農業研究

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柑桔砧木試驗

第二報「中間砧木」影響柑桔製罐崩裂率與白濁程度之研究

翁仁祿

一、前言

本省產柑桔罐頭由於使用材料之桶柑具有果形高果肉鬆，瓤皮脆弱，果心硬，種子數多等缺點，製罐時之果肉崩裂率相當高，又因果肉色不鮮，果汁淡，白濁現象嚴重等原因，商品價值甚低。

溫州蜜柑在目前公認爲最適宜製罐之品種，惟由於本省過去該品種之栽培少，爲迅速供應加工材料起見，近年來普通採用高接法在酸桔砧木之桶柑或椪柑植株上行「二重接」，但二重接之溫州蜜柑果實品質易受中間砧木之影響而起變化（請參閱本刊十五卷第一期柑桔砧木試驗第一報，「二重接」對於柑桔生理形態及品質變化之研究一文報告），所得果實是否仍持有該品種原有製罐之特性等問題，須加以研究。

相反地將目前在本省栽培最普遍，樹勢强健，收量高，最適於本省氣候栽培之桶柑接穗利用二重接之中間砧木可改變接穗品質之原理高接於枳殼砧溫州蜜柑植株上時，所得桶柑果實是否受中間砧木（溫州蜜柑）同化養料之支配，變成爲適宜製罐之品質等問題亦需併行研究。

本研究係採用「二重接」溫州蜜柑及桶柑果實，調查形態並製罐（瓶）貯藏，觀察崩裂率，白濁程度及品質等，與加工成本及品質有關之事項，探究中間砧木對於農產加工上之應用價值。

本試驗承國家長期科學發展委員會之經費補助得以進行，當試驗進行時果汁成分分析得本所林禮輝先生，製罐操作得新竹青果運銷合作社新埔加工廠林文禮先生之協助，又英文部份承蒙臺大馬溯軒教授摘譯，特此謹致謝忱。

二、材料及方法

㈠ 材料

A. 溫州蜜柑部份：

代號　　處理別

1. 溫州蜜柑/椪柑/酸桔
   (Citrus unshiu Marc/c. reticulata Blanco/c Sunki Sakurai)
2. 溫州蜜柑/桶柑/酸桔
   (C. unshiu Marc/c. Tankan Hayata/c. Sunki Sakurai)
3. 溫州蜜柑/酸桔
   (C. unshiu Marc/c. Sunki Sakurai)
4. 溫州蜜柑/枳殼（埔里平地）
   (C. unshiu Marc/poncirus trifoliata Rafin)
5. 溫州蜜柑/枳殼（宜蘭山地）
   (C. unshiu Marc/poncirus trifoliata Rafin)
6. 溫州蜜柑/廣東檸檬
   (C. unshiu Marc/C. Limonia osbeck)

B. 桶柑部份：

代號	處理別	各處理比率
1.	桶柑/溫州蜜柑/枳殼	1：4：1
	(C. Tankan Hayata/c. unshiu Marc/poncirus trifoliata Rafin)	
2.	桶柑/溫州蜜柑/枳殼	1：2：1
	(C. Tankan Hayata/C. unshiu Marc/poncirus trifoliata Rafin)	
3.	桶柑/溫州蜜柑/枳殼	1：1.5：1
	(C. Tankan Hayata/C. unshiu Marc/poncirus trifoliata Rafin)	
4.	桶柑/溫州蜜柑/枳殼	1：1：1
	(C. Tankan Hayata/C. unshiu Marc/poncirus trifoliata Rafin)	
5.	桶柑/溫州蜜柑/枳殼	1.5：1：1
	(C. Tankan Hayata/C. unshiu Marc/poncrius trifoliata Rafin)	
6.	桶柑/溫州蜜柑/枳殼	2：1：1
	(C. Tankan Hayata/C. unshiu Marc/poncirus trifoliata Rafin)	
7.	桶柑/溫州蜜柑/枳殼	4：1：1
	(C. Tankan Hayata/C. unshiu Marc/poncirus trifoliata Rafin)	
8.	桶柑/酸柑	
	(C. Tankan Hayata/C. Sunki Sakurai)	

㈡ 方　法

A.果實形態調查：採取「二重接」果實在省農業試驗所園藝系使用 Calipar, Dial thickness gauage 測定果實形狀，果皮厚，瓤皮厚度，瓤囊數，並計算果形指數，果肉百分率，瓤囊指數，含核率等與製罐率，崩裂率及簡化製造工程等有關之事項。

B.果實化學分析：試驗果汁在同系採用氫氧化鈉滴定法測定枸櫞酸含量，以折光鏡及蔗糖比重計測定糖分及比重等，再將每樣果汁送至同所農化系採用 Bertrand 法測定還元糖及全糖之含量等與製品品質有關之各項。

C.製罐(瓶)過程：將同樣處理之「二重接」果實，另送至新竹青果合作社新埔加工廠加工試驗室以⑴熱燙 (90°C 熱水 30 sec)——⑵剝皮分瓣（用手行之）——⑶去膜（常溫下 a. HCl 0.6% 30 min b. NaOH 0.3% 10 min)——⑷裝罐（瓶）（以手行之）——⑸加糖液（調整全罐糖度到17%）——⑹脫氣（加熱至中心溫度爲 75°C)——⑺殺菌，（90°C 熱水 15 min)——⑻冷却（用常溫水）之過程製罐（瓶）。

D.貯藏：將製品放置於常溫室，黑暗保險鐵櫃內。自製造日期起，每隔一個月調查一次果瓤白點及白濁程度，並糖液透明度，於民國55年 6 月20日開罐檢查果肉組織，食味等與製品品質有關之事項。

三、試　驗　結　果

㈠ 果實形態：各處理樣品據成熟之前後，送至試驗室，測定果實形態，其成績如表一。

A.溫州蜜柑：採用中間砧木之1、2，與其他不採用中間砧木之3、4、5、6比較之，1、2之果形略扁平，果瓤最肥短，果肉百分率最高，以果實形態而觀，最適於製罐。雖有少數種子之存在，但合核率似乎受產地氣溫高低之影響大，而處理間差異甚微，氣溫較高南部所產果實合核率平均較高。果肉色澤而言，不論二重接與否，以酸桔爲砧木者，果肉色均較其他砧木者爲淡白。

B.桶柑：枳殼砧溫州蜜柑再行二重接之桶柑及酸桔砧桶柑果實兩者比較之1、2、3、4、5、6、7 不拘「中間砧木」溫州蜜柑之數量多寡，果形，果肉百分率，果汁百分率方面均與對照 8 之間不

表一 果 實 形 態

品種	處理代號	供試個數	果實					果瓤						果肉			果汁		種子數	產地
			重量(g)	橫徑	縱徑	果指形數※1	皮厚	瓤數	高度	寬度	厚度	果指瓤數※2	瓤皮厚	重量	百分率	色澤※3	重量	百分率		
溫州蜜柑	1	2	186.86	7.27	5.60	1.32	270.71	10.29	3.89	2.06	1.17	0.6201	15.86	151.87	81.30	ⅢⅠ	116.71	62.50	1.71	公館鄉
	2	5	147.40	6.79	5.30	1.28	228.50	11.00	4.09	2.30	1.28	0.7168	15.60	119.40	81.00	ⅡⅠ	92.40	62.70	1.20	公館鄉
	3	14	163.64	7.41	6.24	1.19	290.00	11.04	3.25	1.74	0.96	0.5184	19.93	126.64	77.39	ⅡⅠ	92.29	56.39	0.60	關西鎮
	4	20	98.70	5.92	4.73	1.25	315.10	11.05	3.36	1.61	1.18	0.5364	19.25	66.45	67.46	ⅢⅠ	49.85	50.61	5.10	埔里鎮
	5	20	106.05	6.28	4.47	1.40	279.40	11.60	2.98	1.65	1.11	0.6105	15.35	80.25	75.67	ⅢⅠ	59.45	56.06	0	員山鄉
	6	20	99.10	5.97	5.02	1.19	265.40	10.20	3.15	1.45	1.00	0.4603	15.80	70.50	71.14	ⅢⅠ	54.65	55.15	4.80	埔里鎮
桶柑	1	10	78.90	5.60	4.97	1.13	352.00	9.70	3.38	1.55	1.08	0.486	19.9	56.80	71.99	ⅡⅠ	44.30	56.15	0.7	頭城鎮
	2	10	78.20	5.24	4.86	1.08	314.00	9.80	3.22	1.44	1.06	0.477	20.7	56.40	71.12	ⅡⅠ	43.70	55.88	0.4	
	3	10	82.60	5.63	4.97	1.13	375.20	9.50	2.98	1.38	0.92	0.423	21.2	59.70	72.28	+	42.00	50.85	0.4	
	4	29	75.39	5.08	5.04	1.01	330.00	9.40	3.26	1.44	0.96	0.422	20.7	60.76	80.60	ⅡⅠ	40.87	54.21	0.3	
	5	20	80.70	5.43	4.92	1.11	356.50	9.50	3.35	1.52	1.09	0.490	21.3	56.15	69.58	ⅡⅠ	42.75	52.97	0.6	
	6	10	76.20	5.41	4.87	1.11	339.00	9.40	3.17	1.44	1.10	0.495	21.6	53.50	70.21	ⅡⅠ	41.30	54.20	0.6	
	7	10	73.50	5.20	4.94	1.05	329.00	9.00	3.16	1.40	0.93	0.409	20.2	48.70	66.26	ⅡⅠ	39.60	53.88	0.6	
	8	20	56.80	4.90	4.41	1.11	294.40	9.10	2.99	1.51	1.03	0.520	22.3	40.00	70.42	ⅡⅠ	32.05	56.43	--	

