rice cultivation and the flooding influence for 4.5 years. It was altered the color of surface and sub- surface soils only from 5YR to 7.5YR in color hue. It was not influence by elluviation from irrigated water but it was the results of hydration of iron compound of the soil body.
4. Base from the chemical analysis, there is a trend of some iron and manganese which illuviated on the subsoils but there is not any trace on the soil morphology so the illuviation of those soils are still very weak, no-elluvial and illuvial horizon are formed. In other word, there is not any appearance of paddy soil forming process.
5. The most great effect which influence to the reddish brown latosols by flooding rice plantation for 4.5 years was the decrease of soil acidity of the surface soil, the pH value increase from 4.4 to 5.6. The increase of sub-soil is less than that of the surface soil.
6. The availability of the phosphorous and the potash of the surface soils has increased after flooding rice plantation for 4.5 years, and so do the available silica of surface and subsurface soils, but there is a little effect on the soil organic matter, total nitrogen and cation exchange capacity.
7. Base on the results o soil morphology, physico-chemical properties, it is hard to formed apparent soil development of latosols after dry land which was altered to paddy field for a short time (4.5 years) . So the genesis of the paddy soils which developed from latosols is still needed to weathered for a long time and we have to continue its study in the future.

Study on the Nitrate Reductase(I)

NAD(P)H-and FMNH-dependent nitrate reductase

Chi-ying Huang[1], Tao Lon[2]

It has been reported that reduction of nitrate by NAD (P) H is dependent on light, and the enzyme machinery needed for the nitrate reduction is contained in the chloroplast (3, 6, 12). These observations would explain the enhancement of nitrate reduction by light, and that the enzyme is NAD(P)H-dependent. In contrast to these reports, in 1964, Kessler(8) demonstrated that photochemically reduced NAD(P)H did not serve as an electron donor for nitrate reductase, and the nitrate reduction was not coupled to light.

In 1954, Nicholas and Nason (10) reported that $FMNH_2$($FADH_2$) also serve as electron donor for NAD(P)H-dependent nitrate reductase in Neurospora. In 1956, Stoy (14) reported that $FMNH_2$ ($FADH_2$) served as a more effective electron donor than that $NADH_2$ ($NADPH_2$) to nitrate reductase in higher plants.

The purpose of our present study is expected to determine if the nitrate reduction in higher plants is completed by a single enzyme that utilizes NAD(P)H or $FMNH_2$($FADH_2$) as electron donor, or by two different enzymes utilize two different kinds of co-factor as electron donor.

Material and methods

(1) Plant Culture Soybean seeds were soaked for two hours prior to planting in trays of vermiculate well irrigated with Haogland solution. The seedlings were grown in the green house until 10-day old. The leaves were harvested for enzyme extraction.

(2) Extraction and Purification of Enzyme In order to prepare a chlorophyll free preparation which had a minimum of gum like material, we followed the procedures of Colowick (5) for making an acetone powder. The dried acetone powder was extracted with 12 volume of cold phosphate buffer (0.2M, pH 7.5). The crude extracts were purified by ammonium sulphate precipitation and calcium phosphate gel adsorption as described by Evans and Nason (6).

(3) Preparation of Cofactors $NADPH_2$ and $NADH_2$ were chemically reduced as the method described by Lehninger (5*) $FADH_2$ and $FMNH_2$ were enzymatically reduced by the method of Felton (5*).

* The methods preparing the reduced cofactors as described by Lehninger, Felton are collected in "Methods in Enzymology" by Colowick. et al.

(4) Preparation and Assay of Nitrate Reductase Activity The assay systems were prepared as indicated in the accompanying table :

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1. Instructor, National Taiwan University
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Reaction mixture	NAD (P) H-NR*	$FADH_2$ ($FMNH_2$) -NR
KNO_3, 10^{-2}M	1 ml	1 ml
NAD (P) H, 1.0×10^{-3}M	0.25 ml	---
$FADH_2$ ($FMNH_2$) ,10×10^{-3}M	---	0.25 ml
Phosphate buffer, 0.2M pH 7.5	1.50 ml	1.50 ml
Enzyme extract	0.25 ml	0.25 ml
Final volume	3.0 ml	3.0 ml

* NR is abbreviation for Nitrate Reductase.

The reaction mixture was incubated for 30 minutes at 37°, then the reaction was stopped by adding 2 ml of Uranyl acetate reagent. This was centrifuged and the precipitate discarded. To the supernatant fraction was immediately added 1 ml of N-(naphythyl) ethylenediamine solution (0.02%) to develope the color of NO_2^-. After 15 minutes the optical density was determined with a Spectronic 20 at 540 mμ.

The optical density of the control reaction mixture containing all the constituents except the enzyme extracts was used to correct for turbidity.

(5) Definition of Enzyme Unit and Specific Activity One unit of nitrate reductase is defined as that amount of enzyme resulting in the formation of one μ mole of nitrite under this assay condition.

Specific activity is expressed as the units of enzyme per milligram of protein.

The protein in the extracts was precipitated by Trichloroacetic acid, and its amount determined by micro-Kjeldahl method.

Results and discussion

(1) Purification of Nitrate Reductase. Both NAD(P)H- and $FMNH_2$-dependent nitrate reductase to be present in the crude extract ammonium sulfate precipitate and calcium phosphate gel elute, there is a slight excess of NAD(P)-NR. Ammonium sulfate precipitation followed by gel adsorption resulted in an 12 fold purification of the enzymes under study (Table I).

Table I. Purification of Nitrate Reductase.

Fraction	Protein		Specific activity of enzyme	
	mg/ml	total amount	NAD (P) H-NR*	FMNH-NR*
Crude extract	4.49	18765	38.5	35.7
Fraction I 43% $(NH_4)_2SO_4$ ppt	2.65	588.6	66.0	54.4
Fraction II 46% $(NH_4)_2SO_4$ ppt	1.06	188.52	139.1	129.2

Fraction III Ca-phosphate gel elute	0.58	12.18	483.3	471.0

**NAD(P)H-NR=NAD(P)H-dependent nitrate reductase.

FMNH-NR=$FMNH_2$ (or $FADH_2$) -dependent nitrate reductase.

(2) Induction of Nitrate Reductase. The ten-day-old seedlings were excised at the ground level and submerged them in a medium containing desired level of substrate and inhibitor. The results of these experiments (Table II) show that: (a) appearance of the activity of NAD (P) H-NR and FMNH-NR are in identical physical properties each other, (b) synthesis of nitrate reductase is depended upon the present of nitrate, i.e. the nitrate reductase is an adaptive enzyme, (c) if the seedlings deficient in nitrate are excised and incubated in the induction medium containing nitrate, the seedlings show a linear increase in production of nitrate reductase. The longer the incubation time for seedlings, the greater amount of nitrate reductase it induced. On the contrary, if the seedlings well supplied with nitrate in the nutrient solution, the seedlings show no further increasing in production of nitrate reductase when they are in the induction medium, (d) if cycloheximide are added to the medium, the nitrate reductase can not be induced with the nitrate. The longer the incubation times for seedlings in the induction medium containing cycloheximide, the lesser amount of nitrate reductase it induced. Since the cycloheximide is an inhibitor of protein synthesis.

Table II. The Condition for Induction of Nitrate Reductase.

Induction* medium	Induction time, hour	Enzyme activity a-1 Preinduced NAD(P)H-NR	a-1 Preinduced FMNH-NR	a-2 Not preinduced NAD(P)H-NR	a-2 Not preinduced FMNH-NR
Nitrate	0	38.5	35.7	11.4	10.5
	2	38.6	35.9	19.8	15.3
	4	38.9	35.9	22.2	20.1
	16	39.6	36.3	29.5	28.2
Nitrate, cycloheximide	0	38.5	35.7	11.4	10.5
	2	32.1	31.2	7.7	7.8
	4	25.6	24.2	3.9	4.2
	16	1.12	0.77	–	–
-nitrate, -cycloheximide	0	38.5	35.7	11.4	10.5
	2	37.0	34.8	8.0	7.9
	4	33.3	32.1	6.7	6.3
	16	27.9	24.4	5.5	5.1

* The induction media was prepared as the method described by White

a-1 The seedlings were planted in a nutrient solution containing nitrate.

a-2 The seedlings were transferred to a nutrient solution lacking nitrate.

The unit expressed here is the specific activity of enzyme.

(3) Sulfhydryl requirement. In 1953, Evans and Nason (6) showed that sulfhydryl group was required for nitrate reductase activity in higher plants. This-SH group is inhibited by the p-chloromercuribenzoate (PCMB). In our experiments with a crude nitrate red-

uctase extracted from soybean leaves showed that preincubating the enzyme with 10^{-3}M or 10^{-6}M p-chloromercuribenzoate resulted in complete or 50%, respectively, inhibition of both NAD(P)H-NR and FMNH-NR. If 1 x 10^{-3}M of cysteine hydrochloride was added to the assay mixture, the inhibition due to p-chloromercuribenzoate (10^{-3}M) was reduced to 30% or mars, and little inhibition when concentration of p-chloromercuribenzoate was below 10^{-4}M (Figure I). From the date presented in the Figure 1 and Table 111, we verify that; 1. high concentration of exogenous cysteine increases in stability of NAD(P)H-and $FMNH_2$ (or $FADH_2$) -dependent nitrate reductase activity, 2. addition of cysteine prevents p-chloromercuribenzoate inhibition of enzyme activity.

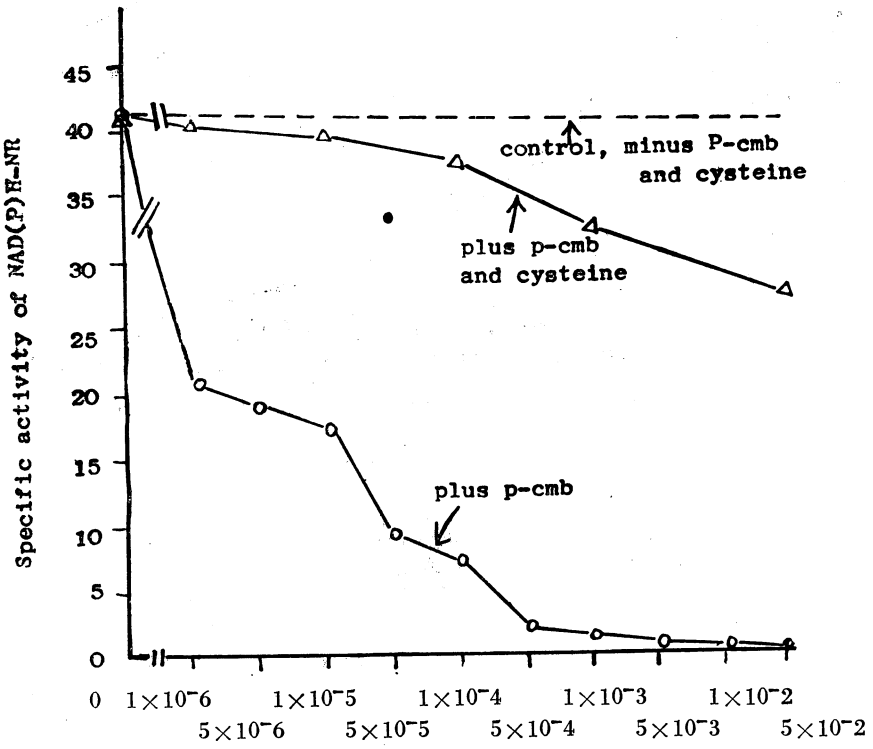
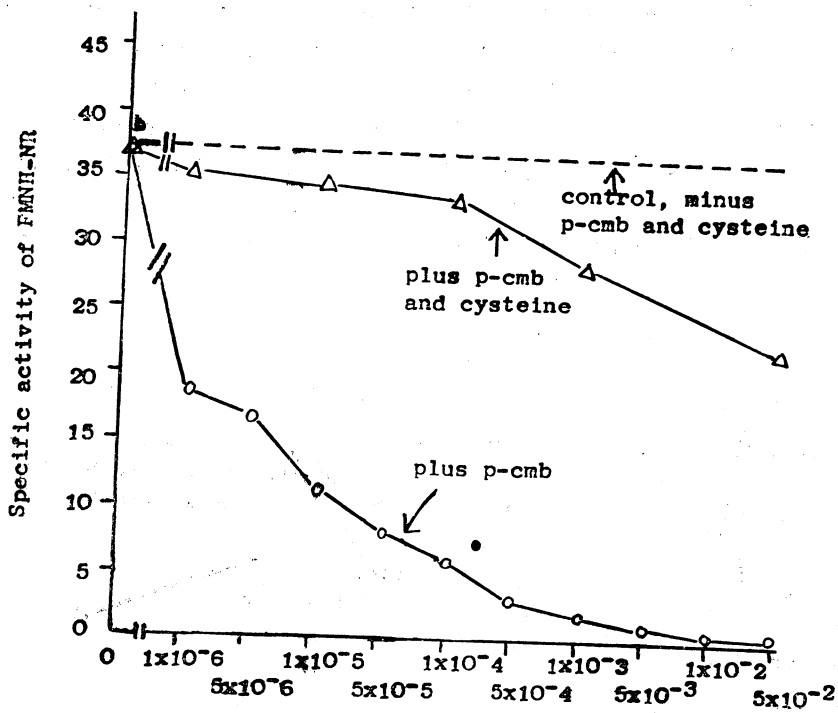


Figure 1-A, The inhibition of NAD(P)H-NR by p-chloromercuribenzoate and reversal by cysteine.



