農業研究

第二十卷　第四期

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臺北市羅斯福路四段

臺灣省農業試驗所出版

中華民國六十年十二月

水稻雜種後代分期選育效果之研究

Ⅱ：後期世代分期選拔之效果測驗[1]

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一、前　言

臺灣第一期稻作與第二期稻作的生育環境完全不同，但目前的推廣品種，除了極少數的臺灣在來稻因對感光性特別敏感，只能栽培於第二期作，大部份的品種兩期作均可栽培。就產量而言，同一品種在第一期作的產量大致均比第二期作爲高，換言之，本省目前尚缺乏適合於第二期作栽培之水稻品種。本試驗第一報顯示早期世代分期選拔的效果不顯著；相反的，一、二期連續選拔的慣用法對農林48號×臺中在來1號組合比分期選拔者爲優。鑒於水稻許多量的性狀，諸如穗數、產量等在早代選拔的效果並不明顯，故本試驗之初期（F_2—F_5）世代仍用混合法（Bulk method）連續進行世代繁殖，第六世代（F_6）起始行分期選拔，用以比較後期分期選拔之效果。

二、試驗材料及方法

供試材料爲農林48號×臺中在來1號及嘉農242號×Rizzotto二組合之雜交後代，試驗處理爲一期作選育，二期作選育及一、二期作連續選育三種。雜種後代在早期世代之處理，係採用混合法，F_2至F_5世代在一期作及二期作環境連續分離繁殖。每組合繁殖之個體數F_2約3,500株，用單本植，F_3至F_5代約10,000株，用普通植，每叢4～5苗，成熟時混合收穫，隨機抽取種子，F_5代種子則分出三個樣品，供F_6代分期選育之用。F_6代各處理繁殖8,000個體，單本植，成熟時按一般育種目標，選拔優良個體80株，F_7代繁殖爲系統，每系統種植三行，凡45株，行株距25×20公分，同時將一、二期連續選育處理選拔之系統栽培，初步觀察比較分期選育與連續選育各系統主要農藝性狀之變異。成熟時各處理繼續分別選拔最優良者21系統，至F_8代連合三種不同處理選育之品系共63種，加入對照種，分別在一期作及二期作環境進行產量測驗。田間排列採用逢機完全區集設計，重複二次，三行區，行長4公尺，小區面積3平方公尺，調查各小區之穀粒產量。

三、試驗結果及討論

分期選育之處理，經F_6及F_7代之選拔，連同一、二期連續選育處理選拔之系統，組成三種不同期作選育品系共63種，及對照品種臺中65號，分別在一期作及二期作環境進行產量測驗，其結果分述如下：

（一）二期作環境試驗

在57年（1968）二期作進行，分期選育與一、二期連續選育品系之產量變異情形如下表：

本研究獲國家科學委員會之補助，並承農藝系黃眞生主任指正，謹此致謝。

1.試驗報告農試字第五三三號。　　2.臺灣省農業試驗所技士。

表 1. 二期作選育與一、二期連續選育品系（F_8）在二期作環境之產量分佈

組合	處理	產量分佈（克/3m²） 201–260	261–320	321–380	381–440	441–500	501–560	561–620	621–680	681–740	741–800	801–860	861–920	921–980	總數	平均產量
農林 48 號 × 臺中在來 1 號	一期作選育	3	—	3	2	1	1	6	2	2	1	—	—	—	21	508
	二期作選育	2	3	5	5	—	—	3	2	1	—	—	—	—	21	430
	一、二期選育	—	—	—	5	6	3	4	3	—	—	—	—	—	21	510
	對照種	—	—	1	—	—	—	—	—	—	—	—	—	—	1	365
嘉農 242 號 × Rizzotto	一期作選育	1	1	2	5	1	3	3	4	1	—	—	—	—	21	499
	二期作選育	1	1	2	1	3	4	2	3	2	—	1	—	1	21	558
	一、二期選育	1	1	1	2	5	2	3	4	—	1	—	1	—	21	533
	對照種	—	—	1	—	—	—	—	—	—	—	—	—	—	1	335

農林48號×臺中在來 1 號組合選育各品系之產量普遍較低。處理間各品系之產量分佈，兩組合略有不同；農林48×臺中在來 1 號組合，一期作及二期作選育之品系，其變異較一、二期連續選育及二期作選育處理之品系變異較大。處理間平均產量之高低，兩組合之趨勢並未相同。至於各組合各處理間之差異，以變方分析法測驗之，結果列如下表：

表 2. 分期選育與一、二期連續選育品系（F_8）在二期作環境之產量變方分析

組合	變因	自由度	平方和	均方	F 值
農林 48 號 × 臺中在來 1 號	區集	1	6328.10	6328.10	—
	品系	(63)	2379580.50	37771.10	6.03**
	一期作選育	20	1100097.62	55004.88	8.78**
	二期作選育	20	795107.14	39755.36	6.34**
	一、二期選育	20	279657.14	13982.86	2.23**
	來源	(3)	204718.56	68239.52	10.89**
	處理對 ck	1	27272.93	27272.93	4.35**
	處理間	2	177445.63	88722.81	14.15**
	機差	63	394836.90	6267.25	—
	總數	127	2780745.50	—	—
嘉農 242 號 × Rizzotto	區集	1	9028.30	9028.30	—
	品系	(63)	3055471.70	48499.50	12.18**
	一期作選育	20	684832.90	34241.60	8.60**
	二期作選育	20	1191482.50	59574.10	14.96**
	一、二期選育	20	969839.30	48491.90	12.18**
	來源	(3)	148066.20	49355.40	12.39**

處理對ck	1	75014.14	75014.14	18.84**
處理間	2	73052.77	36526.29	9.17**
機差	63	250834.20	3981.50	—
總數	127	3315334.20	—	—

分期選育及兩期連續選育各品系之產量，F值極顯著，各處理內之品系產量差異亦顯著，處理間之產量差異亦極顯著，而二組合之結果相同。處理間平均產量之顯著性，其測驗結果如表3。

表3. 分期選育與一、二期連續選育品系（F_8）在二期作環境之平均產量差異

1. 農林48號×臺中在來1號　　2. 嘉農242號×Rizzotto

處理	平均產量(克)	差異		處理	平均產量(克)	差異	
一、二期選育	510	—	—	二期作選育	558	—	—
一期作選育	508	2	—	一、二期選育	553	5	—
二期作選育	430	80**	78**	一期作選育	499	59**	54**

不同期作選育處理之產量差異，二個組合之趨勢並不相同。試驗係在二期作環境進行，結果農林48號×臺中在來1號組合，却以二期作選育處理之產量最低，一、二期連續選育處理之產量最高，兩者相差達1%的極顯著水準，而一期作選育品系亦比二期作選育品系表現優異。嘉農242號×Rizzotto組合，以二期作選育處理之產量最高，一、二期連續選育處理次之，但二期作選育與一、二期連續選育處理之產量差異不顯著，而一期作選育處理的產量顯著比其他兩處理爲低。上述資料顯示二期作選育處理選出之品系，在二期作環境之產量，其分佈情形以及平均產量，均未能比一、二期連續選育者爲優，故分期選育處理選出品系產量之高低，與選獲之品系優劣有關，而對選育環境影響較小。

（二）一期作環境試驗

在58年（1969）一期作進行，除了期作環境不同外，供試品系、田間設計、耕種管理等均與二期作試驗同，處理間之穀粒產量分析與比較，仍與二期作試驗同。其結果列如下表：

表4. 分期選育與一、二期連續選育品系（F_8）在一期作環境之產量分佈

組合	處理	產量分佈(克/3m²) 301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	701-750	751-800	801-850	851-900	901-950	總數	平均產量
農林48號×臺中在來1號	一期作選育	—	—	1	1	2	—	—	5	5	6	1	—	—	21	691
	二期作選育	—	1	—	—	2	4	3	6	5	—	—	—	—	21	641
	一、二期選育	—	—	—	—	—	1	3	4	11	1	—	—	—	21	676
	對照種	—	—	—	—	—	—	—	1	—	—	—	—	—	1	700
嘉農242號×Rizzotto	一期作選育	—	—	—	—	—	3	9	4	3	—	1	1	—	21	668
	二期作選育	—	—	—	—	3	—	3	5	4	—	4	—	2	21	712
	一、二期選育	—	—	—	—	—	—	1	—	5	3	1	6	5	21	826
	對照種	—	—	—	—	—	—	—	1	—	—	—	—	—	1	675

由上表結果，農林48號×臺中在來1號組合，各處理之產量分佈較嘉農242號×Rizzotto 組合爲差。處理間之產量，二組合之趨勢並未盡相同。農林48號×臺中在來1號組合以一期作選育之品系分佈較優異，平均產量最高，其次爲一、二期連續選育處理。嘉農242號×Rizzotto 組合則爲一、二期連續選育處理之產量分佈最優，一期作選育之品系却爲最差。供試各品系及處理間之產量，以變方分析法測驗之，結果列如表5.。

表5. 分期選育與一、二期連續選育品系（F_8）在一期作環境之產量變方分析

組合	變因	自由度	平方和	均方	F值
農林48號×臺中在來1號	區集	1	37984.57	37984.57	—
	品系	(63)	1198446.68	19022.96	4.48**
	一期作選育	20	455097.62	22754.88	5.35**
	二期作選育	20	342083.33	17104.17	4.02**
	一、二期選育	20	344389.29	17219.46	4.05**
	來源	(3)	56876.44	18958.81	4.46**
	處理對ck	1	1871.68	1871.68	0.44
	處理間	2	55004.76	27502.38	6.47**
	機差	63	267777.93	4250.44	—
	總數	127	1504209.18	—	—
嘉農242號×Rizzotto	區集	1	59728.32	59728.32	—
	品系	(63)	1754793.55	27853.86	9.94*
	一期作選育	20	256832.14	12841.60	4.58**
	二期作選育	20	541140.47	27057.02	9.65**
	一、二期選育	20	388890.47	19444.52	6.94**
	來源	(3)	567930.46	189310.15	67.55**
	處理對ck	1	7172.12	7172.12	2.56
	處理間	2	560758.33	280379.16	100.04**
	機差	63	176559.18	2802.53	—
	總數	127	1991081.05	—	—

由上表結果，供試品系間之差異達1%極顯著水準，三種處理各品系之差異亦達極顯著，處理間之差異亦達極顯著，而兩組合之結果均爲相同。處理間產量之差異，爲主要之探討問題，其差異顯著性測驗如表6。

處理間平均產量之差異，兩個組合之趨勢不同。農林48號×臺中在來1號組合爲一期作選育處理之產量最高，但與一、二期連續選育處理差異不顯著，與二期作選育處理差異顯著。嘉農242號×Rizzotto 組合反爲一、二期作連續選育處理之產量最高，一期作選育處理最低，而一、二期連續選育處理與二期作選育及一期作選育處理均達1%極顯著水準。

綜觀一期作及二期作的試驗結果，農林48號×臺中在來1號組合，無論一期作或二期作，一期作選育品系之平均產量，均比二期作選育者顯著增加。而嘉農242號×Rizzotto 組合，無論在一期作或

表 6. 分期選育與一、二期連續選育品系（F_8）在一期作環境之平均產量差異

處理	農林48號×臺中在來1號 平均產量 (克)	差異		處理	嘉農242號×Rizzotto 平均產量 (克)	差異	
一期作選育	691	—	—	一、二期選育	826	—	—
一、二期選育	676	15	—	二期作選育	712	114**	—
二期作選育	641	50**	35**	一期作選育	668	158**	44**

二期作，二期作選育品系之平均產量，均比一期作選育者爲多。表示水稻分期選拔效率受期作×組合所影響。可是在第一期作產量高之處理，在二期作亦同樣有較高的產量。就一、二期作連續選拔與分期選育之效果加以比較，無論在農林48號×臺中在來一號或嘉農 242號×Rizzotto 組合，分期選育品系之平均產量，均不比一、二期連續選育者顯著增加。相反的，一、二期連續選育品系，在農林48號×臺中在來 1 號組合，無論在一期作或二期作均比二期作選育品系之平均產量爲高。在嘉農 242號×Rizzotto 組合，無論在一期作或二期作，一、二期連續選育品系之平均產量均比一期作選育者顯著增高，表示一、二期連續選育品系，無論組合及期作之不同，均有較分期選育品系爲穩定之趨勢。

嘉義農業試驗分所（張，1967）以系比 52145×臺南 5 號組合之品系試驗爲材料，發表期作對選拔效率之報告指出，在第一期作選拔或兩期作均加以選拔育成的品系，其期作適應性可能較只在第二期作選拔育成者爲大。但就本試驗結果，僅農林48號×臺中在來 1 號組合具同樣之結果，嘉農 242號×Rizzotto 組合則以二期作選育及一、二期連續選育品系的適應性較大。本試驗第一報（楊等，1971）顯示，一期作選拔品系與二期作選拔品系之平均產量，無論在一期作或二期作均無顯著的差異；但農林 48 號×臺中在來 1 號組合，一、二期連續選育品系在第一期作比一期作選育及二期作選育品系都優異。在第二期作亦比一期作選育品系優異。因此，就這些資料推論，分期選育似不能提高選拔效率。

四、摘　要

本試驗以農林48號×臺中在來一號及嘉農242號×Rizzotto 二組合，雜交後代以混合法處理，至 F_6 代始按期作分別選拔，爲探討後期世代實行分期育種之選拔效果，能否受氣候環境之影響。F_6 世代始按選拔方式分爲三種處理，即一期作選育，二期作選育及一、二期連續選育。F_6 世代選單株，當選之 F_6 單株在 F_7 成爲系統，並各選出21系統，聯合各處理當選品系及一對照品種，在一期作及二期作環境試驗，所獲結果摘要如下：

在二期作環境，嘉農242號×Rizzotto 組合，以二期作選育品系之平均產量最高，但與一、二期作連續選育品系相比較無顯著差異；一期作選育品系則顯著地比其他二者爲差。農林48號×臺中在來 1 號組合，以一、二期連續選育品系之平均產量最高，而二期作選育品系比其他兩者爲差。一期作環境之試驗與二期作之結果相類似，但在嘉農242號×Rizzotto 組合，一、二期連續選育品系之平均產量比二期作選育者爲高。本試驗結果表示，一、二期連續選拔育種法所育成之品系，較分期育種法所育成之品系，無論在一期作或二期作，均有較穩定的產量。

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附錄：57年（1968）第一期作，進行一期作選育處理選拔系統時，與一、二期連續選育處理各系統同時栽培，比較處理間主要農藝性狀之變異，結果如下表：

表 7.　一期作選育與一、二期連續選育系統 (F_7) 在一期作環境農藝性狀之差異

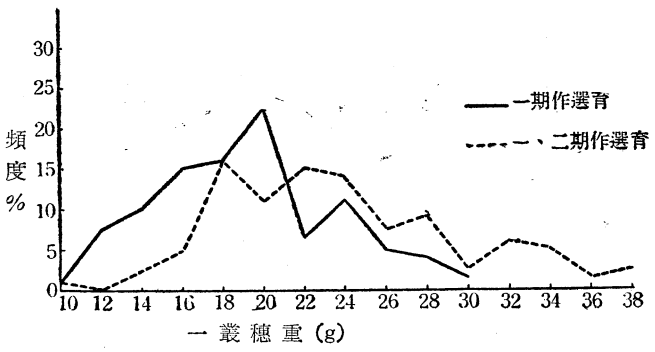
組合	處理	生育日數	株高（公分）	有效分蘗數（本）	一叢穗重（克）	單穗重（克）	單穗長（公分）
農林 48 號 × 臺中在來 1 號	一期作選育	87.4±7.09	123.4±3.82	12.9±2.23	18.9±4.80	2.17±0.47	23.0±2.55
	一、二期選育	85.9±6.93	122.5±8.20	13.5±2.37	23.6±5.24	2.43±0.57	23.6±2.71
	差異	1.50	0.9	−0.6	−4.7	−0.27	−0.6
	t 值	1.364	0.895	−0.176	−5.870**	−3.29**	−0.139
嘉農242號 × Rizzotto	一期作選育	85.0±3.99	127.7±6.24	11.3±1.91	20.7±2.80	2.73±0.52	24.0±1.66
	一、二期選育	81.0±3.60	122.5±9.64	9.7±2.30	22.8±3.84	3.21±0.58	23.0±1.86
	差異	4.0	5.20	1.60	−2.1	−0.48	1.0
	t 值	6.705**	4.10**	4.83**	−3.89**	−5.51**	0.359

由上表結果，農林48號×臺中在來1號組合，一期作選育處理各系統，其平均之生育日數稍長，株高稍高，有效分蘗數稍少，但差異不顯著。一叢穗重及單穗重、穗長，則爲一、二期連續選育處理較優異，而一叢穗重及單穗重之差異達極顯著程度。嘉農 242號× Rizzotto 組合，一期作選育處理之平均生育日數、株高、有效分蘗數，均較一、二期連續選育處理爲優，差異極顯著。但一叢穗重、單穗重仍以一、二期連續選育者爲優，差異亦極顯著。兩種處理之株高、穗重、穗長等農藝性狀之標準機差均爲一、二期連續選育者稍大，而二組合之趨勢相同，表示一、二期連續選育處理各系統變異較大。

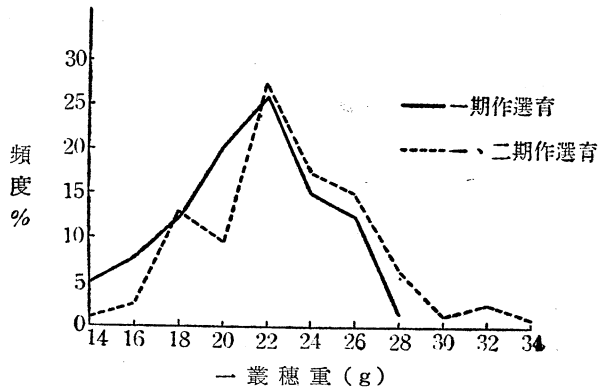
一叢穗重可表示產量之高低，在一期作選育及一、二期連續選育處理之平均值，均以一、二期連續選育者爲高，且二組合之結果相似。再以各系統之分佈情形觀察，農林48號×臺中在來1號組合，一期作選育之系統，其峯度稍高，但其歪度則一、二期連續選育系統較偏於高產量。嘉農 242號× Rizzotto 組合，其峯度則一期作選育與一、二期連續選育系統無差異現象，但其歪度仍爲一、二期連續選育系統較偏於高產量。茲將分佈情形示如圖 1。

圖 1.　一期作選育與一、二期連續選育各系統 (F_7) 在一期作環境一叢穗重之分佈

1. 農林48號×臺中在來1號



2. 嘉農242號×Rizzotto



EFFECTS OF SELECTION IN TWO HYBRID POPULATIONS OF RICE PROPAGATED IN DIFFERENT CROP SEASONS

II. SELECTION IN LATE SEGREGATING GENERATIONS

by

F. P. Young and Y. C. Teng

Summary

As reported previously (6), the difference in selection efficiency in different crop seasons on several agronomic traits like grain yield, number of tillers per plant, etc., in early segregating generations were not always significant. In this study the effect of selection in different crop seasons initiated from late segregating generations of the same hybrids will be reported. Two hybrids, Nohrin 48× Taichung (Native) 1 and Chianung 242 × Rizzotto, were separately grown in both the first and the second crop seasons consecutively under the bulk method up to F_5 generation. Then, three seed samples were taken from the harvested seed lot of each F_5 population to provided the seed for growing the F_6 and F_7 in three different groups, the first crop season alone, the second crop season alone and both crop seasons. Eight thousand plants consisted a population in the F_6 and 80 plants were selected from them to establish plant-row in the successive F_7. Finally, 21 lines were selected from each of the 3 populations to establish strains for yield trial.

In the second crop of 1968, the difference among average yields of three strain-groups derived from the F_1 of Chianung 242× Rizzotto was highly significant. The strains selected in the second crop yielded the highest in average among these three strain groups, though their average yield did not significantly differed from that of the strains selected in both crop seasons. Among the three strain groups derived from the F_1 of another cross, Nohrin 48 × Taichung (Native) 1, the strain group selected in both crop seasons yielded higher in average than the rest of two strain groups, though significantly outyielded only the strain group selected in the second crop season. The result of the 1969 first crop was similar with that obtained in the 1968 second crop, except in those strains derived from the F_1 of Chianung 242 × Rizzotto, among which the strain group selected in both crop seasons significantly outyielded the strain group selected in the second crop season. The results of this experiment seem to indicate there is little advantage in growing F_6 and F_7 hybrid materials in a particular season for efficient selection.

MANIFESTATION OF HYBRID VIGOR IN RICE[1]

W. L. Chang, E. H. Lin and C. N. Yang[2]

INTRODUCTION

Over the years, much of varietal improvement in rice has centered around the development of purelines. The improved varieties were generally high yielding and had contributed greatly to the increase of unit yield production of rice in the past years. However, the efficiency of varietal improvement in rice in terms of the percent of newly developed varieties outyielding the standard commercial varieties has been steadily decreasing. For instance, Kariya (1966) has reported that average yield increase of the Norin Number varieties has decreased from 6.8% for those developed during 1931–1941 to only 2.1% for those registered during 1962–1965. Thus, a remarkable improvement in the yielding ability of rice appears unlikely unless more efficient breeding techniques become available. The successful utilization of heterosis may set up a new level of varietal productivity in rice.

Heterosis is but one requisite for commercial production of hybrid rice. Research results indicated that the amount of heterosis exhibited in crosses among varieties and strains of rice varied greatly. Jones (1926) found a distinct vigor in the number of tillers and the yield per plant among four crosses of American varieties. Hsu *et al.* (1969) also reported that F_1 plants produced more grain yield than their respective high yielding parents in 44 out of 90 crosses evaluated. However, Jennings(1967)and Kawano *et al.*(1969) indicated that heterosis in grain yield may not be generally expected under commercial planting of rice where close spacing and heavy application of nitrogen are usually recommended. Before commercial hybrid rice becomes a reality, it is imperative that sufficient hybrid vigor be available through specific parental combinations so that hybrids will produce signif icantly more grain than their conventional varieties. This paper presents results from three-year study of heterosis displayed for several agronomic characters by a group of 265 rice hybrids studied at Chiayi, Taiwan.

MATERIALS AND METHODS

Heterosis in F_1 hybrids of rice was evaluated at the Chiayi Agricultural Experiment Station for six crops from the second crop of 1967 to the first crop of 1970. Various cross

1. Series No. (Q) 534. This experiment was supported by the Taiwan Agricultural Research Center (TARC) and the Joint Commission on Rural Reconstruction (JCRR) under the projects of 69-A11-A-1951 (TARC) and 70-A11-A-2035 (TARC) .

2. Agronomist and Research Assistants, respectively, Chiayi Agricultural Experiment Station, TARI. The writers wish to express their sincere thanks to Mr. C. H. Huang, Senior Rice Specialist, JCRR for his valuable advice during the course of this experiment.

combinations were made either between local varieties or between local varieties and foreign introductions. The number of crosses evaluated in this experiment is shown in Table 1. Inter-type crosses were excluded from the tests after the first crop of 1969 because seed sterility associated with these hybrids prohibited accurate measurement of hybrid vigor. F_1 hybrids between early and late maturing varieties or between short and tall varieties were also not included in the tests after 1969 to prevent excessive segregation for these traits in the F_2 population since the possiblity of utilizing hybrid vigor in advanced generations of rice is also considered.

Table 1. Number of crosses evaluated.

Crosses between	Second crop 1967	First crop 1968	Second crop 1968	First crop 1969	Second crop 1969	First crop 1970	Total
Early maturing japonica varieties	—	—	—	27	24	13	—
Late maturing japonica varieties	—	—	—	18	28	25	—
Indica varieties	—	—	—	15	29	27	—
Total	22	17	20	60	81	65	265

Field test was conducted separately for early maturing japonica, late maturing japonica, and indica crosses. The F_1 hybrids, parental and check varieties of each group were arranged in either randomized or lattice design with two to three replications. Plot size was 0.5×2.0 m and consisted of 2 rows. The plants were grown at the spacing of 25 $\times 20$ cm with single seedling being transplanted at each hill.

Fertilization was made at the rate of 100, 50, and 50 kg per ha for N, P_2O_5, K_2o respectively. Data for grain yield, yield components, and several important agronomic characters were recorded and their heterosis estimated. Analysis of variance was made for grain yield per plant only in 1969 tests. Correlations between F_1 hybrid and midparental values were calculated for grain yield and heterosis of grain yield. Correlation coefficients for the heterosis of grain yield and its components were also calculated to indicate the association of grain yield and four components of grain yield in F_1 hybrids.

In this experiment, heterosis of F_1 hybrids was expressed in the percentage of (a) the high or more favorable parent, i.e., more productive, earliness, etc., (b) the midparental value, and (c) the standard check varieties. Rice varieties Taichung 180, Tainan 5, and Taichung native 1 were selected to represent standard check varieties for early maturing japonica, late maturing japonica, and indica crosses. Special emphasis was, however, given to the heterosis expressed in the percentage of standard check varieties since the hybrid population will need to exceed the leading commercial varieties in one or more characteristics if hybrid rice is to be very appealing.