※ 1. 果形指數：橫徑/縱徑（商值越大，果形越扁平）。

※ 2. 果瓤指數：果瓤寬度/果瓤高度×果瓤厚度（得數越大果瓤越肥短，崩裂率越低）。

※ 3. 果肉色澤：依 Ridgway 1912 Color Standards And Nomenclature 參考書中 cadium orange ⅢⅠ, orange ⅡⅠ, cadium yellow + 爲標準表示之。

發生明顯差異，前者之果瓤反較後者爲瘦長，含核率稍增，略有提高製罐崩裂率之可能。

㈡ 果汁成分：

各處理間果汁化學成分之分析結果如表二。

A.溫州蜜柑：1、2與3比較之，前者所含各成分量，均較後者爲高，果汁濃厚，各處理間4之各成分含量爲最高。

B.桶柑：雖因限於試驗材料而無法得整齊之上昇直線，惟各成分之含量略隨殘留中間砧木之多寡，以1、2、3、4、5、6、7之順序中間砧木枝葉之數量越少，各成分之含量越高，全糖及還元糖之含量較8特別高。

表二 果汁成分表

品種 \ 項目 / 代號		還元糖	全糖	枸櫞敏	糖分	糖酸比	比重	pH	採收時期
溫州蜜柑	1	3.56	6.46	0.68	9.23	13.57	8.0	3.7	54.10.11
	2	3.59	6.57	0.77	8.20	10.65	6.6	3.6	54.10.11
	3	2.79	—	0.46	8.10	17.61	8.5	—	54.10. 4
	4	4.79	7.96	1.16	11.25	9.70	7.0	3.4	54.10. 9
	5	2.68	5.65	0.92	7.96	8.66	5.5	3.4	54.10.25
	6	3.60	6.96	0.75	9.56	12.75	8.0	3.7	54.10. 9
桶柑	1	3.26	9.33	0.57	10.68	18.76	7.5	4.5	55. 2.14
	2	3.01	8.58	0.61	11.92	19.54	7.0	4.9	55. 2.14
	3	3.45	9.72	0.55	12.68	23.05	8.0	4.5	55. 2.14
	4	3.73	10.42	0.63	12.62	20.03	7.7	4.2	55. 2.14
	5	3.90	10.87	0.66	13.81	20.92	7.8	4.4	55. 2.14
	6	4.24	11.06	0.61	13.42	22.00	8.0	4.1	55. 2.14
	7	3.89	10.49	0.67	13.74	20.51	8.5	4.1	55. 2.14
	8	3.01	8.58	0.61	12.00	19.67	7.0	4.9	55. 2.14

㈢ 製品品質：

製品經3—6個月之貯藏，外觀調查及開罐品質檢查成績如表三、圖一、圖二。

A.溫州蜜柑：經8個月之貯藏觀察，各處理間，除瓤皮及沙瓤之少量碎片沉澱以外，均無明顯白濁現象之發生，白點與果汁透明度間亦無顯著差異。果肉組織以2爲最粗糙沙瓤分離，乾燥程度最嚴重，1次之，3居三，似乎呈以酸桔爲砧木者，果肉組織較其他砧木者爲粗糙而鬆，沙瓤乾燥果肉較硬之現象，果肉淡白，商品價值低。各處理間仍以枳殼爲砧木4、5之之沙瓤最細小，果肉組織緊密，果肉多汁而柔軟，品質最優良。

B.桶柑：製品經3個月半之貯藏觀察，白點，果汁透明度，白濁程度，果肉組織，果肉色間無顯著差異，沙瓤均乾燥，發生嚴重 granulation 現象，果肉粗硬商品價值低，殘留「中間砧木」溫州蜜柑枝葉之數量多寡，與桶柑果實品質之間亦無明顯相差。1、2、3、4、5、6、7 之食味較8爲苦，醱酵味强，商品價值更低。

溫州蜜柑與桶柑兩者果實罐頭品質比較之，不論採不採用中間砧木，前者之白濁程度均較低，沙瓤多汁，果肉組織聚密，商品價值高。白點及果汁透明度略相似，果肉色以後者爲鮮。

四、結論及討論

由本試驗結果，柑桔二重接之「中間砧木」對於接穗品質變化之影響，尤其崩裂率及白濁程度

表三 製品品質

種類	處理代號	製造日期	調查日期	白點※1	液糖透明度※2	白濁※3	果肉組織	味，品質	果肉色	備考
溫州蜜柑	1	54.10.13	54.12.20 55. 3.21 55. 6.20	2 4 5	8 8 8	無白濁 無白濁＋ 輕微白濁	粗糙而鬆，沙瓤粗大如柚者，呈易崩裂狀態沙瓤間裂縫大	味淡酸低，全果中約1/2沙瓤乾燥果肉稍柔軟	Capucine yellow	浮力中
	2	54.10.13	54.12.20 55. 3.21 55. 6.20	1 3 3	9 9 9	無白濁 無白濁 無白濁	甚粗糙而鬆，沙瓤粗大如柚者，呈易崩裂狀態，沙瓤間裂縫大	味淡而酸，全果中約1/2 沙瓤乾燥，果肉稍柔軟	Capucine yellow ＋ orange	浮力中
	3	54.10. 5	54.12.20 55. 3.21 55. 6.20	1 2 4	8 8 6	無白濁 無白濁＋ 輕微白濁	粗糙而鬆，呈易崩裂狀態，沙瓤粗大如柚者	酸味强，稍具發酵味全果中約 $1/_{10}$ 沙瓤乾燥果肉粗硬	Capucine yellow ＋ Capucine orange	浮力大果肉色不鮮
	4	54.10.11	54.12.20 55. 3.21 55. 6.20	2 4 4	5 5 4	無白濁 無白濁＋ 輕微白濁	緊密，果瓤，沙瓤均細小	味淡，稍具發酵味果肉柔軟	Cadium orange ＋ orange	浮力小果肉色鮮白點顯明
	5	54.10.27	54.12.20 55. 3.21 55. 6.20	1 5 5	9 7 6	無白濁 無白輕＋ 輕微白濁	稍緊密，略呈易崩裂狀態	沙瓤中等大，全果中約1/10沙瓤乾燥果肉稍緊	orange	白點雖小但果肉色鮮之故白點明顯
	6	54.10.12	54.12.20 55. 3.21 55. 6.20	1 3 3	8 8 7	無白濁 無白濁＋ 輕微白濁	稍粗糙，略呈易崩裂狀態，沙瓤中等大	味淡，稍酸，沙瓤含水量多，果肉柔軟	Cadium orange	浮力小
桶柑	1	55. 3. 2	55. 3.21 55. 6.20	3 4	8 8	無白濁＋ 輕微白濁	粗糙	酸苦，全果瓤中之約1/2沙瓤乾燥果肉硬	orange	
	2	55. 3. 2	55. 3.21 55. 6.20	3 4	8 8	無白濁卄 輕微白濁	粗糙沙瓤分離，組織脆弱	味淡，稍酸帶苦味約1/2沙瓤乾燥	Capucine yellow ＋ orange	
	3	55. 3. 2	55. 3.21 55. 6.20	6 8	9 8	無白濁卅 白濁程度稍最重	粗糙	味酸而苦帶發酵味	Capucine yellow	
	4	55. 3. 2	55. 3.21 55. 6.20	3 4	9 9	無白濁＋ 輕微白濁	粗糙	味稍酸，全果瓤中約1/5 沙瓤乾燥果肉粗硬	orange	
	5	55. 3. 2	55. 3.21 55. 6.20	4 4	9 9	無白濁＋ 輕微白濁	粗糙尤其瓤囊中央種子部沙瓤乾燥並收縮	味甚酸，稍苦約1/2沙瓤乾燥	orange	
	6	55. 3. 2	55. 3.21 55. 6.20	2 3	8 8	無白濁卄 輕微白濁	粗糙沙瓤分離	味稍酸，略苦，約2/5沙瓤乾燥	orange	
柑	7	55. 3. 2	55. 3.21 55. 6.20	3 3	8 8	無白濁卄 輕微白濁	粗糙	味甚酸，味如荔枝約1/5沙瓤乾燥	orange	
	8	55. 3. 2	55. 3.21 55. 6.20	3 3	9 8	無白濁卄 輕微白濁	粗糙	稍酸約2/3沙瓤乾燥	orange	