Concentratfon of p-chloromercuribenzoate (p-cmb) (M)

Figure 1-B The inhibition of FMNH-NR by p-chloromercuribenzoate and reversal by cysteine

Table Ⅲ. The Effect of Cysteine on the Extraction of Nitrate Reductase.

Reaction mixture	Specific enzyme activity	
	NAD (P) H-NR	FMNH-NR
Phosphate buffer	38.5	35.7
Phosphate buffer plus cysteine	55.1	40.0
% increase brought about by cysteine	43	20

The concentration of cyseine used here is 1.0×10^{-3}M.

(4) Thermal Stability of NAD(P)H-NR and FMNH-NR. No differential loss of NAD (P) H-NR and FMNH-NR was noted in vivo at the higher temperature. However, the data in the Table IV show that at 45°c, NAD(P)H-NR in vitro is more heat labile than the FMNH-NR. Therefore, selective denaturation by heating to 45°c could result in separation and purification of NAD (P) H-NR from FMNH-NR.

Table IV. Relative Stability of NAD(P)H-NR and FMNH-NR to Temperature

Temperature °C	Specific activity of enzyme			
	NAD(P)H-NR		FMNH-NR	
	10 min.	20 min.	10 min.	20 min.
20	28.7	29.4	27.7	28.6
30	38.5	41.0	36.1	36.6
45	23.9	18.2	33.7	32.4

From the data in The Table IV, it shows that: (a) the higher the temperature (below 45°c) for enzyme reaction, the greater enzyme activity it shows, The Q_{10} for nitrate reductase is 1.3 to 1.4 (b) the longer the incubation time for enzyme reaction, the greater amount of nitrite are produced.

(5) The Effectiveness of Electron Donors for Nitrate Reductase. For the purpose of determining the relative effectiveness of electron donors for nitrate reduction, $NADPH_2$, $NADH_2$, $FADH_2$, and $FMNH_2$ were added individually or in combination to the reaction mixture. The results (Table V) show that reduced nicotinamide adenine nucleotindes are the most effective electron donors in higher plants. $FMNH_2$ is somewhat less effective, $NADH_2$ and $FADH_2$ fall in between of them. Combination of $NADPH_2$ and $FADH_2$ gave no greater activity than did $NADPH_2$ alone. This observation are comparable to the apparent Km values of cofactor which presented in the Figure II.

Table V. Relative Effectiveness of Electron Donors for Nitrate Reductase.

Electron donor	conc.	u moles cofactor oxidized 340m/u	450m/u	u moles NO_3^- consumed	u moles NO_2^- produced
$NADPH_2$	157x10-6M	0.199	---	0.214	0.197
$NADH_2$	157x10-6M	0.185	---	0.200	0.189
$FADH_2$	262x10-5M	---	0.189	0.191	0.186
$FMNH_2$	262x10-5M	---	0.181	0.171	0.175
$NADPH_2$ plus $FADH_2$	78x10-6M / 131x10-5M	0.106	0.084	0.212	0.195

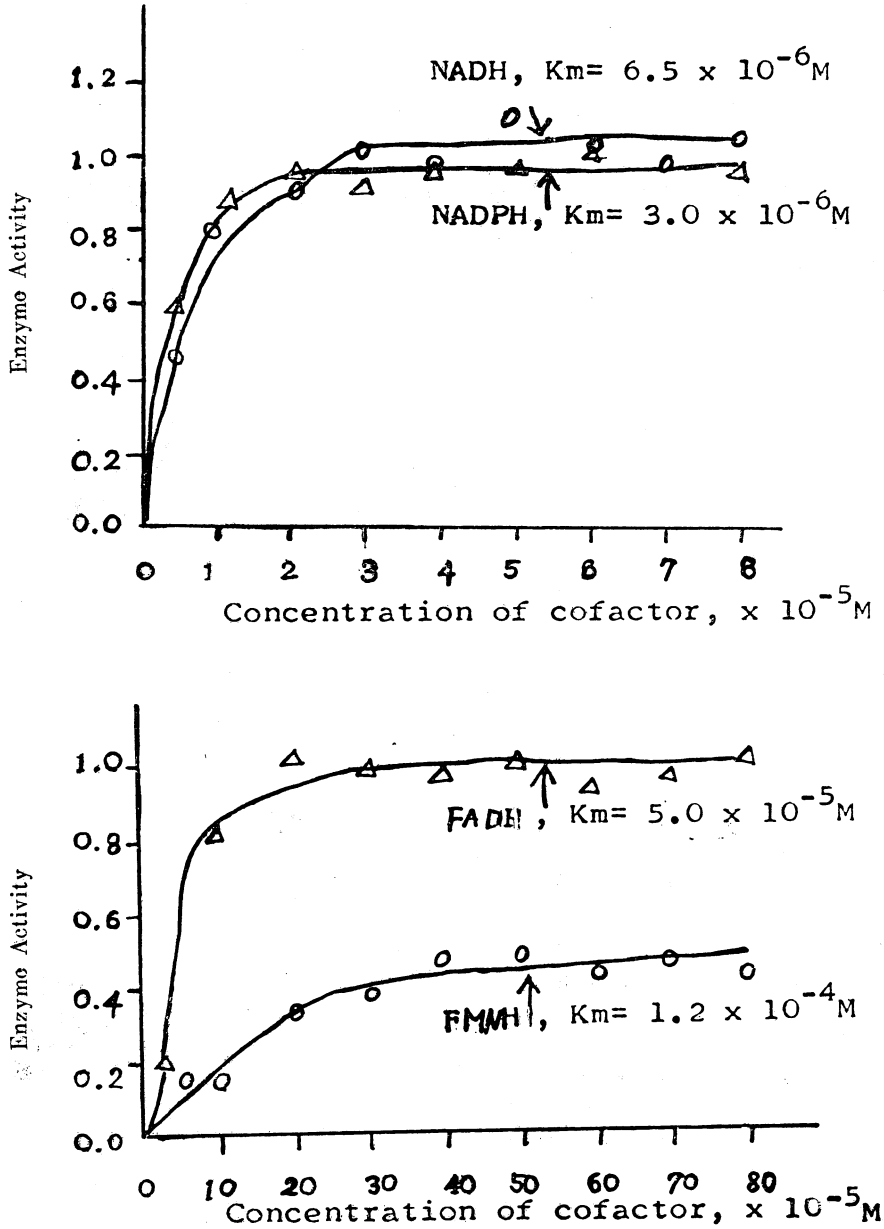
The concentration of cofactor oxidized were determined by the Extinction Coefficient: i.e. 6.24×10^6 cm^2/mole for $NADPH_2$ and $NADH_2$.

1.13×10^7 cm^2/mole for $FADH_2$ and $FMNH_2$.

Amount of cofactor oxidized, NO_3^- consumed, and NO_2^- produced were in agreement, i.e. when one mole of NO_2^- are produced, there one mole of NO_3^- are reduced, and one mole of cofactor are oxidized at the same time.

(6) Apparent Km value for the Cofactors and the Nitrate. (a). $FMNH_2$ concentration required for achieving the half maximal rate of nitrate reduction was greater than that

of $FADH_2$, and the concentration of $NADH_2$ required for half maximal rates was greater than when $NADPH_2$ was used. In general, higher concentration (10-fold to 100-fold) of reduced flavin nucleotides is required to achieve a half maximal rate of nitrate reduction than when reduced nicotinamide adenine nucleotides were used (Figure II). These results indicate that a greater affinity of the enzyme for NAD(P)H than for $FADH_2$ ($FMNH_2$), i. e. $NAD(P)H_2$ is a more efficient hydrogen donor for nitrate reductase than $FADH_2$ (or $FMNH_2$) is, (b)the concentration of NO_3^- required for one half maximal NAD(P)H-NR activity was 2.0×10^{-4} M and that for $FADH_2(FMNH_2)$-NR Was 3.9×10^{-4}M (FigIII) These results indicate that a greater affinity of the NAD(P)H-NR for nitrate than is $FADH_2$ ($FMNH_2$)-NR for nitrate.



FigII (P.57)

Figure II. The apparent Km value for NADPH, NADH, FADH, and FMNH. The velocity (EcgymeActivity)expressed here is u moles NO_2-Produced, per milligram of protein, per hour.

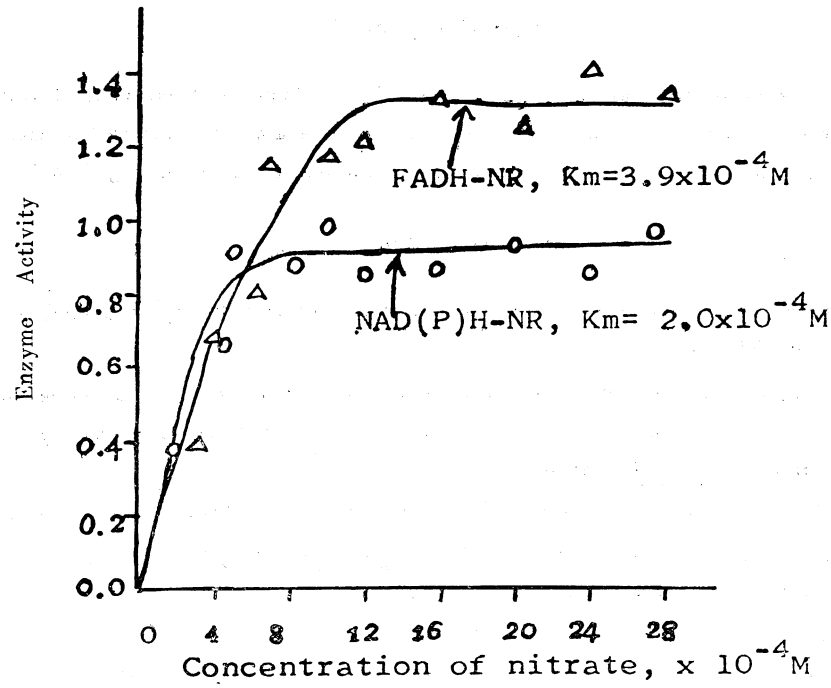


Figure III. Apparent Km value for nitrate.

Summary

1. There show a little differential activity in NAD(P)H-NR and FMNH-NR. The activity of NAD(P)H-dependent nitrate reductase predominate to that of FMNH- dependent nitrate reductase.
2. NAD(P)H-NR and FMNH-NR are equally susceptible to the inhibition of p-chloromercuribenzoate, but this inhibitory effect can be reversed by cysteine in the reaction mixture.
3. Presence of cysteine in the extraction medium results in increasing enzyme activity. NAD(P)H-NR and FMNH-NR activity are increased about 43% and 20%, compared to that of the control lacking cysteine, respectively.
4. Activity of NAD(P)H-NR decrease more rapidly that of FMNH-NR at the temperature above 45°C, i.e. NAD(P)H-NR is more heat labile.
5. Relative affinity of cofactors to enzyme are arranged, according to their apparent Km values, in order of

   $NADPH_2$> $NADH_2$ for NAD(P)H-dependent nitrate reductase.