EXPERIMENTAL RESULTS

Heterosis for Grain Yield

Average performance of the hybrids, parental and check varieties for grain yield and its four components is presented in Table 2. The 6-crop average grain yield of all F_1 hybrids was equal to the higher yielding parent but the hybrids exhibited advantages of 10.6 and 6.3 % over their mid-parent and standard check varieties, respectively. A summary of the number of hybrids with means above those of their respective higher parents, mid-parent, and check varieties in Table 3 shows that 54.7% of the hybrids had yield higher than better parents while 72.5% of the hybrids outyielded both mid-parent and check varieties. The average heterosis for these outstanding hybrids was 18.6, 20.3 and 19.1% based on the better parent, mid-parent, and check varieties, respectively. Tabulations of the levels of heterosis on an individual cross basis are too voluminous for presentation herein and only several instances of high percentage heterosis in both crops of 1969 and the first crop of 1970 are given in Table 4. It can be seen that each of the hybrids exhibited considerably large amount of heterosis in relation to its mid-parent. Heterotic effects (F_1 minus mid-parent values) of these crosses all reached the 1% level of significance. The heterosis based on higher yielding parent was also substantially high for each cross combination, although the amount of heterosis was somewhat smaller than that based

Table 2. Mean performance of grain yield and its components of F_1 hybrids, parental and check varieties, 1967-70.

	Grain yield (g/plant)	Number of panicle per plant	Number of grains per panicle	Weight of 1,000 grains (g)	Percentage of fertility (%)
Mean of					
High-parent (HP)	30.2	15.8	128.2	22.6	87.5
Mid-parent values (MP)	27.3	14.3	114.8	21.9	84.2
Check varieties (CK)	28.4	14.2	114.7	21.9	83.8
F_1 hybrids	30.2	15.0	117.6	22.3	81.5
F_1 hybrids as					
% of HP	100.0	94.9	91.7	98.7	93.1
% of MP	110.6	104.9	102.4	101.8	96.8
% of CK	106.3	105.6	102.5	101.8	97.3

on mid-parent value. The greatest heterosis was manifested by the cross of IR8 × Liu-tou-tze in the first crop of 1970 which outyielded mid-parent and high parent by as much as 79.1%, respectively. This hybrid also yielded 46.7% more than the commercial variety, Taichung native 1 but the highest percentage increase of 80.4% over the standard check variety was recorded for the cross of Ti-chueh-min-tan × IR 9-60 in the second crop of 1969.

Table 3. Number of F_1 hybrids with heterosis for grain yield and average heterosis shown by these hybrids, 1967–70.

Crop	Number of hybrids tested	Number of hybrids with mean			Mean yield of these hybrids as		
		Above high parent	Above mid-parent	Above check variety	% of HP	% of MP	% of CK
Second crop, 1967	22	6 (27.3)*	15 (68.2)	11 (73.3)	119.5	121.9	106.3
First crop, 1968	17	4 (23.6)	8 (47.1)	10 (58.8)	161.7	131.7	132.2
Second crop, 1968	20	3 (15.0)	8 (40.1)	3 (15.0)	117.1	121.8	123.6
First crop, 1969	60	39 (65.0)	51 (85.0)	55 (91.7)	113.6	116.9	116.6
Second crop, 1969	81	51 (63.0)	61 (75.3)	60 (74.1)	115.8	120.0	122.0
First crop, 1970	65	39 (60.0)	42 (64.6)	40 (61.5)	112.4	119.1	117.2
Total	265	145 (54.7)	192 (72.5)	192 (72.5)	118.6	120.3	119.1

* Number in the parenthesis represents % of the total number of hybrids tested.

Heterosis for Components of Grain Yield

Comparisons of average parent and F_1 hybrid performance for four components of grain yield i. e. number of panicles per plant, number of grains per panicle, weight of 1,000 grains, and percentage of fertility are also shown in Table 2.The average performance of the hybrids for these traits was generally inferior to that of their corresponding better parents but was superior to those of mid-parents and check varieties in 3 out of 4 yield components. The average heterosis expressed by the hybrids for these three components was 4.9, 2.4, and 1.8% in relation to mid-parents and 5.6, 2.5, and 1.8% in relation to standard check varieties for the number of panicles per plant, number of grains per panicle, and weight of 1,000 grains, respectively. The percentage of fertility was the only component of yield that did not show hybrid vigor. Correlation coefficients between heterosis for grain yield and its components all reached a significant level when F_1 hybrids of all six crops were pooled(Table 5). The"r"values obtained between grain yield and the number of grains per panicle, number of panicles per plant, and percentage of fertility were +.4980, +.4206,and +.3714 respectively, whereas correlation coefficient between grain yield and the weight of 1,000 grains was only +.1569. The former three correlation coefficients were significant at the 1% level while the latter one was significant only at the 5% level of probability.

Table 4. F_1 hybrids showing high heterosis for grain yield.

Crop	F_1 cross	Hybrid yield (g/plant)	Mid-parent yield (g/plant)	Hybrid minus mid-parent (g/plant)	Heterosis, % increase over mid-parent	Heterosis, % increase over high parent	Heterosis, % increase over check variety
First	Tainan 5x Line 561111	50.6	34.6	16.0**	46.2	45.8	45.8
crop,	Taichung (N) 1 x CP 231	46.0	27.4	18.6**	67.9	40.2	40.2
1969	CP 231 x Taichung (N) 1	40.4	27.4	13.0**	47.5	23.2	23.2
	IR8 x Taichung (N) 1	39.9	29.5	10.4**	35.3	21.7	21.7
	IR8 x Hsinchu-ai-chueh-chien	39.1	29.9	9.2**	30.8	16.4	19.2
	Taichung 180 x Fukunishiki	38.0	31.6	6.4**	20.3	19.5	19.5
	Taitung 138 x Taichung 180	36.5	32.7	3.8**	11.6	8.6	14.8
Second	Ti-chueh-min-tan x IR 9-60	42.4	27.3	15.1**	55.3	36.3	0.4
crop,	IR 8 x Ti-chueh-min-tan	41.7	30.9	10.8**	35.0	34.1	77.5
1969	IR 8 x IR 9-60	37.4	27.1	10.3**	38.0	22.2	59.2
	IR 9-60 x Saturn	26.7	17.3	9.4**	54.3	13.6	13.6
	C 236 x Tainan 5	25.2	20.1	5.1**	25.4	21.7	29.9
	C 223 x Taichung 65	25.1	18.5	6.6**	35.7	19.5	29.4
	C 236 x Hsinchu 61	24.3	19.1	5.2**	35.9	28.0	36.6
	Taichung 186 x Yachikogane	18.1	12.2	5.9**	48.3	44.4	29.2
	Taichung 186 x BC-68	17.8	11.6	6.2**	53.4	41.7	26.8
First	IR8 x Liu-tou-tze	58.4	32.6	25.8**	79.1	75.9	46.7
crop,	Taichung (N) 1 x IR8	47.4	35.9	11.5**	32.0	19.1	19.1
1970	Taichung 122 x C-early-1	45.4	37.6	7.8**	20.7	16.4	28.3
	Tainan 1 x Tainan 3	45.3	37.5	7.8**	20.8	12.1	28.0
	Taichung 122 x Hsinchu 61	44.0	35.6	8.4**	23.6	21.9	24.3
	Ti-chueh-min-tan x C230	41.5	30.5	11.0**	36.1	8.1	4.3
	Line 54233 x Taichung 180	40.7	31.9	8.9**	27.6	18.0	38.9
	Taichung 180 x Line 54233	40.2	31.9	8.3**	26.0	16.5	37.2

**Significant at 1% level.

Table 5. Simple correlation coefficients of heterosis between grain yield and its components of F_1 hybrids, 1967–70.

Crop	D.F.	Grain yield and panicles per plant	Grain yield and grains per panicle	Grain yield and 1,000-grain weight	Grain yield and fertility percentage
Second crop, 1967	26	0.6355**	0.3591	0.0554	0.0271
First crop, 1968	15	0.2269	0.8210**	0.0775	0.7112**
Second crop, 1968	18	0.7119**	0.7531**	0.6338**	−0.1464
First crop, 1969	58	0.6178**	0.1562	0.3119*	−0.1253
Second crop, 1969	79	0.5901**	0.5796**	0.0336	0.4918**
First crop, 1970	63	0.3925**	0.4707**	0.3659**	0.0956
All six crops	263	0.4206**	0.4980**	0.1569*	0.3714**

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

Relationship Between Parental Performance and Hybrid Performance

Correlation coefficients between the grain yields of mid-parent and the hybrid, between the grain yield of mid-parent and heterosis for grain yield of the hybrid, and between the hybrid yield and its heterosis are shown in Table 6. Heterosis is expressed as a percentage of the mid-parent value. Correlation coefficients between the grain yields of mid-parent and the hybrid were significant in 3 out of 6 crop seasons. However, when pooled data of 6 crop seasons were considered, the correlation coefficient was significant at the 1% level, indicating that a close relationship exists between the parental performance *per se* and the performance of their hybrids. Correlation coefficients between the grain yield of mid-parent and heterosis for grain yield of the hybrid were mostly negative and attained significance in 3 out of 6 crops, suggesting that the percent increase in yield over the mid-parent of the hybrids tends to decrease as average yield of the mid-parent increases. This, of course, is expected if the actual amount of heter osis on a gram of grain per plant basis for the hybrid remains fairly constantrover a range of yield levels for the mid-parent. A close relationship was also observed between the hybrid yield and its heterosis as indicated by highly significant correlation coefficients. It appears, therefore, that high level of grain yield of F_1 hybrids is likely to accompany relatively large amount of heterosis.

Table 6. Simple correlation coefficients between yield performance of mid-parents and their hybrids, 1967-70.

Crop	D.F.	Mid-parent yield and yield of F_1 hybrids	Mid-parent yield and heterosis for yield of F_1 hybrids	Yield of F_1 hybrids and heterosis for yield of F_1 hybrids
Second crop, 1967	20	0.4366*	− 0.4173	0.6180**
First crop, 1968	15	− 0.0115	− 0.5066*	0.8409**
Second crop, 1968	18	0.6176**	− 0.2363	0.6080**
First crop, 1969	58	0.2457	− 0.5750**	0.6445**
Second crop, 1969	79	0.8496**	0.2247*	0.6931**
First crop, 1970	63	0.1000	− 0.3505**	0.7857**
All six crops	263	0.8326**	− 0.0735	0.4662**

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

Comparison of F_1 Hybrids and Parents for Grain Yield

In this experiment, yield comparison of F_1 hybrids and parents was based on the yield data obtained in the first and second crops of 1969. A part of the analyses of variance pertinent to the heterosis is given in Table 7. It was observed that differences in grain yield of various F_1 hybrids and parents were highly significant. In order to find out

Table 7. Analysis of variance for grain yield of F_1 hybrids and their parents, 1969.

Crop	Source of variation	Early maturing japonica		Late maturing japonica		Indica		Pooled	
		D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
First	Entries	40	53.84**	28	60.98**	23	80.59**	93	72.00**
	F_1 vs. P	(1)	474.68**	(1)	169.19**	(1)	841.41**	(1)	1,252.39**
	F_1 vs. HP	(1)	1.43	(1)	26.53	(1)	257.52**	(1)	135.63**
	F_1 vs. CK	(1)	49.31*	(1)	78.39	(1)	78.34*	(1)	179.14**
	Residuals	(37)	44.01	(25)	57.34	(20)	33.81*	(90)	56.99**
	Error	80	11.71	56	35.59	46	17.35	186	21.48
Second	Entries	44	20.60**	50	32.01**	52	210.09**	148	134.03**
	F_1 vs. P	(1)	1.23	(1)	427.74**	(1)	1,274.89**	(1)	1,200.77**
	F_1 vs. HP	(1)	7.61	(1)	27.09	(1)	31.74	(1)	24.06
	F_1 vs. CK	(1)	2.83	(1)	17.67	(1)	32.91	(1)	60.94*
	Residuals	(41)	21.82**	(47)	24.13**	(49)	195.61**	(145)	127.94**
	Error	88	3.50	100	8.37	104	15.79	296	9.58

*Signficant at 5% level. **Signficant at 1% level.

whether grain yield of the hybrids was significantly different from those of parents and standard check varieties, single degrees of freedom associated with F_1 hybrids vs. parents,

F_1 hybrids vs. high parents, and F_1 hybrids vs. check varieties were partitioned from the variation among entries. The yield difference of F_1 hybrids vs. parents attained significance except for early maturing japonica group in the second crop of 1969 while that of F_1 hybrids vs. high parents was significant only for indica group in the first crop of 1969. The differences in grain yield of F_1 hybrids vs. check varieties were significant in the early maturing japonica and indica groups in the first crop of 1969. However, when three varietal groups were pooled together, all comparisons were significant except that of F_1 hybrids vs. high parents in the second crop of 1969.

Comparison of reciprocal crosses for grain yield was also made in the first crop of 1969 for the purpose of finding out whether there was a significant difference between each of F_1 hybrids and its reciprocal cross. The results are presented in Table 8. It was found that mean squares associated with reciprocal crosses all failed to reach a significant level, indicating that there was no evidence of maternal effect on the expression for the grain yield of F_1 hybrids. Thus, a given variety may serve equally well either as male or as female parent.

Table 8. Analysis of variance for reciprocal effect of grain yield of F_1 hybrids, first crop, 1969.

Source of variation	Early maturing japonica		Late maturing japonica		Indica		Pooled	
	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
Hybrids	19	41.44**	11	51.02	11	31.88	43	44.32**
Reciprocals	(1)	1.74	(1)	7.94	(1)	6.77	(1)	3.74
Residuals	(18)	43.64**	(10)	55.33	(10)	34.41	(42)	45.28*
Error	38	16.98	22	49.43	22	20.30	86	27.42

* Significant at 5% level.

** Significant at 1% level.

Heterosis for Grain Yield Under Different Crop Seasons

Data on the amount of heterosis averaged over all entries at the different crop seasons are presented in Table 9. Heterosis is expressed both as the difference between yields of the hybrid and the mid-parent value on a gram of grain per plant basis and as percentage of the mid-parent value. Examination of heterosis expressed on a gram per plant basis revealed that larger heterosis occurred in the first rather than in the second crop. The average actual increase of the hybrids over the mid-parent was 3.7and 2.0 grams per plant respectively for the first and second crops, indicating that average heterosis in the first crop was 85% higher than that of the second crop. When heterosis is expressed on a percentage basis, however, there was a marked tendency for the hybrids to have similar level of heterosis in different crop seasons. The average percentage increase for the first and second crops was 11.1 and 9.7% respectively with a difference of only 1.4%

in the magnitude of heterosis between the two crop seasons. In other words, average heterosis in the first crop was only 14% higher than that of the second crop.

Table 9. Average heterosis for grain yield at different crop seasons, 1967–70.

Crop	Hybrid yield (g/plant)	Mid-parent yield (g/plant)	Hybrid minus mid-parent (g/plant)	Heterosis, %increase over mid-parent
Second crop, 1967	25.8	23.1	2.7	11.7
First crop, 1968	24.2	24.1	0.1	0.4
Second crop, 1968	23.0	23.2	− 0.2	− 0.9
First crop, 1969	37.6	33.7	3.9	11.6
Second crop, 1969	21.6	19.2	2.4	12.5
First crop, 1970	40.6	35.9	4.7	13.1
Mean of first crop	36.9	33.2	3.7	11.1
Mean of second crop	22.6	20.6	2.0	9.7

Heterosis for Major Agronomic Traits

The heterosis of five important agronomic characters is shown in Table 10. It can be seen that the greatest heterosis was exhibited by the leaf area index (LAI) measured at heading stage. The average heterosis for LAI was 1.4, 14.5, and 22.0% in relation to the high-parent, mid-parent, and standard check varieties, respectively. The manifestation of heterosis for LAI was more pronounced in the first than in the second crop. The average increase of the hybrids over the mid-parent for LAI was 18.1 and 11.5%, respectively for the first and second crops (Table 11) . However, the correlation coefficients given in Table 11 indicated that the LAI value was more closely associated with grain yield of the hybrids in the second than in the first crop. Correlation between LAI and grain yield gave"r" values of +.1902 and +.7467 for the first and second crops, respectively. The coefficient for the first crop failed to reach a significant level but that for the second crop was significant at the 1% level. When data of all five crops were pooled, a highly significant correlation coefficient was also obtained.

Table 10. Mean performance for major agronomic traits of F_1 hybrids, parental and check varieties, 1967–70.

	LAI*	Days to heading	Plant height (cm)	Panicle length (cm)	Panicle weight (g)
Mean of					
High-parents (HP)	4.44	74.1	108.0	21.6	2.80
Mid-parent values (MP)	3.93	76.7	100.7	20.5	2.50
Check varieties (CK)	3.69	79.7	102.3	20.3	2.50
F_1 hybrids	4.50	74.6	104.4	20.8	2.56
F_1 hybrids as					
% of HP	101.4	100.7	96.7	96.3	91.4
% of MP	114.5	97.3	103.7	101.5	102.4
% of CK	122.0	93.6	102.1	102.5	102.4

*Average of five crops, 1967–69.

The heterosis for days to heading is expressed by an earlier heading date in comparison with mid-parent and check varieties. On the average, heading date of the hybrids was very similar to that of the earlier parents but it was 2 and 5 days earlier than the mid-parent and standard check varieties, respectively. For mature plant height, panicle length and panicle weight, the hybrids had no advantage over the high parental values but they expressed heterosis for these three characters in relation to mid-parent and check varieties, although the advantage for these characters was less significant than that for the LAI.

Table 11. Average heterosis for LAI and correlation between LAI and grain yield, 1967–69.

Crop	Heterosis			Correlation	
	Hybrid LAI	Mid-parent LAI	Heterosis, % of MP	D.F.	r
Second crop, 1967	3.19	3.05	104.6	20	0.4837*
First crop, 1968	6.32	4.82	131.1	15	0.1381
Second crop, 1968	3.72	3.73	99.7	18	0.8100**
First crop, 1969	5.53	4.86	113.8	58	0.4453**
Second crop, 1969	3.83	3.30	116.1	79	0.7271**
First crops pooled	5.73	4.85	118.1	75	0.1902
Second crops pooled	3.70	3.32	111.5	121	0.7467**
All 5 crops	4.50	3.93	114.5	198	0.4810**

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

Heterosis Expressed at Different Stages of Growth

The performance of the hybrids was compared with their respective mid-parents at three stages of rice growth i.e. late tillering stage (50 and 40 days after transplanting in the first and second crops respectively) , heading stage, and maturity stage. A summary of the number of hybrids showing heterosis for plant height and number of tillers per plant based on mid-parent values is presented in Table 12. The hybrid advantage was equally evident at three growth stages for plant height and number of tillers per plant. The average percentages of F_1 hybrids showing heterosis for plant height and tiller number were 73.6, 72.8, 66.4 and 67.6, 62.3, 67.6% at late tillering, heading, and maturing stages respectively, indicating that the manifestation of heterosis was not greatly affected by the stage of rice development.

Table 12. Number of F_1 hybrids with heterosis for plant height and number of tillers per plant based on mid-parent at different growth stages, 1967-70.

Crop	Number of hybrids tested	Plant height			Number of tillers per plant		
		Late tillering	Heading	Maturity	Late tillering	Heading	Maturity
Second crop, 1967	22	17 (77.3)*	15 (68.2)	10 (45.5)	14 (63.6)	12 (54.6)	12 (54.6)
First crop, 1968	17	15 (88.2)	9 (52.9)	8 (47.1)	13 (76.5)	13 (76.5)	15 (88.2)
Second crop, 1968	20	18 (90.0)	8 (40.0)	11 (55.0)	7 (35.0)	5 (25.0)	5 (25.0)
First crop, 1969	60	42 (70.0)	45 (75.0)	33 (55.0)	37 (61.7)	39 (65.0)	43 (71.7)
Second crop, 1969	81	59 (72.8)	67 (82.7)	66 (81.5)	58 (71.6)	58 (71.6)	57 (70.4)
First crop, 1970	65	44 (67.7)	49 (75.4)	48 (73.9)	50 (76.9)	38 (58.5)	47 (72.3)
Total	265	195 (73.6)	193 (72.8)	176 (66.4)	179 (67.6)	165 (62.3)	179 (67.6)

* Number in the parenthesis represents % of the total number of hybrids tested.

DISCUSSION

The data obtained in this experiment indicate that certain hybrids are clearly superior in grain yield to both the higher yielding parents and the standard checks represented by leading commercial varieties. Although average heterosis exhibited by the hybrids may vary with cross combinations, a conservative estimate of the magnitude of this superiority might range from 10 to 20%. Since comparisons between hybrids and their respective parents as well as check varieties were carried out under growing conditions of close spacing (20 hills per m^2) and heavy fertilization (100, 50, and 50 kg per ha of N, P_2O_5 and K_2O, respectively) , the results of this experiment also demonstrate that substantial amount of heterosis could be obtained under intensive cultural practices used for growing rice commercially in Taiwan. These results are generally in agreement with those reported by

Hsu *et al.* (1969) but contrast with the findings of Jennings (1967) and Kawano *et al.* (1969). However, it should be pointed out that yield data were based on individual plants rather than whole plots as in the case of ordinary yield trials and the number of plants sampled for each cross combinations were also relatively small. It appears likely, therefore, that the performance of the hybrids could have been either over- or under-estimated in this experiment.

For a highly self-fertilized species such as rice (*Oryza sativa L.*), two requirements are generally considered necessary for a successful commercial production of F_1 hybrid. The first requirement is that significant heterosis in grain yield must have been demonstrated to occur in F_1 hybrid populations and the second requirement is that techniques must be available for economically producing large quantities of hybrid seeds. It has been shown in Table 4 that certain hybrids significantly outyielded their parents and heterosis expressed in the percent increase over their parents and check varieties was substantially high, suggesting that the first requirement for commercial production of hybrid rice could be fully satisfied. As for the second requirement, no techniques is currently available for economically producing large quantities of F_1 seed for rice. However, it is fortunate that materials for cytoplasmic male sterility and genetic restoration of fertility have already been found in rice. It appears, therefore, that hybrid rice will sooner or later become practical on a commercial scale. Before hybrid rice being actually developed, the use of heterosis in F_2 populations of rice seems to be another promising way. Preliminary results so far obtained at this Station on the performance of F_2 populations are generally encouraging. Furthermore, F_2 seeds can also be rapidly increased by the vegetative propagation of F_1 plants (Chang *et al.*, 1971) which may considerably reduce the cost of seed production.

It was observed that among four components of grain yield, the hybrids seem to have the advantage of producing more number of panicles per plant and more number of grains per panicle, but there was no pronounced effect on the weight of 1,000 grains and the percentage of fertility. Correlation coefficients of heterosis between grain yield and each of its components also indicated that the number of grains per panicle and the number of panicles per plant were the components most highly associated with grain yield. This suggests that heterosis for grain yield in F_1 hybrids of rice depends largely on the hybrid vigor manifested for number of panicles per plant and number of grains per panicle. As most ponlai rice varieties are rather weak in their tillering ability, any increase in the number of panicles per plant (or hill) will undoubtly result in the increase of grain yield in rice. From this standpoint, hybrid advantage shown for number of panicles per plant is highly encouraging. The degree of heterosis exhibited by the number of grains per panicle appeared slightly lower than that expressed by the number of panicles per plant. This may be due largely to the fact that most ponlai rice varieties are associated with relatively large panicles. Kawano *et al.*(1969) also reported that majority of the F_1 hybrids had larger number of panicles per plant than mid-parent. The highly significant correlation coefficients between grain yield and number of panicles per plant as well as number of grains per panicle may also be of value in determining useful avenues for indirect

selection of grain yield for the hybrids.

The correlation coefficient between yields of mid-parent and the hybrids (+.8326) was highly significant as the data of all six crops were pooled. This coefficient was of a high value and would transpose to a high coefficient of determination accordingly. This suggests that parental values could be effectively used as a criterion for the prediction of hybrid performance for grain yield. It appears likely that little is to be gained from testing hybrids in which one or more of the parents are clearly inferior in yield to the standard check varieties with which they would be compared. Preliminary screening of materials for potential hybrids might depend entirely on the basis of the performance of the varieties or strains. Of course, potential parents must perform at acceptable levels for other important economic traits if the hybrids can be commercially accepted. This procedure would permit the elimination of a large amount of undesirable parental materials and thus avoid the necessity of testing numerous cross combinations. It should be pointed out, however, that the correlation between mid-parent values and the hybrid performance is obviously less than unity. It has been suggested that average heterosis and the mean square for parents vs. hybrids may serve as measures of nonadditive gene effects (Kirby and Atkins, 1968) . Thus, significant mean squares for the parents vs. hybrids component in Table 7 plus sizable heterosis value for the grain yield may indicate that nonadditive gene effects also played an important role in the expression for grain yield. Obviously, the performance of the parental varieties or strains themselves might not be sufficient to insure the production of superior yielding hybrids. This should be supplemented by thorough evaluation of individual cross combinations for specific combining ability. Frequently, two cultivars of a specific combination may nick especially well to result in an exceptionally high yielding F_1 hybrid.

The finding that the hybrids exhibited less heterosis for grain yield in the second crop was somewhat surprising. The hybrids are generally considered to have greater adaptability than their homogeneous parental varieties. Thus, the hybrids are likely to perform better than their parents under less optimum environments. Present data indicate, however, that greater heterotic effect was observed in the first rather than in the second crop season. In Chianan district of Taiwan where this Station is located, environmental conditions in the first crop season are usually more favorable for rice production than in the second crop season. It appears, therefore, that greater heterosis for grain yield may occur when the hybrids are grown under conditions approaching a more optimum environment for high yield. It should be noted, however, that when heterosis is expressed as a percentage of mid-parent value instead of actual increase in grams per plant, the difference in advantage for the hybrids between the two crop seasons tended to become smaller. For instance, average heterosis in the first crop was 85% higher than that in the second crop when heterosis is expressed on a gram per plant basis, but it was only 14% higher in the first than in the second crop if expressed on a percentage basis. This emphasizes the need for careful interpretation of heterosis data expressed on a percentage basis.