※ 1. 白點係果瓤維管束之跡，白點過多者頗損外觀，商品價值低。

※ 2. 果汁透明度以肉眼檢查。以無色透明者10，混濁完全不透明者 0 ，爲標準定之。

※ 3. 白濁程度中以＋爲最輕微，卄爲稍嚴重，卌爲最嚴重之標準定之。

等，對於柑桔製罐成本及商品價值直接有關之事項，加以研討如下：

1. 以椪柑或桶柑爲中間砧木之酸桔砧溫州蜜柑及不採用中間砧木之酸桔砧木溫州蜜柑兩者比較之，前者之果形扁平，果瓤肥短崩裂率低，瓤皮薄，果肉百分率高，製罐率較高。果實各成分較後者爲高。就果實形態，果汁成分而言；頗有中間砧木之利用價值，惟加工後之果肉組織粗糙且鬆，沙瓤乾燥 granulation 嚴重，商品價值仍低。

2. 枳殼砧溫州蜜柑再行二重接之桶柑果實與酸桔砧桶柑之果實兩者比較之，不拘殘留中間砧木之枝葉多寡，均無法致果形，果肉果汁百分率發生變化，前者之果瓤反較後者爲瘦長，種子數稍多，略增高製罐崩裂率。果汁成分之含量卽與中間砧木枝葉之數量反比，殘存中間砧木枝葉越多，果汁成分含量越低。製品外觀（白點，果汁透明度，白濁現象，果肉色）及果肉組織（沙瓤乾燥度，果肉柔軟度）雖相近，惟前者之果肉略帶醱酵苦味，品質較後者爲劣。中間砧木之利用價值低。

3. 溫州蜜柑果實與桶柑果實比較之：桶柑果實如採收時期較晚時，果肉色鮮橙，糖液透明，外觀雖不亞於溫州蜜柑，惟白濁程度嚴重，沙瓤乾燥，果肉粗硬，且略帶醱酵苦味，商品價值甚低。以酸桔砧椪柑或桶柑再接溫州蜜柑時，其果實之製罐價值，雖無法與枳殼砧溫州蜜柑者競美，但遠較原來之酸桔砧椪柑或桶柑株所結果實品質爲優，反之以枳殼砧溫州蜜柑爲砧木，再行二重接之桶柑果實，不易得中間砧木溫州蜜柑之優良製罐特性，製罐價值更低。

4. 本試驗中加工處理係於新竹青果合作社新埔加工廠加工試驗室，以最標準之藥劑濃度及時間之下處理，並於最綿蜜之操作下進行剝皮分瓣。去膜工作細心，沖洗時間長，因此崩裂率頗低，白濁主因之瓤皮殘留物稀，hesperidin 之析出少，白濁程度較一般製品爲輕微。

——·附　　記·——

本試驗製品復於民國56年2月21日（製罐14～16個月後）再開罐檢查一次，結果如下：（參照另圖一，另表一，另表二）。

㈠ 白濁現象：

1. 溫州蜜柑罐頭採用中間砧木者（1、2）較不採用中間砧木者（3）糖液透明度低，白濁程度嚴重。

2. 中部平地產溫州蜜柑（4）與北部山地產溫州蜜柑（5）比較之，前者之糖液混濁，兩者間差異頗大，後者之透明度最高，白濁現象最輕。

3. 溫州蜜柑果實罐頭平均較桶柑果實罐頭透明度高，白濁現象輕微。

4. 採用溫州蜜柑爲中間砧木之桶柑果實罐頭糖液透明度，平均雖較不採用中間砧木之桶柑果實罐頭爲高，但差異不顯。所採用中間砧木量之多寡與白濁程度之間，並無明顯相關關係。

㈡ 果肉品質：

1. 製品糖液糖度經貯藏後均增高，溫州蜜柑部份由17%增至18.97%，桶柑增至17.05%，兩者間差異仍大。

2. 溫州蜜柑中採用中間砧木者糖度平均較不採用中間砧木者爲低，而桶柑以採用中間砧木者爲高。

3. 果肉品質除肉質普遍軟化並桶柑略加茉莉花香味外，變化少。

五、摘　　要

「溫州桶柑」由於果瓤肥短，果肉聚密而柔軟，含核率低，果肉色鮮紅，而目前公認爲最適製罐之品種，本省之製罐品種「桶柑」雖有獨特之香味，但因具果形高，果肉鬆，瓤皮脆弱，果心硬，種子數多等之缺點，製罐時之果肉崩裂率較高，浪費材料，提高成本。又因果肉不鮮，果汁白濁現

象嚴重等原因在一般市場未得好評。爲迅速供應加工材料，在本省栽培最多之桶柑或椪柑株上再嫁接溫州蜜柑是否適當？另是否可利用中間砧木可影響接穗品種品質之原理，在溫州蜜柑株上高接桶柑等問題，急待解決。

本試驗從民國54年7月起，至民國55年6月止計1年，其目的在調查二重接柑桔果實形態，品質與製罐後之崩裂率，白濁程度及品質等與加工成本及品質有關之事項，探究中間砧木於農產加工上之應用價值。

1. 以椪柑或桶柑爲中間砧木之酸桔砧溫州蜜柑與不採用中間砧木之酸桔砧溫州蜜柑果實比較之，前者之果形扁平，果瓤肥短，崩裂率低，瓤皮薄，果肉百分率高。果汁成分濃厚，就果實形態，果汁成分而言；頗有中間砧木之利用價值，但加工後之果肉組織粗糙且鬆，沙瓤乾燥，發生嚴重 granulation ，商品價值仍低。

2. 枳殼砧溫州蜜柑再行二重接之桶柑果實與酸柑砧桶柑之果實兩者比較之，果形，果肉百分率相似，二重接者果瓤瘦長，種子數稍多，製罐崩裂率略高，加工品之外觀及果肉組織雖相似，惟前者之果肉略帶醱酵苦味，品質較後者爲劣，中間砧木之利用價值低。

3. 溫州蜜柑與桶柑果實比較之，桶柑果實如採收時期較晚時果肉鮮橙，糖液透明，外觀雖不亞於溫州蜜柑者，惟白濁程度嚴重。沙瓤乾燥，果肉粗硬，略帶醱酵苦味，商品價值甚低，以酸桔砧椪柑或桶柑再接溫州蜜柑時，其果實製罐價值雖無法與枳殼砧溫州蜜柑者競美，但遠較原來之酸桔砧桶柑株所結果實爲優。反之以枳殼砧溫州蜜柑爲砧木再行二重接之桶柑果實，不易得中間砧木溫州蜜柑之特性，製罐價值更低。

EFFECT OF INTERMEDIATE-STOCKS ON SEGMENT BREAKAGE AND HESPERIDIN SEDIMENT OF CANNED MANDARIN ORANGE

By

J. L. WENG

In order to get information on the desirability for topworking mature Ponkan or Tankan trees to Satsuma orange for rapid increasing the production of fruit for canning, studies were made on fruits produced from Satsuma orange on Trifoliate orange, Satsuma orange topworked on Tankan or Ponkan both with Sunki rootstock, and Tankan topworked on Satsuma orange with Trifoliate orange rootstock for comparing their suitability for canning. The results were as follows:

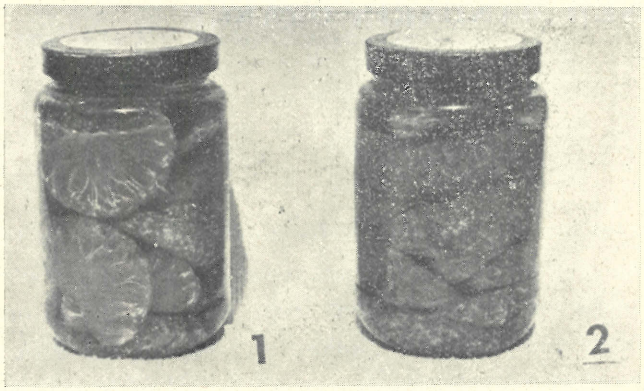
(1) Satsuma orange topworked on Tankan or Ponkan with Sunki rootstock produced flat fruits, shorter segments, thiner segment wall, a lower percentage of segment breakage after canning, a higher percentage of flesh, and a higher soluble solid content in comparison with fruits of Satsuma orange directly on Sunki rootstock. But, after canning, fruit segments from Satsuma orange topworked Tankan or Ponkan became coarse and showed a high degree of granulation.