   $FADH_2$> $FMNH_2$ for FMNH-dependent nitrate reductase.

   Relative affinity of nitrate to enzyme:

   NAD(P)H-dependent nitrate reductase> FMNH-dependent nitrate reductase.

   By comparison of the characteristics of enzyme described above, the so-called nitrate

reductase may be a mixture of NAD(P)H_and FMNH_dependent nitrate reductase. Although these kinds of enzyme are nearly identical in chemical and physical properties.

Acknowledgement

We wish to express our thanks to Dr. Shepley S. C. Chen and Charles E. Devol of our department for their critical reading of this manuscript. We also indebted to Professor C. J. Yue who gave us advices and answered the inquiries for us during we engaged in this study.

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植物體內硝酸鹽還原酵素活性之研究

黃啓穎[1] 藍調[2]

摘 要

從前一般學者都認爲於植物體內硝酸鹽還原過程中，祇有一種硝酸鹽還原酵素參與催化作用，又依酵素的特性而言，一種酵素蛋白（Apoenzyme）與一種輔酵素（Coenzyme）構成爲一種完全酵素，所以硝酸鹽還原酵素似乎不可能與兩種輔酵素（NADPH或$FADH_2$）結合。本研究爲針對此問題加以探討，究由一種酵素蛋白可利用兩種輔酵素，或兩種酵素各利用其所需的輔酵素，同時參與硝酸鹽還原作用，玆以大豆爲材料經實驗結果摘要如下：

1.在此實驗我們已獲知：當硝酸鹽被大豆吸收後，在轉變爲銨的過程中有兩種硝酸鹽還原酵素參與作用，則 NADPH和FMNH 硝酸鹽還原酵素，此兩種酵素在理化性上很近似，但是以活性而言，NADPH 硝酸鹽還原酵素大於 FMNH 硝酸鹽還原酵素。

2.NADPH 硝酸鹽還原酵素和 FMNH 硝酸鹽還原酵素的活性同樣可受 P—Chloromercuribenzoate 所抑制；可是此種抑制作用，又可被半胱氨酸（Cysteine）所克服，由此可見半胱氨酸對此兩種酵素的活性有促進作用，與對照比較其活性效率可使 NADPH 硝酸鹽還原酵素的活性約增加 43%，而對 FMNH 硝酸鹽還原酵素也可以增加約20%，所以半胱氨酸對 NADPH 硝酸鹽還原酵素之作用大於 FMNH 硝酸鹽還原酵素。

3.FMNH 硝酸鹽還原酵素較 NADPH 硝酸鹽還原酵素耐熱，當溫度大於 45°c 時 ， NADPH 硝酸鹽還原酵素之活性則急減。

4.依照Km值比較，在 NADPH 硝酸鹽還原酵素所結合的輔酵素 $NADPH_2$（$TPNH_2$）較$NADH_2$（$DPNH_2$）爲佳，而於 FMNH 硝酸鹽還原酵素則以 $FADH_2$ 比 $FMMH_2$ 爲佳。所以在大豆體內而言，參與硝酸鹽還原作用的酵素， NADPH 硝酸鹽還原酵素比FMNH硝酸鹽還原酵素爲佳。

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蘆筍莖枯病之研究
(II)生理性質及藥劑防治①

楊一郎　侯秀明　陳永利②

Studies on the stem blight of Asparagus caused by *Phoma asParagi*

(II) Physiological characteristics and chemical control

I.L. Yang, S.M. Hour, Y.L. Chen

一、緒　　言

蘆筍（*Asparagus officinalis* L.）爲多年生百合科作物(Liliaceae)，因全年常綠性，且多係母莖採筍方式，故病害潛伏蔓延亦甚，尤以莖枯病（*Phoma Asparagi* Sacc.）之發生最厲，在本省各地均有發生，在發生嚴重季節平均罹病率可高達80%。關於*Phoma asparagi*首見於1884年Saccrdo之報告，在本省早於1919年澤田氏報告該病在台灣之猖獗情形，1963年吳福壽君報告本病及蘆筍褐斑病等在本省之發生情形，1969年吳福壽、許忠雄及孫守恭等氏報告本病之發生、分佈、生態及胞子發芽試驗等，1970年作者報告本病在本省之消長、罹病與植體生長之關係，及品種間感受性等。又目前本省推廣之品種，美麗華盛頓(Mary Washington)對本病爲感受性，而對銹病 *puccinia asparagi* 爲抵抗性。本試驗工作從事莖枯病菌之生理性質及防治試驗，爰將試驗結果，提出報告以供參考。本工作承國貿局、農復會、農林廳、省農會之輔助，並承羅宗爵技正、謝靜吾技正、孫守恭教授、徐茂樟股長、杜宏周股長、古煥松先生、吳福壽先生之鼓勵與指導，筆者敬致謝忱。

二、材料與方法

1.以組織分離法及Keitt氏單胞分離法，由蘆筍莖部病斑分離病菌，並移植於馬鈴薯斜面培養基上，置28°C定溫箱中，得純粹培養，經1至2週卽出現黑褐色粒狀柄子器（Pycnidia），其柄胞子（Pycnidiospores, conidia）與蘆筍莖部病斑上之柄胞子相同。

2.供試培養基皆爲馬鈴薯、蔗糖、洋菜培養基。

3.供試蘆筍係向台灣省農會索取之美麗華盛頓Mary washington 種子，經播種並移植於8寸花缽供試。

4.供試農藥爲：Takeda-mer, Duter, Suju, Polyram-combi, Brestan 60, Dithane M45, Antracol, Difolatan 等8種。

5.本試驗於1968年至1970年間進行，詳細方法分述於後。

三、研究結果

1.溫度與本菌生長之關係：本試驗在探討本菌發育適宜溫度及發育溫度範圍，本菌菌絲塊，經

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①本研究計劃承國貿局、農復會之補助，謹致謝忱。

②嘉義農業試驗分所。

移植平面培養於不同溫度定溫箱中，每種溫度五個重複，每天觀察其發育情形，結果如表1及表2：

表1. 蘆筍莖枯病菌菌落生長與溫度之關係（培養6天）

項目 / 結果 / 溫度	菌落周緣	菌落外觀	菌落高度	基底色	氣生菌絲色	菌絲量	發育程度
7°c	無生長	—	—	—	—	—	—
18	圓形棉毛狀	臍狀(平坦)	+	淡乳紅色，放射狀	乳白色稀疏	+	+
20	同上	同上	++	同上	同上	++	+++
26	同上	同上	+++	淡乳白橙色	同上	+++	++++
30	同上	同上	+++	紅褐色，放射狀	同上	+++	++++
35	同上	同上	++	淡乳紅色	同上	++	++
40	—	—	—	—	—	—	—

表2. 蘆筍莖枯病病菌菌落生長與溫度之關係

菌落直徑mm / 培養日期 / 溫度	2天	4天	6天	8天	發育情形
7°c	0	0	0	0	—
10	0	5	14	24.3	+
18	10.16	36.6	55	78.8	++
22	29.7	55.5	74.5	85	+++
25	18	39	59	86	++++
28	22.8	59.6	82	89.6	++++
32	27.5	42.3	63.5	76.6	+++
35	25	45.7	58.3	67.8	++
40	0	0	0	0	—

由上表可知，本菌生長最適宜溫度爲25°C至28°C，生長溫度範圍爲18°C至35°C。

2．氫離子濃度與本菌發育之關係：以NaOH與HCl之1N及0.1N溶液調節PH值，並以比色法(colorimethods)測定之，以各種不同PH值培養基四個重複，培養本菌於28°C定溫箱中，結果如表3：

表3. 氫離子濃度與莖枯病病菌發育之關係（28°c）

菌落直徑mm / 培養日期 / PH值	2天	3天	4天	5天	6天	發育情形
3	12	17	18	20	23	+
4	14	25	28	30	32	++
5	15	22	29	32	34	++
6	21	25	32	37	41	+++
7	28	32	36	40	47	++++
8	13	18	26	29	35	+++

9	12	15	20	26	32	++
10	12	16	20	25	27	++

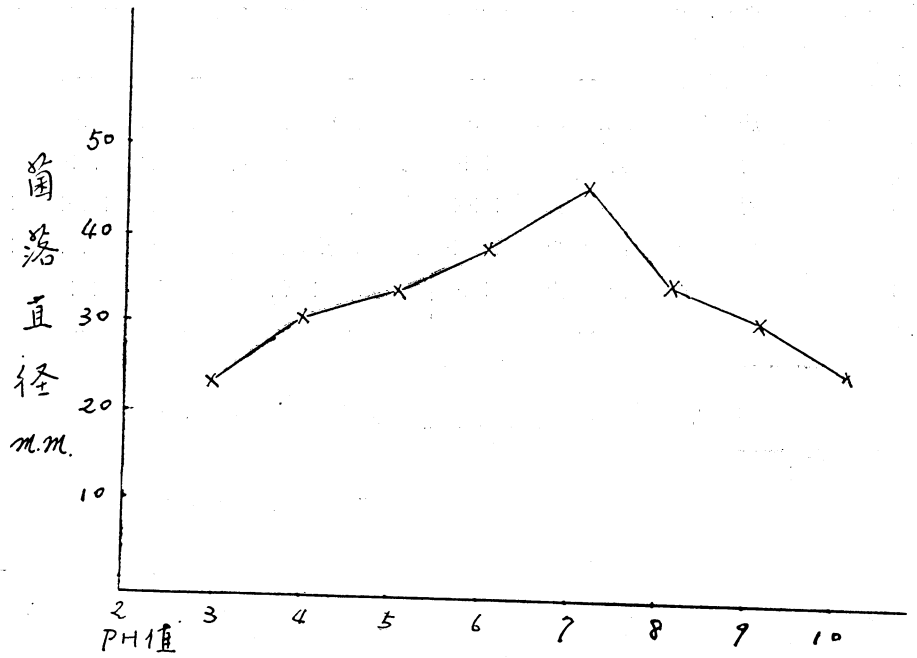


圖1：菌落生長與氫離子濃度關係之比較（28°c）

由上表、圖可知，本菌發育最適酸度爲 PH 6 至 PH 8，生長極限酸度低於 PH 3，極限鹽基度高於PH 10。

3．食鹽濃度與本菌發育之關係：以食鹽（Nacl）含量0%至7%之不同濃度培養基各四個重複，培養本菌於28°C定溫箱中，結果如表4：

表4. 蘆筍莖枯病菌菌絲發育與食鹽濃度之關係（28°c）

培養日期 / 菌落直徑m.m. / 食鹽濃度	1 日	2 日	3 日	4 日	6 日
0%	2	6	17	31	63
0.1	2	6	22	41	73
0.3	4	18	40	61	101
0.5	4	7	22	45	88
1	3	20	42	55	93
2	3	6	27	50	79
3	4	13	36	57	76
5	3	12	38	45	64
7	4	8	34	38	57