It is of interest to note that substantial amount of heterosis for leaf area index(LAI) occurred at heading stage. Under recommended levels of spacing and fertilization for

commercial production of rice in Taiwan at the present time, grain yield usually increases with the increase in LAI value especially in the second crop season when LAI tends to become smaller (Chang, 1968) . This indicates that hybrid advantage for LAI at heading stage may have contributed greatly to the expression of heterosis for grain yield in this experiment. Jennings (1967) reported that the absence of heterosis for grain yield in the tropical environment was due largely to the extremely vigorus vegetative development of the hybrids during the early growth stage, resulting in excessive mutual shading which retarded net assimilation and also reduced the amount of storage products available for translocation to the grain after flowering. The situation in Taiwan is apparently different from that of the tropical countries. Mutual shading seldom constitutes a serious problem for the improved varieties provided that the recommended cultural practices are followed. On the contrary, low LAI has been identified as one of the main causes for low yield in the second crop season (Lian *et al.*, 1969) . It becomes apparent that heterosis for LAI could greatly enhance the yielding potential of the hybrids. The correlation between LAI and light transmission ratio (LTR) at heading stage gave "r" value of +.0049 for the hybrids in the first crop of 1969, showing that the transmission of light may not be affected by increased LAI of the hybrids.

In Taiwan, a farming practice of growing one or more upland crops between two rice crops on the same piece of land during a single year has been widely adopted by farmers. As successful operation of this multiple cropping system depends largely on the growing of early maturing rice varieties, the finding that the hybrids headed earlier than both the earlier parents and the commercial check varieties was highly encouraging. The successful utilization of the hybrids would make it possible to grow more upland crops which are otherwise difficult to fit into the multiple cropping system. It was also noted that the plant height of the hybrids was taller than shorter parents or check varieties. Heterosis for plant height may contribute to the yield increase for the hybrids between semi-dwarf cultivars. However, when parental varieties with plant height exceeding 110 cm are involved, hybrid advantage for plant height might bring in the problem of lodging because plant height is negatively correlated with lodging resistance factor (Chang, 1967) . Careful selection of parental materials based on plant height appears to be necessary.

SUMMARY

The manifestation of heterosis for grain yield, yield components and several important agronomic characters by a group of 265 F_1 hybrids of rice over a six-crop period from the second crop of 1967 to the first crop of 1970 are reported. Among 265 F_1 hybrids evaluated, a total of 192 or 72.5% of the total hybrids outyielded their mid-parent and check varieties while grain yield of 145 or 54.7% of the hybrids exceeded their respective high-parent. The average heterosis for these outstanding F_1 hybrids was 20.3, 19.1 and 18.3% in relation to mid-parent, check varieties and high-parent, respectively. However, the magnitude of hybrid advantage over the mid-parent and check varieties reduced to 10.6 and 6.3% respectively when the average data of the six crops were considered. The superiority of F_1 hybrids over high-parent was also reduced to nil when averaged over all

entries. The number of panicles per plant and the number of grains per panicle were found to be the most important components associated with the manifestation of heterosis for grain yield.

The correlation coefficient between mid-parent yield and yield of the hybrids was large enough to indicate that mid-parent value would be highly effective indicator of hybrid performance. However, mean square associated with F_1 hybrids vs. parents also attained significance in some cases. There was no evidence of maternal effect on the grain yield of the hybrids.

The heterosis expresses for grain yield in the first crop was generally larger than that in the second crop. F_1 hybrids also exhibited large leaf area index, earlier heading, taller plant, longer and heavier panicle in comparison with mid-parent and check varieties. The expression of heterosis for plant height and number of tillers per plant was not affected appreciably by the stages of rice growth.

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水稻雜種優勢之表現

張萬來、林恩輝、楊建南

摘　要

本文係報告自民國56年第2期作至民國59年第一期作觀察265個 F_1 雜種對稻谷產量，產量構成因素，及其他主要農藝性狀所表現雜種優勢之結果。在供試F_1中，有192個或 72.5%之F_1，其稻谷產量超過中間親本及標準對照品種，其平均雜種優勢分別爲20.3與19.1%。又有145個或 54.7% F_1，其稻谷產量超過高產量親本，其平均雜種優勢爲18.3%。惟全部供試F_1之平均雜種優勢只分別超過中間親本及對照品種 10.6與6.3%，而對高產量親本則未見呈現絲毫雜種優勢。在產量構成因素中，以每株穗數及每穗粒數兩性狀對稻谷產量雜種優勢之表現，貢獻最大。

中間親本產量與F_1產量之間，其相關係數數值頗大，顯示可以中間親本之數值作F_1產量表現之初步推測，惟若干親本對F_1之均方和亦達顯著水準。正反交對F_1產量似無太大之影響。

F_1稻谷產量之雜種優勢，第1期作者較第2期作爲優。F_1在葉面積指數，生育日數，株高，穗長與穗重等性狀，對中間親本及對照品種而言，亦均顯示不同程度之雜種優勢。不同生育時期對株高及每株分蘖數之雜種優勢表現，似無太大之影響。

稻穗之物理性與小型水稻聯合收穫機工作性能之關係試驗

鄔清標[2]　黃光華[2]

一、前　言

水稻收穫與調製工作所花費的工時，在整個水稻栽培作業中佔有相當份量的比例，故如可利用機器從事收穫工作，則一方面可省去很多工時，另方面可簡化工作者繁忙艱辛的工作程序。但如果機器的性能不適宜，則對於收穫物的損傷將遠比手工作業爲大，尤其在臺灣的小農情況下所要求的精植栽培方式，歐美各國的大型收穫機一時尚無法應用，而目前由於農村勞力的外流，必須儘速設法促進收穫工作之機械化。但如衆所知，目前推廣之水稻品種，其稻稈之高低，抗倒伏性，及脫粒性均相差甚大，對收穫機具之適應性可能有很大之差異；再則水稻葉面上之潮濕度亦可能影響機器之工作性能。因此，爲使收穫工作機械化能圓滿達成，必須先了解稻穗之物理性和機械收穫工作適應性之關係，問題方可解決，爰作本項試驗。

二、供試機型與試驗方法

（一）供試機型

（1）型式　井關牌兩行用 HD—50型小型水稻聯合收穫機。

（2）機器規格　長 233cm，寬 168～249cm，高 138.5cm，重 580Kg 。

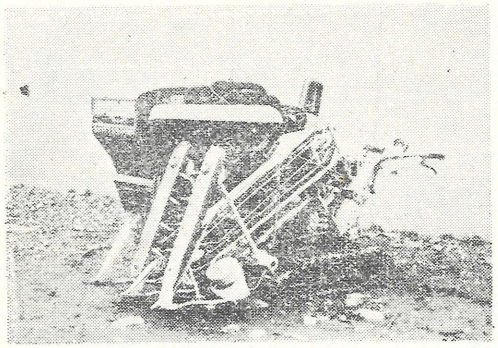
（3）刈刀寬度　50cm

（4）行走方式　橡膠塊鏈履帶式。

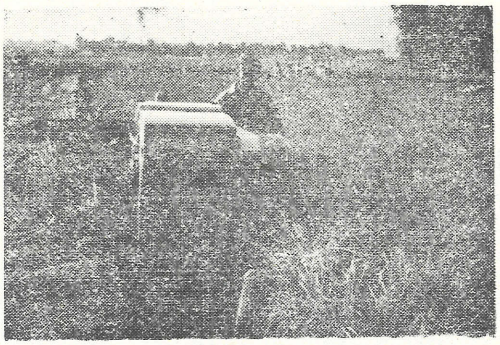
（5）脫穀筒尺寸　直徑 46cm，寬 50cm。

（6）選別方式　風選。

（7）引擎程式　井關 KF900 型 7 — 9 馬力氣冷式 4 衝程汽油引擎。



第一圖　小型水稻聯合收穫機



第二圖　小型水稻聯合收穫機田間作業情形

本試驗承中國農村復興委員會撥贈供試聯合收穫機，並承國家科學委員會撥給研究補助費，文成時復孚萬所長雄及農復會彭技正添松之斧正，謹此一併致謝。

1 試驗研究報告農試字第五三五號　　2 臺灣省農業試驗所技正及技佐。

（二）試驗方法

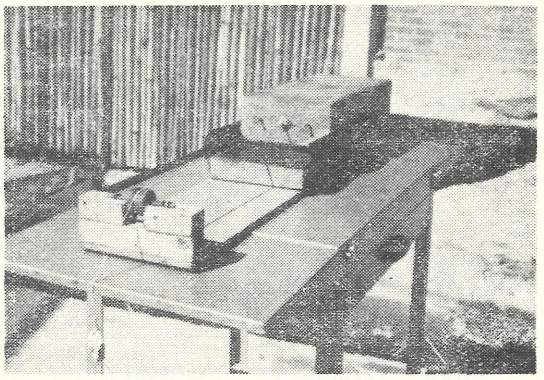
因每一塊田只能當一個試驗點，爲達到統計上計算用樣品點數，需要很廣大之面積，而此廣大面積的水稻田，必須從許多農家借用，因此每一項因子都無法預先加以控制，只有利用既有之結果，用層次分類法計算較爲明顯之因子對結果之影響度百分比。各因子測定方法如下：

（1）表土貫穿深度（表土硬度）

土壤表層之軟硬，對機器之行走性能有密切關係，所以利用 1 cm 直徑， 10 cm 長，先端作成 60°角，74.5 gr 重之圓錐落下錘，在內徑 1.1cm 之導管內自 1m 之高度落下，測定落下錘插入土層之深度，以表示土層阻力或表土硬度之差異。每試區選測定點 5 點，求其平均值。

（2）抗拉强度

將稻穗倒掛後，在穗部分成上、中、下三段，在各段任選三支小穗，再在小穗之先端、中段、後段任選三粒，用夾子夾住穀粒，在夾子下端掛一水瓶，逐漸滴入水滴，至稻粒脫落爲止，然後秤其懸掛重量。每一試區任選三穗作試驗，求其平均值及最小值。



第三圖　摩擦掉粒試驗

（3）摩擦掉粒數百分比（%）

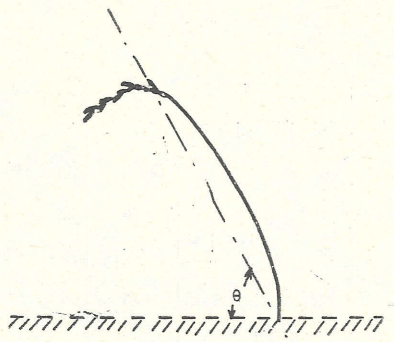
利用兩塊 36.5cm×15cm×7.5cm重2.7kg之木板，在接觸面各貼上 0.3cm厚度之橡皮板，然後將二支稻穗從中央部份剪成兩段，分成四支，平均分佈放置在木板間，然後將上面的木板輕輕拉動 10cm 之距離，調查原有穗粒數和脫落之穀粒數而求其掉粒數之百分比。每試區任選6穗，作3次試驗，求其平均值。

（4）掉粒數

水稻割完後，在田間以逢機方式任選3點，然後用手工檢起 1m²以內之掉落穀粒，作爲比較掉粒數之依據。

（5）稻株倒伏程度

測定稻欉基部中心和稻穗頸節之假想連結直線對地面之傾斜角度，每試區選10點，測稻束中央部之傾斜角。



第四圖　稻株倒伏角度之表示法

（6）穀粒損失百分比（%）

在試驗田區內抽取10欉稻株，分別秤其稻稈及穀粒重量，以推定全區稻稈重量及稻穀產量，然後逢機取樣測得每 m² 內田面的掉粒數，及每公斤稻稈內未被脫粒的稻穀粒數，推算全區的損失量及損失率。

三、試驗結果及討論

（一）稻穗穀粒最小抗拉强度、穗粒數，及穀粒含水分率對摩擦掉粒數之影響

表一、小型水稻聯合收穫機試驗紀錄（一）

項號	編號 / 項目	單位	No.3	No.4	No.5	No.6	No.9	No.11	No.13
1	地點		中壢後寮	中壢後寮	中壢後寮	中壢後寮	中壢五塊厝	中壢五塊厝	中壢五塊厝
2	割稻日期		59. 7.12	59. 7.13	59. 7.13	59. 7.14	59.7.16	95.7.16	59. 7.19
3	品種		186	糯米種	糯米種	高雄153	在來1號	蓬萊178號	東京 1號
4	行株距	cm	23.4×23.4	24.8×23.8	25.6×24.0	25.8×23.0	24.2×23.8	24.6×23.8	24.3×22.4
5	分蘖數	支	16.7	17.3	20.0	17.7	16.9	17.6	16.6
6	株高:自然／全長	cm	76.3/102.7	79.7/100.8	79.0/106.4	81.3/97.0	75.9/90.7	64.7/98.0	67.0/84.2
7	倒伏程度（穗）	度	64.6	72.7	59.6	75.8	68.7	52.3	68.4
8	表土硬度（重錘貫穿深度）	cm	1.4	1.2	1.8	1.4	1.8	2.2	1.0
9	稻穗成熟度	%	80	75	75	80	80	80	90
10	抗拉強度最小/平均	gr	39.0/68.0	24.5/64.3	32.0/55.0	40.1/76.2	20.1/59.8	28.9/68.5	60.4/85.1
11	穀粒含水分率	%	14.9	16.5	16.9	17.8	26.7	30.4	22.3
12	穗粒數	粒	52.7	69.4	63.6	65.3	86.0	72.1	60.0
13	摩擦掉粒數	%	48.8	31.9	29.6	18.1	35.9	22.0	13.5
14	行車速度	m/sec	0.49	0.60	0.56	0.60	0.58	0.61	0.64
15	掉粒數	粒/m²	93	184	176	202	290	40	107
16	稻葉含水分率	%	59	63	62	58	66	60	45
17	田區面積	m²	678	970	743	940	123	875	570

項號	編號 / 項目	單位	No.14	No.17	No.18	No.19	No.20	No.21	No.24
1	地點		中壢五塊厝	水尾	水尾	水尾	水尾	水尾	彰化三滌鄉
2	割稻日期		59. 7.19	59. 7.22	59. 7.22	59. 7.22	59. 7.22	59. 7.23	59. 6.26
3	品種		東京 1號	糯米8號	糯米8號	糯米8號	蓬萊13號	草螺種	臺南5號
4	行株距	cm	24.7×24.0	24.8×24.2	25.8×25.2	25.3×24.8	24.9×24.2	25.2×23.8	24.2×21.2
5	分蘖數	支	18.2	18.6	17.7	16.0	16.7	18.7	23.0
6	株高自然／全長	cm	65.3/84.6	71.4/105.2	70.0/103.0	70.0/103.0	69.4/100.4	75.1/105.7	—/103.6
7	倒伏程度（穗）	度	67.9	57.7	50.3	54.3	57.4	57.9	65.3
8	表土硬度（重錘貫穿深度）	cm	1.8	1.7	1.7	1.9	2.8	1.3	2.1
9	稻穗成熟度	%	90	80	80	80	80	75	80
10	抗拉強度最小/平均	gr	46.2/76.5	41.0/53.2	23.7/40.2	25.6/44.0	69.8/91.0	34.1/58.6	92.1/110.5
11	穀粒含水分率	%	10.8	31.0	28.7	16.7	27.0	30.0	17.8
12	穗粒數	粒	63.3	80.7	63.5	81.0	59.8	67.3	77.0
13	摩擦掉粒數	%	14.1	29.1	19.7	25.4	24.8	13.1	30.9
14	行車速度	m/sec	0.58	0.630	0.61	0.60	0.58	0.59	0.64

15	掉粒數	粒/m²	99	200	134	97	222	50	70
16	稻葉含水分率	%	24	49	49	50	75	76	60
17	田區面積	m²	622	728	754	769	635	627	1,600

項號	編號 / 項目	單位	No.25	No.26	No.27	No.28	No.30	No.31	No.32
1	地點		三滌鄉	三滌鄉	楊梅	楊梅	楊梅	楊梅	楊梅
2	割稻日期		59. 6.29	59. 6.30	59.11. 8	59.11. 8	59.11. 9	59.11. 9	59.11.12
3	品種		臺南5號	臺南5號	蓬萊1050	蓬萊1050	糯米48	糯米48號	蓬萊 臺南5號
4	行株距	cm	24.2×18.2	24.2×21,2	24.×24.0	23.7×23.8	23.6×23.3	23.8×23.6	24.7×23.8
5	分蘖數	支	17.8	17.8	11.2	11.7	14.3	13.1	14.0
6	株高自然／全長	cm	65.7/104.6	60.9/105.8	73.5/90.5	77.8/95.5	74.0/98.3	80.0/99.1	76.3/94.3
7	倒伏程度（穗）	度	55.0	46.7	74.6	74.7	72.8	78.8	76.6
8	表土硬度（童錘貫穿深度）	cm	1.6	1.8	1.2	1.5	1.6	1.6	1.5
9	稻穗成熟度	%	80	80	85	80	85	85	80
10	抗拉强度最小/平均	gr	90.3/108.4	85.3/117.2	180.0/195.0	1360./172.0	110.0/198.0	152.0/187.0	130.0/175.0
11	穀粒含水分率	%	17.0	15.9	11.0	20.0	15.0	18.0	28.0
12	穗粒數	粒	84.6	80.8	84.0	106.0	82.0	79.0	75.0
13	摩擦掉粒數	%	22.4	26.2	10.0	7.0	13.0	5.0	10.0
14	行車速度	m/sec	0.59	0.43	0.66	0.55	0.55	0.57	0.56
15	掉粒數	粒/m²	107	119	127	110	72	101	46
16	稻葉含水分率	%	57	55	47	54	50	51	55
17	田區面積	m²	1,345	1,020	995	760	698	988	992

項號	編號 / 項目	單位	No.33	No.35	No.36	No.37	No.39	No.40
1	地點		楊梅	楊梅	楊梅	水尾	本所	本所
2	割稻日期		59.11.12	59.11.12	59.11.13	59.11.17	59.12.10	59.12.10
3	品種		蓬萊臺南5號	蓬萊臺南5號	蓬萊臺南5號	高雄163	臺農糯8號	臺農 蓬萊61號
4	行株距	cm	25.2×24.0	25.1×23.3	25.0×24.0	26.4×24.0	26.0×24.6	22.8×22.5
5	分蘖數	支	14.1	16.3	15.6	15.5	15.5	10.6
6	株高:自然/全長	cm	75.5/93.3	73.1/91.3	75.5/93.6	72.0/101.5	75.1/96.1	81.2/94.4
7	倒伏程度（穗）	度	78.6	76.8	79.5	62.0	81.0	84.0
8	表土硬度（童錘貫穿深度）	cm	1.5	1.4	1.4	1.7	1.4	1.4
9	稻穗成熟度	%	80	80	80	90	90	90
10	抗拉强度最小/平均	gr	161.0/199.0	125.0/192.0	115.0/163.0	106.0/118.0	78.0/123.00	62.0/95.0
11	穀粒含水分率	%	19.0	23.0	23.0	19.0	20.0	26.0

12	穗粒數	粒	80.0	86.0	63.0	99.0	63.0	71.0
13	摩擦掉粒數	%	10.0	12.0	18.0	5.0	19.0	32.0
14	行車速度	m/sec	0.53	0.61	0.61	0.50	0.63	0.57
15	掉粒數	粒/m^2	49	72	67	126	147	106
16	稻葉含水分率	%	50	58	54	53	66	62
17	田區面積	m^2	416	890	1,182	672	1,430	649

將稻穗夾在摩擦掉粒試驗板中試驗時，穀粒最小抗拉强度、穗粒數、及穀粒含水分率等因素對摩擦掉粒數之影響，經逐次分層分析結果，列如表二，其變方分析結果如表三。

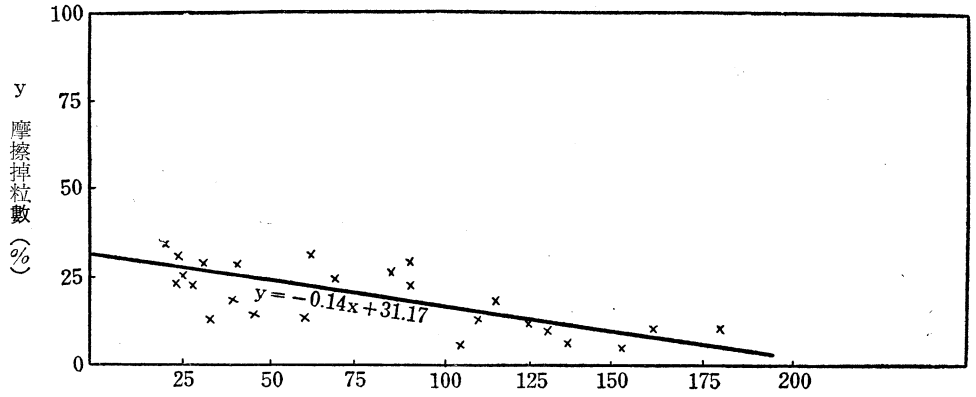
表二、穀粒最小抗拉強度、穗粒數、穀粒含水分率和摩擦掉粒數之逐次分層表

最小抗拉强度（gr）	穗粒數（粒）	穀粒含水分率（%）	摩擦掉粒數（%）
39.0	52.7	14.9	48.8
32.0	63.6	16.9	29.6
23.7	63.5	28.7	19.7
24.5	69.4	16.5	31.9
40.1	65.3	17.8	18.1
34.1	67.3	30.0	13.1
25.6	81.0	16.7	25.4
20.1	86.0	26.7	35.9
28.9	72.1	30.4	22.0
78.0	63.0	20.0	19.0
60.4	60.0	22.3	13.5
69.8	59.8	29.0	24.8
46.2	63.3	10.8	14.1
92.1	77.0	17.8	30.9
62.0	71.0	26.0	32.0

85.3	80.8	15.9	26.2
90.3	84.6	17.0	22.4
41.0	80.7	31.0	29.1
152.0	79.0	18.0	5.0
115.0	63.0	23.0	18.0
130.0	75.0	28.0	10.0
180.0	84.0	11.0	10.0
110.0	82.0	15.0	13.0
161.0	80.0	19.0	10.0
106.0	99.0	19.0	5.0
136.0	106.0	20.0	7.0
125.0	86.0	23.0	12.0

表三、最小抗拉強度、穗粒數、穀粒含水分率和摩擦掉粒數之變方分析表

因素	自由度	平方和	均方	F	Q
最小抗拉度	2	1,474.46	737.23	13.07**	0.465
穗粒數	2	14.35	7.18	—	—
穀粒含水分率	2	15.44	7.72	—	—
最小抗拉强度×穗粒數	4	298.86	74.72	1.33	0.025
最小抗拉强度×穀粒含水分率	4	606.78	151.70	2.69	0.130
穗粒數×穀粒含水分率	4	64.84	16.21	—	—
機差	8	451.12	56.39	—	0.380
總數	26	2925.85	—	—	1.000



第五圖　穀粒最小抗拉强度和摩擦掉粒數之關係

根據表三、分析結果，可知最小抗拉强度不同時，摩擦掉粒數將有顯著差異。最小抗拉力愈大，則脫粒愈少，此一關係示如第五圖，兩者爲一負的關係。

$y=-0.14X+31.17$　　x　穀粒最小抗拉强度（gr）。

y　摩擦掉粒數（%）

至於穗粒數和穀粒水分不同時，雖亦使摩擦掉粒數有差別，但並不顯著，亦即摩擦掉粒數多少與穗粒數和穀粒水分含量的多寡關係較少；同時最小抗拉力是否受穀粒水分含量及一穗粒數之影響，由交感作用可知雖F值並不顯著，但穀粒水分含量似對最小抗拉力有相互關係；一穗粒數則對最小抗拉的交感甚小。

茲爲明瞭上列因素對摩擦掉粒數之影響程度，乃計算Q值，Q值依下列公式求得：

$$Q_A = \frac{(\text{A因子平方和}) - (\text{A因子自由度}) \times (\text{機差均方})}{\text{總平方和}}$$

表三、所示Q值，可看出穀粒最小抗拉强度對摩擦掉粒數之影響度約佔46.5%，最小抗拉强度和穀粒含水分率之交感影響度約佔13%，最小抗拉强度和穗粒數之交感影響度約佔2.5%。