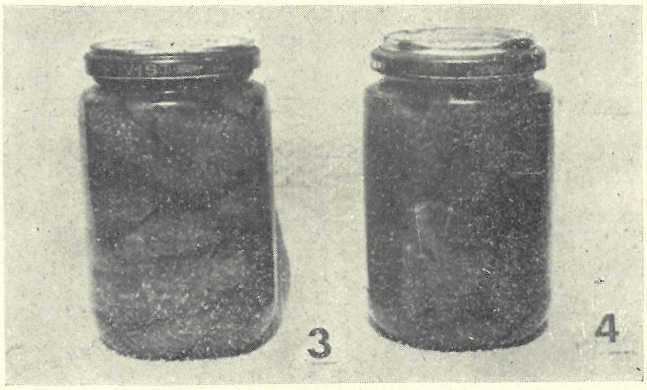
(2) Tankan topworked on Satsuma orange originally on Trifoliate orange rootstock produced fruit much the same in form and in percentage of flesh as fruits produced on Tankan directly on Sunki rootstock. But Tankan fruits from tree with an intermediate-stock of Satsuma orange had more slender segments, a higher seed content and a higher percentage of segment breakage after canning. Although the appearance and texture of the canned products were the same, but fruits from Tankan topworked on Satsuma orange gave a bitter taste after canning in comparison with fruit produced by Tankan directly on Sunki rootstock. Therefore, topworking Satsuma orange to Tankan would be of limited value.

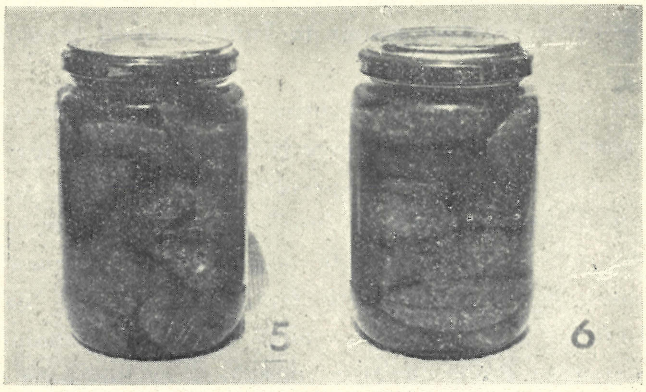
(3) In comparison with Satsuma orange, Tankan fruite picked during the later part of harvesting season gave bright orange colored flesh and clear syrup after canning, but with a high degree of hesperidin sediment, dry segment, coarse flesh and bitter taste, which materially lowered the value for canning. Satsuma orange topworked on Tankan or Ponkan originally with a Sunki rootstock produced fruits in no way comparable with fruits produced by Satsuma orange directly on Trifoliate orange, but it was much better for canning than Tankan produced on Sunki rootstock. But Tankan topworked on Satsuma orange originally on Trifoliate orange rootstock produced fruits inferior for canning, in other words, the Satsuma orange intermediate-stock gave no benifit influence on fruits produced by variety topworked on it.