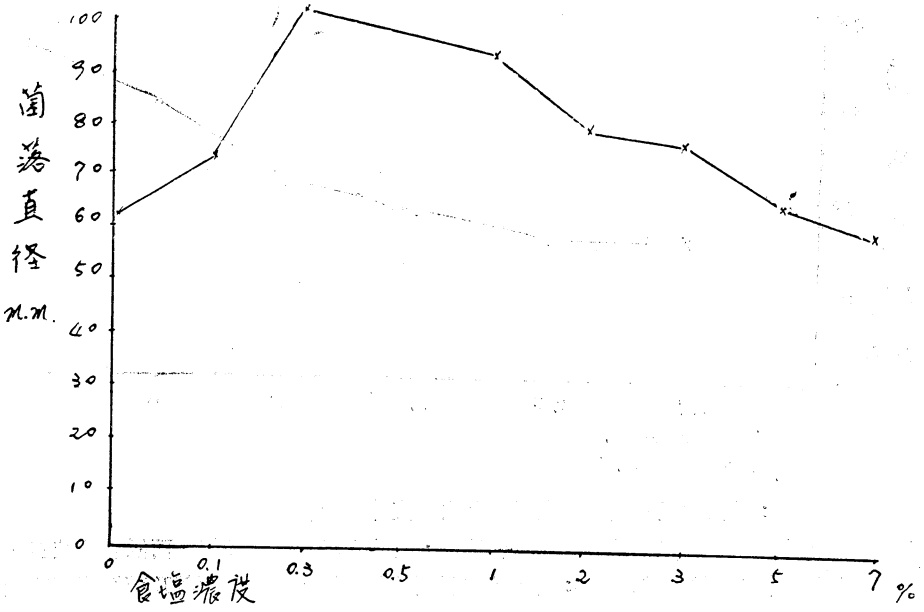


圖 2 ：菌落生長與食鹽濃度關係之比較圖（28°c）

由上圖可知，食鹽濃度對本菌發育之影響不大，而以 0.3%至 3 %較好，惟其差異並不顯著。

4．蔗糖濃度與本菌發育之關係：以蔗糖（Sucrose）含量0.1%至 8 %之不同濃度培養基各四個重複，培養本菌於25°C定溫箱中，結果如表 5 。

表5. 蘆筍莖枯病菌菌絲生長與蔗糖濃度之關係（25°c）

培養日期 / 菌落直徑m.m. / 蔗糖濃度	3 日	5 日	7日	10日	發 育 情 形
0.1%	4	6	7	15	+
0.4	5	7	8	15	+
0.8	6	7	8	12	+
2	5	15	17	21	++
4	5	8	18	30	+++
8	7	10	23	55	++++

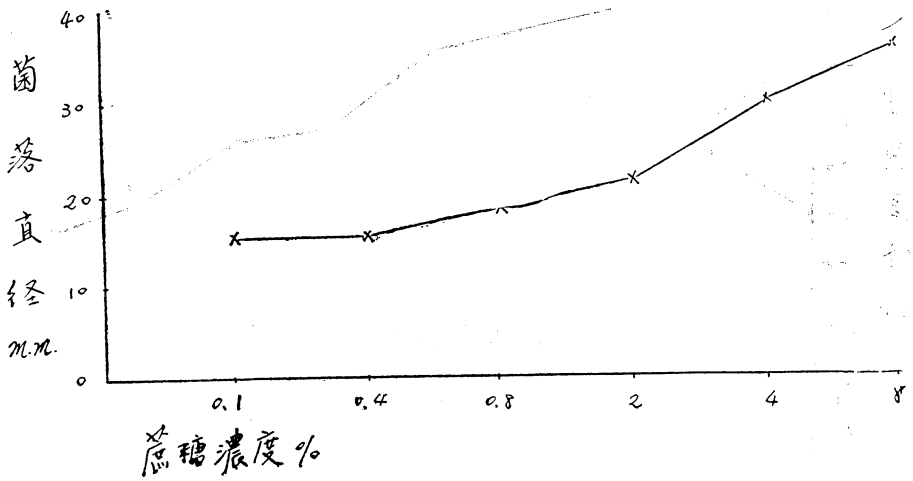


圖3：菌落生長與糖份濃度關係之比較表（25°c）

由上表可知，本菌之發育以蔗糖含量8%者較好，其濃度高者發育較好，而低者卽較差。

5.本菌對低溫（-5°C）之抵抗力：將本菌在斜面培養基培養7天之菌絲及蘆筍病斑組織中潛伏之菌絲，以菌落及乾燥病莖之形態置於零下5°C之冰箱中，定期移植培養，以檢定其菌絲生活力之有無，結果如表6：

表6. 蘆筍莖枯病菌對低溫（-5°c）之抵抗力

材料 \ 低溫處理時間 / 生活力之有無	10日	40日	80日	100日	120日	130日	140日	150日
培養基中培養七天之菌絲	++	+	+	±	±	±	±	±
蘆筍病莖組織中潛伏之菌絲	+++	+++	++	+	+	+	+	+

由上表可知，本菌菌絲在低溫（-5°C）環境下，經150天尙有生活力，惟經100天後卽漸失去生活力，而於乾燥病莖組織中者，對低溫之抵抗力較强。

6.藥劑試驗：供試藥劑爲 Takeda-mer, Duter, Suju, Polyram-combi, Brestan 60, Dithane M45, Antracol, Difolatan 等8種。

(1)本菌菌絲對藥劑之反應：

以馬鈴薯洋菜培養基平板培養五天之菌落，切取 2mm² 之菌絲塊，分別浸漬於各種不同濃度之藥劑水溶液中，經處理1分鐘後，以無菌水水洗後移植培養於28°C定溫箱中，每種處理重複四個菌絲塊，結果如表7。

表7. 蘆筍莖枯病菌菌絲對藥劑之反應

藥劑別 \ 項目 / 菌落生長	使用濃度 ppm.	培養日期 3日	培養日期 5日
Takeda-mer	100ppm	—	—
	500	—	—
	1000	—	—

Duter	100	±	+
	500	−	±
	1000	−	−
Suju	100	−	++
	500	±	+
	1000	−	±
Polyram-combi	100	±	+
	500	−	−
	1000	−	−
Brestan 60	100	−	±
	500	−	−
	1000	−	−
Dithane M45	100	±	±
	500	−	±
	1000	−	−
Antracol	100	±	+
	500	−	±
	1000	−	−
Difolatan	100	+	++
	500	−	−
	1000	−	−
CK	無		+++

由上表可知，供試藥劑濃度 500ppm 以上者，對本菌菌絲皆有顯著之抑制作用。

(2)本菌柄胞子對藥劑之反應：

供試柄胞子爲蘆筍病斑所產生者，以此製成高濃度之胞子懸浮液，在載玻片上滴上 0.1cc 藥劑水溶液，待其水分蒸發乾燥後再滴上 0.1cc 胞子懸浮液，同一種處理各重複三次，置於 28°C 定溫箱中，於48小時後觀察其發芽率，結果如表 8 。

表8. 蘆筍莖枯病菌之胞子對藥劑之反應

藥劑名稱	濃度 ppm	經48小時後之胞子發芽率%
Takeda-mer	500 ppm	0%

Duter	500	C
Suju	500	2
Polyram-combi	500	4
Brestan 60	500	2
Dithane M45	500	3
Antracol	500	1.5
Difolatan	500	2
ck	水	34

由上表可知，供試藥劑之500ppm溶液對本菌柄胞子皆具有殺死作用。尤以 Takeda-mer 及Duter 最强。

(3)缽栽蘆筍病株之藥劑防治：以美麗華盛頓罹病率均勻之二年生缽栽植株 360 缽供試，施用 8 種藥劑與對照不施藥處理計 9 種處理，每種處理40缽，隨機排列計 360 缽，自 6 月至10月間每隔20天噴藥 1 次，計施藥 8 次，每週紀錄發病枝數，以計算其發病枝率，結果如表 9 。

表9. 蘆筍莖枯病藥劑防治試驗（缽栽）

藥劑別	稀釋倍數	調查枝數	發病株數(小分枝)	發病枝率	指數	防治率
Takeda-Mer	1000倍	1500株	399	26.6%	46.6	53.4
Duter	800	1500	359	23.9	41.8	58.2
Suju	1000	1500	385	25.6	44.8	55.2
Polyram-combi	500	1500	432	28.8	50.4	49.6
Brestan 60	1000	1500	512	34	59.5	40.5
Dithane M45	400	1500	416	27.7	48.5	51.5
Antracol	400	1500	493	32.8	57.8	42.2
Difolatan	700	1500	314	20.9	36.6	63.4
ck	無施藥	1500	865	57.1	100	0

由上表可知，所施用 8 種藥劑中，以 Difolatan 700倍之防治效果最好，其防治率爲63.4，Duter 800倍及 Suju 1,000倍次之，Takeda-mer 1,000倍，Dithane M45 400倍及 Polyram-combi 500倍次之，惟藥劑防治效果並不理想，因蘆筍枝芽生長急速，一天生長長度可達10公分，在此新生長幼嫩部，並無藥劑之保護，此爲本病胞子最易侵入之部分，殘留之母莖病斑上形成極多數之柄子器，由此噴出無限量之柄胞子，終年侵入感染各季長出之幼株幼芽，使本病極難以藥劑防治。

四、摘　要

本試驗內容爲蘆筍莖枯病病菌之生理性質及藥劑防治，其結果如次。

1.本菌菌絲之發育，最適溫度爲25°C至 23°C，最適酸度爲PH 6 至 8 ，食鹽濃度以0.3至 3 %較好，蔗糖濃度以 8 %者較好。

2.培養基中及蘆筍病莖組織中之菌絲，在低溫（-5 °C）環境下， 經150天尙有生活力，而以病莖組織潛伏之菌絲較强。

3.供試 Takeda-mer, Duter, Suju, polyram-combi, Brestan 60, Dithane M45, Antracol, Difolatan等 8 種藥劑，其濃度 500ppm 者皆對本菌菌絲生長及胞子發芽有抑制作用，而對缽栽蘆筍病

株之防治效果，以 Difolatan 最好，Duter及Suju 次之 ， Takeda-mer, Dithane M45, 及Polyram-combi 又次之。

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Summary

The physiological characteristics and chemical control of *Phoma asparagi* were studied. The results have been summarized as follows:

1. For the mycelial growth, the optimum temperature was 25° to 28°c, the optimum pH range was 6 to 8, the optimum NaCl concentration was 0.3 to 3%, and the optimum sucrose concentration was 8%.
2. The mycelia formed on the agar media and on the stems of asparagus remained active after 150 days at low temperature (-5°c).
3. Eight fungicides were evaluated for their effectiveness in inhibiting the mycelial growth and spore germination and in cotrolling the infectivity of the causal organism under laboratory condition. Takeda-mer, Duter, Suju, Polyram-combi, Brestan 60, Dithane M45, Antracol and Difolatan showed the inhibiting effect on the myclial growth and spore germination at the concentration of 500 ppm respectively. Difolatan showed the best contolling effect on the infected plants of asparagus, Duter and Suju the better, Takeda-mer, Dithane M45 and Polyram-combi the next.

甘藷簇葉病之研究(V)種子傳染①

楊 一 郎②

Studies on W tches' Broom of Sweet Potato (V) Seed Transmission

I. L. Yang

一、緒 言

關於植物毒素病之種子傳染文獻，始自Reddick與Stewart (1919) 兩氏之報告，謂 French bean mosaic virus 可經由種子傳染。以後經 Fajardo (1930) Nelson (1932) 及Harrison (1935) 諸氏報告，其種子傳染率受 French bean 品種及感染時期之影響。 Reddick (1931) 報告稱，其種子傳染經由花粉。Nelson 與 Down (1933) 報告其種子傳染經由胚珠及花粉。Crowley 氏 (1957) 報告，French bean 的 bean mosaic virus 及 bean yellow mosaic virus 兩種毒素病，前者可經種子傳染，其種子胚中經證實存有病原毒素；後者不能經種子傳染，其種子胚中無病原毒素存在。此項事實復經 Medina 與 Grogan (1961) 氏證實。土崎、與良、明日山等氏 (1970) 報告稱Cowpea aphid - borne mosaic virus 在 Cowpea 可經種子傳染，而在 Azuki bean 卽不能經種子傳染 ， 又此項毒素病在 Cowpea 不同品系間之種子傳染率有顯著之差異。總之，植物毒素病種子傳染之可能性，繫於其寄主植物體與病原毒素双方。關於甘藷簇葉病 (Sweet potato witches' broom disease), 新海昭氏 (1964) 報告，該病不能由其媒介黑斑浮塵子 (Nesophrosyne ryukyuensis ishi-hara) 經卵傳染，亦不能經由甘藷種子傳染。作者 (1970) 亦報告甘藷等10種寄主植物可經嫁接傳染。作者研究甘藷簇葉病在甘藷等 6 種不同品種寄主植物之種子傳染可能性，爰將其結果草成此文，藉供參考。

二、材料與方法

民國57 (1968) 年至59(1970)年間，以甘藷簇葉病之寄主植物 Ipomoea Batatas Lam., Ipomoea nil Roth, Ipomoea pes-caprae Sweet, Ipomoea aquatica Forsk, Ipomoea satifera, Vinca rosea L. 等爲供試植物，分別播種或扦插於 8 寸花缽，每缽 2 至 4 株，每品種各 5 缽 ， 爲促進甘藷開花結實，使用美國黃皮爲砧木、沖繩 100 爲接穗，各供試植物分別將甘藷簇葉病病穗，施以嫁接傳染，嫁接木成活或接穗枯死者，重複補施嫁接，直至感病並呈現簇葉病徵。後期感染之病株得獲開花結實，每種寄主植物採收種子 9 至45粒，分別播種於 8 寸花缽，並將幼苗移植後，經 6 個月之觀察，紀錄其生長狀況及病徵之出現與否。

三、研究結果

甘藷簇葉病之 6 種不同品種寄主植物之種子傳染可能性，試驗結果如次表：

①本研究工作承農復會之補助，並承羅宗爵技正，劉和元博士及村山大記博士之鼓勵與指導，筆者敬致謝忱。

②嘉義農業試驗分所薦任技士，本研究工作期間得國家科學委員會之輔助。

表1. 甘藷簇葉病之種子傳染

Table 1. Transmission of Sweet potato witches' broom through seeds.