（二）摩擦掉粒數及行車速度、水稻成熟度等因素對小型水稻聯合收穫機掉粒損失之影響：

利用小型水稻聯合收穫機收割水稻後，每一平方公尺內之掉粒數和摩擦掉粒數及機器行車速度、水稻成熟度等因子之關係試驗，經逐次分層結果列於表四，其變方分析結果如表五。

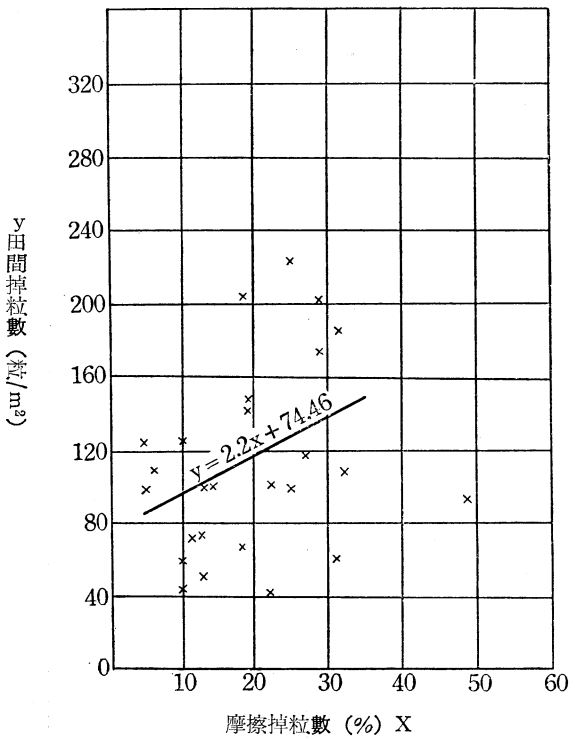
表四、摩擦掉粒數、行車速度、水稻成熟度和田間掉粒數之逐次分層表

摩擦掉粒數（%）	行車速度（m/sec）	水稻成熟度（%）	田間掉粒數（粒/m²）
10.0	0.53	80	49
13.0	0.55	85	72
5.0	0.50	90	126
10.0	0.56	80	46

7.0	0.55	80	110
5.0	0.57	85	101
13.1	0.59	75	50
12.0	0.61	80	72
10.0	0.66	85	127
22.4	0.59	80	107
24.8	0.58	80	222
14.1	0.58	90	99
18.0	0.61	80	67
19.7	0.61	80	134
18.1	0.60	80	202
22.0	0.61	80	40
13.5	0.64	90	107
19.0	0.63	90	147
29.6	0.56	75	176
48.8	0.49	80	93
26.2	0.43	80	119
25.4	0.60	80	97
35.9	0.58	80	290
32.0	0.57	90	106
31.9	0.60	75	184
30.9	0.64	80	70
29.1	0.63	80	200

表五、摩擦掉粒數、行車速度、水稻成熟度和田間掉粒數之變方分析表

因素	自由度	平方和	均方	F	Q
摩擦掉粒數	2	19,238.35	9,619.18	2.36	0.12
行車速度	2	1,360.30	680.15	—	—
水稻成熟度	2	10,972.17	5,486.09	1.35	0.03
摩擦掉粒數×行車速度	4	3,927.11	981.78	—	—
摩擦掉粒數×水稻成熟度	4	9,466.40	2,366.60	—	—
行車速度×水稻成熟度	4	17,510.99	4,377.75	1.07	0.01
機差	8	32,579.55	4,072.44	—	0.84
總數	26	95,054.87	—	—	1.00



第六圖　摩擦掉粒數和田間掉粒數之關係

表中各因素之F值均不顯著，表示摩擦掉粒數不同，對田間掉粒數雖有影響，但並不顯著，而由表五、可知機差甚大，此因脫穀部分之選別機構調節適當與否，其影響田間掉粒之程度遠大於上述各項因素；其他如駕駛員操作技術之熟練與否，水稻行株距之整齊度，等因素亦大有影響，所以摩擦掉

粒數之影響度只佔12%左右。茲將摩擦掉粒數和田間每平方公尺內穀粒掉粒數之關係式示之如下：

$y=2.2x+7.446$　　x ：摩擦掉粒數（%）

y ：田間掉粒數（粒/m^2）

行車速度對田間掉粒數之影響似更爲微小，此因行車速度受到表土硬度、行株距整齊度，及操作熟練與否等情形所支配，並且脫穀部份之調節和行車系統又完全獨立，因此不致發生顯著之影響。

水稻成熟度之F值亦不顯著，其Q值爲3%。但從水稻成熟度和掉粒數之關係式：

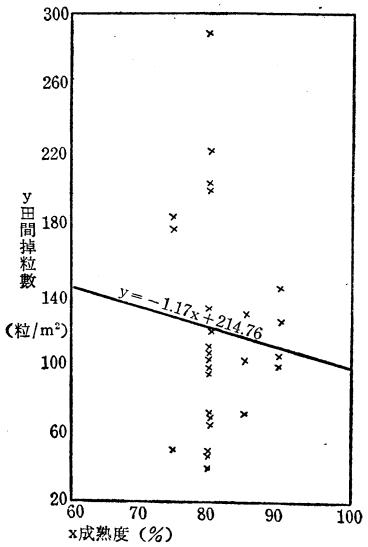
$y=-1.17x+214.76$　　x ：成熟度（%）

y ：田間掉粒數（粒/m^2）

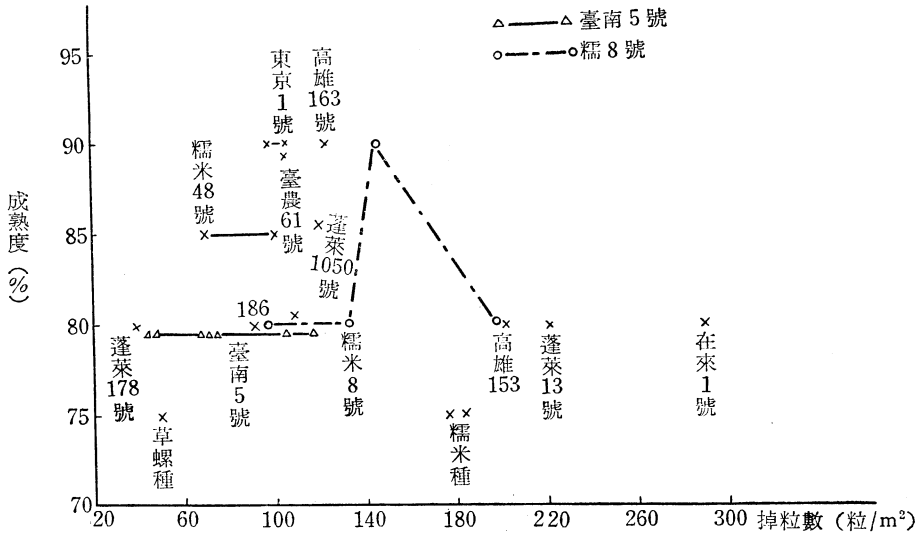
可看出具有矛盾，但從第八圖可看出水稻成熟度一項因素實可代表水稻不同品種之因素，因農民均了解各品種在何等成熟度收割最爲適當，而各不同品種間之掉粒性和成熟度無一定之關係，所以水稻成熟度之影響似可視爲不同品種之影響。

（三）表土貫穿深度、稻葉含水分率及田區面積等因素對工作能量之影響

各因子之逐次分層結果如表六，其變方分析結果如表七



第七圖　稻穗成熟度和田間掉粒數之關係



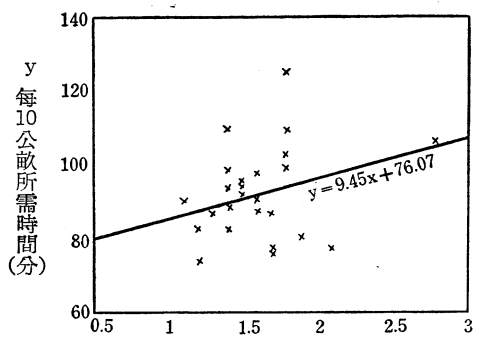
第八圖　田間穀粒掉粒數和成熟度之關係

表六、表土貫穿深度、稻葉含水分率、田區面積和機器工作能量之逐次分層表

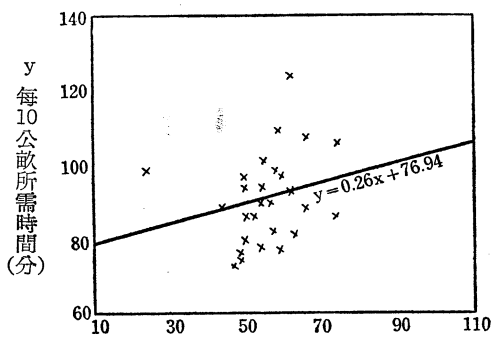
表土貫穿深度 (cm)	稻葉含水分率 (%)	田 區 面 積 (m^2)	工作能量 (min/10a)
2.8	75	635	106
1.8	62	743	124
1.8	66	1,231	108
2.2	60	875	96
1.8	55	1,020	102
2.1	60	1,600	77
1.8	24	622	99
1.7	53	672	87
1.9	50	769	80
1.4	59	678	109
1.5	55	992	95
1.6	57	1,345	90
1.5	50	416	95
1.5	54	760	91
1.6	51	988	87
1.6	50	698	97
1.7	49	728	76
1.7	49	754	76
1.3	76	627	88
1.2	63	970	82
1.4	66	1,430	89
1.4	62	649	93
1.4	58	890	99
1.4	58	940	83
1.1	45	570	91
1.2	47	995	73
1.4	54	1,182	78

表七、表土貫穿深度、稻葉含水分率、田區面積和機器工作能量之變方分析表

因素	自由度	平方和	均方	F	Q
表土貫穿深度	2	621.76	310.88	10.87**	0.15
稻葉含水分率	2	1,002.13	501.07	17.52**	0.25
田區面積	2	622.92	311.46	10.89**	0.15
表土貫穿深度×稻葉含水分率	4	543.74	135.94	4.75*	0.12
表土貫穿深度×田區面積	4	300.74	75.19	2.63	0.05
稻葉含水分率×田區面積	4	405.80	101.45	3.55	0.08
機差	8	228.76	28.6	—	0.20
總數	26	3,725.85	—	—	1



第九圖 表土貫穿深度和機器工作能量之關係



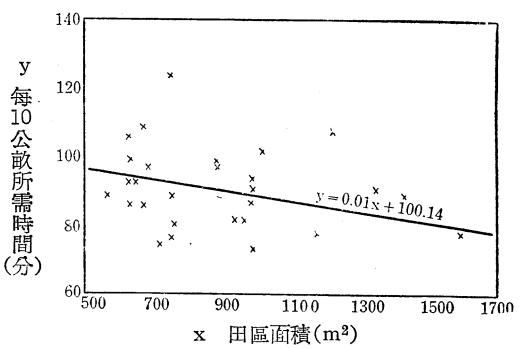
第十圖 稻葉含水分率和機器工作能量之關係

從F值及Q值均可以看出各因子都有極顯著的影響，尤其葉面含水分率之影響較強，其影響度約佔25%，與其他兩因素之交感影響亦不小，各佔12%及8%。稻葉含水分率和機器工作能量之間的關係式爲：

$$y=0.26x+76.94$$

y ：工作能量（min/10a）

x ：稻葉含水分率（%）



第十一圖 田區面積和工作能量之關係

但假若在葉面上有露水或雨水等水滴時，經過脫穀後之穀粒和碎葉片將黏貼在一起，而使脫穀機之選別作用失效，機器大約前進15m左右即發生堵塞現象，所以葉面上有水滴時未實施試驗。

表土貫穿深度及田區面積之大小對工作能量均有顯著影響，其影響度各佔15%，其他機差之影響度佔20%。表土利用圓錐重錘貫穿深度在 3cm 以內時，機器之操作可保持正常，此時，表土貫穿深度和機器工作能量之間的關係爲：

$$y=9.45x+76.07$$

y ：工作能量（min/10a）

x ：表土貫穿深度（cm）

但假若重錘貫穿深度超過 3cm 時，機器向前行走尙不致受太大影響。惟在後退時，刈刀受到機器反轉作用力，被壓入土中，且履帶前端高度太低，回復前進時未能立即浮出土面，使刀片在土中刺插，所以在轉向操作時必須暫停機器，將收割部份抬起，影響工作速度甚大，否則就要用大旋轉轉向法，使機器不用倒退。但採取此種割稻法時，田埂旁邊需要用人工預先割去很大面積稻株，對總工作效率而言，頗受影響，且在稻稈未收拾之前，田面極爲零亂。

重錘貫穿深度超過 6cm 以上時，機器行走將甚困難，時常發生打滑，以及在履帶與驅動輪之間捲繞很多稻稈及泥漿，作業很困難，不受農民歡迎。因此，在本次試驗，假若重錘插入深度超過 3cm 時，即放棄試驗。

田區之大小和工作能量之關係式爲：

$$y=-0.01x+100.14$$

y ：工作能量 （min/10a）

x ：田區面積（m^2）

田區愈大工作能量愈高。

（四）手割田邊稻和機割之面積及時間分配情況

此種型式的聯合收穫機，收割部份與脫穀部份裝置於並行的位置，因此在機器本身未下田從事收割工作前，對於稻田的四個角落及靠近田埂的田邊水稻須用手工或其他方法先行割去 3～6 行，並於適當時候予以脫谷。試驗結果列如表八。

表八、小型水稻聯合收穫機試驗紀錄（二）

項號	項目 \ 編號	單位	No. 3	No. 4	No. 5	No. 6
1	面積 田區總面積	m^2	678	970	743	940
2	面積 機器作業面積	m^2 %	490 72	750 77	553 74	727 77
3	時間 機割時間×人數	分×人 %	53.3×1=53.3 41	61.8×1=61.8 38	68.5×1=68.5 40	60.0×1=60.0 29
4	時間 田邊稻手割時間×人數	分×人 %	48.8×1=48.8 38	53.1×1=53.1 33	44.4×1=44.4 26	51.5×1=51.5 24
5	時間 田邊稻機脫耗時×人數	分×人 %	9.2×3=27.6 21	16.0×3=48.0 29	19.7×3=59.1 34	33.0×3=99.0 47
6	時間 工作累積時間	分	111.3	130.9	132.6	144.5
7	時間 總工時	分	129.7	162.9	172.0	210.5
8	每 10 公畝所需總工時	分	191	168	231	224
9	機割工作能量	分/10a	109	82	124	83

10	田間有效工作效率	%	67	69	43	65
11	理論工作效率	%	47	63	41	62

備註

1. 總工時＝（機割時間）×（人數）＋（田邊稻手割時間）×（人數）＋（田邊稻機脫時間）×（人數）
2. 工作累積時間＝機割時間＋田邊稻手割時間＋田邊稻機脫時間
3. 機器作業面積%＝$\frac{\text{機器作業面積}}{\text{田區總面積}}\times 100$
4. 機割時間×人數的%＝$\frac{\text{機割時間}\times\text{人數}}{\text{總工時}}\times 100$
5. 田邊稻手割時間×人數的%＝$\frac{\text{田邊稻手割時間}\times\text{人數}}{\text{總工時}}\times 100$
6. 田邊稻機脫時間×人數的%＝$\frac{\text{田邊稻機脫時間}\times\text{人數}}{\text{總工時}}\times 100$
7. 每10公畝所需總工時＝$\frac{\text{總工時}}{\text{田區總面積}}\times 1000$

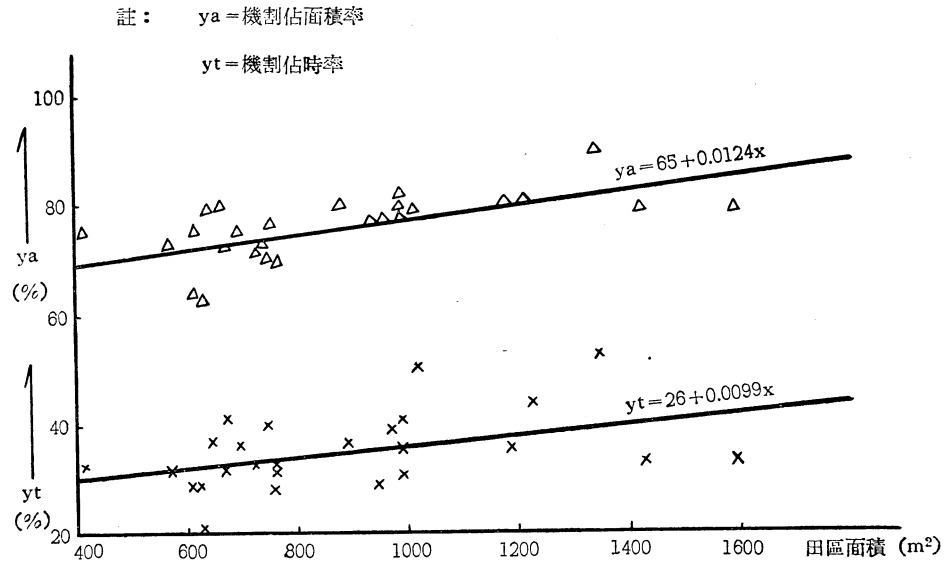
項號	No. 9	No.13	No.14	No.17	No.18	No.19
1	1,231	570	622	728	754	769
2	996 81	418 73	468 75	521 72	526 70	542 70
3	107.4×1＝107.4 43	37.9×1＝37.9 30	46.3×1＝46.3 29	39.9×1＝39.9 31	40.1×1＝40.1 28	43.8×1＝43.8 32
4	57.7×1＝57.7 23	40.2×1＝40.2 31	37.3×1＝37.3 23	49.2×1＝49.2 38	61.0×1＝61.0 43	51.0×1＝51.0 37
5	28.3×3＝84.9 34	16.8×3＝50.4 39	25.4×3＝76.2 48	10.0×4＝40.0 31	10.3×4＝41.2 29	10.5×4＝42.0 31
6	193.4	94.9	109.0	99.1	111.4	105.3
7	250.0	128.5	159.8	129.2	142.3	136.8
8	203	225	257	177	189	178
9	108	91	99	76	76	80
10	58	59	59	65	70	69
11	47	57	52	62	67	64

項號	No.20	No.21	No.24	No.25	No.26	No.27
1	635	627	1,600	1,345	1,020	995
2	400 63	402 64	1,255 78	1,200 89	896 88	770 77

3	42.5×1=42.5 21	35.3×1=35.3 29	96.5×1=96.5 34	108×1=108.0 52	91×1=91.0 50	56.0×1=56.0 31
4	55.9×1=55.9 27	54.4×1=54.4 44	97.7×1=97.7 35	47.5×1=47.5 23	41×1=41.0 23	56.8×1=56.8 32
5	35.2×3=105.6 52	10.9×3=32.7 27	22.0×4=88.0 31	13.0×4.0=52.0 25	12.0×4.0=48.0 27	23.1×1=69.3 38
6	133.6	100.6	216.2	168.5	144.0	135.9
7	204.0	122.4	282.2	207.5	180.0	182.1
8	322	195	176	154	175	187
9	106	88	77	90	102	73
10	55	64	70	65	79	72
11	48	58	67	57	50	70

項號	No.28	No.30	No.31	No.32	No.33	No.35
1	760	698	988	992	416	890
2	579 76	526 75	776 79	811 82	310 74	713 80
3	52.7×1=52.7 33	51.0×1=51.0 36	67.8×1=67.8 35	77.3×1=77.3 40	29.3×1=29.3 32	70.3×1=70.3 36
4	46.6×1=46.6 30	45.2×1=45.2 31	54.7×1=54.7 29	45.7×1=45.7 23	27.8×1=27.8 31	43.1×1=43.1 22
5	19.4×3=58.2 37	15.8×3=47.4 33	23.3×3=69.9 36	24.3×3=72.9 37	11.3×3=33.9 37	21.0×4=84.0 42
6	118.7	112.0	145.8	147.3	68.4	134.4
7	157.5	143.6	192.4	195.9	91.0	197.4
8	207	206	195	198	219	222
9	91	97	87	95	95	99
10	70	66	70	63	66	55.1
11	56	53	59	54	54	52

項號	No.36	No.37	No.39	No.40	平均
1	1,182	672	1,430	649	880.9
2	952 81	537 80	1133.0 79	505 78	682.9 78
3	74.3×1=74.3 34	46.5×1=46.5 31	100.4×1=100.4 33	47×1=47.0 37	61.7 35
4	58×1=58.0 27	39×1=39.0 26	70.5×1=70.5 23	20.8×1=20.8 16	50.0 28
5	28.6×3=85.8 39	16.0×4=64.0 4.3	34×4=136.0 44	15.2×4=60.8 47	64.5 37
6	160.9	101.5	204.9	83.0	131.1
7	218.1	149.5	306.9	128.6	176.2
8	184	222	215	198	204.3
9	78	87	89	93	91.3
10	70	72.8	57	69	64.9
11	66	59	58	55	57.6



第十圖　田區大小與機割佔時率及機割佔面積率之關係

表八、可看出雖然田邊稻面積只佔總面積的22%，但所耗工時則手割佔28%，脫穀佔37%，總共佔65%，使節省工時方面受到很大影響，亦使收穫作業趨於複雜。欲使每天工作量達於最高度，則對於此三種作業應有良好的配合，尤其不能因手割田邊稻致使機器停止作業。

又機器直接收穫所佔總工時百分率隨面積之增大而增加，如第十圖所示。其相關係數爲0.75，關係式爲：

$$y_t=0.0099x+26$$

機器直接收穫所佔總面積百分率亦隨面積之增加而增加，其相關係數爲 0.6，關係式爲：

$$y_a=0.0124x+65$$

由於 $m_a=0.0124$ 大於 $m_t=0.0099$ ，由此可知工時方面節省，不如機器直接收穫面積比率的增加來得快。

註：y_t＝機器直接收穫佔總工時之百分率（%）

y_a＝機器直接收穫佔總面積之百分率（%）

x＝面積（m^2）

（五）田間工作效率

工作效率分理論工作效率與有效工作效率。理論工作效率係由機器原有的標記收割寬度與速率及工作時間相乘所得的理論工作量與實際田間工作量之比率而得；有效工作率則由田間實測之收割寬度與直進速率及工作時間相乘所得之有效工作量與田間實際工作量之比率而得。由於有效工作率對於機器之機構本身所影響之程度較少，便於了解在既定的環境及機器條件之下，如何發揮其使用效率。至於理論工作效率爲包涵所有的因素，對機器結構的合理性及其他種種因子的探討較爲方便。

依試驗結果，田間理論工作效率平均爲57%；田間有效工作效率平均爲64.9%。顯示有百分之三十五左右的時間，用於轉彎、後退、調整、換袋等工作上。欲使此一數目儘量縮減，則應一方面增大田區的長邊與寬邊比，同時田區形狀不宜過份彎曲；另一方面應儘量減少機器的調整。但機器的調整仍是依照機器本身的結構，作業者的技術及作業環境而定。此機器因脫穀選別機構之調整過份精細，而且能量有限，以及調整頻繁，而致工作效率未能提高。

註：田間理論工作效率＝$\frac{1}{36}\times\frac{C}{WV}$。

田間有效工作效率＝$\frac{1}{36}\times\frac{c}{We\times Ve}$。

C＝每小時機器實際工作量(m^2/hr)。

W＝標記收割寬度(cm)。

V＝標記收割行進速度(m/sec)。

We＝田間實際收割寬度 (cm)。

Ve＝田間實際行進速度(m/sec)。

$\frac{1}{36}$＝單位換算因子。

（六）成本分析：

1.一天工作量之推定　依照試驗結果，機器收穫每 0.1公頃平均約需90分鐘（包括收割及脫穀，用人工收割田邊稻部份不計在內），一天工作時間設爲10小時，實際作業率爲90%，則一天可工作面積約爲 0.6公頃。

2.各項費用之估計

機器折舊費　目前小型水稻聯合收穫機之試銷價格在新臺幣100,000元至120,000元之間，如果將來推廣數增加時，推銷費用及服務費用均可減低，所以估計機器之正當售價爲90,000元左右。機器報廢後之剩餘價值依照一般之估計法，以原價之10%計算，則應爲 9,000元。可使用年限爲x年，則每年機器折舊費爲$\frac{81,000}{x}$元。

利息　依照政府最近公佈購買農機用貸款之利率，以年息9%計算則$\frac{90,000+9,000}{2}\times 0.09=$

4,455元。

修護費　機器新的時候修護費之支出甚微，但隨使用時數之增加，支出額亦相對增加，但其增加比率在目前未有適當之參考資料，因此以定額法估計之。普通農機具之定額估計係每年以購買機器價格之約5％計算。但本次供試之小型聯合收穫機，其構造經觀察結果，並不比一般耕耘機、噴霧器以及其他農業機械堅牢，可能修護費之支出要較多，所以暫以8％計算，則 $90,000\times0.08=7,200$元。

固定費總支出　固定費總支出＝折舊費＋利息＋修護費＝$\frac{81,000}{x}+4,455+7,200=\frac{81,000}{x}+11,655$元。

每公頃固定費支出　假設一年總收穫面積＝A（公頃）則每公頃固定費支出＝$\frac{81,000}{Ax}+\frac{11,655}{A}$

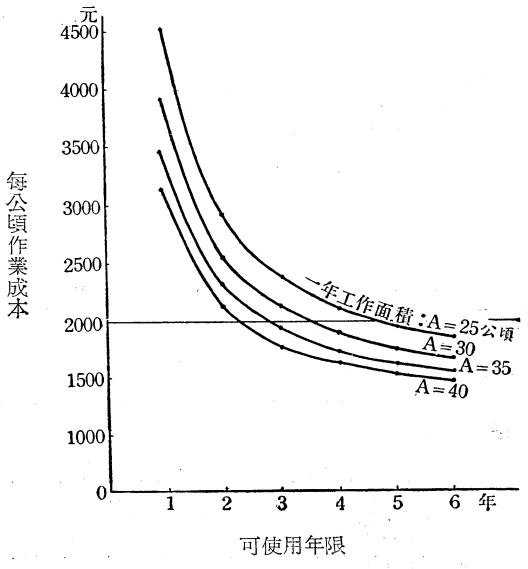
燃料費　依照試驗結果，每公頃需用 34ℓ汽油，每 ℓ5.7 元，所以每公頃所需燃油費爲$5.7\times34=194$元。