圖一　加工柑桔果實品質

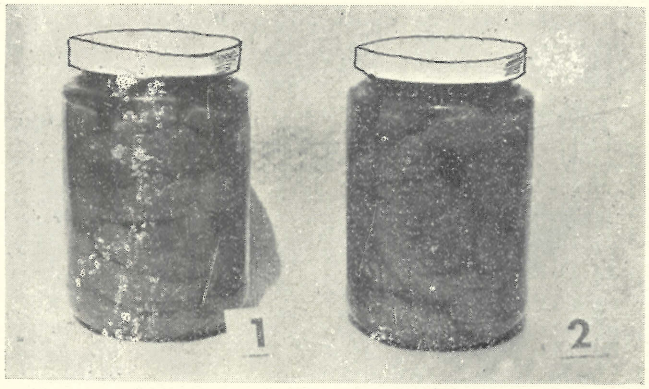
㈠　溫州蜜柑

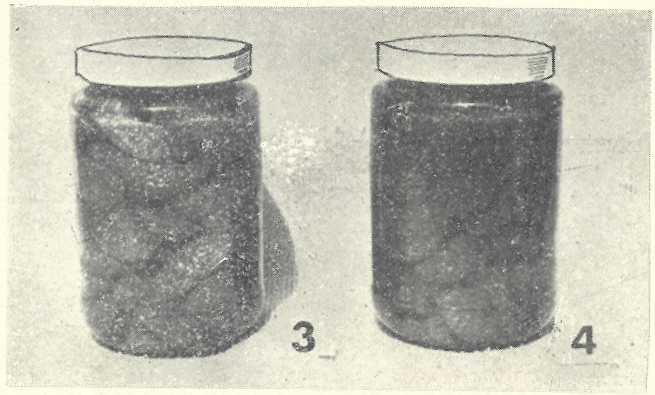


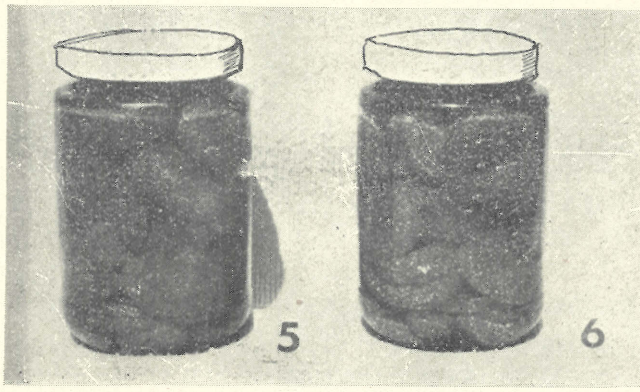


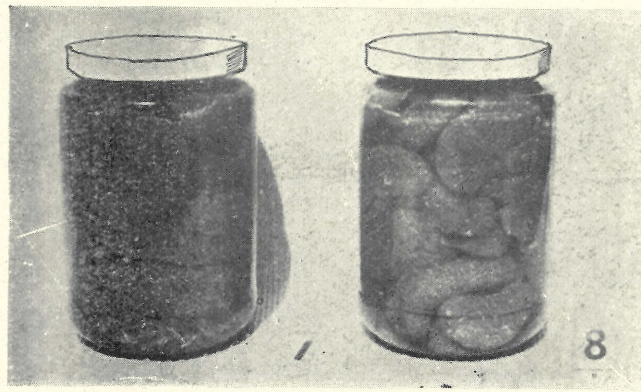


㈢ 桶　　柑



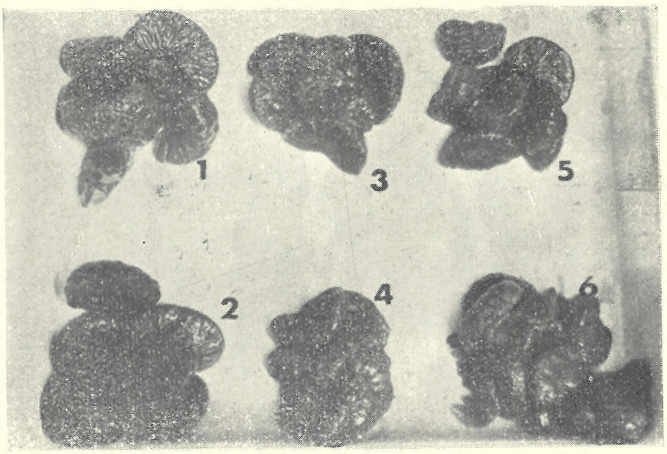




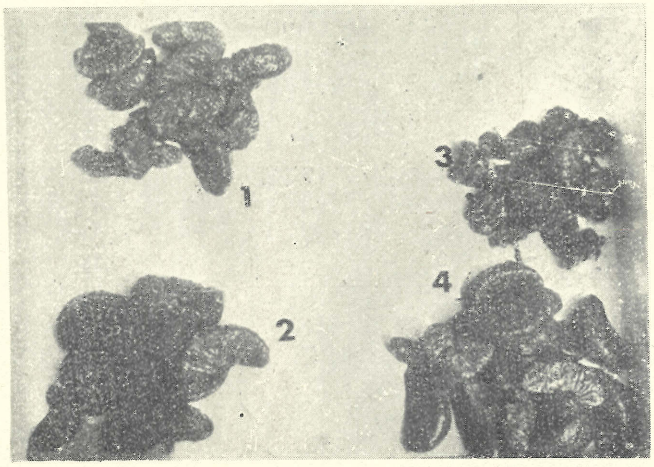


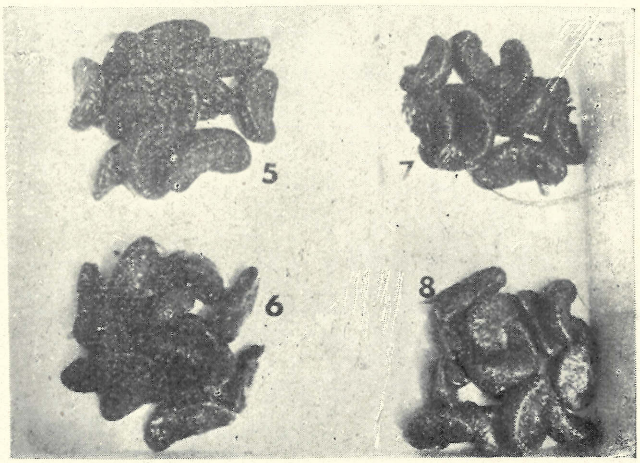
圖二　加工柑桔果肉品質

㈠ 溫州蜜柑



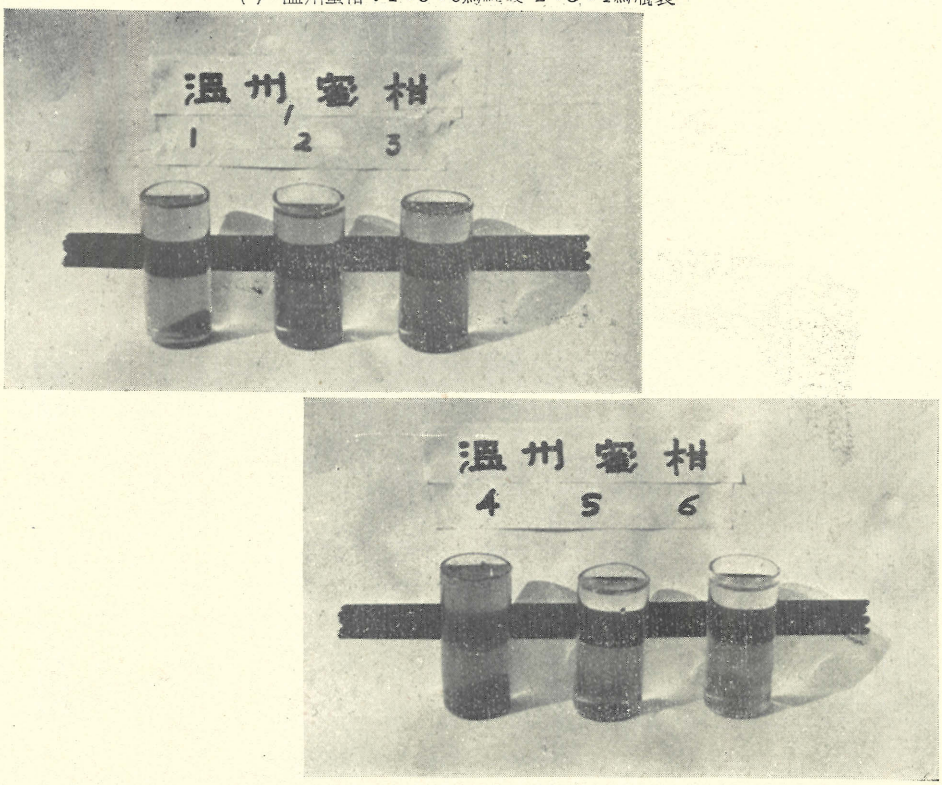
㈡ 桶　柑



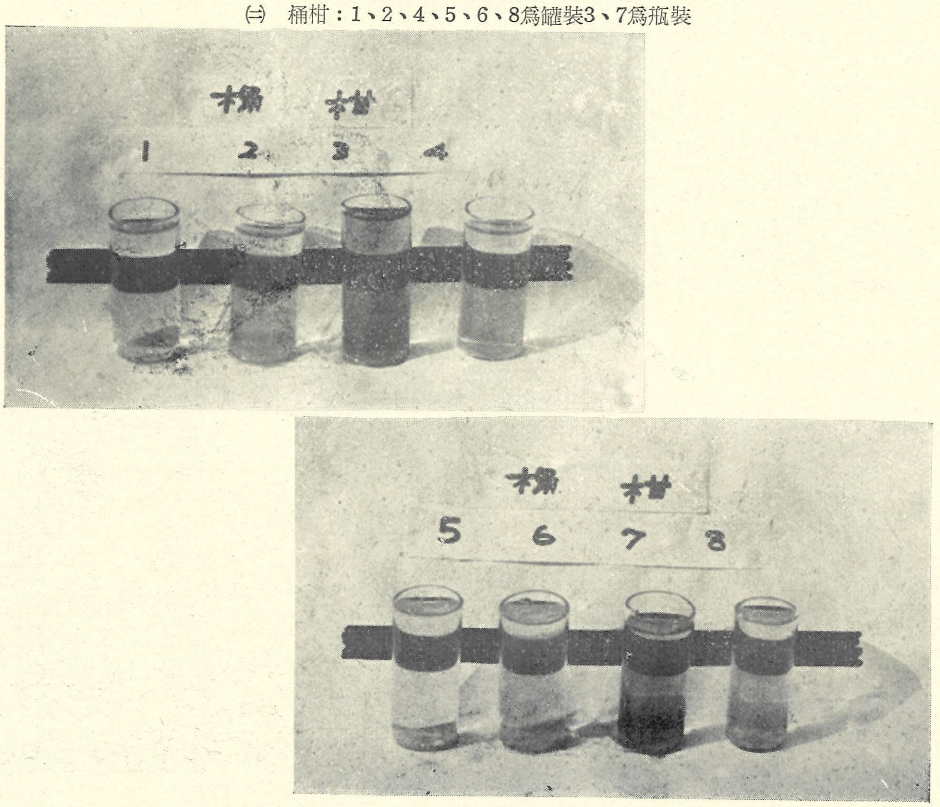


圖一　柑桔罐頭糖液透明度

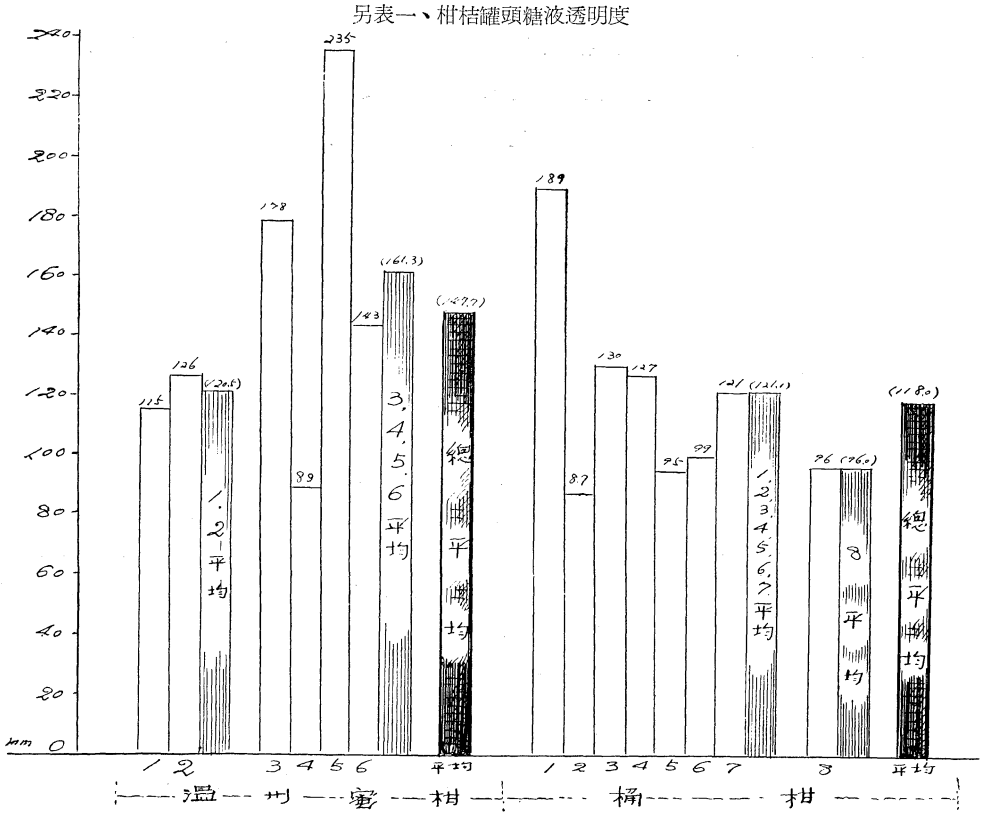
㈠　溫州蜜柑：1、5、6爲罐裝 2、3、4爲瓶裝



㈡　桶柑：1、2、4、5、6、8爲罐裝3、7爲瓶裝

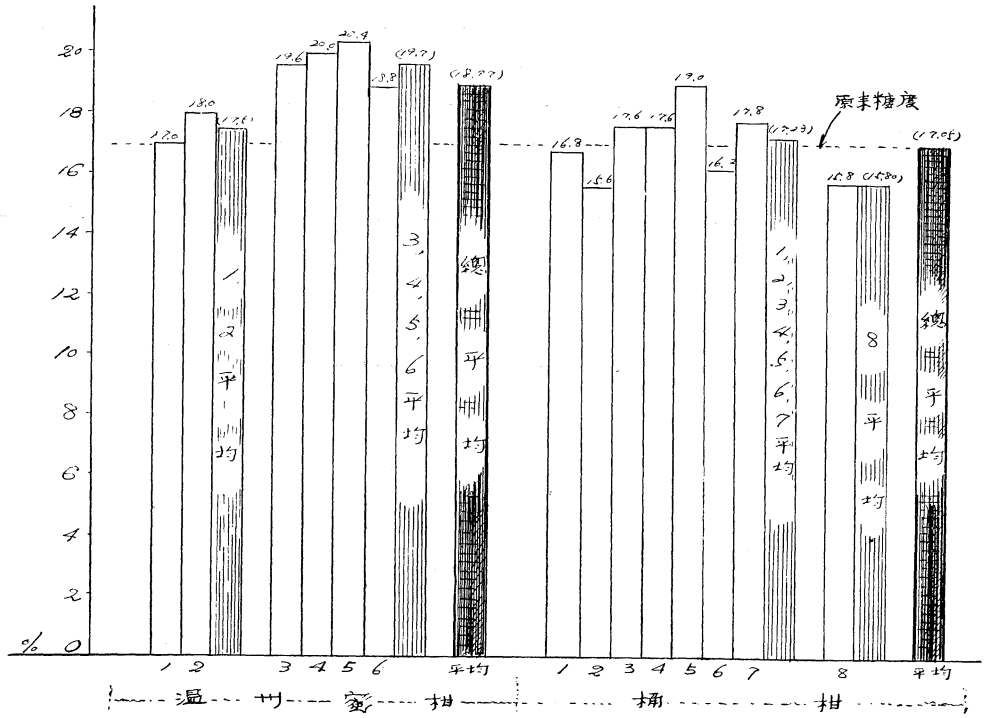


另表一、柑桔罐頭糖液透明度



備註：透明度採用量筒法測定之

另表二、貯藏柑桔罐頭糖度之變化（標準糖度17%）



備註：糖度係採用折光鏡測定之

INFLUENCE OF SPACING ON HERITABILITY AND INTERRELATIONSHIPS AMONG AGRONOMIC TRAITS IN THE F_2 POPULATION OF A RICE CROSS[1]

By

W. L. CHANG[2]

Grain yields of rice generally increase with increased planting density. One of the major difficulties confronted with dense planting is lack of commercial varieties adapted to this growing conditions. This can be explained partly that the present varieties now commercially available are developed without paying special attention to their spacing responses during the course of selection, suggesting that some basic changes in the architecture of rice plant for these varieties may be needed (Chang, 1965). Hence, considerable emphasis has been placed on breeding rice varieties for dense planting in recent years. An understanding of the impact of spacing on yield and several other characters commonly obtained in the evaluation of individual plants or lines will permit the use of more efficient breeding techniques.

Estimates of heritablity and the interrelationships among important agronomic traits are useful in designing an effective breeding program. Heritabilities and correlations for most agronomic characters in rice have been reported by a number of investigators (Bollich, 1957; Toriyama and Futsuhara, 1953; Nei, 1960; Futsuhara et al., 1965). However, these values change with spacing (Kariya and Yamamoto, 1963; Sakamoto *et al.*, 1963; Chang, 1564), and time of planting (Akemine and Kumagai, 1958). Thus, in breeding rice varieties for dense planting, such estimates are of most value when based upon materials grown under different spacings.

The objectives of this study were to estimate heritability and interrelationships among important agronomic traits of the F_2 population of a rice corss grown under three spacings.

MATERIALS AND METHODS

Japonica varieties, Tainan 3 and Pi No. 4 were used as parents to make a cross which was studied in the F_2 generation in the second crop of 1965 at the Rice Experimental Farm of Chiayi Agricultural Experiment Station. Tainan 3, developed by Tainan Agricultural Improvement Station, is a commercial variety noted for its high yielding ability and wide adaptablity, while Pi. No. 4, an introduction from Japan, has been widely used as the breeding material because of its high level of resistance to rice blast disease (*Piricularia oryzae*). Both