供試品種 Species of plants tested	供試種子粒數 No. of seeds tested	實生苗數 No. of seedlings	發病株數 No. of plants developed symptoms	發病株率 % of plants developed symptoms
Ipomoea Batatas Lam.	28	22	0	0
Ipomoea nil Roth.	9	7	0	0
Ipomoea pes-caprae Sweet.	15	12	0	0
Ipomoea aquatica Forsk.	23	19	0	0
Ipomoea satifera	12	11	0	0
Vinca rosea L.	45	31	0	0

由上述結果，可知甘藷簇葉病不能經由Ipomoea Batatas Lam, Ipomoea nil Roth, Ipomoea pes-caprae Sweet, Ipomoea aquatica Forsk, Ipomoea satifera, Vinca rosea L. 等6種寄主植物病株之種子傳染。此項結果與新海昭氏(1964)所報告該病不能經由 Ipomoea Batatas Lam. 及 Ipomoea Hardwickii Hemsl. 兩種寄主植物病株之種子傳染相類似。

四、摘　要

甘藷簇葉病不能經由 Ipomoea Batatas Lam., Ipomoea nil Roth, Ipomoea pes-caprae sweet, Ipomoea aquatica Forsk, Ipomoea satifera, Vinca rosea L. 等6種寄主植物病株之種子傳染。

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Summary

Seed transmission of sweet potato witches' broom disease was examined in artificially infected plants of Ipomoea Batatas Lam., Ipomoea nil Roth., Ipomoea pes-caprae Sweet., Ipomoea aquatica Forsk., Ipomoea satifera and Vinca rosea L., the negative results showed that the disease may not be transmitted by seed in different species of host plants so far tested.

石刁柏病害之病原學的調查(第一報)

吳　福　壽

一、緒　言

本省石刁柏(又稱蘆筍，學名爲 *Asparagus officinalis* L. var. *altilis* L.)生產事業，年來由於園藝學者之研究及有關當局之倡導，以及農、工雙方之努力，近年來突飛猛進，據台灣省政府農林廳(6)（1967）報告，至民國55年其栽培面積已增至10,877公頃，其收穫量達44,120公噸，價值爲新台幣362,899,000元，現已成爲頗有發展前途之新興事業。

本省石刁柏因其栽培歷史短暫，對於病害方面之研究缺乏，惟發現有多種病害，例如由 *Phoma asparagi* 所引起之莖枯病，由*Cercospora asparagi*所引起之褐斑病等，頻繁引起石刁柏植株不能忽視之損害，如此減低石刁柏產量及品質至鉅。爲明確有效之防治對策，石刁柏病害之基本研究係必需者，以確保石刁柏生產事業之不斷發展。

茲將本年度本省石刁柏主要病害之發生，分佈狀態及劇烈度等之調查，及石刁柏莖枯病菌之侵害方法，及藥劑防治試驗等，所得結果列述如下，以供參考。

本試驗經費承蒙中國農村復興聯合委員會補助，當試驗工作進行期間並蒙該會蘇博士鴻基之指導，文成後復蒙蘇博士校閱，特此謹誌謝忱。

二、石刁柏病害之病原學的調查

㈠調查方法：

民國五十六年，逐月分別前往本省石刁柏栽培區，三重（台北縣）、大甲（台中縣）、芳苑（彰化縣）、土庫、褒忠（雲林縣）、東石（嘉義縣）、新園（屏東縣）、池上（台東縣）、壽豐（花蓮縣）等市、鎮、鄉實地調查所發生病害種類，分佈狀態及病害劇烈度等，罹病標本採集後攜回送至實驗室以便鑑定其病原。

調查時，每一地區，每次均以隨機取樣法調查200莖，求其發病莖率，並據全莖之發病情形分成6等級，其標準如下：

0 ……無病斑者
1 ……莖枝、葉病斑約佔20%者
2 ……莖枝、葉病斑約佔40%者
3 ……莖枝、葉病斑約佔60%者
4 ……莖枝、葉病斑約佔80%者
5 ……全莖枯死者

然後據下列公式求其被害程度：

$$\text{被害程度} = \frac{0A^* + 1B + 2C + 3D + 4E + 5F}{N}$$

*A. B. C. ……等係示該被害狀況等級別之莖數

N……調查總莖數

㈡調查結果：如表一、二。

表一、石刁柏病害之病原學的調查結果

Table 1. Etiological survey of asparagus diseases

地區 Locality	病害名稱 Name of diseases	月別 Month																							
		1		2		3		4		5		6		7		8		9		10		11		12	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
三重市 San-chung City	莖枯病 Stem blight	92	2.85	100	3.54	0	0.00	30	0.52	50	0.78	69	0.98	71	1.06	75	1.50	79	1.80	82	1.90	87	2.27	90	2.50
大甲鎮 Ta-chia Chen	莖枯病 Stem blight	33	1.10	49	1.33	10	0.11	27	0.45	35	0.51	66	0.94	67	1.04	70	1.06	71	1.32	75	1.46	79	1.90	81	2.00
	褐斑病 *Cercospora* blight	0	0.00	0	0.00	0	0.00	15	0.21	20	0.23	36	0.43	29	0.50	27	0.40	2	0.03	0	0.00	0	0.00	0	0.00
	灰黴病 Gray-mold rot	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	19	0.84	0	0.00	0	0.00	0	0.00
土庫鎮 Tuh-ku Chen	莖枯病 Stem blight	41	1.07	58	1.47	14	0.20	33	0.56	37	0.59	41	0.70	46	0.80	60	1.12	85	1.49	85	1.51	86	1.65	87	2.03
	褐斑病 *Cercospora* blight	80	2.36	71	2.16	31	0.53	42	0.81	69	1.35	76	1.69	77	1.70	78	1.73	79	1.76	79	1.78	80	1.81	82	1.85
褒忠鄉 Pao-chung Hsiang	莖枯病 Stem blight	23	0.34	32	0.63	9	0.10	25	0.43	46	0.73	51	0.78	52	0.94	61	1.13	66	1.19	68	1.23	69	1.40	72	1.53
	褐斑病 *Cercospora* blight	70	1.42	42	0.99	30	0.40	31	0.47	53	1.03	54	1.08	55	1.11	56	1.18	57	1.22	57	1.28	59	1.34	60	1.44

註：A. 係示發病莖率，B. 係示被害程度。

Note: A. indicates the percentage of diseased stem(%).
B. indicates disease index.

表二、石刁柏病害之病原學的調查結果

Table 2. Etiological survey of asparagus diseases

地區 Locality	病害名稱 Name of diseases	月別 Month 8 A	8 B	10 A	10 B	12 A	12 B
芳苑鄉 Fang-yuan Hsiang	莖枯病 Stem blight	17	0.35	68	1.41	70	1.85
	褐斑病 *Cercospora* blight	42	1.09	48	1.56	46	1.66
東石鄉 Tung-sh Hsiang	莖枯病 Stem blight	64	0.80	66	1.13	68	1.50
	褐斑病 *Cercospora* blight	66	0.92	74	1.09	67	1.23
	灰黴病 Gray-mold rot	0	0.00	0	0.00	22	1.10
新園鄉 Hsin-yuan Hsiang	莖枯病 Stem blight	96	2.15	97	2.31	97	2.72
	褐斑病 *Cercospora* blight	97	2.23	98	2.66	97	2.71
池上鄉 Ch-shang Hsiang	莖枯病 Stem blight	68	0.96	70	1.35	73	1.79
	褐斑病 *Cercospora* blight	99	3.89	86	2.70	85	2.71
壽豐鄉 Shou-feng Hsiang	莖枯病 Stem blight	57	0.81	58	1.20	64	1.70
	褐斑病 *Cercospora* blight	65	1.71	56	1.77	55	1.78

註：A. 係示發病莖率（%）. B. 係示被害程度。

Note: A. indicates the percentage of diseased stem (%),
B. indicates disease index.

據上表（一、二）之調查結果所示，在所調查地區之範圍內，祇發現莖枯病、褐斑病兩種病害發生嚴重，另雨天連續時，或排水缺佳之園地，時可見及灰黴病之發生，惟發病莖尙低。

㈢ 被害狀況：

茲就目前所發生之莖枯病、褐斑病、灰黴病之爲害狀況分述於下：

(1)莖枯病：係由 *Phoma aspvragi* Sacc. 所引起者，起初莖、枝上發生紡錘形或絲狀暗褐色病斑，接着周緣呈水腫狀，隨病斑之擴大，中心部份呈褐色凹陷，上面密生多數黑色小顆粒，被害劇烈病斑圍繞莖周圍時，其上部卽乾枯。小枝病斑雖不甚顯明，在不定處呈暗褐色乾枯，病害劇烈時，有時可使地上部殆全枯死。

(2)褐斑病：係由 *Cercospora asparagi* Sacc. 所引起者，此病雖可在成株發生，惟主要在苗期或新栽植之幼植株，莖、分枝、擬葉上現出多數褐色或灰色之小病斑，莖葉全體呈褐色，提早落葉，通常損害不嚴重（環境良佳時植株可恢復，再生新擬葉），但往往可招起劇烈落葉並枯死。

(3)灰黴病：係由 *Botrytis* spp. 所引起者，嫩莖初出土面時即被侵害，其頂端生長之後招起莖、分枝頂端枯死，莖上不定處形成不定形汚白色乃至灰褐色病斑，上面可見灰色病原菌菌絲繞生，在園地高濕狀態連續時易起分枝頂端枯死，嫩莖腐朽。

三、石刁柏莖枯病病原菌之侵害方法研究

(一) 材料：病原菌 *Phoma asparagi* Sacc.
石刁柏植株

(二) 方法：於溫室內花盆育成石刁柏健全株，進行有傷及無傷接種，接種源取自培養於 potato sucrose agar 上經10日，已形成柄子殼者，注入殺菌水，以套有橡皮管之玻璃棒輕磨培養基表面，使柄胞子浮懸，用紗布過濾而得，將此柄胞子浮懸液以小型玻璃製噴霧器噴霧接種，此時接種植物分爲有傷及無傷而接種，接種後植株保持濕度（置放京大式接種箱內），同時保持28°C，經24小時後取出置放溫室內，觀察各區之發病狀況。

(三) 結果：調查之結果如表三。

表三、盆栽植株經有傷及無傷接種後之發病狀況

Table 3. Stem blight disease development in inoculated plants with and without wound

接種 Inoculation / 接種後日數 Days after inoculation	有傷接種 Wound inoculation	無傷接種 Woundless inoculation	CK_1**	CK_2**
5	3*	0*	0	0
7	7	2	0	0
14	20	15	0	0
21	40	20	0	0

註 ： 表內數字係示病斑數，有傷接種：以 carborundum 磨傷莖表皮。
** CK_1 磨傷、噴殺菌水，CK_2 無傷、噴殺菌水。

Note: * A number of lesions on plants, Wound-inoculated: (Rubbing the rind of asparagus stem by carborundum), ** CK_1: Wounded and sprayed with the sterilized water, CK_2: Sprayed with sterilized water on intact surface.