機油費　機油耗油量以燃油之5％計算，則每公頃所需機油量爲$34\times0.05=1.7$（ℓ）。每ℓ以16元計算，則$16\times1.7=27.2$元。

人工費　駕駛員一人，割田邊稻及協助收集稻束等工作二人，共三人，每人工資平均以 120元計算，則人工費＝$120\times3\times\frac{1}{0.6}=600$元。

每公頃工作成本　每公頃工作成本＝固定費＋燃油費＋機油費＋人工費＝$\frac{81,000}{AX}+\frac{11,655}{A}+194+27+600$

一年工作總面積分別定爲25、30、35、40公頃，則可得曲線表如第十二圖所示。



第十二圖　每公頃作業成本分析圖

目前在本省收割一公頃水稻，所需工資平均約爲 2,000元，所以從圖中可看出，假使一台機器之年作業面積爲40公頃時，其可使用年限必須有2年以上，假若年作業面積爲25公頃時必須有4年以上。但此次所供試之機器，經觀察結果，由於各部份構造複雜，調節精細，且各活動部份都暴露在外面，保養困難，爲達到 2,000元平衡線所示之應有可使用年限，已感到很勉强，所以目前所使用之機器，雖可達到節省人工的目的，但對減低生產成本之目的則未有太大之貢獻。

（七）今後應改進之方向

依上述各項分析，可知工作成本極高，因此，如何使工作成本降低，乃目前急要課題，下列幾點尤亟待改進者。

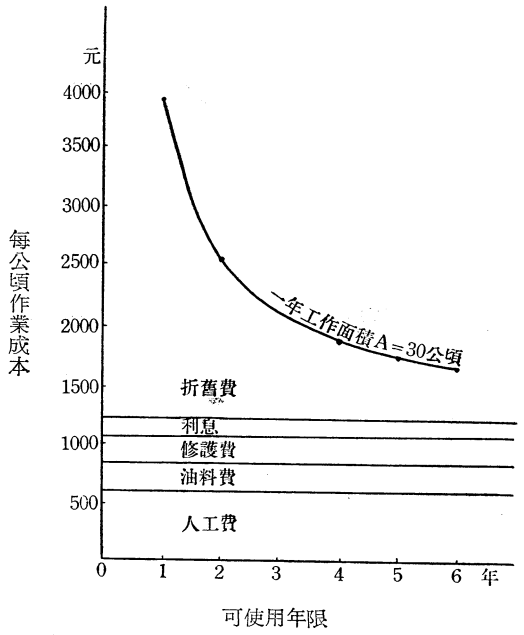
（1）減少工作人員：機器在收穫作業時，因田邊稻須由手工先行割除，並予脫穀，因此需要三個人員，每公頃需費 600元，如果能將機器修改，免除此項作業，則至少可節省三分之一以上的費用，同時亦使作業由複雜趨於簡單。

（2）提高工作量：該機器的選別方式係採用風選式，因此脫穀能量有限，日工作量不易提高，同時在雨天露晨都無法使用，無形中年工作時數受到限制，一年內總工作面積平均不過30公頃。如果能以搖動式粗選機構代替風力精選，則工作速度及工作量將可能有大幅度的增加。

（3）加强耐久性能：如前所述，由於機器結構複雜，機件脆弱，維護困難，因此應儘量簡化機器，同時增加活動部份牢固性，尤其履帶前輪輪徑太小，在軟泥田作業，刈刀容易插入泥裡；而鱗片式的橡膠履片及其插梢容易損壞，影響工作進行。宜改用鐵片代替橡膠，同時將輪徑加大，以解決泥田區的問題，同時增强其耐久性能。

（4）機器經上述修改後，工作人員可以節省三分之一，年工作量可達四十公頃，耐久性延長到四年，則每公頃的工作成本便可降到1,400元以下，這對於水稻聯合收穫作業將有極大幫助。

（5）增加機器之機動性：爲增加機器之利用率，收穫作業必須在廣大的地區實施。但現有收穫機之行走機構在公路或農路上無法快速行走，遇到長途時，需僱用卡車搬運。在近距離時，利用機器本身行走，亦極費時間，因此在可能作業期間，將影響到實際作業日數，所以機器之機動性必須加以改進，始可增加其利用率。



第十三圖　作業成本分配

四、參考文獻

1.農業機械實驗便覽。東大農工教室，養賢堂。

2.實驗計劃法。田口玄一，丸善書局。

3.稻穗脫粒要素之研究。鄔清標，農工學報十四卷三、四期。

摘　　要

1.稻穗穀粒最小抗拉强度對摩擦掉粒數之影響度Q值爲46.5%，其與穀粒含水分率之交感作用及與穗粒數之交感作用之Q值，亦各佔 13%及2.5%，所以穀粒最小抗拉强度之大小對摩擦掉粒之影響極大，兩者間之關係式爲：

$y=-0.14x+31.17$　　y：摩擦掉粒數（%）

x：穀粒最小抗拉强度（gr）

2.目前小型水稻聯合收穫機所使用之脫穀選別機構，極易受到稻葉水分含量以及稻束供給速度及供給深度之影響，所以具有各種調節裝置，使機器能適應各種情況之水稻，但由於調節裝置過繁，相互間不易使其完全配合，因此摩擦掉粒數、行車速度、水稻成熟度等因素對水稻聯合收穫機收穫作業掉粒損失之影響，往往比人爲因素小，因而各因素之F 值均不顯著。

3.田間表土硬度（貫穿深度），稻葉含水分率及田區面積大小對工作能量均有顯著之影響，稻葉含水分率之影響度約佔25%，與其他兩因素之交感影響亦各佔12%及8%。

稻葉含水分率與機器工作能量之間的關係式爲：

$y=0.26x+76.94$　　y：工作能量（min/10a）

x：稻葉含水分率（%）

表土貫穿深度及田區面積大小對工作能量之影響度各爲15%，其他機差之影響度爲20%。

表土貫穿深度與工作能量之關係式爲：

$y = 9.45x + 76.07$　　y＝工作能量（min/10a）

x＝表土貫穿深度（cm）

田區面積大小與工作能量之關係式爲：

$y = -0.01x + 100.14$　　y＝工作能量（min/10a）

x＝田區面積（m^2）

4. 割切機構上所附裝之扶稻桿作業性能極佳，且割切高度及脫穀時稻束之供給深度均有良好之調節裝置，只要節調妥當，則稻株之高度、分蘖數、倒伏程度等對機器之作業性能均無太大影響，但完全倒伏之水稻即無法收割。

5.因機器之履帶高度不高，表土太軟，重錘貫穿深度超過 3cm以上時，機器之行走即不甚方便，影響工作效率，超過 6cm以上時，工作極爲困難。

6.目前之小型水稻聯合收穫機，每天工作效率平均約爲 0.6公頃，但葉面有水滴時即無法工作，同時，稻束供給量稍爲過量，即隨時發生堵塞現象。故爲提高機器工作效率，目前之下方供給稻束脫穀法及風選式選別機構不甚適用，應改爲上方供給稻束脫穀法及搖動選別法之脫穀選別機構。

7.稻谷的損失率爲0.5～2%之間，損失量並不太嚴重。

8.每公頃所需總人工時數爲34小時，其中聯合收穫機正常作業所佔比例爲35%，手工刈割田邊稻佔28%，利用聯合收穫機之脫穀選別機構脫田邊稻爲37%。可知工時分配上極爲不經濟。改進的方法，惟有增大田區面積，及修改機器本身，使能免去處理田邊稻的工作。

9.機器的田間理論工作效率平均爲57%，田間有效工作效率平均爲 64.9%。提高有效工作效率的方法，在於一方面使田區長邊與寬邊長度比例加大，另一方面簡化機器的結構，儘量減少調節手續。

10. 每公頃所需工作成本，可以下列方程式表示之：

$$y = \frac{81{,}000}{AX} + \frac{11{,}655}{A} + 821$$

式中A 爲年工作面積（公頃），x 爲可使用年限，因機器價格頗高，所以年工作量及可使用年限爲影響成本最大的因子。依照目前使用情形推算，年工作量爲30公頃，可使用年限爲 4 年，則每公頃所需工作成本爲 1,780元。欲使成本降至低於1,300元，則機器必需經過修改，使操作人員減爲二員，年工作面積能在40公頃以上，耐久年限 4 年以上，始可達成。

11. 爲降低工作成本，今後應改進的方向略如下列：

（1）將刈切部份置於脫穀部份的前端，藉以免去手割及機脫田邊稻的手續。

（2）將脫穀選別部份工作容量加大，並使之適用於雨天、露晨。

（3）加大履帶的驅動輪徑，或改良履帶的結構，使收穫機能適用於軟泥田區。

（4）簡化各部份的結構與調整，並增强其耐久性能。

（5）增加機器之機動性，以便提高其利用率。

TESTS ON THE PERFORMANCE OF SMALL RICE COMBINE HARVESTER IN RELATION TO SOME PHYSICAL PROPERTIES OF RICE

C. P. Wu & K. H. Huang

Summary

1. The minimum tensile strength of rice grain significantly affected the friction loss of grain. The"Q"value was 46.5%. The moisture content of grain and the number of grain affected the friction loss were not as important as the minimum tensile strength. The"Q" values were 13% and 2.5% for moisture content of grain and number of grain per panicle respectively. The regression equation between minimum tensile strength and friction loss of grain is

$$Y = -0.14X + 31.17$$

Where X=the minimun tensile strength of grain. (gr.)

Y=the percentage of the friction loss of grain. (%)

2. The effect of friction loss of grain, the forward speed of the combine & the degree of maturity of rice on grain loss caused by combine harvester were not significant. This would be possible that factors other than the above mentioned three were involved. For instance, the moisture content of the leaves, the feeding speed of rice bundle and the length of rice plant feeding inside the threshing machine. For the purpose of fitting and easing the handling of rice bundles under different conditions, this combine is equiped with various attachments which are so encepliated that the operator is not very easy to familiar with it and run it properly. therefore the improper handling of the combine would cause more grain loss.

3. The hardness of the surface soil or top soil, the moisture content of the leaves, and the size of working plot all greatly affected the working capacity of the combine harvester.

The regression equations for the moisture content of the leaves, hardness of the surface soil and the size of working plot with the working capacity are:

a. moisture of leaf: $Y = 0.26X + 76.94$

where: Y=working capacity (min/10a)

X=moisture content (%)

b. Hardness of surface soil $Y = 9.45X + 76.07$

where: Y=working capacity (mim/10a)

X=the depth of the weight droped into the surface soil (cm)

c. The size of working plot: $Y = -0.01X + 100.14$

where: Y=working capacity (min/10a)

X=size of each working plot (m^2)

4. The rice pick-up attached to the cutting mechanism of the small rice combine is excellent, The rice cutting height and the length of rice plant for feeding to the threshing mechanism can be adjusted properly. Hence, if all parts are properly adjusted, these factors such as the height of rice plant, the number of rice plants per hill, and the declination angle of rice plant will not affect much on the operation of combine. However, this type of small combine won't work well when lodging of rice plants is very serious.

5. The height of the track on both side of the combine isn't sufficient. If the surface soil of the field is too soft (when a given weight is droped down from a height of one meter to the soil surface and penetrates into the surface soil by 3 cm but less than 6 cm.) combine won't proceed well and its efficiency is very low. When the given weight penetrates into the soil by 6 cm or more, this combine won't work any more.

6. The working capacity of this small rice combine is 0.6 hectare per day in average under normal conditions. However the capacity of this machine is greatly reduced or even won't work when the leaves are wet. In the meantime, the threshing machine will be in trouble when more too much rice plants are fed. The combine would be efficient if the present rice feeding mechanism, which is fed under the threshing drum, be changed to feed rice plants on the threshing drum, and the wind cleaning mechanism be changed to vibrating sieve.

7. The percentage of grain loss is ranging from 0.5 to 2%, which is considered not a very serious loss of grain.

8. To harvest one hectare of rice required 34 man-hours, which included 35% for by combine in normal operation, 28% for cutting rice in the border rows, 37% for combine threshing the rice harvested in the border rows. Therefore, it is quite clear that the size of farm for using combine with great efficiency and better benefit is exstremely important. Because 65% of manhour required for harvesting the rice on the border row is quite unreasonable.

9. The theoretical field efficiency of the machine is 57% in average, and the effective field efficiency is 64.9% in average. The effective field efficiency can be increased if the proportion of length to width of a field is increased in order to reduce the turn of combine, the machine construction be further simplified and the regulating process be abated.

10. The following equation expressed the total cost for harvesting one hectare of rice.

$$Y = 81{,}000/AX + 11{,}655/A + 821$$

Where :

A = Hectare of rice to be harvested per year.

X = Effective service life of the machine.

The high price of the machine, the acreage harversted per year and the service life of the machine affected the total cost greatly. From this test, 30 hectares of rice harvested per year, and 4-year service life will be the minimum requirements for economic use of the combine. Under this conditions, the total cost for harvesting one hectare of rice is NT$ 1,780.00. If we want to reduce the cost to less than NT$ 1,300.00, then the machine should be improved to allow 2 operators to work on, more than 40 ha. of rice be harvested per year and the service life of the machine be more than 4 years.

11. We would suggest that the following improvements be made in order to reduce the cost of operation to a more economic level :

(1) Set the cutter before the threshing sorting parts in order that the cutting and threshing of rice in the border row could be avoided.

(2) Improve the working ability of the threshing and sorting parts, in order to make the machine to be able to work in rainy day and high humidity in the morning hours.

(3) Enlarge the diameter of both the driver and the driven sprocket, or improve the track structure to made it suitable for soft, muddy field operation.

(4) Simplify the structure and ease the regulation of the machine parts and intensify their durability.

(5) Make the machine easy to transfer, in order to promote its availability.

稻苗立枯病症之初步觀察[1]

簡 錦 忠[2] 洪 雲 卿[3]

前 言

最近本省稻作栽培作業要求節省人力，進而促進農業機械化。自插秧機進入實用階段以來，縮短栽培水稻的作業勞動時間，所得成果極佳，頗受農民重視及歡迎。但因利用插秧機插秧時，其育苗法和過去大不相同，爲適合插秧機之用，故必須用育苗箱（其大小一般爲60×30×3公分），可縮短育苗時間，係本省稻作栽培技術的一大進步。

本（1971）年2月間，於彰化縣花壇鄉內促進農業經營現代化實驗區利用育苗箱育苗時，曾發生苗立枯病症之病徵，其爲害程度頗嚴重，重者部份被迫重新播種。此現象在本省係首次發生，缺乏參考資料，如何防治乃有束手無策之感。筆者曾往發生地區勘查及鑑定病原菌，以及作初步防治試驗，茲將所得結果簡述於下，作今後防治參考。

育苗方法及立枯病症發生之經過

因使用「野馬式」插秧機，故育苗箱（60×30×3公分）內放置紙製或塑膠製的條播模型，然後裝入打碎的水田土壤。稻種子先精選後行種子消毒（Riogen 片劑，每片加水 2 公升，浸漬 2 小時），並再浸水4晝夜，然後催芽（其催芽程度爲胚芽露出即可）。每箱播種量爲 320公克種子，蓋土及灑水後放置於保持 32～35°C 塑膠布覆蓋之電熱育苗室內育苗，待苗長達3公分左右時，將育苗箱搬出屋外。爲促進稻苗的生長，夜間曾用塑膠布蓋於育苗箱上，以保持溫度，當時在屋外之溫度平均爲10～12°C（最高 17°C，最低 7～8°C）。自電熱育苗室搬出後約一星期，始發現自稻苗葉尖開始似缺水份狀，呈青枯現象，被害苗的根部發育不良，呈褐色，地上部的莖葉經數天後，嚴重者呈褐色而枯死。濕度高時，被害稻苗附近有菌絲之形成。在同一箱內最初係局部性的發生，而後蔓延至全箱，被害嚴重者稻苗全滅，而需重新播種。

被害稻苗上的菌類

引起稻苗立枯病的病原菌極複雜，橋岡氏(6)（1958）曾提及稻苗生長初期如果氣溫不穩定，或陸秧田，温床秧田，或電熱秧田常見立枯病之發生，其病原菌多屬 *Fusarium* 菌或其他土壤菌，而不見水棲菌類。青柳氏(2)（1959）報告，在日本群馬縣山間地帶發生稻苗立枯病之病原菌，最常見者爲 *Pythium* 菌，其次爲 *Fusarium* 菌。日本植物防疫協會(2)（1968）對稻苗立枯病之病原菌舉出 *Fusarium* sp., *Pythium* sp. 及 *Rhizoctonia* sp. 等三種。又據中田氏(1)等（1963）將 *Achlya*, *Pythium*, *Saprolegnia*, *Pythiomorpha*, *Dictyuchus* 及 *Fusarium* 等皆列爲稻苗腐敗病之病原。但在臺灣，陳氏(4)（1956）將 *Achlya Ftagellata* Coker., *Dictyuchus* sp., *Fusarium* sp., *Rhizoctonia* sp., etc. 等皆列爲稻苗腐敗病之病原菌；而稻立枯病之病原菌爲 *Pyth-*

1.試驗報告農試字第五三六號。2.臺灣省農業試驗所薦任技士。3.同所技佐。

ium spp. 一種。筆者爲明瞭本次在中部發生的該病症之病原，曾自彰化縣花壇鄉用育苗箱育苗所發生的被害稻苗，以酵母洋菜培養基行組織分離，所獲菌類及頻度如表一、二。

表一、自枯死稻苗分離所得菌類

菌名	出現數	百分比(%)
Sclerotium sp.	2	6.9
Helminthosporium sp.	7	24.1
Monilia sp.	5	17.2
Fusarium sp.	10	34.5
Alternaria sp.	1	3.5
雜菌	4	13.8

表二、自尙未完全枯死，呈青枯稻苗分離所得菌類

菌名	出現數	百分比(%)
Helminthosporium sp.	3	25.0
Monilia sp.	4	33.3
Fusarium sp.	1	8.3
Alternaria sp.	1	8.3
雜菌	3	25.0

自被害稻苗根部分離者：將採取之被害苗根部經組織分離 5 條結果，*Sclerotium* 菌出現 2 次，*Monilia* 菌出現 3 次。

自土壤中檢出似菌核分離者：本省稻作每期作受菌核性病害之加害極嚴重，在稻收穫後落於田間之菌核數量頗多，因育苗箱所用之土壤皆取於水田，故將所採土壤樣品50公克，泡水後，用肉眼檢取似菌核16個，經培養結果，屬 *Sclerotium* 菌者有 4 個，其餘12個皆未長菌絲。

如上所述，本次自稻苗立枯病症稻苗分離所得菌類有 *Helminthosporium* sp., *Fusarium* sp., *Alternaria* sp., *Monilia* sp., *Sclerotium* sp., 等菌類，與上述諸氏所謂立枯病或腐敗病之病原菌略有出入，故對病原菌有繼續研討之必要。在本文暫定爲「稻苗立枯病症」，待今後病原菌明瞭後再作最後判定。

藥劑防治

供試土壤採自彰化縣花壇鄉，土壤分爲無消毒及蒸氣消毒(120°C 保持30分鐘)二種。稻種爲臺南 1 號，稻種首先浸水二晝夜後放於 28°C 定溫箱內催芽，催芽程度爲稻種的胚部裂開可見白色部即行播種。每箱播種量爲 250 公克。播種用條播，每育苗箱播種50行，每處理10行，各處理之間則用木板隔離。播種前將土壤無消毒及消毒者分別裝入育苗箱約三分之一時，各接種自被害苗分離所得的病菌，即接種眞菌之菌類爲 *Fusarium* sp., *Alternaria* sp., *Helminthosporium* sp., *Monilia* sp., 等

菌類，供用量爲每種菌試管各3支，計 12支試管共加注殺菌水 400cc 作成胞子浮懸液，每處理灌注胞子液 50cc。

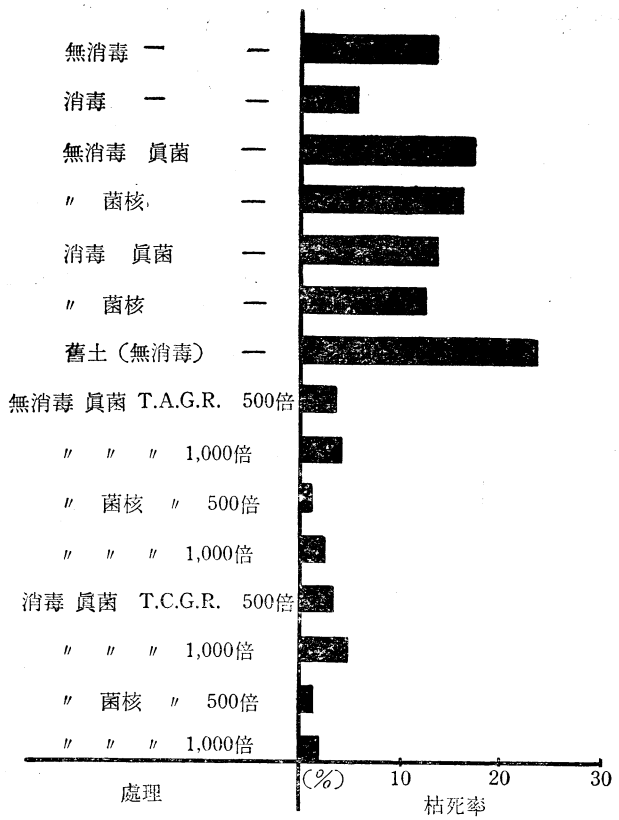
另將菌核（*Sclerotium* sp.）自試管內用白金耳連洋菜一起取出，並每行放 4 小塊，每支試管之菌核接種兩處理 （ 20 行 ）。病菌接種後再將土壤覆蓋於上約三分之一，然後播稻種。播種後用 Tachigaren 液劑（30% 3-hydroxy-5-methylisoxazole），其施用濃度爲500及1,000倍稀釋液，各處理用吸管取 100cc 灌注於稻種上，然後再蓋土，蓋土後再灌注同量的 Tachigaren 液一次。處理及播種完竣，放置於 24°C 定温箱內三天，始移置於温室內。

本次試驗於60年3月17日播種，4月13日觀察各處理區之稻苗生育狀況及罹病苗（枯死苗）數目，所得結果如表三、圖一、及圖二。

表三、稻苗立枯病症之防治效果

處理代號	土壤消毒與否	接種菌類	Tachigaren 使用濃度	罹病狀況			生育狀況			
				調查苗數	枯死苗數	枯死率(%)	苗高(cm)	每支苗平均葉數	每支苗平均根數	平均根長(cm)
1	無消毒	—	—	482	50	10.37	11.22	2.10	5.53	7.17
2	消毒	—	—	512	28	5.47	16.89	2.18	5.58	9.43
3	無消毒	眞菌	—	455	81	17.80	10.99	2.23	5.73	6.05
4	〃	菌核	—	461	75	16.16	13.38	2.25	5.15	5.63
5	消毒	眞菌	—	470	65	13.83	16.63	2.05	6.43	7.65
6	〃	菌核	—	478	59	12.34	18.06	2.43	6.35	7.94
7	舊土	—	—	429	102	23.78	11.49	2.13	5.05	4.57
8	無消毒	眞菌	500倍	490	15	3.06	15.63	2.43	5.85	4.32
9	〃	〃	1,000倍	485	19	3.92	13.13	2.05	5.63	5.01
10	〃	菌核	500倍	507	5	0.99	14.71	2.23	5.28	3.74
11	〃	〃	1,000倍	518	12	2.32	14.80	2.10	5.48	4.33
12	消毒	眞菌	500倍	514	16	3.11	17.26	2.50	6.30	4.66
13	〃	〃	1,000倍	502	25	4.98	20.72	2.23	5.83	6.02
14	〃	菌核	500倍	520	6	1.15	18.98	2.38	6.05	4.35
15	〃	〃	1,000倍	517	8	1.55	17.18	2.10	5.73	6.68

據表三、及圖一、得知，育苗箱所用之土壤無消毒區，其稻苗枯死率達 10.37%，而經蒸氣消毒者僅 5.47%， 約前者的半數；又用舊土（曾育苗一次而發生稻苗立枯病症之土壤）區之枯死率高達23.78%，可見育苗所用之土壤本身所含之病原頗多。將無消毒土壤或消毒土壤各別接種眞菌(*Fusarium* sp., *Alternaria* sp, *Helminthosporium* sp., *Monilia* sp., 等四種菌類)，或菌核(*Sclerotium* sp. 者，皆較無接種區之稻苗枯死率爲高，但無論土壤經消毒與否，接種眞菌區比接種菌核區之稻苗枯死率略高。如果在土壤（無論消毒與否）接種菌類後，再灌注 Tachigaren（分爲 500 倍及1,000倍兩處理）處理者，皆可得防治效果，但灌注濃度 500倍區較1,000倍區之效果略佳，不過其差異並不顯著。按此使用濃度之計算標準，500倍區即每育苗箱用藥量爲 2ml，1,000倍區用藥量爲 1ml，而兩者之防治效果無顯著差異，故實際上每育苗箱用 Tachigaren 1 ml 較爲經濟。



圖一、稻苗立枯病症之防治效果比較

Fig.1. Comparative control effect of rice seedling disease

就各處理區稻苗生育狀況觀察之，用舊土或無消毒區之稻苗生長較差，經過蒸氣消毒或供用 Tachigaren 處理區之生長較佳。每苗平均葉數各處理間之差異不大，但每支苗平均根數土壤消毒區比無消毒區略多，而且供用 Tachigaren 處理區中，500倍區較1,000倍區稍多，不過平均根長則反之，即1,000 倍區比 500倍區爲長。又無藥劑處理，只經蒸氣消毒區亦比無消毒之平均根長較長。

高橋氏(5) (1971) 對育苗箱水稻立枯病之防除對策，曾提出（1）實行稻種消毒，在實施稻種消毒操作上最重要者，消毒液之温度，應保持 20°C 以上，如果降至 15°C 以下時將影響其消毒效果。（2）土壤消毒 (a) 用氯化苦 (Chloropicrin) 消毒，該藥劑雖有預防效果，但自處理後約2星期間須用草袋等物覆蓋，其後並需使其完全發散（約需7～10天），因此，自處理後必須經3週以上始能使用該土壤，在時間及準備工作上極費事，且如處理工作不妥時將影響稻種之發芽率。 (b) 用 Tachigaren 消毒，如果用粉劑，每公升土壤加一公克的藥劑充分混合均勻後即可播種，如果用液劑，播種覆土後用 Tachigaren 1,000 倍液每箱灌注 500ml （約每平方公尺用3公升），或在稻苗生育中欲防止立枯病之蔓延時，亦可灌注500倍液，可獲良好防治效果。

本試驗所得和高橋氏(5) (1971) 在日本所得結果極爲相似，故今後在臺灣欲防治稻苗立枯病症之爲害，應勵行稻種消毒及利用 Tachigaren 1,000 倍稀釋液，於播種後，每育苗箱灌注500～1,000 ml. 則可得優良防治效果。

摘 要

本年（1971）第1期稻作在彰化縣花壇鄉爲配合插秧機作業的育苗箱上所發生的稻苗立枯病症，其被害程度頗嚴重，探討其病原菌以及防治方法，所得結果摘要如下：

自枯死稻苗或尚未完全枯死稻苗分離所得菌類有：*Sclerotium* sp., *Helminthosporium* sp., *Fusarium* sp., *Alternaria* sp. 及 *Monilia* sp. 等。又自被害稻苗根部或土壤中的菌核分離結果，皆可得 *Sclerotium* sp.。

爲防治該病症，應勵行稻種消毒，及育苗箱在播種後每箱灌注 Tachigaren 1,000 倍稀釋液 500～1,000 ml，可得良好之防治效果。

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PRELIMINARY INVESTIGATION ON THE RICE SEEDLING DISEASE

by

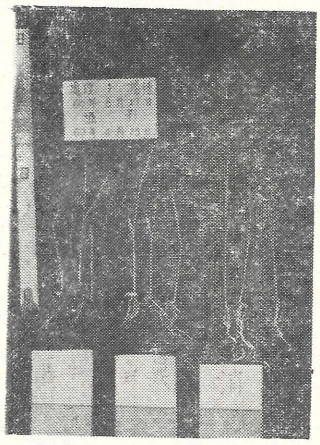
C. C. Chien and Y. C. Hung

Summary

In order to pair with the operation of rice transplanter, seedling cultivation boxes are used at Hua-tan Hsiang of Chang-hua Hsien. In the first crop of this year (1971), the rice seedling disease severely occurred in seedling cultivation box. Concerning with the pathogen and controlling methods, the results are obtained as follows.