1. This study was partly supported by the National Council of Science Development.
2. Agronomist, Chiayi Agricultural Experiment Station, TARI.

parents and F_2 population were grown under three spacings given in Table 1. For each spacing, more than 200 plants for each parent and 500 plants for F_2 generation were represented. One seedling was transplanted to each hill. Standard cultural practices were strictly followed for the management of the experimental plot. Climatic conditions were favorable for good rice growth and yield during the test period.

Table 1. Spacing for experimental materials

Spacing	Distance between row (cm)	Distance between hills (cm)	Number of hills per m^2
Wide	25	40	10
Standard	25	20	20
Close	25	10	40

About 50 and 100 plants were selected at random from each parent and F_2 population respectively in each spacing. Data for all traits were obtained on each plant as follows: heading date recorded in days from transplanting to the date when the first ear emerged, plant height, number of panicles per plant, panicle length, panicle weight, number of grains per panicle, weight of 100 grains, and grain yield per plant. Data thus collected for both parents and F_2 population in each spacing were analyzed for each trait by the analysis of variance and for each pair of traits by the analysis of covariance, based on the data of individual plants. Heritability estimates and correlation coefficients were computed from variance and covariance components by the same procedure used in the previous study (Chang, 1964).

EXPERIMENTAL RESULTS

Effect of Spacing on Agronomic Traits of Rice Plant

Means of eight agronomic traits of both parents and F_2 population in each spacing treatment are given in Table 2. The effects of spacing treatments upon the agronomic traits of parental varieties and F_2 plants were quite remarkable. Means of number of panicles and grain yield per plant showed a drastic decrease with the increase of planting density, while close spacing caused only a slight decrease in the means of plant height, panicle weight, and number of grains per panicle. Heading date and 100-grain weight were not affected by spacing.

The average number of panicles per plant of F_2 population was smaller than parental varieties in each spacing, whereas the means for the other characters were located in general midway between those of both parents. Parental differences in the means of heading date, plant height, number of panicles per plant, number of grains per panicle, and grain yield per plant reduced with increased planting density, especially the number of panicles per plant at close spacing where difference between both parents almost disappeared completely.

However, differences of parental varieties in the means of panicle length, panicle weight, and 100-grain weight increased as plants were being spaced closer together.

Table 2. Means of 8 agronomic traits for both parents and F_2 population grown under 3 spacings in the second crop of 1965.