據上表所示，石刁柏莖枯病病原菌在有傷或無傷之植株上均能感染，而病徵在有傷接種較無傷接種提早2天出現，由此可認出病原菌在有傷之組織上極易侵入並迅速感染。

四、石刁柏莖枯病藥劑防治試驗

(一) 材料：

(1)供試病原菌 *Phoma asparagi* Sacc. 係自台北縣三重市郊採集之石刁柏莖枯病罹病莖上所分離培養者。

(2)供試殺菌劑：計8種，玆將其名稱及有效成分列於表四。

表四、供試殺菌劑及其有效成分

Table 4. Fungicides tested and their active ingredients

殺菌劑 Fungicides	有效成分 Active ingredients	製造廠商 Manufacturer
Dithane M-22	80% Maneb (Manganese ethylene bisdithiocarbemate)	美國Rohm & Haas Co.
Dithane Z-78	75% Zineb (Zinc ethylene bisdithiocarbamate)	〃
Dithane M-45	80% A co-ordination product of zinc ion manganese ethylene bisdithiocarbamate	〃
Dithane stainless	50% Ammonium ethylene bisdithiocarbamate	日本東京有機化學工業公司
Miltox	16% zineb (Zinc ethylene bisdithiocarbamate) 65% Copper oxychloride	瑞士 Sandoz Ltd.
Arasan	50% Thiram (Tetramethyl-thiuramdisulfide)	美國 E. I. Du Pont de Nemour
KB-90	90% Basic copper sulphate	日本三共公司農藥部
Suzu tablet	20% Triphenyltin acetate	日本北興化學工業公司

㈡ 試驗方法與結果：

A 室內藥劑試驗：

1．各殺菌劑對石刁柏莖枯病菌柄胞子發芽之毒效：柄胞子自曾培養於Potato sucrose agar斜面，經10天已形成柄子殼之病原菌，加殺菌水準備柄胞子浮懸液，浮懸液調節成每一個顯微鏡視野（400×）約含有30～40個胞子之濃度，將各殺菌劑全部調製成5種濃度（31.25, 62.5, 125, 312.5, 625 p.p.m.），胞子發芽時各取 0.5ml 胞子浮懸液，添加於各供試劑之稀釋列（每一濃度2ml.）如此殺菌劑溶液或浮懸液能成爲 25, 50, 100, 250, 500p.p.m. 胞子浮懸液與殺菌劑混合後滴下於載玻片（上面被一層 Collodion 薄膜）上，爲保持濕度將載玻片置於給濕培養皿 (Petri dish moist chamber) 內，並保存於28°C定溫箱，經48小時之後測定各殺菌劑之效果。其結果如表五。

表五、各殺菌劑對莖枯病菌柄胞子發芽之毒效

Table 5. Toxic effect of fungicides on pycnidiospore germination

殺菌劑 Fungicides	濃度 Concentrations (p.p.m.)	調查胞子數 No. of spore examined	發芽胞子數 No. of germinated spore	發芽率 (%) Rate of germination	指數(CK爲100時) Index number (CK 100)
Dithane M-22	500	900	0	0.00	0.00
	250	900	0	0.00	0.00
	100	900	0	0.00	0.00
	50	900	0	0.00	0.00
	25	900	0	0.00	0.00
Dithane Z-78	500	902	10	1.11	2.00
	250	905	17	1.88	3.39
	100	956	86	9.00	16.22
	50	943	202	21.42	38.59
	25	928	265	28.56	51.46

Dithane M-45	500	900	0	0.00	0.00
	250	900	0	0.00	0.00
	100	900	0	0.00	0.00
	50	900	0	0.00	0.00
	25	902	8	0.89	1.60
Dithane stainless	500	900	0	0.00	0.00
	250	900	0	0.00	0.00
	100	900	0	0.00	0.00
	50	900	0	0.00	0.00
	25	900	0	0.00	0.00
Miltox	500	900	0	0.00	0.00
	250	900	0	0.00	0.00
	100	900	0	0.00	0.00
	50	900	0	0.00	0.00
	25	900	5	0.56	1.01
Arasan	500	900	0	0.00	0.00
	250	900	0	0.00	0.00
	100	900	0	0.00	0.00
	50	900	0	0.00	0.00
	25	900	0	0.00	0.00
KB-90	500	925	164	17.73	31.95
	250	951	188	19.77	35.62
	100	961	252	26.22	47.24
	50	947	347	36.64	66.02
	25	962	453	47.09	84.85
Suzu tablet	500	900	0	0.00	0.00
	250	900	0	0.00	0.00
	100	900	0	0.00	0.00
	50	900	0	0.00	0.00
	25	900	0	0.00	0.00
CK		4645	2578	55.50	100.00

據表五顯示 Dithane M-22, Dithane stainless, Arasan, Suzu tablet 等之效果良佳，其濃度25p.p.m.尙能抑制柄胞子之發芽，其次 Dithane M-45, Miltox 在50p.p.m.之濃度能抑制其發芽，而Dithane z-78, KB-90之效果最差，其濃度至 500p.p.m. 尙無法完全抑制柄胞子之發芽。

2. 各殺菌劑對石刁柏莖枯病菌菌絲之殺滅效果：

在此試驗，將供試殺菌劑稀釋成25, 50, 100, 250, 500, 1000, 2000, 4000, p.p.m. 8 種濃度，證明活而生長之病原菌菌絲洋菜薄圓板，自培養於Potato sucrose agar上，經10天之病原菌菌叢，用直徑 5 mm之 Cork borer 切取， 並浸漬於上述不同濃度之各種殺菌劑溶液或浮懸液中，各經 10, 20, 30, 60 分鐘之後，用殺菌水充分洗滌三次，然後用吸水紙（經殺菌者）吸取圓板上之過多水分，每個濃度各浸漬 4 圓板，殺菌劑之效力，依測定處理後之馬鈴薯平板上之菌絲生長評價，其結果如表六。

表六、各殺菌劑對石刁柏莖枯病菌菌絲之殺滅效果

Table 6. The killing effect of varios fungicides on the mycelium of *Phoma asparagi* Sacc.

殺菌劑 Fungicides	濃度 Concentrations (p.p.m.)	浸漬時間 (分) Time of dipping (min.)			
		10	20	30	60

Dithane M-22	4000	+	−	−	−
	2000	+	+	−	−
	1000	+	+	+	+
	500	++	++	++	++
	250	++	++	++	++
	100	++	++	++	++
	50	++	++	++	++
	25	+++	+++	++	++
Dithane Z-78	4000	+	+	+	+
	2000	+	+	+	+
	1000	+	+	+	+
	500	++	++	++	++
	250	++	++	++	++
	100	++	++	++	++
	50	+++	+++	+++	+++
	25	+++	+++	+++	+++
Dithane M-45	4000	+	+	+	+
	2000	+	+	+	+
	1000	++	++	++	+
	500	++	++	++	++
	250	++	++	++	++
	100	+++	++	++	++
	50	+++	+++	+++	+++
	25	+++	+++	+++	+++
Dithane stainless	4000	−	−	−	−
	2000	+	+	+	−
	1000	+	+	+	+
	500	++	++	++	+
	250	++	++	++	++
	100	+++	++	++	++
	50	+++	+++	+++	+++
	25	+++	+++	+++	+++
Miltox	4000	++	++	++	++
	2000	++	++	++	++
	1000	++	++	++	++
	500	++	++	++	++
	250	++	++	++	++
	100	+++	++	++	++
	50	+++	+++	+++	+++
	25	+++	+++	+++	+++
Arasan	4000	+	+	−	−
	2000	+	+	+	+
	1000	+	+	+	+
	500	+	+	+	+
	250	+	+	+	+
	100	+	+	+	+
	50	++	++	++	++
	25	+++	++	++	++
KB-90	4000	++	++	++	++
	2000	++	++	++	++
	1000	++	++	++	++
	500	++	++	++	++
	250	++	++	++	++
	100	++	++	++	++
	50	++	++	++	++
	25	+++	+++	+++	++
Suzu tablet	4000	−	−	−	−
	2000	−	−	−	−
	1000	−	−	−	−
	500	−	−	−	−
	250	−	−	−	−
	100	+	+	+	+
	50	+	+	+	+
	25	++	++	++	++
CK		+++	+++	+++	+++

註：十之多寡表示菌絲發育程度，－表示無菌絲長出。

Note: Number of + marks indicates the grade of mycelial development,
— mark indicates no mycelium growth.

據上表所示，供試殺菌劑中以 Suzu tablet 最爲有效，在 250 p.p.m. 之濃度浸漬10分鐘能殺滅莖枯病病原菌菌絲，其次 Dithane M-22 之 2,000 p.p.m. 浸漬30分鐘，Dithane stainless 之 2,000 p.p.m. 浸漬60分鐘，Arasan 之 4,000 p.p.m. 浸漬30分鐘亦有效果，其餘殺菌劑在此供試濃度之範圍內均無效果，其濃度高至 4,000 p.p.m. 亦無法完全殺滅菌絲。

五、討　論

逐月在本省石刁柏栽培區三重（台北縣）、大甲（台中縣）、土庫、褒忠（雲林縣）等市、鎮、鄉調查石刁柏主要病害之發生、分佈狀態、病害之劇烈度等，另芳苑（彰化縣）、東石（嘉義縣）、新園（屏東縣）、池上（台東縣）、壽豐（花蓮縣）等鎮、鄉係後來方隔月進行。在所調查地區之範圍內，祇發現莖枯病、褐斑病，灰色黴病等三種病害之發生。莖枯病在每地區均有發生，而爲害劇烈，其發病莖率有高至100%者，被害程度達3.54（病斑佔全植株60—80%）。此病周年均可發生，在3月間發病最少（有些地區此時割除地上部份），自4月開始逐漸增加，至次年2月發病最劇，其次褐斑病亦甚普遍，除三重一地之外，其餘地區均有發生，其發病莖率有高至99%者，被害程度有高至3.89之高者。此病周年均可發生，3—4月間發病最少，自5月開始逐漸增加，8月至次年1月間發病最多。灰色黴病祇在大甲，排水缺佳之園地及東石雨天連續時發生，惟發病莖率尚低。

綜觀以上石刁柏病害發生之種類及爲害程度，因受栽培習慣、環境等之影響而有差異，凡土壤過濕排水缺佳，雨天連續時及所留母莖過多，枝葉繁茂或周圍爲竹欉所圍繞，雨露水較緩乾燥之園地發病較多。

應用盆栽石刁柏植株進行莖枯病菌之有傷及無傷接種，研討病原菌之侵害方法，結果顯示，石刁柏莖枯病病原菌在有傷或無傷之植株上均能感染，而在有傷口之組織上較易並迅速感染。

就發病較嚴重之石刁柏莖枯病進行室內藥劑試驗結果，據表（五、六）所示，供試8種殺菌劑對莖枯病菌柄胞子發芽之毒效以Dithane M-22，Dithane stainless, Arasan, suzu tabet等之效果良佳，其濃度 25p.p.m. 尚能抑制柄胞子之發芽，其次 Dithane M-45, Miltox 在 50p.p.m. 之濃度能抑制其發芽，而 Dithane Z-78, KB-90 效果最差，其濃度至 500p.p.m. 尚無法完全抑制柄胞子之發芽。各殺菌劑對石刁柏莖枯病菌菌絲之殺滅效果，則以 Suzu tablet 爲最著，250p.p.m.浸漬10鐘能殺滅其菌絲，其次 Dithane M-22 之 2,000p.p.m. 浸漬30分鐘，Dithane stainless 之 2,000 p.p.m.浸漬60分鐘Arasan之4,000p.p.m. 浸漬 30 分鐘，亦有殺滅菌絲之效果，其餘殺菌劑在此供試濃度之範圍內均無效果，其濃度高至 4,000 p.p.m. 尚無法完全殺滅。

至於對石刁柏莖枯病病原菌之抑制有效之藥劑，在盆栽植株或田間實際應用上之效果，仍待日後之進一步研究探討。

六、摘　要

1. 民國五十六年度，本省石刁柏常見之病害有莖枯病、褐斑病、灰色黴病等。

2. 所發生病害之中，尤以莖枯病最爲嚴重，此病在所調查地區之範圍內均有發生，發病莖率有高至100%者，被害程度達3.54，影響石刁柏產量、品質至鉅。

3. 褐斑病亦甚普遍，除三重市一地之外，其餘地區均有發生，其發病莖率有高至99%者，被害有至3.89之高者。

4. 灰色黴病祇在雨天連續時及排水缺佳之園地時可見及其發生，而發病莖率尚低。

5. 石刁柏莖枯病病原菌雖在有傷或無傷之植株上均能感染，而在有傷口之組織上較易並迅速感染。

6. 供試殺菌劑中 Dithane M-22, Dithane stainless, Arasan, Suzu tablet 等對莖枯病病原菌柄胞子發芽之毒效良佳，在 25p.p.m. 之濃度尙能抑制其發芽。

7. 各殺菌劑對石刁柏莖枯病病原菌菌絲之殺滅效果以 Suzu tablet 爲最佳，在 250p.p.m. 之濃度浸漬10分鐘能殺滅其菌絲，其次 Dithane M-22, Dithane stainless, Arasan等亦稍有效果。

8. 在室內藥劑試驗所選對石刁柏莖枯病病原菌抑制有效藥劑，在盆栽植株或田間實際應用上之效果，仍待日後之進一步研究探討。

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ETIOLOGICAL SURVEY OF ASPARAGUS DISEASES IN TAIWAN (I)

by

F. S. Wu

Summary

The present experiment deals with etiological surveys of incidence, distribution and severity of the major diseases of asparagus throughout the island, and study on the infection of causal fungus of asparagus stem blight in greenhouse, and fungicidal test, in order to evaluate control measure of the stem blight. The results will be summarized as follows:

1. In 1967, stem blight caused by *Phoma asparagi* Sacc., *Cercospora* blight caused by *Cercospora asparagi* Sacc., gray-mold rot caused by *Botrytis* spp. etc. were noticed frequently to cause considerable damages to asparagus plants in some asparagus growing areas.