The fungi isolated from dead tissues of the diseased seedlings or tissues not yet completely dead, were *Sclerotium* sp.; *Helminthosporium* sp.; *Fusarium* sp.; *Alternaria* sp. and *Monilia* sp.. On the other hand, there was same fungus *Sclerotium* sp. obtained from the roots of diseased seedlings and from sclerotia existed in the contaminated soil.

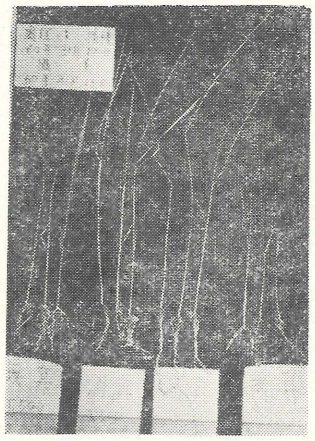
For the control of seedling disease, seed disinfection and application of "Tachigaren" onto the seedling cultivation box at the rate of 500～1,000ml per box at 1:1,000 dilution, might give good control.



1 2 3

A

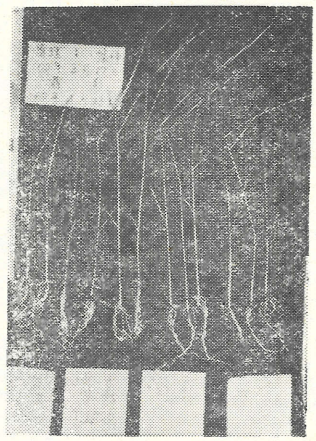
1.土壤用舊土（無消毒）。
2.土壤無消毒，無接種。
3.土壤消毒，無接種。



1 2 3 4

B

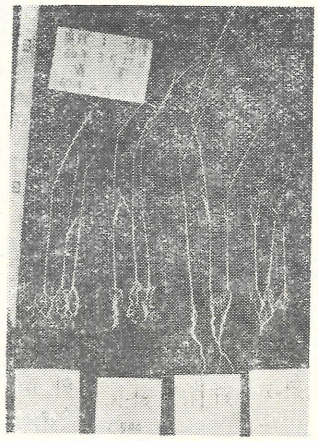
1.土壤無消毒，接種眞菌類並灌注 Tachigaren 500倍液。
2.土壤消毒，接種眞菌類並灌注 Tachigaren 500倍液。
3.土壤消毒，接種眞菌類。
4.土壤無消毒，接種眞菌類。



1 2 3 4

C

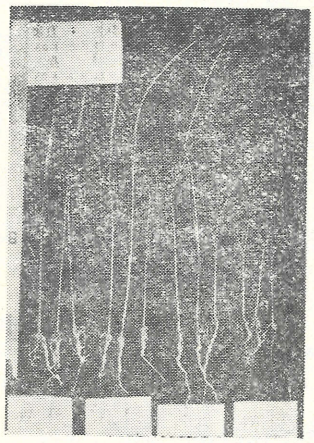
1.土壤無消毒，接種眞菌類並灌注 Tachigaren 1,000倍液。
2.土壤消毒，接種眞菌類並灌注 Tachigaren 1,000倍液。
3.土壤消毒，接種眞菌類。
4.土壤無消毒，接種眞菌類。



1 2 3 4

D

1.土壤無消毒，接種菌核並灌注 Tachigaren 500倍液。
2.土壤消毒，接種菌核並灌注 Tachigaren 500倍液。
3.土壤消毒，接種菌核。
4.土壤無消毒，接種菌核。



1 2 3 4

E

1.土壤無消毒，接種菌核並灌注倍液。 Tachigaren 1,000倍液。
2.土壤消毒，接種菌核並灌注 倍液。 Tachigaren 1,000倍液。
3.土壤消毒，接種菌核。
4.土壤無消毒，接種菌核。

圖二、灌注 Tachigaren 對稻苗生長之影響

Fig.2 : The influence of Tachigaren on the growth of rice seedling.

改進臺灣蘆筍品質及產量之研究[1]

Ⅲ.綠蘆筍經濟栽培基礎試驗

林　昭　雄[2]

一、前　言

綠蘆筍（Green asparagus）因採收期間不培土之關係，其單位面積產量一般比白蘆筍（White asparagus）低15～20%，但其營養價值（尤其維他命 C 含量）比白蘆筍爲高。綠蘆筍爲頗有前途之冷凍蔬菜之一，而且外銷市場頗大，故值得吾人提倡。爲引起生產者之興趣，提高生產者之經濟收益，及加速發展臺灣綠蘆筍產業，其栽培技術有待試驗研究。茲就栽植密度，冬季間作蔬菜，以及利用除草劑除草，先加以試驗。

二、材料及方法

（一）綠蘆筍栽植密度試驗

1.蘆筍供試品種：UC　711（二年生）。

2.植距處理：A：120×20cm, B：120×30cm, C：120×40cm, D：120×50cm,

3.田間設計：小區面積 1.2m×10m＝12m² 每一植距處理栽一小區，4 重複，逢機區組排列，試區面積爲192m²。

（二）綠蘆筍園冬季間作冷凍用菜豆試驗

1.蘆筍供試品種：UC72 （二年生）

2.矮性菜豆供試品種：Tender pod

3.間作處理：A：間作矮性菜豆採種區。　B：間作矮性菜豆採收軟莢區。　C：不間作（對照區）。

A、B間作物在10月播種於綠蘆筍兩側畦上，株距 30cm。

4.田間設計：小區面積1.2m×10m＝12m²，3 處理，8 重複，逢機區組排列，試區面積爲288m²。

（三）綠蘆筍園除草劑應用試驗

1.蘆筍供試品種：UC 309（二年生）。

2.除草劑處理：A：Diuron 80% W.P. 1.0公斤/公頃　B：Monuron 80% W.P. 1.0公斤/公頃
C：Herban 80% W.P. 1.2公斤/公頃　D：Afalon 50% W.P. 1.2公斤/公頃
E：Lasso 48% E.C. 2.0公升/公頃　F：Alicep 45% W.P. 2.4公升/公頃
G：Lasso 48% E.C. 1.0公升＋Herban 80% W.P. 0.6公斤/公頃
H：Lasso 48% E.C. 1.0公升＋Diuron 80% W.P. 0.5公斤/公頃
I：人工除草對照區。　J：放任對照區。

本研究得國家科學委員會之研究補助，蘆筍生產改進基金經費補助，暨蒙農復會陸組長之琳，謝技正靜吾，郁分所長宗雄之指導，黃敏雄先生之協助，謹此深致謝忱。

1.試驗報告農試字第五三七號（本專題研究Ⅰ、Ⅱ兩篇刊載在中國園藝季刊）

2.臺灣省農業試驗所鳳山熱帶園藝試驗分所薦任技士

3.田間設計：小區面積1.2m×6m＝7.2m²，10處理。4重複，逢機區組排列，試區面積爲288m²。

三、結果及討論

(一)綠蘆筍栽植密度試驗

1.株距對嫩莖產量之影響：試驗結果如表1.

表1. 株距處理對嫩莖產量之影響

Table 1. Effect of planting distances on the yield of spears

處理 Treatment	12m² 小區平均產量 Ave. yield per 12m² plot		10公畝產量 yield per 10 are		指數 Index	
	嫩莖數(支) No. of spears	嫩莖重(kg) Wt. of spears	莖數(支) No. of spears	嫩莖重(kg) Wt. of spears	嫩莖數 No. of spears	嫩莖重 Wt. of spears
A 20cm	264.50	3.278	22,040.79	273.14	120.50	124.85
B 30cm	264.75	3.228	22,061.62	268.96	120.62	123.94
C 40cm	247.25	3.103	20,603.34	258.60	112.64	118.20
D 50cm	219.50	2.626	18,290.94	218.78	100	100

2.株距處理與累積產量之關係：示如表2.

表2. 株距處理與二年累積產量之關係

Table 2. The relationship between planting distances and accumulated yield of spears

處理 Treatment	第一年		第二年		二年平均	
	產量 (kg/10a)	指數 Index	產量 (kg/10a)	指數 Index	平均產量 (kg/10a)	指數 Index
A 20cm	232.98	137.88	273.14	124.85	253.06	130.52
B 30cm	179.70	106.35	268.96	122.94	224.33	115.71
C 40cm	183.87	108.81	258.60	118.20	221.24	114.11
D 50cm	168.97	100	218.78	100	193.88	100

3.株距處理與嫩莖平均重之關係：示如表3.

表3. 株距處理與嫩莖平均重之關係

Table 3. The relationship between planting distances and ave. wt. of spears

處理 Treatment	第一年		第二年		二年平均	
	平均重量 Ave. Wt. (g)	指數 Index	平均重量 Ave. Wt. (g)	指數 Index	平均重量 Ave. Wt. (g)	指數 Index
A 20cm	11.59	98.47	12.39	103.60	11.99	101.01
B 30cm	10.93	92.86	12.19	101.92	11.56	97.39
C 40cm	11.33	96.26	12.55	104.93	11.94	100.59
D 50cm	11.77	100	11.96	100	11.87	100

根據本年產量調查結果，產量仍以株距 20cm (A處理) 區爲最高，30cm(B處理)區，40cm (C處理) 區次之，50cm (D處理) 區產量最低。本試驗20cm區比50cm 區第一年增產 37%，第二年增產24%，平均可增產30%，亦即株距愈小，產量愈高。此結果亦與 Jones & Hanna (1940) ,Hanna (1950) Morgan & Isacs (1960) 諸氏試驗之結果相吻合。惟嫩莖平均重在本試驗之株距處理間未獲得顯著之差異，此與 Morgan & Isacs 氏之報告不盡相同。Morgan & Isacs (1960) 報告指出株距18吋或24吋處理區之嫩莖平均重比株距 6 吋或12吋處理者稍重，且其差異達 5 %顯著平準。但 6 吋與12吋之處理間，18吋與24吋之處理間均未有顯著差異。蘆筍爲雌雄異株，又爲多年生作物，單位面積產量因雌雄株之比例及植株年齡之增加而有變異，故臺灣地區之綠蘆筍株距試驗仍有繼續研究之必要。

(二)綠蘆筍園冬季間作冷凍用菜豆試驗

1.間作處理對蘆筍嫩莖產量之影響：試驗結果如表4.及5.

表 4. 間作處理對第一年蘆筍嫩莖產量之影響

Table 4. Effect of intercropping on the spear yield of the first year

處理 Treatment	12m² 小區平均產量 Ave. yield per 12m² plot		10 公畝產量 yield per 10 are		指數 Index	
	嫩莖數 (支) No. of spears	嫩莖重量 (kg) Wt. of spears	嫩莖數 (支) No. of spears	嫩莖重 (kg) Wt. of spears	嫩莖數 No. of spears	嫩莖重 Wt. of spears
A 間作矮性菜豆採種區	187.13	2.468	15,593.54	205.66	87.14	80.31 a
B 間作矮性菜豆採收軟莢區	195.63	2.649	16,301.85	220.75	91.10	86.20 b
C 不間作對照區	214.75	3.073	17,895.12	256.09	100	100 c

註：處理間之差異顯著性係採用 Duncan's Multiple Range Test 法測定，同欄內列有不同英文字母者係指處理間之差異極顯著。

表 5. 間作處理對第二年蘆筍嫩莖產量之影響

Table 5. Effect of intercropping on the spear yield of the second year

處理 Treatment	12m² 小區平均產量 Ave. yield per12m² plot		10 公畝產量 yield per 10 are		指數 Index	
	嫩莖數 (支) No. of spears	嫩莖重 (kg) Wt. of spears	嫩莖數 (支) No. of spears	嫩莖重 (kg) Wt. of spears	嫩莖數 No. of spears	嫩莖重 Wt. of spears
A 間作矮性菜豆採種區	188.75	2.064	15.729	172.01	106.34	102.03
B 間作矮性菜豆採收軟莢區	185.75	2.138	15.479	178.15	104.65	105.67
C 不間作對照區	177.50	2.023	14.791	168.59	100	100

根據本試驗間作處理結果，每10公畝綠蘆筍園冬季可多收875公斤之冷凍用豆莢原料 (B 處理)，或86公斤之冷凍用菜豆品種之乾種子(A 處理)，多生產間作物一作，可增加筍農在短期內之經濟收益。表4.爲第一年，係在不另施間作物肥料之條件下，測定現有土壤肥力對翌年蘆筍嫩莖產量之影響。根據第一年試驗調查結果，綠蘆筍園冬季間作菜豆，對翌年蘆筍嫩莖之生產有影響，而且間作處理區比不間作對照區略減15～20%，此產量經變方分析結果，達到極顯著之差異，此可能由於生產一作

菜豆所需之營養分相當多，如不另施菜豆之肥料，則地力被菜豆所吸收消耗，故間作物之肥料仍甚重要，不應認爲間作荳類而忽視施肥。

表5.爲第二年，係在冬季間作期間施用間作物之肥料，在多肥之條件下，測定間作物對翌年蘆筍嫩莖生產力及土壤有機物含量有否影響。根據表5.所示，在冬季間作另施間作物之肥料時，不僅可多收一作菜豆，而且對翌年嫩莖之生產力，增加5～6%。

(三)綠蘆筍園除草劑應用試驗

1. 臺灣地區蘆筍園重要雜草種類之調查：列如表6。

表6. 臺灣地區蘆筍園重要雜草種類

Table 6. Important weeds of asparagus field in Taiwan area

雜草名稱	科名	學名	備註
1.牛筋草	禾本科	Eleusine indica Gaertn.	
2.絹毛指草	〃	Digitaria sericea Honda	
3.鐵綠草	〃	Digitaria longiflora (Retze) Pers.	
4.小指草	〃	Digitaria chinensis Hornem.	Beanv.
5.紫果指草	〃	Digitaria violascens Link.	
6.臺灣野稗	〃	Echinochloa crus-galli. Beauv.	
7.芒稷	〃	Echinochloa colona (Linn) Link.	
8.細菜野稗	〃	Echinochloa crus-galli Beauv.	
9.埃及指草	〃	Dactyloctenium aegyptium (Linn) Richt.	
10.小畫眉草	〃	Eragrostis plumosa Link.	
11.茅草	〃	Imperata cylindrica (L.) Beauv.	
12.土香	莎草科	Mariscus cyperinus Vahl.	
13.球花高草	〃	Cyperus difformis Linn.	無頭土香
14.莎草	〃	Cyperus iria Linn.	
15.香附草	〃	Cyperus rotundus Linn.	
16.波緣竹仔菜	鴨趾草科	Commelina undulata Br.	竹葉
17.小返魂	大戟科	Phyllanthus niruri Linn.	
18.馬蓼	蓼科	Polygonum caespitosum Bl.	
19.野莧菜	莧科	Amaranthus viridis Linn.	
20.節節花	莧科	Alternanthera nodiflora R.Br.	節節花
21.滿天星	〃	Alternenthera sessilis R.Br.	
22.臺灣馬齒莧	馬齒莧科	Portulaca oleracea Linn.	猪母菜
23.鵝兒腸	石竹科	Stellaria aquatica (Linn) Scop.	鵝腸草
24.山芥菜	十字花科	Rorippa atrovirens (Hornem.)	
25.含羞草	豆科	Mimosa pudicea Linn.	
26.酢醬草	酢醬草科	Oxalis corniculata Linn.	

27.鐵莧草	大戟科	Acalypha australis Linn.	
28.龍葵	茄科	Solanum nigrum Linn.	
29.炮仔草	〃	Physalis angulata Linn.	苦識草
30.蒼香薊	菊科	Ageratum conyzoides Linn.	
31.小葉灰藋	藜科	Chenopodium ficifolium Sm.	狗尿菜
32.黃花田蘿草	菊科	Wedelia chinensis (osbeck) Merr.	
33.昭和草	〃	Erechtites valveianafolia DC.	
34.假吐金菊	〃	Soliva anthemifolia R. Br.	
35.石胡荽	〃	Centipeda minima Linn.	
36.擬青天白地	〃	Gnaphalium purpureum Linn.	風麵舅
37.山萵苣	〃	Lactuca indica Linn.	
38.鬼針草	〃	Bidens bipinnata Linn.	
39.紫背草	〃	Emilia sonchifolia (L) DC.	
40.山土香	荳科	Alysicarpus nummularifolius (L) DC.	

本試驗圃之雜草、尖葉草類以牛筋草、土香、絹毛指草、鐵線草、野稗、紫果指草等發生較多，濶葉草類以小葉灰藋（狗尿菜）、野莧菜、馬齒莧（猪母菜）、節節花、擬青天白地、酢醬草等發生較多。

2. 除草劑處理對雜草發生之影響：試驗結果如表7。

表7. 除草劑處理與雜草生長量之關係

Table 7. The relationship between herbicide treatment and weed emergence.

調查日期 Date / 雜草分類 Weeds / 處理 Treatment	處理後30天			處理後45天			處理後60天			處理後75天		
	尖葉	濶葉	合計	尖葉	濶葉	合計	尖葉	濶葉	合計	尖葉	濶葉	合計
A	2.90	2.00	2.45	1.73	4.30	3.02	2.08	0.40	1.24	4.40	1.00	2.70
B	2.65	1.15	1.90	1.58	0.45	1.02	1.68	0.30	0.99	3.74	1.78	2.76
C	2.75	3.05	2.90	1.60	1.55	1.58	1.53	1.18	1.36	4.95	2.44	3.69
D	3.02	3.40	3.21	1.90	0.55	1.28	1.53	0.63	1.08	4.07	2.22	3.14
E	4.12	2.77	3.45	2.68	0.93	1.81	2.45	0.93	1.69	5.82	2.44	4.13
F	3.75	3.67	3.74	3.10	1.55	2.33	2.60	1.10	1.85	6.92	3.89	5.41
G	1.87	2.60	2.24	2.73	2.18	2.46	1.80	2.23	2.02	5.93	4.67	5.30
H	3.70	1.70	2.70	1.80	0.13	0.97	2.10	0.20	1.15	4.84	0.44	2.64
I	6.45	7.32	6.89	5.43	4.78	5.11	6.33	6.43	6.38	7.69	11.33	9.51
J	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

註：雜草生長量每次調查均以放任對照區（J處理）之雜草數10爲比較。

3.季節對雜草發生之影響：調查結果如表8。

表 8. 春、夏兩季雜草生長量之比較與除草效果

Table 8. Weed emergence and control effect between Spring and Summer season

季節 Season / 雜草量 Weeds / 處理 Treatment	春季雜草量 小區平均 (g/7.2m²)	春季雜草量 10公畝 (kg)	春季雜草量 指數 Index	夏季雜草量 小區平均 (g/7.2m²)	夏季雜草量 10公畝 (kg)	夏季雜草量 指數 Index	主要雜草
A	78.8	10.94	11.6	1576.8	218.99	30.99	香附子、牛筋草、野莧菜、埃及指流草
B	111.3	15.46	16.4	832.8	15.66	16.37	紫果指草、馬齒莧、香附子、擬青天白地
C	104.6	14.54	15.4	1023.0	142.07	20.10	紫果指草、滿天星、馬齒莧、埃及指流草
D	122.7	17.04	18.1	1248.8	173.43	24.54	牛筋草、擬青天白地、茅草、紫果指草
E	87.6	12.17	12.9	1520.0	211.10	29.87	紫果指草、狗尿菜、馬齒莧、野莧、香附子
F	404.2	56.14	59.7	2398.8	333.15	47.14	紫果指草、牛筋草、馬齒莧、酢醬草
G	247.2	34.33	36.5	1821.8	253.01	35.80	馬齒莧、擬青天白地、埃及指流草
H	45.5	6.32	6.7	675.8	93.86	13.28	香附子、紫果指草、野牽牛
I	280.5	38.96	41.4	976.0	135.55	19.18	狗尿菜、牛筋草、馬齒莧、酢醬草
J	677.6	94.11	100	5088.7	706.72	100	擬青天白地、馬齒莧、野莧菜、牛筋草、埃及指草。

註：1.春季雜草量係在冬季12月12日處理後75天，2月24日調查。

2.夏季雜草量係在春季4月29日處理後35天，6月3日調查。

4. 除草劑之殘效性：列如表 9。

表 9. 供試藥劑殘效性比較

Table 9. Comparison of residual effects of herbicides used

單位：什草數／什草重 g/7.2m² 小區

處理 Treatment	第一次（春季） 處理後75天之雜草量		人工除草後50天之雜草量		合計125天之雜草量		第二次（夏季） 處理後35天之雜草量		人工除草後35天之雜草量		合計70天之雜草量	
A	12.25	78.8	13.75	24.65	26.00	103.45	79.50	1576.8	—	89 50	—	10,526.8
	(27.07)	(11.63)	(29.73)	(22.06)			(54.17)	(30.99)		(100.88)		
B	12.50	111.3	11.50	106.50	24.00	217.80	39.25	832.8	—	32 04	—	4,036.8
	(27.62)	(16.43)	(24.86)	(95.30)			(26.75)	(16.37)		(36.11)		
C	16.75	104.6	26.50	31.33	43.25	135.93	29.50	1023.0	—	95 62	—	10,585.0
	(37.02)	(15.44)	(57.30)	(28.04)			(20.10)	(20.10)		(107.78)		
D	14.25	122.7	26.00	64.50	34.25	187.20	57.00	1248.8	—	80 20	—	9,268.8
	(31.49)	(18.11)	(43.24)	(57.72)			(38.84)	(24.54)		(90.40)		
E	19.00	87.6	15.80	91.00	34.80	178.60	47.50	1520.0	—	60 37	—	7,557.0
	(41.99)	(12.93)	(34.16)	(81.43)			(32.37)	(29.87)		(68.05)		
F	24.50	404.2	30.00	143.60	54.50	547.80	52.75	2398.0	—	59 10	—	8,308.0
	(54.14)	(59.65)	(64.86)	(128.50)			(35.95)	(47.12)		(66.61)		