Character	Wide spacing			Standard spacing			Close spacing		
	P_1*	P_2**	F_2	P_1	P_2	F_2	P_1	P_2	F_2
Heading date (days)	60.0	46.8	50.5	59.9	46.4	50.4	57.7	48.4	50.6
Plant height (cm)	106.5	86.0	96.4	106.2	85.5	93.9	105.9	87.4	93.6
Panicles per plant	17.2	19.3	17.2	11.4	14.0	10.8	6.6	6.8	6.0
Panicle length (cm)	21.2	19.5	19.7	19.5	16.8	18.5	20.4	17.1	18.2
Panicle weight (g)	3.6	2.3	3.0	2.8	1.9	2.6	3.1	1.9	2.6
Grains per panicle	146.6	76.7	108.2	122.4	69.1	96.7	131.4	65.0	92.5
Weight per 100-grain (g)	2.6	3.0	2.9	2.7	2.9	2.9	2.7	3.0	2.9
Grain yield per plant (g)	49.8	33.2	39.6	29.5	22.6	24.9	19.7	12.0	14.6

* P_1=Tainan 3. ** P_2=Pi No. 4.

Estimates of Heritability

Heritabilities in the broad sense for 8 agronomic traits in each spacing calculated as the percent genotypic portion of the total F_2 variance, are presented in Table 3. Estimates of heritability generally decreased with increased planting density. Differences between wide and standard spacings in heritability estimates were less than those between wide and close spacings. The number of panicles per plant at wide spacing were twice as large as that of standard spacing and 20 times larger than that of close one. The rates of decrease in heritability estimates for the other traits with increased planting density were more or less slower and the heritabilities of wide spacing were only slightly larger than those of standard spacing and 2 to 4 times larger than those of close one.

Table 3. Heritability estimates for 8 agronomic traits of F_2 plant grown under 3 spacings in the second crop of 1965.

Character	Wide spacing (%)	Standard spacing (%)	Close spacing (%)
Heading date	86.38	65.39	42.99
Plant height	75.34	71.50	48.89
Panicles per plant	40.39	17.59	1.92
Panicle length	58.16	60.12	17.68
Panicle weight	58.06	38.46	29.17
Grains per panicle	59.74	47.65	26.10
Weight per 100-grain	79.41	44.83	15.23
Grain yield per plant	44.12	50.67	24.73

Table 4. Genotypic, phenotypic, and environmental correlations between 8 agronmic traits of F_2 plants grown under 3 spacings in the second crop of 1965.

Traits correlated	Wide spacing			Standard spacing			Close spacing		
	r_G	r_P	r_E	r_G	r_P	r_E	r_G	r_P	r_E
Heading date and									
plant height	.382	.348**	−.065	.454	.377**	−.222	.339	.231**	−.084
panicles per plant	−.202	−.252	−.257	−.363	−.271**	−.041	−.287	−.166	.042
panicle length	.218	.186	−.076	.236	.176*	−.103	.219	.044	−.322**
panicle weight	.330	.272**	−.233	.557	.337**	−.438**	.268	.149	−.127
grains per panicle	.435	.353**	−.367*	.546	.355**	−.398**	.436	.285**	−.055
weight per 100-grain	−.046	−.045	−.026	−.048	−.020	.091	−.139	−.131	−.115
grain yield per plant	.005	−.036	−.361*	.208	.103	−.328*	.208	.122	−.074
Plant height and									
panicles per plant	.137	.116	.017	.131	.121	.114	.276	.202*	.077
panicle length	.489	.473**	.386**	.663	.596**	.254	.062	.070	.228
panicle weight	.538	.497**	.236	.754	.643**	.255	.709	.554**	.176
grains per panicle	.487	.470**	.365*	.835	.709**	.186	.687	.572**	.303*
weight per 100-grain	−.021	−.007	.136	.042	.041	.041	−.138	−.062	.105
grain yield per plant	.410	.366**	.179	.590	.534**	.295*	.629	.510**	.236
Panicles per plant and									
panicle length	.157	.127	.002	.194	.207*	.260	−.208	−.103	.041
panicle weight	.060	.051	.014	.117	.097	.061	−.062	−.098	−.153
grain per panicle	.091	.099	.133	.046	.107	.245	.052	.011	−.051
weight per 100-grain	−.104	−.075	.104	.120	−.001	−.265	.094	−.101	−.372**
grain yield per plant	.561	.563**	.568**	.653	.649**	.671**	.841	.816**	.792**
Panicle length and									
panicle weight	.796	.765**	.609**	.812	.752**	.574**	.577	.627**	.719**
grains per panicle	.731	.700**	.542**	.822	.773**	.606**	.415	.547**	.776**
weight per 100-grain	.012	.025	.125	.070	.088	.154	−.121	−.039	.093
grain yield per plant	.657	.589	.314*	.654	.630**	.541**	.106	.195*	.348*
Panicle weight and									
grains per panicle	.957	.921**	.734**	.878	.854**	.790**	.947	.881**	.754**
weight per 100-grain	.341	.326**	.240	.122	.105	.059	−.326	−.082	.357**
grain yield per plant	.748	.698**	.516**	.729	.708**	.651**	.260	.350**	.638**
Grains per panicle and									
weight per 100-grain	−.107	−.097	−.029	−.112	−.096	−.049	−.457	−.383**	.023
grain yield per plant	.767	.711**	.484**	.813	.781**	.680**	.530	.467	.349*
Weight per 100-grain and									
grain yield per plant	−.055	−.021	.187	.021	.009	−.194	−.147	−.151	−.160
Degree of freedom		109	43		114	53		114	53

* Correlations significant at 5% level.

** Correlations significant at 1% level.

In each spacing treatment, estimates of heritability for heading date, plant height, panicle length and number of grains per panicle were generally high, whereas those of panicle weight, weight of 100 grains, grain yield per plant and number of panicles per plant were relatively low. However, heritability estimates for 100-grain weight and panicle weight were quite high under the condition of wide spacing.

Genotypic, Phenotypic, and Environmental Correlations

Genotypic, phenotypic, and environmental correlations measured over 3 spacings between all possible pairs of 8 traits are given in Table 4. Genotypic correlations were generally higher than the corresponding phenotypic correlations. Environmental correlations were larger than either genotypic or phenotypic correlations in certain combinations and smaller in the other ones. Genotypic and phenotypic correlations between various pairs of 3 spacings had like signs with the following exceptions, i.e., negative phenotypic correlations between heading date and grain yield per plant in wide spacing, and between panicles per plant and weight of 100-grain in standard and close spacings to their corresponding positive genotypic correlations. In general, more phenotypic correlations were found to be significant in standard spacing than in the other two.

Heading date gave negative environmental correlations with the rest of 7 traits in all spacings. The genotypic and phenotypic correlations between heading date and other traits were rather small in magnitude, especially in close spacing. Associations of plant height with both panicle weight and grains per panicle were high, particularly in standard and close spacings. The size of genetic correlations between plant height and grain yield, as well as all 3 correlations between panicles per plant and grain yield per plant increased as plants were being closely spaced together. Genotypic and phenotypic correlations between panicle length and panicle weight, grains per panicle, and grain yield per plant were high in standard spacing, but the magnitude of correlations decreased when population increased or decreased. Correlations between panicle weight and grains per panicle showed the highest values in all spacings, the phenotypic and environmental correlations being highly significant. Grain yield per plant was found to be closely associated with both panicle weight and grains per panicle, especially in wide and standard spacings. Weight per 100-grain was negatively correlated with other traits in close spacing while some positive associations were found in the other two.

DISCUSSION

Parental varieties, Tainan 3 and Pi No. 4 differ quite greatly in agronmic characters and a sufficient segregation in F_2 population for 8 traits measured in this experiment was available. Agronomic traits showed different responses to

spacing indicating that the ability to make adjustment to spacing varied with characters. Panicles and grain yield were found to be more easily influenced by spacing than others which is in agreement with the result of Chang (1965). Difference in panicle per plant among parental and F_2 plant was negligible under close spacing. Kariya and Yamamoto (1963) also suggested that rice varieties tend to become a similar type under close spacing, as far as tillering is concerned. Since competition is more intense under densely planted condition, the reduction in average values of agronomic traits observed in this experiment may be partly attributable to the effect of competition.