2. Among them, stem blight was the most wide-spread and serious disease of asparagus plants, this disease occurred in all of the asparagus growing areas. Percentage of diseased stem was noticed frequently up to 100 percent, the degree of disease severity was at index, 3.54, thus lowering both the quantity and quality of the asparagus production.

3. *Cercospora* blight was the very widespread asparagus disease also. The disease occurred in all asparagus growing areas, except in San-chung City. The percentage of diseased plants was noticed frequently up to 99 per cent.

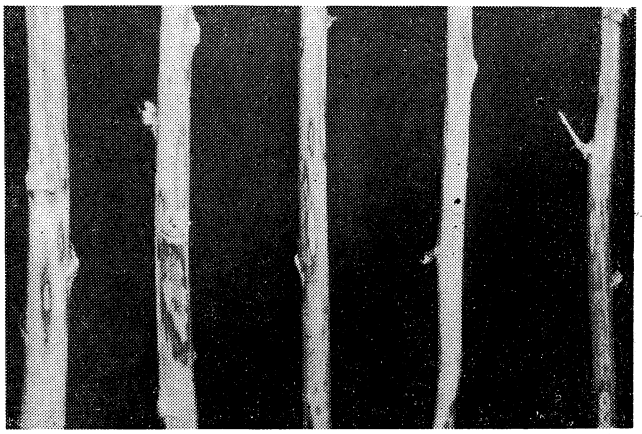
4. Gray-mold rot occasionally occurred in continuous rainy climate and in poorly drained fields. The percentage of disease infection was not high yet.

5. The infection of the causal fungus of stem blight takes place on either wounded or unwounded asparagus plants, while it takes place more easily and rapidly on wounded tissue.

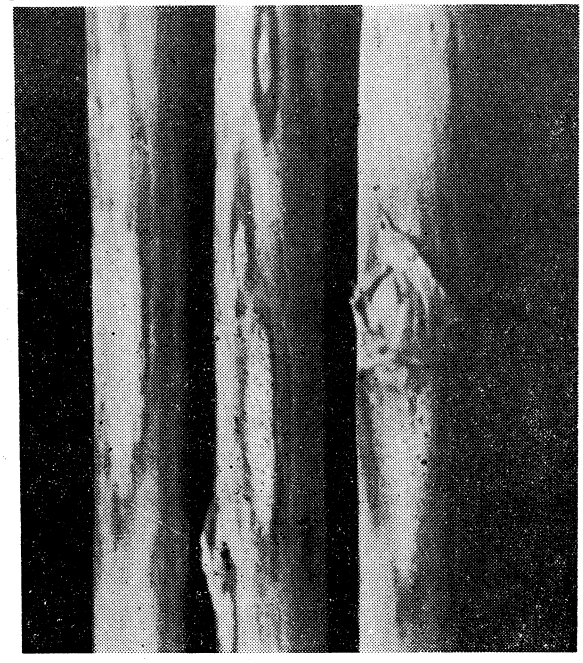
6. Toxic effect of various fungicides on pycnidiospore germination of *Phoma asparagi* sacc. was conducted in laboratory. Dithane M-22, Dithane stainless, Arasan, and Suzu tablet were found to be more effective, inhibiting the pycnidiospore germination at the concentration of 25 p. p. m.

7. In the fungicidal test with the fungus mycelium, Suzu tablet at concentration of 250 p. p. m. was the most effective ones, the mycelium are killed by dipping for 10 minutes, and Dithane M-22, Dithane stainless, Arasan showed some effectiveness.

8. Effective fungicides on inhibiting the development of causal organism screened by laboratory test are expected to be checked by green-house and field experiment.



A



B

FIG. 1. Stem blight of asparagus A, lesions on stems; B, pycnidia on old stem lesions.



FIG. 2. *Cercospora* blight of asparagus. lesions on stems and branches.



FIG. 3. Gray-mold rot of asparagus

AN ECOLOGICAL STUDY OF WHITE-BACK PLANTHOPPER, *SOGATELLA FURCIFERA* HORVATH IN VIETNAM, 1968

By

Chia-hwa Tao and Ngo-Dinh Ngoan

Introduction

Although the *sogatella furcifera* is found throughout the rice-producing areas of the world, its outbreak is not as important as the brown plant hopper, *Nilaparvata lugens*, whose damaging infestation is usually connected with climatic conditions and agricultural practices throughout the year. Severe injury is frequently found on the heading stage of rice plants on this period due to the favorable weather. Population level of either the nymphs or the adults reaches a peak. Since successful eradication of rice stem borers was obtained with new certain synthetic insecticide, the pest frequently causes heavy damage to rice plants, particularly in Taiwan, Japan, Korea and the Philippines. In South Vietnam, however, the *S. furcifera* is a major pest of rice plants, since climatic condition is favorable for its multiplication throughout the year. The ecological studies of this pest were carried out at Japan and Taiwan, while no available datum is obtained from Indo-China, especially from Vietnam. Therefore, Ngo-Van-Quyen, Chief, Plant Protection Service, encouraged us to make the ecological studies of this pest is purpose to contribute to the establishment of the economic control measures in the future. Results are presented in this paper.

Distribution

Japan, Okinawa, Korea, Taiwan, Micronesia, Siberia, Manchuria, China, Indo-China, India, Ceylon, North Africa, the Philippines, Sumatra, although widely distributed, the pest is found more or less only along the equator, and is considered to be tropicopolitan. (see 4)

Host Plants

Oryza sativa L., *Saccharum officinarum* L., *Zizania latiforia* Turcz., *Hordeum vulgare* L., *Setaria italica* Beauv., *Panicum crusgalli* L., *Zea mays* L., *Poa anua* L., *Phalaris arundinacea* L., *Alopecurus aequallis* Schol., *Sporobolus elongatus* R., *Digitaria adscendens* Henr., and *Eleusine indica* Gaertner. The most preferred host plants of this pest is the rice plant. The pest passes several generations in the weedy areas, if no rice plant is offered. (see 4)

Observation on the Infestation of rice plant

Vietnam is situated in the tropical zone. Its ecological dimension is particularly suitable for rapid multiplication of *Sogatella*. With regards to the climatic conditions, the multiplication is more favorable in the Mekong Delta area than in the coastal region of central Vietnam. In contrast, the brown plant hopper does not mutiply readily under the Mekong delta coastal region this year. This pest generally attacks the rice plants during the tillering, differential, booting and heading stages, causing losses of vegetation, reduction of tillers leaf withering, burning of stems, and production of empty rice panicles. Usually the differential stage is the most susceptible stages, during this stage of the rice plants are often entirely destroyed by overlapping generations of the plant hoppers. The population of the nymphs is generally prevailing that of the adults. During the growing season of the rice plants, the plants are usually attacked by 3 or 4 overlapped generations especially in rice areas where multiple rice crops are practiced. Sometimes sporadic outbreaks of this pest are found in the old seedling beds. The degree of infestation depends upon microclimatic conditions and cultural practices.

Materials and Methods

The study was consisted of the bionomics, survival of adults, the rate of population of wing-form, seasonal fluctuation of egg population, percentage of parasitism of egg parasites, and the rate of population of newly-hathced nymphs. All the works were carried out in the green house of Plant Protection Service from January to December in 1968.

1. Bionomics: The life history of this pest is quite variable with the ecological conditions. The number of generations per year varies from two to three in the northern part of Japan to as many as five or more in the southern part of Japan, four in Korea and seven or eight in Taiwan. In the present observation, this hopper has sixteen generations in a year due to the favorable temperature, it developed and multiplicates throughout the year. The results showed that the duration of various stages of each generation was not significantly different. In each generation egg stage last 5.2 to 10.5 days with exception of the lst generation being the longest and was not significantly different. Nymphal stages of each generation last from 9.6 to 15.4 days excepted with 10th generation being shortest. This was also insignificant. The entire cycle from egg to adults requires 15.3 to 21.9 days, excepted with 10th generation being shortest. This was not significantly different while the variance of both the temperature and the humidity is not notable all year round. As shown in table 1:

Table 1: Duration of various growing stages in each generation

Giner-ation	Duration of egg stage (days)	Duration of nymph-al stage (days)	Duration of entire cycle (days)
1st	10.5	14.0	24.5
2nd	—	—	21.0

3rd	7.5	10.5	18.0
4th	5.6	12.5	18.1
5th	5.4	11.5	16.9
6th	5.6	11.4	17.0
7th	5.2	11.2	16.4
8th	5.3	13.6	18.9
9th	5.2	12.6	17.8
10th	5.7	9.6	15.3
11th	5.8	11.0	16.8
12th	6.4	11.4	17.8
13th	6.7	10.1	16.8
14th	6.2	12.6	18.8
15th	6.5	15.4	21.9
16th	6.0	14.0	20.2

2. Behavior: Most of the adults emerge in the morning. The male adults usually emerge 1 to 2 days earlier than the females. The brachysterous emerge later than macropterous females; both individuals lay eggs 3 or 4 days after the copulation. while laying, the female inserts are ovipositors into the tissues of the leaf sheath. Eggs are laid massly, and each mass consists of 5 to 20 eggs arranged side by side. Newly-laid eggs are milky in color become yellowish before hatching. Part of the tissues around the eggs-mass is harmed by oviposition and turns dark brown color. Newly hatched nymphs which are grey in color stay on their egg shells for 3 to 5 minutes. They are gregarious during the early instars and suck the sap of rice stems. After the first moult they begin to dispers each other and crawl to the other part of the rice plant to suck the sap of rice stems particulary in its mature stage. The outbreak of this hopper depends on the population density of both the nymphs and the adults under favorable conditions, while the nymphs cause serious damage to rice plants, as they are moke important than adults.