G	24.00	247.2	23.25	142.63	47.25	389.83	61.75	1821.18	—	81 40	—	9,961.8
	(53.04)	(36.48)	(50.27)	(127.63)			(42.08)	(35.80)		(91.75)		
H	12.00	45.5	23.00	62.38	25.00	107.88	40.50	675.8	—	83 75	—	9,050.8
	(26.52)	(6.71)	(49.73)	(55.82)			(27.60)	(13.28)		(94.40)		
I	38.52	280.5	18.50	53.75	56.75	334.25	134.50	976.0	—	67 40	—	7,716.0
	(84.53)	(41.40)	(40.00)	(48.10)			(91.65)	(19.18)		(75.97)		
J	45.25	677.6	46.25	111.75	91.50	789.35	146.75	5088.7	—	88 72	—	13,960.7
	(100)	(100)	(100)	(100)			(100)	(100)		(100)		

註：1.（ ）內數字係指數。

2.第一次（春季），在12月12日處理，2月24日及4月15日調查。

第二次（夏季），在4月29日處理，6月3日及7月7日調查。

5. 除草劑處理對作物產量之影響：調查結果如表10。

表10. 除草劑處理年產量比較表

Table 10. Effect of herbicide treatment on the crop yield

處理 Treatment	7.2m² 小區平均產量 Ave. yield per 7.2m² plot		10 公畝產量 yield per 10 are		指數 Index	
	嫩莖數（支） No. of spears	嫩莖重（kg） Wt. of spears	嫩莖數（支） No. of spears	嫩莖重（kg） Wt. of spears	嫩莖數 No. of spears	嫩莖重 Wt. of spears
A	157.00	1.826	21,804.16	253.53	89.84	93.01
B	153.25	1.773	21,283.36	246.23	87.70	90.33
C	141.75	1.820	19,686.24	252.80	81.12	92.24
D	153.00	1.704	21,248.64	236.62	87.55	86.80
E	153.00	1.824	21,248.64	253.25	87.55	92.91
F	181.25	1.967	25,172.00	273.14	103.72	100.20
G	158.25	1.769	21,977.76	245.64	90.56	90.12
H	148.00	1.881	20,554.24	261.16	84.69	95.81
I	200.50	2.466	27,845.44	342.48	114.74	125.64
J	174.75	1.963	24,269.28	272.59	100	100

本試驗供試除草劑有 Diuron, Monuron, Herban, Afalon, Lasso, Alicep 六種，處理有6種單用處理，2種混用處理及2種對照處理，共計10種處理。藥劑處理第一次在冬季12月12日施行，雜草生長量分別在施藥後30天、45天、60天、75天調查，並在50天後（59年4月15日）調查其藥劑殘效性；第二次在春季4月29日施藥，35天後（6月3日）調查其雜草生長量；35天後（7月7日）調查藥劑之殘效性。

根據本試驗結果，供試除草劑對於濶葉草與尖葉草類均有顯著之除草效果，其除草效果遠較人工除草爲優。（參閱表7、8）

對於濶葉草類似以 Monuron (1kg/ha)，Diuron (1kg/ha) 之除草效果較佳；對於尖葉草類似以Lasso 1 ℓ/ha+Herban 0.6 kg/ha 混用處理之除草效果較佳。

又據本試驗兩次除草結果，供試之藥劑種類及用量，在本年均未發生對蘆筍植株及新產生之嫩莖有外觀的藥害，但如年年使用除草劑，藥劑在土壤內之殘存（retention）與累積（accumulation），或在土壤層內之溶解與下滲（leaching），是否將影響蘆筍之生育或產生藥害，有待更進一步之探討。

依本試驗供試藥劑，經初步田間觀察結果，Alicep 及 Afalon 之殘效性似較短，Monuron 及 Lasso 之殘效性似較長。根據 Sandhu & Greig (1966) 報告，兩氏曾利用 Bioassay 法測定土壤樣品，獲知 Monuron每公頃1～2公斤，Simazine 2～4公斤之用量，9個月後在土層0～3吋及3～6吋深處各有遺留，但在6～9吋深處，尚未見有任何藥劑之殘留。

就清除雜草之總量結果而言，春季以Lasso 1ℓ/ha+Diuron 0.5 kg/ha處理（H處理），Diuron 1kg/ha 處理（處理A）及 Lasso 2ℓ/ha處理（E處理）之除草效果最佳，發生之雜草量均僅爲放任對照區（J處理）之12%以下，亦即有9成之除草效果。Alicep 2.4ℓ/ha處理（F 處理）之除草效果最差，其雜草總量爲放任對照區（J處理）之60%，亦即僅有4成之除草效果。根據夏季再處理及調查結果，仍以 Lasso 1ℓ/ha+Diuron 0.5kg/ha混合處理（H處理）之除草效果最佳，Monuron 1kg/ha 處理（B處理）次之。Alicep 2.4ℓ/ha處理（F處理）之除草效果最差。（參閱表7、8）

根據本試驗雜草調查結果，春季施藥後75天每10公畝雜草量爲95公斤，而在夏季施藥後僅35天，雜草量達700餘公斤，雜草發生量高出7倍以上（參閱表8），影響作物生育甚大，而且夏季雨多土濕，人工除草不便，又不經濟，故以使用適當除草劑除草爲得計。

根據本試驗結果，所有供試藥劑雖對蘆筍植株及本年內新發生之嫩莖無外觀的藥害發生，但對嫩莖之產量略有影響，年產量略減4～13%之間。就施藥後前二個月之產量而言，處理區嫩莖數之發生減少8～20%，嫩莖重量減少4～13%，與年產量之結果相似。而蘆筍年產量與前2個月之早期產量經變方分析結果，減產之差異未達顯著之標準，因此，筆者認爲在雜草可能發生少之季節或土地，使用除草劑除草其效果不大，而且其產量亦受影響，且處理濃度愈高，其產量低減之趨勢亦愈顯著，故不宜使用除草劑。若在雜草發生繁茂之季節或土地，或人工除草不經濟之前提下，以使用除草劑爲得策。

總之，除草劑之選擇，除應具備良好之除草效果，及對作物無藥害，對產量無不良之影響而外，更應考慮其殘效期間及其遺毒問題。

四、摘　　要

綠蘆筍在植距20～50cm範圍內，栽植密度愈密，單位面積產量愈高，株距 20cm處理比 50cm區可增產30%。綠蘆筍園冬季間作冷凍用菜豆，如另施間作物之肥料，不僅可多收一作冷凍用菜豆，而且翌年蘆筍嫩莖之生產量能增加5～6%；但如不施間作物之肥料，則間作處理區之蘆筍嫩莖生產力比不間作對照區減低15～20%。

綠蘆筍園之濶葉草類，以 Monuron (1kg/ha) 或 Diuron (1kg/ha) 之除草效果較佳；對於尖葉草類，以Lasso (1ℓ/ha)+Diuron (0.5kg/ha) 混用處理及 Monuron (1kg/ha) 之除草效果較佳，而以Alicep (2.4kg/ha) 之除草效果最差。本試驗供試除草劑種類及用量，對於蘆筍植株及在同年內新發生之嫩莖，均無外觀之藥害發生，但對嫩莖產量略減4～13%。因此在雜草發生少之季節或土地，不宜使用除草劑；但在雜草發生繁茂或人工除草不便之條件下，仍以適量使用適當之除草劑爲得策。

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STUDIES ON THE IMPROVEMENTS OF QUALITY AND YIELD OF ASPARAGUS IN TAIWAN

III. Fundamental Experiments for Commercial Production of Green Asparagus

by

Chao-hsiung Lin [2]

Summary

Three experiments including (1) Plant spacing study, (2) intercropping study, (3) herbicide study were conducted under field condition with the objective of providing profitable information for asparagus growers to establish commercial production of green asparagus in Taiwan.

Spacing study showed that increased yield resulted from reducing distance between plants, i.e. the closer plant spacing we used, the higher yield per unit acreage we obtained. The yield from the 20 cm spacing plot was 30% higher than that from 50 cm spacing plot. The intercropping of snap beans for processing in winter asparagus field showed to be profitable, i.e. not only get one more crop of snap bean but also get 5-6% increase in asparagus yield of next year, provided that extra fertilizer of intercrop was applied. Otherwise, the yield of spears from the intercropped plot would be decreased by 15-20% than that from unintercropped plot. Effects of several herbicides such as Diuron, Monuron, Herban, Afalon, Lasso, Alicep and their combination in asparagus field were evaluated. Monuron (1 kg/ha) and Diuron (1 kg/ha) showed to have remarkable control for broad-leaved weeds, while, the combination of Lasso (1 L/ha) +Diuron (0.5 kg/ha) and Monuron (1 kg/ha) showed good control for narrow-leaved weeds. And the herbicides and rates used in this experiment didn't show phytotoxicity on old plant and new spears. Since these herbicides showed to have some slight influences on the yield of spears, the herbicides should not be applied in the season or on the land which weeds might be less vigorous. In case that weeds would thrive vigorously and costly, they would take water, fertilizer and light from the crop plants, the application of appropriate herbicide and rate seemed to be profitable. However the selection of appropriate herbicides, we should consider residual toxicity of herbicide in addition to the effectiveness of weed control, phytotoxicity on plants and yield of spears.

This study is a research problem supported by NSC & JCRR.

1 Published with the approval of the Director as paper No.537 (Q)

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石刁柏莖枯病藥劑防治試驗[1]

吳　福　壽[2]

一、緒　言

石刁柏又稱蘆筍，學名爲 *Asparagus officinalis* L. var. *altilis* L. ，現已成爲本省頗有前途之新興事業，惟其栽培歷史短暫，有關病害方面之基本知識尙感缺乏，爲此，本所曾進行石刁柏病害之病原學的調查(8) (1970)，據調查所獲初步結果顯示，本省石刁柏常見有莖枯病 (*Phoma asparagi*) 、褐斑病 (*Cercospora asparagi*) 、灰黴病 (*Botrytis* spp.) 及萎凋病 (*Fusarium oxysporum* f. *asparagi*) 等病害發生，尤以莖枯病在全省石刁柏栽培地區普遍蔓延，引起石刁柏植株不可忽視之損害，降低石刁柏產量及品質至鉅。又根據實驗室內試驗所得初步結果獲悉，Suzu tablet, Dithane M-22, Dithane stainless 等三種殺菌劑在 agar 平板上，對莖枯病菌 *Phoma asparagi* 之生長有抑制效果。爲確立石刁柏莖枯病之有效防治對策，保障石刁柏事業之不斷發展，乃進行各殺菌劑對石刁柏莖枯病之防治試驗。茲將所得結果整理成文，以供今後石刁柏栽培上莖枯病防治之參考。

二、試驗材料及方法

(一) 試驗材料

(1)供試石刁柏植株　美麗華盛頓品種。

(2)供試病原菌　*Phoma asparagi* 係自臺北縣三重市郊採集之石刁柏莖枯病罹病莖經分離培養者。

(3)供試殺菌劑　計 4 種，茲將其名稱及成分列於表一：

表一、供試殺菌劑及其有效成分

Table 1. 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 bisdithiocarbamate)	美國 Rohm & Haas Co.
Suzu tablet	20% Triphenyltin acetate	日本北興化學工業公司
Difolatan	80% Cis-N-〔(1,1,2,2-tetrachloroethyl) thiol〕 4-cyclohexene-1,2-dicarboximide	美國 Chevron Chemical Co.
Tenhide	19% Triphenyltin hydroxide	日本兼商公司

本試驗承蒙所長萬雄博士及本系胡主任開仁指示與鼓勵，文成後復蒙胡主任審閱。謹致謝忱。

1 試驗報告農試字第五三八號

2 臺灣省農業試驗所技佐

(二) 試驗方法

A. 室內藥劑試驗：

根據上年度實驗室內試驗所獲結果，發現在 agar 平板上對莖枯病菌 *Phoma asparagi* 生長有抑制效果之 Suzu tablet, Dithane M-22 兩種，本年又加入 Difolatan, Tehide 兩種殺菌劑進行試驗。

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日已形成柄子殼之病原菌，加殺菌水準備柄胞子浮懸液，浮懸液調製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(31.5, 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藥液中(每一種濃度 2ml.)；使殺菌劑溶液或浮懸液能成爲 25, 50, 100, 250, 500 p.p.m.濃度，另設無處理者爲對照。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)，並保存於 28°C 定温箱內，經48小時後測定各殺菌劑之效果。

2.各殺菌劑對石刁柏莖枯病菌菌絲之殺滅效果

本試驗將供試殺菌劑稀釋成 25, 50, 100, 250, 500, 1,000 2,000 4,000 p.p.m. 8 種濃度，自培養於 Potato sucrose agar 上經10日之病原菌菌叢，用直徑 5mm. 之 Cork borer 切取成洋菜薄圓板，並浸漬於上述不同濃度之各種殺菌劑溶液或浮懸液中（每一種濃度 10ml.)各經 10,20,30,60分鐘之後，用殺菌水充份洗滌三次，然後用吸水紙（經殺菌者）吸取圓板上過多水分，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培養基平板上之菌絲生長評價。

B. 生莖藥劑預防試驗

在無自然感染之虞之園地，選生長程度略同之美麗華盛頓石刁柏植莖，莖頂端附近留着有擬葉之分枝，插入三角瓶水中，每日換水，使其不枯萎。供試殺菌劑調製成 100, 250 p.p.m. 兩種濃度，另設無施藥區爲對照，用小型噴霧器向供試個體同量均勻噴射後，置放室內催乾 2～3 小時，然後以同型噴霧器噴霧莖枯病菌柄胞子浮懸液接種，接着移放具有温濕度控制之接種箱內，保持 28°C，經48小時取出移放室內，15日後調查莖上病斑數，檢討各殺菌劑之防病效果。

C. 盆栽植株試驗

應用花盆（內盛無菌土壤）培育生長同樣健旺之石刁柏植株，根據室內試驗及生莖藥劑預防試驗所獲結果，將對莖枯病菌生長抑制有效及有預防莖枯病發生效果之 Suzu tablet,Dithane M-22兩種殺菌劑供試，爲使其接近田間實地施藥，將其濃度 Suzu tablet 分爲 1/800(=250p.p.m.),1/1,000(=200p.p.m.),1/1,200(=約 167p.p.m.) 三種， Dithane M-22 分爲 1/400 (=2,000p.p.m.) ，1/500(=1,600p.p.m.) ，1/600(=約1,333p.p.m.) 三種供試。供試殺菌劑溶液調製後，分別以玻璃製小型噴霧器（附橡皮雙連球）噴霧（另設無施藥區爲對照），經 3 小時催乾之後，以同型噴霧器噴霧莖枯病菌柄胞子浮懸液（每 ml. 約含有 250,000 個胞子之濃度）接種，然後移放有温濕度控制之接種箱內，保持28°C，經48小時後取出置放温室內，經 7 日及15日分別調查各處理之發病情形，檢討各殺菌劑預防莖枯病發生之效果。

三、試 驗 結 果

(一) 各殺菌劑對莖枯病菌柄胞子發芽之毒效

本試驗每一處理（每種藥劑之每種濃度）用載玻片 3 片，重複 6 次，經48小時後測定柄胞子發芽率。其結果如表二：

表二、各殺菌劑對莖枯病菌柄胞子發芽之毒效

Table 2. 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
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
Difolatan	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
Tenhide	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		4,645	2,578	55.50	100.00

據表二，顯示 Suzu tablet, Dithane M-22, Difolatan, Tenhide 等之效果均良佳，其濃度 25p.p.m. 尙能抑制柄胞子之發芽。

(二) 各殺菌劑對石刁柏莖枯病菌菌絲之殺滅效果

本試驗每一處理（每一種藥劑之每一種濃度）各浸漬 4 個洋菜圓板，重複 6 次，經 4 日後觀察菌絲之生長情形，其結果如表三：

表三、各殺菌劑對石刁柏莖枯病菌菌絲之殺滅效果

Table 3. The killing effect of various 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	4,000	+	−	−	−
	2,000	+	+	−	−
	1,000	+	+	+	+
	500	++	++	++	++
	250	++	++	++	++
	100	++	++	++	++
	50	++	++	++	++
	25	+++	+++	++	++
Suzu tablet	4,000	−	−	−	−
	2,000	−	−	−	−
	1,000	−	−	−	−
	500	−	−	−	−
	250	−	−	−	−
	100	+	+	+	+
	50	+	+	+	+
	25	++	++	++	++
Difolatan	4,000	+++	++	+	+
	2,000	+++	++	++	+
	1,000	+++	++	++	++
	500	+++	+++	++	++
	250	+++	+++	+++	++
	100	+++	+++	+++	+++
	50	+++	+++	+++	+++
	25	+++	+++	+++	+++
Tenhide	4,000	+	+	+	−
	2,000	+	+	+	−
	1,000	+	+	+	+
	500	+	+	+	+
	250	+	+	+	+
	100	++	+	+	+
	50	++	++	+	+
	25	++	++	+	+
CK		+++	+++	+++	+++

註：+ 之多寡表示菌絲發育程度，− 表示無菌絲長出。

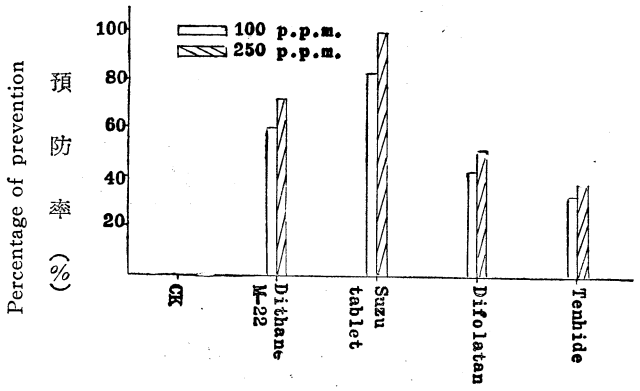
Note: Number of + marks indicates the grade of mycelial development, − mark indicates no mycelium growth.

據上表㈢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

滅莖枯病菌菌絲，其次 Dithane M-22 之 2,000 p.p.m. 浸漬30分鐘，Tenhide 之 2,000 p.p.m. 浸漬60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，其濃度即使高至 4,000 p.p.m. 亦無法完全殺滅菌絲。

（三）生莖藥劑預防試驗

本試驗施藥接種後，將生莖置放 28°C 接種箱內，經48小時後取出移放室內，經15日後調查莖上病斑數，檢討各殺菌劑之預防效果，其結果如圖一：



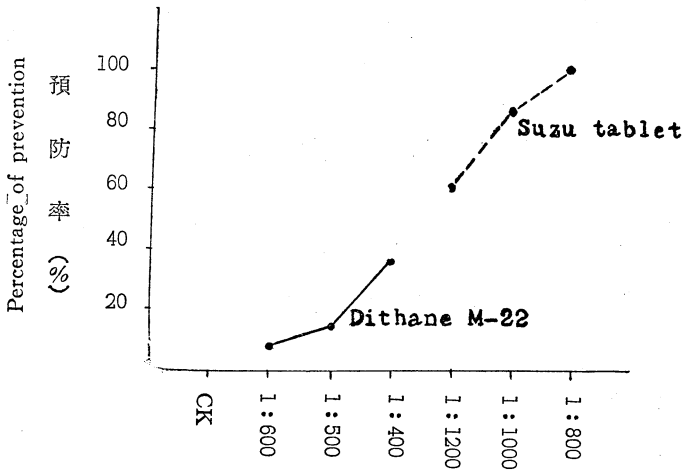
圖一・各殺菌劑對石刁柏莖枯病之預防效果（生莖）

Fig. 1. The effectiveness of various fungicides for prevention of asparagus stem blight (stalk)

據上圖㈠所示，供試殺菌劑中以 Suzu tablet 最爲有效，在 250 p. p. m. 之濃度，其預防率達100%，而在 100 p.p.m. 亦有相當效果，其次， Dithane M-22 亦稍有效果，其餘殺菌劑效果較差。

（四）盆栽植株試驗

本試驗以石刁柏植株施藥接種後置放 28°C 接種箱內，經48小時後取出移放温室內，15日後調查莖上病斑數，檢討各殺菌劑之預防效果，其結果如圖二：



圖二・各殺菌劑對石刁柏莖枯病之預防效果（盆栽植株）

Fig. 2. The effectiveness of various fungicides for prevention of asparagus stem blight (potted plant)

據上圖(二)顯示 Suzu tablet 之效果較優，就濃度而言以 $^1/_{800}$液（=250 p.p.m.）之效果最著，其次爲 Suzu tablet 之$^1/_{1,000}$液（=200p.p.m.），而 Dithane M-22 之預防效果較遜。

四、討　　論

據上年度實驗室內試驗所獲結果，發現在 agar 平板上對莖枯病菌之生長有抑制效果之 Suzu tablet, Dithane M-22，另加入 Difolatan, Tenhide 等兩種殺菌劑繼續進行試驗結果，4種殺菌劑均有抑制莖枯病菌柄胞子發芽之效；對莖枯病菌菌絲之殺滅效果仍以 Suzu tablet 爲最優，其次除 Dithane M-22 之 2,000 p.p.m. 浸漬30分鐘之外，尙有 Tenhids 2,000 p.p.m. 浸漬60分鐘亦有殺滅菌絲之效果。

在無自然感染之虞之圃地所選石刁柏生莖進行施藥、接種莖枯病病原菌結果，如圖一、所示供試4種殺菌劑對莖枯病之預防效果以 Suzu tablet 最爲有效，在 250 p.p.m. 之濃度其預防率達100%。

應用盆栽植株施藥、接種莖枯病病原菌結果，Suzu tablet 之效果爲最優，就濃度而言，以$^1/_{800}$液（=250 p.p.m.）之效果爲最著，此與室內試驗及生莖藥劑預防試驗結果相符，而 Dithane M-22 之效果較遜。

至於對石刁柏莖枯病在室內藥劑試驗，生莖藥劑預防試驗及盆栽植株試驗效果均佳良之殺菌劑 Suzu tablet，在田間應用上之效果如何，仍待日後進一步之研究探討。

五、摘　　要

1.供試殺菌劑 Suzu tablet, Dithane M-22, Difolatan, Tenhide 等均對莖枯病菌柄胞子發芽之毒效甚佳。

2.對莖枯病病原菌菌絲之殺滅效果，供試殺菌劑中以 Suzu tablet 爲最優，其次 Dithane M-22, Tenhide 之 2,000 p.p.m. 亦有抑制之效。

3.殺菌劑對莖枯病之預防效果，在生莖藥劑預防試驗以 Suzu tablet 之 250 p.p.m. 爲最優，其次 Dithane M-22 亦稍有效果。

4.在盆栽植株試驗，殺菌劑對預防莖枯病發生之效果，仍以 Suzu tablet 爲最著，而 Dithane M-22 之效果較遜。

5.在室內藥劑試驗、生莖藥劑預防試驗、盆栽植株試驗效果均優之殺菌劑在田間實際應用上之效果，仍待日後進一步之探討。

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EXPERIMENT ON THE CHEMICAL CONTROL OF STEM BLIGHT OF ASPARAGUS

by

F. S. Wu

Summary

The asparagus stem blight caused by *Phoma asparagi* Sacc. was a destructive disease found in many fields of the asparagus growing areas in this Island. The present experiment deals with the fungicidal test, in order to evaluate cotrol measure of the asparagus stem blight. The results will be summarised as follows:

1. In the toxic effect of various fungicides on pycnidiospore germination of *Phoma asparagi* test, the fungicides Suzu tablet, Dithane M-22, Difolatan, Tenhide gave the good results.

2. In the fungicidal test with the fungus mycelium, Suzu tablet was the most effective ones, and Dithane M-22, Tenhide at concentration of 2,000 p.p.m. had some inhibitory effect.

3. The effectiveness of various fungicides for prevention of asparagus stem blight by asparagus stalk test, Suzu tablet at concentration of 250 p.p.m. was the most effective ones, and Dithane M-22 showed some effectiveness.

4. The preventive effectiveness of fungicides on asparagus stem blight in green house experiment, Suzu tablet was the most excellent ones, and Dithane M-22 be inferior to the former.

5. Effective fungicides on inhibiting the development of causal organism and on prevention of asparagus stem blight disease occurrence, selected by laboratory test, asparagus satlk test and green house experiment are expected to be checked by field experiment.