3. Adult longevity: The observation was begun from the 3rd generation to the 16th generation on 20 pairs of macropterous forms of each generation. All adults emerged from nymphs which were reared in the green-house. Each pair of adults was reared in a glass cylinder (5 cm in diameter and 15 cm in height) with one freshly-rooted rice stem inside. Six glass cylinders were placed in a petri dish, (17 cm in diameter and 3 cm in height). The water was supplied in each petri dish in the case of necessary. Each top of the glass cylinder was covered with fine muslin and fastened with rubber bands to prevent adults from escape. Freshly-rooted rice stems were changed every five days throughout the observation, and records were taken every morning. The results showed that the macropterous females generally lived longer than macropterous males and the longevity of both the females and males were variable in each generation. The relative longevity of adults was probablly affected by the temperature and the humidity throughout the observation. The average of longevity of the females ranged from 2.3 to 16.0 days and that of males from 1.9 to 10.7 days, as shown in table 2:

Table 2: Duration of adult longevity in each generation

Generation	Day of emergence	Day of death		Logevity	
		Female	Male	Female	Male
				(days)	
3rd	22–25/II	3–18/III	25/II–15/III	15.6	10.7
4th	13–19/III	18/III–9/IV	17–21/III	8.7	4.8
5th	4/IV	18/IV=1/V	5–9/IV	16.0	3.5
6th	23–28/IV	24/IV–9/V	24–29/IV	6.2	1.9
7th	19–21/V	13/V–12/VI	23/27/V	9.6	6.1
8th	9/VI	11/VI–2/VII	11/15/VI		
9th	30/VI–1/VII	8–14/VII	2/8VII	8.7	5.4
10th	18/VII	20–22/VII	19–21/VII	2.3	2.1
11th	9/VIII	12–15/VIII	14–17/VIII	4.3	3.1
12th	2/IX	9–12/IX	9–10/IX	7.4	6.9
13th	25/IX	27/IX–10X	16–30/X	8.7	4.8
14th	14–15/X	16–30/X	11–16/XI	9.7	7.2
15th	9/XI	11–17/XI	5–24/XII	5.2	4.3
16th	4–5/XII	9–25/XII		11.5	5.7

4. Population level of wing-form: The observation was made on the 12 to 19 pairs of adults of each generation. They were individually reared in a glass cylinder with freshly-rooted rice stems inside, and were placed in the petri dishes of water which was filled every morning. The top of the glass cylinders was individually covered with a fine muslin and fastened with rubber bands to prevent adults from escape. The change of the freshly-rooted rice stems in each glass cylinder was made at five day intervals and individually transferred into other one until the eggs hatched to emerge from adults through the observation. Newly-emerged adults were counted after being killed by a poison bottle every morning. The period of adult emergence varied in each gendration, it was closely counted with survival of former adults for laying their eggs under climatic conditions. The period of adult emergence of each generation lasted from 3 to 20 days, with the 6th generation being longest and the 12th generation being shortest. The percentage of wing-form of the females and the males varied in each generation. However, the percentage of macropterous males usually was highest in each generation, which was not significantly different. For the females, however, it varied from generation to generation, indicating that the females, particularly, brachypterous ones, were more sensitive to temperature, humidity and other factors. According to the data. the rate of macropterous females ranged from 7.6 to 49.1 per cent; brachypterous females, from O.O to 47.9 per cent; and macropterous males from 40.1 to 63.6 per cent. The severe out-break of the pest was also associated with population density of both the macroptorous females and the brachypterous females. Sometimes, the brachypterous females were as important as the macropterous females, causing injury of the rice plants under favorable conditions. The results obtained showed that

the weather with exception of the environmental conditions, was considerably more suitable to its multiplication in South Vietnam throughout the year, as shown in table 3:

Table 3: Population dynamics of wing-form in each generation

Genera-tion	Date of emergence	Emerging period	No. of emerged adults	Percentage of wing-form		
				Female		Male
				Marco.	Brach.	Macrc.
1st	15–25/I	8	52	11.5	46.2	42.3
3rd	24/II–10/III	14	599	34.5	9.6	55.9
4th	12–26/III	14	621	37.6	9.3	54.0
5th	3/18/IV	15	261	12.5	17.2	63.1
6th	21/IV–12/V	20	359	12.0	47.9	40.1
7th	15–24/V	9	116	28.4	8.6	63.5
8th	12–1 /VI	7	122	30.3	18.0	51.6
9th	25/VI–15/VII	19	195	35.9	12.3	51.8
10th	14–19/VII	5	144	7.6	36.8	55.6
11th	8–12/VIII	4	45	24.4	22.2	53.4
12th	26–29–VIII	3	81	40.7	7.4	52.0
13th	26/IX–8/X	13	263	28.5	21.3	50.2
14th	14–22/X	8	426	37.1	9.9	53.0
15th	6–24/XI	8	658	49.1	0.0	50.9
16th	6–9/XI	5	311	39.2	6.4	54.3

The 2nd generation was not completed because of V. C. offensive in Saigon in February, 1968.

5. Investigation on the seasonal fluctuation of egg population: This was a study on the occurrence of the hopper under climatic conditions. It will be used as a basic reference for outbreak prediction in the furture. Samples of egg Laying rice stems brought in from outside were individually examined under the dissecting microscope and the number of eggs were counted at 5–6 day intervals from April 16 through December 7, 1968. It was usually done six times in each month, except for April, November and December. The average of oviparious rice stems sampled, ranged from 31.5 to 40.8 in each time. According to the data, the number of egg-masses per rice stem, eggs per egg-mass and per rice stem were highest in July and lowest in April and May. With exception of April, May and July, there was no significant difference in each month. The number of eggs laid into the tissues of the rice stems was closely correlated with the number of adults emerged under favorable conditions. It was shown that the climatic conditions were the most important factors concering the outbreak of this pest. Throughout the investigation, the increment of population is especially significant in wet season. Results are given in table 4:

Table 4: Seasonal fluctuation of egg population from April to December

Date survey	Times of survey (total)	No. of rice stems/ survey	No. of egg clusters /survey	No. of eggs/ survey	No. of egg-masses /riee stem (av.)	No. of eggs/ egg-cluster(av.)	No. of eggs/ rice stem (av.)
16-26/IV	3	38.0	114.3	1,028.0	2.9	9.0	26.3
1-27/V	6	31.5	75.2	734.8	2.9	8.0	23.6
1-27/VI	6	36.5	189.5	2,702.8	4.4	13.0	59.8
2-29/VII	6	39.5	341.0	4.876.8	8.7	14.1	124.3
5-28/VIII	6	40.8	255.2	2,510.5	6.2	9.9	61.4
2-28/IX	6	39.3	270.7	2,539.2	6.8	9.7	62.2
5-30/X	6	35.5	254.2	2,312.7	6.9	8.7	61.4
2-25/XI	5	38.8	293.6	2,529.2	7.6	8.5	63.3
2-7/XII	2	38.0	247.5	2,518.0	6.6	10.1	66.9

6. Investigation on the seasonal occurrence of newly-hatched nymphs: This study was carried out on the oviparious rice stems which were brought from outside. Rice variety IR 8 was used as a standard one and was transplanted on the pots on June 25. The number of newly-hatched nymphs were counted 34 days after transplanting, when the initial symptom of rice stem infested by the hoppers was discovered under natural conditions. A samplo of one hill of rice plants was selected at random in each plot and was transferred in each glass cylinder after washing the roots of soft mud. It was placed in the large petri dishes in which the water supplied in the case of necessary. Survey was made at 7 to 12 day intervals from July 28 to September 26. The newly-hatched nymphs were counted after killing them in the poison bottle every morning until all eggs were completely hatched in each time. Popultation density of newly-hatched nymphs generally increased from July 29 to August 26 and decreased in August 30 to September 5, while its population increased again in early mid-September and decreased in late September and early October when the rice plants were entirely destroyed by the hoppers during favorable weather. Results are given in table 5:

Table 5: Seasonal occurrence of newly-hatched nymphs

Date surveyed	Period hatching nymphs	No. of hills surveyed	No. of rice stems/ hills	No. of newly-hatched nymphs (Total)	No. of hewly-hatched nymphs/ rice stem (av.)	No. of newly-hatched nymphs/ hill (av.)
28/VII	29/VII-7/VIII	3	13.3	766	19.2	255.3
8/VIII	9-18/VIII	5	-	2,166	-	433.2

19/VIII	20–28/VIII	5	25.8	5,044	39.1	1,008.8
29/VIII	30/VIII–5/IX	5	19.4	2,033	21.0	407.0
5/IX	5–16/IX	5	13.4	7,745	115.6	1,549.0
17/IX	18–26/IX	5	12.8	5,748	85.8	1,149.6
26/IX	27/IX–2/X	5	14.4	1,354	26.6	270.8

7. Egg parasites: Two species of egg parasites have been found from the eggs of *Sogatella*. According to the morphology of the parasites, they are minute hymenopterous wasps. The larger bluish-black one is supposed as to a *Eulophid* parasite (unidentified). The yellowish-brown one is identified as *Anagrus* sp. Family mymaridae. The parasitism of these species was examined in the egg-masses of *Sogatella* under the dissecting microscope in the laboratory. More than to 72.5% of eggs was parasitized. It seemed that *Eulophid* parasite was more important than the *Anagrus* sp. in reducing hatching rate of *Sogatella* eggs, as shown in table 6:

Table 6: Parasitism of egg parasites of s. furcifera in 1968

Date of survey	No. of oviparous rice stems	No. of eggs	No. of egg per sited	percent of parasitism
25/V I	36	748	605	72.5
15/VIII	14	307	222	72.3

Environmental factors concerning the outbreak

Climatic conditions, cultivating methods, natural enemies and other plants or animals are known as the factors concerning the outbreak of the hopper, among them climatic conditions are the most prominent factors.

According to the observation, length of daytimes temperature and humidity are the climatic factors which seem to have close connection with rice in population density. In the case of many generations, there appeared a constant rice in population density when the daytimes sborten, and the temperature was constant between the day and the night during rainy season namely from June to November. In contrast, the decrease of population ecology was closely connected with a long daytimes and high temperature during dry season namely November through May, particularly significant in April and May. Although the climatic conditions are the most prominent factors for an outbreak of this pest. the environmental factors are also considerably important. Therefore, the serious outbreak of this pest would be closely correlated with climatic and environmental factors.

Results

According to the present study ecological study of this pest, the climatic conditions are the most effective indicator to determine the outbreak of the hopper. Macroptertus and brachypterous adults are usually abundant in the wet season when the temperature does not

change very much between day and night. The length of daytimes may decrease, while the humidity may be constant at about 85%. The population of S. furcifera is gradually built up from June and begins to decrease in December. The increment of population is particularly significant in April and May, in this season the weather becomes hotter and drier in South Vietnam Although climatic conditions are main factors concerning the outbreak of this pest, heavy infestation of rice plant presumably depends upon the cultural practices and microhabitat.

Summary

The White-back plant hopper, *Sogatella furcifera* Horvath is a major pest of rice plants in favorable weather in South Vietnam. It produces more than sixteen generations a year. The degree of infestation varies from year to year and is usually associated with climatic conditions and multiple rice practices. The hopper population is high in wet season and low in dry hot season. The pest attacks rice plants causing more serious injury on differential stage than that of the tillering stage. Because at latter stage, the multiplication of this pest is easily influenced by some external factors such as wind velocity, length of daytimes, number of cloudy days, water level and hill spacing. The damage to rice plants in irrigated fields is more serious than that in the ordinary fields where water level is usually high. Therefore, the outbreak of the pest in Central Vietnam is more serious than in South Vietnam, as the environmental condition would be suitable for it multiplication throughout the rice growing season.

Acknowledgement

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中 文 摘 要

越南白背飛蝨生態之研究

陶 家 驊* 吳 定 秀*

白背飛蝨（*Sogatella furcifera* (Horvath)）爲越南水稻區重要害蟲之一，在越南自然環境之下，適其繁衍滋生，一年發生16世代，其蔓延成災，往往受氣候和水稻栽培制度相互密切之關係。故其爲害水稻程度，隨歷年氣候和環境而異，就其發生環境而言，中越水稻區較湄公河三角洲水稻區有利條件，蔓延猖獗季節恒在高溫多濕時期，構成水稻爲害時期，尤以分化時期最爲嚴重，但品種間亦有顯著差異IR5 及IR8 兩個品種受其爲害較當地品種爲熾烈，一旦適其氣候和環境，常導致嚴重災害發生。通常在水稻分蘗時期，鮮有其構成災害發生，惟時受外界因子干擾而影響所致，諸如風之速力、日照和陰日時間，禾田間水位之高低，以及水稻行距離較大等，足可抑制其發生。故禾田灌溉區，常以灌溉水量限制，遇其繁衍滋生其爲害程度則較普通禾田自然灌溉區爲嚴重，蓋因其水位常高之灌溉區所致也。

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