馬鈴薯捲葉病病原毒素在桃蚜體內之潛伏期研究

楊 一 郎

一、緒 言

馬鈴薯捲葉病 (Potato leaf roll virus) 毒素之經由蚜蟲媒介傳播，首見於Botjes (1920) 之報告。此後Kasai (1921) ， Smith (1929, 1931) ,福士 (1946) ，村山 (1964) 等報告，證實*Myzus persicae* Sulz. , *Aulacorthum matsumuraeanum* Hori, *Macrosiphum euphorbial* Thom. 爲本病之媒介蚜蟲。Kirkpatrick (1948) 報告*Physalis floridana* Rydb. 爲本病之檢定植物。關於本病之經由蚜蟲傳播，Day (1955) , Harrison (1958) , Heinze (1959) , Kassanis (1952) , MacCarthy (1954) ,宮本セツ (1966) ， 大島信行 (1966) ， Smith (1931) , Stegwee (1958, 1961) , Williams (1957) 等謂本病在蟲體內具有潛伏期。 Kirkpatrick (1952) , Klostermeyer (1953) , Meester (1956) ，等則謂本病之蟲媒時間很短， 並無潛伏期。 Day (1955) , Heinze (1959) ，Kirkpatrick (1952) , MacCarthy (1954) , 大島信行 (1966) ， Smith (1965) 等報告則謂蟲媒傳播所需時間，因蟲體，接種源 (virus source plant) 及温度而有異。 Day (1955) 報告說明本病病原毒素，可在蟲體內增殖。Stegwee (1958) 曾以蟲體內注射法， 認定本病病原毒素可在蟲體內增殖；而 Harrison (1958) 則否定其增殖。 本試驗在探究本病之桃蚜媒介傳播所需時間及蟲體內潛伏期，藉供設法防治之參考，1964至1965 年間在日本北海道大學農學院進行，承村山大記教授及小島誠博士指導與輔助，謹誌謝忱。

二、材料與方法

將馬鈴薯捲葉病罹病塊莖（男爵薯）所生長之病株，經以桃蚜 (*Myzus persicae* Sulz.) 傳染接種在*Physalis floridana* Ridb. 及 *Datura stramonium* L., 以此2種植物經感染一個月之幼葉爲接種源，供試接種植物 (*test plants*) 爲栽植在直徑 9 公分，12公分及15公分花鉢之*P. floridana*,*D. stramonium* 及農林 1 號馬鈴薯 ，經移植 2 ～ 4 星期之 2 ～ 4 葉期健全幼苗 。供試桃蚜爲無翅胎生雌蟲，飼育在昆蟲網箱之甜菜上。試驗在玻璃温室中進行 (18～28°C)，蚜蟲移放時使用毛筆。本試驗均以 *Myzus persicae* 供試，並以罹病之 *Physalis floridana*爲接種源，設下列三種處理：

（一）蚜蟲之獲毒吸食時間 (acquisition feeding period) 將蚜蟲先在室温中斷食 (Starvation) 3 ～ 5 小時；然後移至玻璃皿 (直徑 9 公分) 中之接種源病葉，觀察蚜蟲吸食並紀錄其時間。獲毒吸食時間分爲 5 、10 、20 、30 、60分鐘五種。各種獲毒吸食時間終了後將蚜蟲分別移至供試接種植物，每苗放 1 隻蚜蟲，經接種吸食48小時後除去蚜蟲，並觀察接種植物之罹病率。

（二）蚜蟲之接種吸食時間 (inoculation feeding period) 將蚜蟲斷食 3 ~ 5 小時後移至接種源上獲毒吸食48小時，再斷食 3 小時，然後移至接種植物上，每苗放 1 隻蚜蟲，接種吸食時間分爲 5 、10 、20 、30 、60分鐘五種，接種吸食時間終了後除去蚜蟲，並觀察接種植物之罹病率。

（三）蚜蟲體內之潛伏期 (laten period) 將蚜蟲先斷食 3 ～ 5 小時然後移至接種源上獲毒吸食 6 小時再移至接種植物上，每苗放 1 隻蚜蟲，接種吸食 6 小時後將此蚜蟲再移至另 1 株供試植物上，如此將同一隻蚜蟲每隔 6 小時重行移至另 1 株供試植物上，連續 7 次，並觀察其罹病情形。

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1 試驗報告農試字第五三九號
2 臺灣省農業試驗所嘉義農業試驗分所技士

三、結果與討論

（一）不同獲毒吸食時間對桃蚜傳播本病之影響試驗（第一處理），結果如表 1 。

表 1. 不同獲毒吸食時間對桃蚜傳播馬鈴薯捲葉病之影響

Table 1. Transmission of potato leaf roll virus by *Myzus Persicae* using different acquisition feeding periods.

獲毒吸食時間(分) duration of acquisition feeding (min.)	罹病株數／接種株數 Plants infected/Plants inoculated				罹病率 (%) infected percentage
	農林一號	*P. floridana*	*D. stramonium*	total	
5	5/16	1/63	0/10	6/89	6.7
10	7/29	3/88	0/10	10/127	7.9
20	6/11	1/60	0/10	7/81	8.6
30	10/28	1/81	0/10	11/119	9.2
60	0/5	5/22	—	5/27	18.5

由上表可知，桃蚜在本病病株上獲毒吸食 5 分鐘即可傳播本病，所得傳染罹病率達 6.7%；60分鐘者爲18.5%。獲毒吸食時間愈長，其傳播能力愈高。

（二）不同接種吸食時間對桃蚜傳播本病之影響試驗（第二處理），結果如表 2 。

表 2. 不同接種吸食時間對桃蚜傳播馬鈴薯捲葉病之影響

Table 2. Transmission of potato leaf roll virus by *Myzus persicae* vary with different inoculation feeding periods.

接種吸食時間(分) duration of inoculation feeding (min.)	罹病株數／接種株數 Plants infected/Plants inoculated				罹病率 (%) infected percentage
	農林一號	*P. floridana*	*D. stramonium*	total	
5	2/11	2/44	0/30	4/85	4.7
10	16/37	9/61	3/31	28/129	21.7
20	11/36	8/50	10/29	29/115	25.2
30	13/26	11/43	9/27	33/96	34.3
60	14/21	5/21	—	19/42	45.2

由上表可知，本病之帶毒桃蚜在供試植物上接種吸食 5 分鐘即可傳播本病，所得傳染罹病率達 4.7%；60分鐘爲45.2%。接種吸食時間愈長，其傳染罹病率愈高。

（三）馬鈴薯捲葉病病原毒素在桃蚜體內之潛伏期試驗（第三處理）結果如表 3 。

表 3. 馬鈴薯捲葉病病原毒素在桃蚜體內之潛伏期

Table 3. Laten period of potato leaf roll virus in the *Myzus persicae*.

供試植物 Test plants	獲毒吸食時間(小時) Duration of acquisition feeding (hrs.)	接種吸食時間(小時) Duration of infection feeding (hrs.)	接種蟲數 No. of insects per plant	獲毒經過不同時間後之接種所得感染結果 Infected plant discovered after transinoculation (hrs.)						
				12	18	24	30	36	42	48
P. floridana	6	6	1	−	+	+	+	+	+	+
D. stramonium	6	6	1	−	−	+	+	+	+	+

−：健全株 (Healthy)　　+：感染株 (Infected)

由上表可知，桃蚜在本病病株上獲毒吸食帶毒後，須經18～24小時以上之潛伏期，始能傳播本病，即本病病毒在桃蚜體內須經18～24小時之潛伏期始可由蚜蟲媒介傳播。綜合上述三項試驗處理結果，可知桃蚜對本病之傳播，經3～5小時斷食後之桃蚜經5分鐘之獲毒吸食即能帶毒，而經5分鐘之接種吸食即可媒介傳播；又帶毒桃蚜須經18～24小時後始能傳播本病，可見本病病原毒素在桃蚜體內之潛伏期爲18～24小時以上。由上項結果推論桃蚜之獲毒吸食時間愈長，所吸得毒素濃度愈高，故其傳播能力亦愈高。又據Day (1955) 推論蟲體內之潛伏期係病原毒素由蚜蟲之腸移行至唾腺所需之時間。

四、摘　要

本試驗在探究不同獲毒吸食時間及接種吸食時間對桃蚜傳播馬鈴薯捲葉病之影響，及該病病原毒素在桃蚜體內之潛伏期。本試驗結果桃蚜經由 *Physalis floridana* Rydb. 之馬鈴薯捲葉病病株獲得病毒所需較短獲毒吸食時間爲5分鐘。本病帶毒桃蚜對農林1號及 P. floridana傳染病毒所需較短接種吸食時間爲5分鐘。在玻璃溫室中，桃蚜經由本病病株獲毒吸食6小時後，本病病毒在桃蚜體內之較短潛伏期爲18～24小時。本試驗結果與 Day (1955)，Williams (1957)，Stegwee (1961) 及 Tanaka (1970) 之報告相近似。

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LATENT PERIOD OF POTATO LEAF ROLL VIRUS IN THE GREEN PEACH APHID

I. L. Yang

Summary

This paper reports the relationship of acquisition feeding period, inoculation feeding period and latent period to the aphid transmission of potato leaf roll virus by *Myzus persicae* Sulz.,

The shortest period for acquisition feeding of potato leaf roll virus by green peach aphid from infected *Physalis floridana* Rydb. plants was 5 minutes. Viruliferous aphids transmitted the virus to healthy Nunlin No. 1 and *P. floridana* plants by inoculation feeding of at least 5 minutes.

The shortest latent period of potato leaf roll virus in aphids after acquisition feeding of 6 hours was found to be 18-24 hours in green house temperature.

These results are comparable to those described by Day (1955), Williams (1957), Stegwee (1961) and Tanaka (1970).

酸性紅壤施用石灰磷肥與接種對於荳料作物效應之研究

Ⅰ.接種根瘤菌對琉球大豆之影響

張國勤　梁燦生[2]

一、緒　言

在本省臺地紅壤上之果園及牧草地，以土壤地力瘠薄、酸性强，致荳科作物生育欠佳，生草收量甚低，農民得不償失，因此荳科綠肥及牧草栽培不廣。

最近經筆者在此等地區舉行精密田間試驗結果，若能加施石灰（調整土壤 pH）及施用足量磷肥，可使秋植紫雲英及苕子之生草收量達到25,000公斤／公頃以上，春植琉球大豆達到20,000公斤／公頃；同時發現如連續種植某一種荳科作物時，逐年增加生產量甚多。根據中興大學吳敏慧教授之多篇報告，此可能因根瘤菌之作用而提高其收量，祇以根瘤菌種類繁多，且各有其一定之寄主，接種效果難期一致。以筆者上年度試驗結果爲例，苕子根瘤菌接種效果良好，但琉球大豆接種後則無效果可言，此殆琉球大豆非大豆根瘤菌之合適寄主所致。茲爲求得一適於琉球大豆根瘤菌以供接種而增加其產量，特再以自琉球大豆本身分離出之根瘤菌重作試驗，觀察其增產效果。

二、研究方法及步驟

（一）田間設計仍用上年度之試驗地，除新接種外，餘不再行處理，原設計爲複裂區，4重複，石灰2平準，磷肥3平準，接種2平準，共12種處理列如下：

1.大區	（1）石灰500 公斤／公頃（條施）	L_1
	（2）石灰5,000 公斤／公頃（撒施）	L_2
2.中區	（1）P_2O_5 80 公斤／公頃	P_1
	（2）P_2O_5 120 公斤／公頃	P_2
	（3）P_2O_5 160 公斤／公頃	P_3
3.小區	（1）不接種根瘤菌	I_0
	（2）接種根瘤菌	I_1

小區面積 20m², 長 5m, 寬 4m。供試品種爲球琉大豆（Glycine Koidzmii），條播，行距80cm，每小區種植5行，播種量15公斤／公頃，即每小區播種量爲30公克。氮肥暫不施用，視以後生長情形酌予追肥，但以不超過20公斤／公頃爲度；鉀肥用氯化鉀 100公斤／公頃，作爲基肥施用；磷肥及石灰不再施，但接種根瘤菌。試驗地點係在桃園縣平鎮鄉。

（二）根瘤菌之調查方法如下：

本試驗係作者接受國家長期發展科學委員會研究計劃之一，其經費由農復會補助。所用之琉球大豆根瘤菌，由本所農業化學系土壤微生物研究室林技正敬德供應，謹致謝忱。

1.試驗報告農試字第五四〇號

2.臺灣省農業試驗所技士、技佐。

1.在收刈時（始花期）每處理之各小區選擇中庸者5株，分別調查其主根及第一分出之支根上根瘤數目。

2.再將紅色及非紅色之根瘤菌分別計數。

3.將有效根瘤（紅色）用清水洗淨後烘乾，再秤其乾物重。

（三）化學分析：

1.土壤有效磷之測定　試驗地於供試前混合採取表土一份，試驗後各處理每小區分別採土，分析其有效性磷素。

2.土壤PH之測定　前述之土壤以玻璃電極法測定其PH值。

（四）盆栽試驗主要係觀察根瘤菌接種效果，盆栽所用之土壤，係採自田間試驗地附近未曾做過試驗者，以供盆栽之用，其處理計有：

1.不施石灰及磷肥，亦不接種根瘤菌。（L_0 P_0 I_0）

2.不施石灰及磷肥，但接種根瘤菌。（L_0 P_0 I_1）

3.施石灰5,000公斤／公頃及P_2O_5 120公斤／公頃，但不接種根瘤菌。（L_1 P_1 I_0）

4.施石灰5,000公斤／公頃及 P_2O_5 120公斤／公頃，並接種根瘤菌。（L_1 P_1 I_1）

以上各處理重複6次，每盆土壤8公斤，各種琉球大豆3株，調查方法與田間試驗同。

三、結果及討論

本項研究之田間試驗部份，琉球大豆於58年4月28日播種，9月19日收刈；盆栽試驗部份在臺北本所舉行，於58年5月8日播種，8月23日收刈。

田間試驗結果，鮮莖葉收量列於表1.，其變方分析示如表2，差異顯著性比較示於表3。

表1.　田間試驗琉球大豆鮮莖葉收量表

Table 1.　Green weights of Glycine koidzumii

處理代號 Treatment	公斤／小區 kg/Plot				平均 Average	收量 Yield
	I	II	III	IV	公斤／小區 kg/plot	公斤／公頃 kg/ha
$L_1P_1I_0$	21.50	16.10	17.50	19.25	18,588	9,294
$L_1P_1I_1$	22.50	14.70	14.17	18.50	17,468	8,734
$L_1P_2I_0$	20.50	20.00	20.00	18.75	19,813	9,907
$L_1P_2I_1$	19.00	30.50	20.00	22.50	23,000	11,500
$L_1P_3I_0$	28.75	22.50	20.00	18.00	22,313	11,157
$L_1P_3I_1$	39.63	25.00	19.50	23.75	26,970	13,485
$L_2P_1I_0$	19.00	23.00	16.00	20.00	19,500	9,750
$L_2P_1I_1$	21.00	25.70	21.00	15.75	20,863	10,432
$L_2P_2I_0$	35.30	31.10	20.00	28.50	28,725	14,363
$L_2P_2I_1$	32.63	32.20	31.67	25.00	30,375	15,188
$L_2P_3I_0$	38.00	35.80	33.50	21.00	32,075	16,038
$L_2P_3I_1$	50.80	44.20	42.50	33.00	42,625	21,313

表 2， 琉球大豆鮮莖葉收量變方分析表

Table 2. Analysis of variance of the yield of Glycine koidzumii

變異原因 Source of variation	自由度 Degree of freedom	平方和 Sum of squares	均方 Mean squares	F 值 F-Value	理論 F 值 Theoretical F-Value at 5 %	1 %
區集 Block	3	387.62				
大區試因(L) Main-Plot	1	706.34	706.34	28.41*	10.13	34.12
大區機差 (Ea) Error a	3	74.57	24.86			
中區試因 (P) Sub-plot	2	1133.79	566.90	7.81**	3.88	6.93
L×P	2	562.23	281.11	3.73	3.88	6.93
中區機差 (Eb) Error b	12	870.67	72.56			
小區試因 (I) Plot	1	137.80	137.80	3.71	4.41	8.28
P×I	2	1263.52	631.76	17.08**	3.55	6.01
L×I	1	384.07	384.07	10.33**	4.41	8.28
L×P×I	2	383.72	191.86	5.16	3.55	6.01
小區機差 (Ec) Error c	18	669.45	37.15			
總計 Total	47	3338.57				

註 * 表示達顯著平準　　** 表示達極顯著平準

表 3． 琉球大豆鮮莖葉收量差異比較表

Table 3. Difference among treatments

項目 Item		大區 Main plot		中區 Sub-plot			小區 Plot	
處理代號 Treatment		L_2	L_1	P_3	P_2	P_1	I_1	I_0
平均產量 Average yield (kg/ha)		8,708	6,407	6,199	5,096	3,820	8,065	7,050
指數 Index		135	(100)	162	133	(100)	114	(100)
顯著變域 Significant ranges	5 %							
	1 %							

根據以上分析結果顯示：琉球大豆鮮莖葉收量以施用磷肥爲優，已達 1 %顯著平準；而施石灰區以撒施5,000公斤／公頃較條施500公斤／公頃爲優，達 5 %顯著平準。接種根瘤菌之效果略優於未接種者，但不顯著。

琉球大豆盆栽試驗鮮莖葉收量列於表 4 ，其變方分析示於表 5 ，差異顯著性比較示於表 6 。

表 4. 琉球大豆盆栽試驗鮮莖葉收量表

Table 4. Green weight of potting Glycine koidzumii

處理代號 Treatment	重複 Replication						平均 Average
	I	II	III	IV	V	VI	
L_0 P_0 I_0	108.5	84.5	89.0	84.7	74.0	64.5	84.2
L_0 P_0 I_1	92.2	113.5	38.5	57.5	194.0	67.5	93.9
L_1 P_1 I_0	129.0	151.5	170.0	248.0	240.0	149.5	181.3
L_1 P_1 I_1	109.2	271.5	324.5	158.0	196.0	206.0	210.9

表 5. 琉球大豆盆栽試驗鮮莖葉收量變方分析表

Table 5. Analysis of variances of the yield of Glycine koidzumii

變因 Source of variation	自由度 Degree of freedom	平方和 Sum of squares	均方 Mean squares	F 值 F-Value	理論 F 值 Theoretical F-Value 5 %	1 %
區集 Block	5	11932.31	2386.46			
處理 Treatment	3	71676.61	23892.20	7.57*	3.29	5.42
機差 Error	15	47293.29	3152.88			
總數 Total	23	130902.21				

表 6. 琉球大豆盆栽試驗鮮莖葉收量差異比較表

Table 6. Difference among treatments

處理代號 Treatment		L_1 P_1 I_1	L_1 P_1 I_0	L_0 P_0 I_1	L_0 P_0 I_0
平均收量 (克/盆) Average yield (g/pot)		201.9	161.3	93.9	84.2
指數 Index		262	191	111	(100)
顯著變域 Significant ranges	5 %				
	1 %				

根據以上分析結果顯示，琉球大豆接種根瘤菌之結果，在施石灰及磷肥之情況下有效，其差異已達 1 %顯著平準；而在未施石灰及磷肥情況下，雖略有差異，但不顯著。

琉球大豆田間試驗及盆栽試驗之根瘤數與乾物調查結果，示於表7及表8。

表7. 田間試驗琉球大豆根瘤數及乾物重

Table 7. Number and dry weight of nodules obtained by field test

處理代號 Treatment	根瘤數目 (個／株) Number of nodules (No./Plant)	指數 Index	根瘤乾物重(公克／株) Dry weight of nodules (g/Plant)	指數 Index
L_1 P_1 I_0	55.5	(100)	0.53	(100)
L_1 P_1 I_1	127.5	229.7	0.97	183.0
L_1 P_2 I_0	60.8	109.5	0.29	54.7
L_1 P_2 I_1	208.5	375.7	1.31	247.2
L_1 P_3 I_0	35.8	64.5	0.40	75.5
L_1 P_3 I_1	320.8	578.0	1.97	371.7
L_2 P_1 I_0	16.5	29.7	0.17	32.1
L_2 P_1 I_1	281.5	507.3	1.14	215.1
L_2 P_2 I_0	52.5	94.6	0.57	75.5
L_2 P_2 I_1	435.5	784.6	1.68	317.0
L_2 P_3 I_0	60.8	109.5	0.47	88.7
L_2 P_3 I_1	359.5	647.7	1.68	317.0

註：以上數字係由每重複每區採樣5株，計20株之平均數。

表8. 盆栽試驗琉球大豆根瘤數及乾物重

Table 8. Number and dry weight of nodules obtained by Potting test

處理代號 Treatment	根瘤數目 (個／盆) Number of nodules (No./Pot)	指數 Index	根瘤乾物重 (公克／盆) Dry weight of nodules (g/Pot)	指數 Index
L_0 P_0 I_0	57	(100)	0.70	(100)
L_0 P_0 I_1	69	121.1	0.64	91.4
L_1 P_1 I_0	343	601.8	2.65	378.6
L_1 P_1 I_1	370	649.1	2.51	358.6

註：以上數字係由每盆3株，計18株之平均數。

根據上表看出，田間試驗各處理間根瘤菌數及其乾物重對於接種琉球大豆根瘤菌所生之差異甚大，但盆栽試驗所生之差異較小，此可能在生長初期遭受病蟲害影響所致。

田間試驗琉球大豆收割後採取土壤分析整理結果，示於表9及表10。

表 9. 土壤中殘存 P_2O_5 量 (kg/ha)

Table 9. Amount of residual P_2O_5

處理 Treatment	L_1	L_2	平均 Average
P_1	122.3	76.8	99.6
P_2	242.5	92.5	167.5
P_3	334.2	147.0	240.6
平均 Average	233.0	105.6	

註：該試地未施磷肥處理前，其土壤含磷素〔0〕。

根據上表看出，土壤中殘存之磷素與當初施用量間有直接之關係。在石灰多量區之處理殘存磷素較少，此可能因 Bray No. 1 法所施用之磷肥與石灰結合，而抽出效果較差之故。

表10. 跡地土壤 PH值

Table 10. PH value of soil after harvest

處理項目 Treatment	L_1	L_2	平均 Average
P_1	5.15	6.05	5.60
P_2	4.95	6.15	5.55
P_3	5.15	6.10	5.62
平均 Average	5.08	6.10	

註：該試地未施石灰處理前，其土壤 PH 值爲4.8。

根據上表看出，在紅壤上施用多量石灰區，經過二年種植三期作豆科植物，仍可維持土壤 pH在6.0以上，然該試地土壤之 pH 僅降低 0.8左右，由此推測再二年以後，可能該土壤 pH 尙不致降低至5.0以下。

綜合以上試驗結果，可觀察得下列諸事實：

（1）就田間試驗鮮莖葉收量而言，仍以每公頃施用石灰 5,000公斤及磷肥 P_2O_5 160公斤爲優；至於琉球大豆接種根瘤菌之效果，雖不顯著，但均優於未接種者。

（2）盆栽試驗鮮莖葉收量，施用石灰及磷肥均有顯著之效果，琉球大豆接種根瘤菌，在施石灰及磷肥之情形下有效；而在未施石灰及磷肥之情形下，雖略有差異，但不顯著，此可能在紅壤上種植荳科植物，土壤反應及有效性磷含量爲其限制因子，不施石灰及磷肥，雖接種根瘤菌亦不能發生甚大作用。

（3）田間試驗各處理間根瘤菌數及其乾物重，對接種琉球大豆根瘤菌所生之差異甚大，有接種根瘤菌之處理，根瘤數目既多，且根瘤乾物重亦大；但盆栽試驗所生之差異較小，此可能在生長初期遭受病蟲害影響所致。

（4）土壤中殘存 P_2O_5 量與當初施用之量有直接關係，施用多量石灰區，經過二年種植三期作荳科植物，仍可維持土壤 pH 在6.0以上，然該試地土壤之 pH 僅降低 0.8左右，可能再二年後

，該土壤 pH 尙不至於降低至5.0以下。

四、摘要及結論

本試驗分田間及盆栽兩部份，其目的在探求適於琉球大豆根瘤菌，以供接種而增加其產量，特再以自琉球大豆本身分離出之根瘤菌重作試驗，以觀察其增產效果。可得結論如下：

（1）由本試驗結果，確定琉球大豆根瘤，非爲一般大豆之根瘤菌，故必須自琉球大豆本身分離出之根瘤菌接種，方有顯著效果。

（2）在施用石灰及磷肥之情形下，接種琉球大豆根瘤菌有顯著之效果。

（3）田間試驗各處理間，接種琉球大豆根瘤菌與否，對根瘤數及乾物重所生之差異甚大，接種處理之根瘤數既多，根瘤乾物重亦大。

（4）施用石灰與磷肥之殘效，以每公頃施用5,000公斤及磷肥施用160公斤（P_2O_5）爲優。

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A STUDY ON THE RESPONSE OF LEGUME PLANT TO LIME, PHOSPHATE AND INOCULATION ON ACID RED SOILS[1]

1. The Effect of Inoculation on the Growth of *Clycine Koidzum.*

by

K.C. Chang and T.S. LIANG[2]

Summary

Field experiments of double split Plot design with four replications were carried out at Ping-Cheng to investigate the effect of lime, phosophate and inoculation on the growth of legume plant, *Clycine Koidzum.* A pot trial was carried out during the same time at TARI in Taipei for the same purpose but different treatments. In the field expriment, two levels of lime, three levels of phosphate, two kinds of inoculation were involved. While in the pot trial, there were four treatments: (1) without lime, phosphate and inoculation (2) without lime and phosphate, with inoculation (3) with lime and phosphate, without inoculation (4) with lime, phosphate and inoculation.

The experimental results may be summarized as follows:

1. Results showed that *Rhizobium* bacteria isolated from the root nodules of *G. koidzum* was different from the other strains of *Rhizobium japonicum.* Inoculation of the said *Rhizobium* bacteria had a significant effect on growth of *G. koidzum.*
2. Data indicated that liming and phosphate application had a better effect on the fresh weight of G. *koidzum* plants inoculated with the so-called *Rhizobium* bacteria.
3. The results of the yield expriments revealed marked difference in the number and dry weight of nudules between inoculation treatment. There were more number and higher dry weight of nudules in the plots with inoculation than that without inoculation.
4. Application of lime with 5 tons/ha. and phosphate 160 kg/ha had a better results on the residual effect in fertility.

This study is a research Problem supported by the National Science Committee & JCRR.

1 Series No. 540(Q)

2 Junior Agronomist and Technician, TARI, respectively.

Vol. 20, No. 4 December, 1971

JOURNAL OF TAIWAN AGRICULTURAL RESEARCH

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Published by

THE TAIWAN AGRICULTURAL RESEARCH INSTITUTE

TAIPEI, TAIWAN, CHINA

內政部出版事業登記證內版臺誌字第二一二四號
中華郵政臺字第二〇七六號登記爲第一類新聞紙類