Estimates of heritability for heading date, plant height, and grains per panicle were generally higher than panicles and grain yield per plant which were similar to the results reported by other workers (Bollich, 1957; Toriyama and Futsuhara, 1958; Oung and Chang, 1958; Chang, 1960; Nei, 1960). Heritabilities for weight of panicle and 100-grain were also considered to be low (Matsuo, 1956) as was the case in standard and low spacings of this study, but these estimates were quite high under wide spacing, indicating that the variability of these two traits in F_2 population is rather great under the growing conditions of wide spacing. It was noticed that heritability values decreased as population density increased which may be attributable to either the decrease in F_2 genotypic variance or the increase in environmental one. The smallest heritability value obtained in this experiment was 1.91 for panicles per plant under close spacing showing that there was practically no genotypic variance left in total F_2 variance after the removal of environmental one. Under close spacing where competition is rather intense, low heritabilities of several agronomic traits in close spacing will unquestionably render selection for these traits more difficult. Since competitive ability is generally not correlated with productive traits (Yamada, 1950; Oka and Sakai, 1956), and density response (Sakai and Iyama, 1966), genotypes of high yielding and density response are not necessarily strong competitors. Efficiency of selection for these tratis under dense planting would, therefore, be reduced.

Heritabilites and correlations obtained in this experiment appeared different in size and, in some comparisons, in the direction with those of another cross reported in the previous study (Chang, 1964). This indicates that certain estimates of heritability and correlation may be characteristic of certain population in a certain planting and that there would be no reason to expect consistent values in other segregation populations. Akemine and Kumagai (1958) also reported that heritabilities and correlations of certain agronomic traits changed with time of planting.

The estimates of heritability and genetic relationships which exist among different traits must be considered in a breeding program. Gotoh and Osanai (1959) suggested that if a high heritability estimate of a given character is obtainable under a particular set of conditions, the efficiency of selection for

this character could be enhanced in this environment. In this experiment, grain yield per plant was genetically correlated with panicles per plant and plant height in close spacing; and with grains per panicle, panicle weight, and panicle length in wide and standard spacings. Since heritability estimate for panicles per plant was extremely small in close spacing, more effective selection for grain yield in F_2 population may probably be made through selecting tall plants. In wide spacing, grains per panicle appeared to have the highest estimate of heritability, therefore, emphasis should be placed on the selection of plants with more grains per panicle. As for standard spacing, heritabilities for both grains per panicle and panicle weight were lower than that for panicle length, plants high in grain yield may be better obtained by selecting plants with long panicles. Considering the magnitude of heritability and association of characters obtained in this study, it seems highly likely that selection for grain yield in F_2 population would be more effective in wide spacing than in the other two. Kobori (1963) reported that selection on ear weight per plant is more effective under the condition of sparse planting. Sakamoto *et. al.* (1963) also observed that panicle weight per plant of the population cultured in low planting density was significantly higher than the population grown in high planting density.

SUMMARY

Eight agronomic traits of a rice cross, Tainae 3 × Pi No. 4, were studied in in the F_2 population in the second crop of 1965 to 3 spacings, i.e., wide, standard, and close spacings with distance between rows and hills of 25 × 40, 25 × 20, and 25 × 10, respectively. Data for all traits were obtained on individual plants randomly selected.

Close spacing caused a drastic decrease in panicles and grain yield per plant whereas plant height, panicle weight, and grains per panicle decreased very slightly. Heading date and weight of 100-grain were practically not affected by spacing.

Estimates of heritability for panicles and grain yield per plant were low largely due to the low genotypic variance of F_2 population. Heritabilities for other traits were in general higher. Heritability estimates for traits in wide and standard spacings were larger than those in close spacing.

Grain yield per plant was closely associated with panicles per plant and plant height in close spacing, and with grains per panicle, panicle weight, and panicle length in wide and standard spacing.

LITERATURE CITED

1. Akemine, H. and K. Kumagai, 1958. Variation and combination of characters in a cross between widely differing varieties of rice. *Studies on the Bulk Method of plant Breeding*. Yokendo Ltd., Tokyo.
2. Bollich, C.N. 1957. Inheritance of several economic quantitative characters in rice. Diss. Abs. **17**: 1638.

3. Chang, W.L. 1964. Influence of Planting methods on the variability and correlations of agronomic characters in the F_2 populations of a *Japonica* rice cross. Jour. Taiwan Agr. Res. **13**(3): 1-13.
4. Chang, W.L. 1965. Effects of planting density on yield components of rice. Jour. Taiwan Agri. Res. **14**(4): 19-27.
5. Chang, W.T. 1960. Characters of X-ray induced mutations and their inheritance of rice. Jour. Agri. Assoc. China. New Series. **29**: 53-58.
6. Gotoh, K. and S. Osanai. 1959. Efficiency of selection for yield under different densities in a wheat cross. Jap. J. Breeding. **9**(1): 7-11.
7. Futsuhara, Y., K. Toriyama and S. Hashiguchi. 1965. Evaluation of visual selection in rice. I. Path coefficient analysis of factors influencing visual selection. Jap. J. Breeding **15**(4): 271-280.
8. Kariya, K. and T. Yamamoto. 1963. Planting density and selection method in rice plant. Jap. J. Breeding. **13**(1): 25-30.
9. Kobori, O. 1963. Thremmatological and biometrical studies on interaction between genotypes and environments on yield of rice. Mem. Col. Agr. Kyoto. U. 85: 1-72.
10. Matsuo, T. 1956. Breeding method for high yielding rice varieties. Agr. and Hert. **31**(5): 641-646.
11. Nei, M. 1960. Studies on the application of biometrical genetics to plant breeding. Mem. Col. Agr., Kyoto. U. 82: 1-100.
12. Oka, H.I. and K.I. Sakai. 1956. Correlation between competitive ability and other Characters in hybrid populations of rice. Ann. Rep. Nat Inst. Genetics, Japan **7**: 70-71.
13. Oung, T.Y. and W.T. Chang. 1958. Mutations in rice induced by X radiation. Proc. 2nd. International Cont. Peaceful Used Atomic Energy, U.N. Geneva (1958). **27**: 223-226.
14. Sakai, K.I. and S.Y. Iyama. 1956. Studies on competition in plants and animals. XI. competitive abiiity and density response in barley. Jap. J. Breeding. **16**(1): 1-9.
15. Sakamoto, S., T. Yamamoto, and K. Toriyama. 1963. Effect of planting density on genetic constitntion of hybrid popuiation in rice. Bull. Chugoko Agr. Exp. Sta. **9**: 9-16.
16. Toriyama, K. and Y. Futsuhara. 1958. Estimates of heritabilities on individuals and lines in rice. Jap. J. Breeding. **7**: 208-212.
17. Yamada, T. 1950. Competition between different genotypes in the early hybrid population. Breeding Res. **4**: 47-60.

栽植密度影響水稻什交第二代後裔主要農藝性狀遺傳力及相關之研究

張 萬 來

摘 要

水稻品種臺南3號，Pi No 4及其雜交第二代後裔分別種植於三種不同栽植密度即疏植（行株距25×40分分），標準植（行株距25×20公分）及密植（行株距25×10公分）並從各栽植密度隨機選取單株調查有關農藝性狀。

每株穗數及每株谷重均隨栽植密度之增加而急減，株高，穗長與每穗粒數亦有遞減現象，生育日數及百粒重受栽植密度影響甚微。

每株穗數及每株谷重之遺傳力較低，而其他農藝性狀之遺傳力則較高，在疏植及標準環境下估計之遺傳力，一般言之，均較密植處理者爲高。

在密植區每株谷重與每株穗數及株高具有密切正相關，而在疏植及標準植區，其每株谷重與每穗粒數，穗重及穗長等性狀之相關極高。

EFFECT OF SPLIT APPLICATION OF FERTILIZER ON YIELD, COMPONENTS OF YIELD, AND OTHER AGRONOMIC CHARACTERS OF RICE (IV).*

By

W. L. CHANG, S. C. YANG, and J. N. CHAO**

The effect of split application of fertilizers has been under investigation at Chiayi Agricultural Experiment Station since 1963, with a simple objective of finding out whether the efficiency of fertilizer utilization could be further improved by manipulating the time of fertilization. Experimental results obtained so far indicated that split application of nitrogen and potassium fertilizers was generally effective in raising grain yield in both the first and the second crops of rice (Chang and Yang, 1964a,b; 1966), whereas split application of phosphorus fertilizer did not show any significant increase in grain yield of rice (Chang and Yang, 1964b). Similar results were also reported by Tsai *et. al.* (1965) and Tsai and Chen (1966) for nitrogen fertilizer and by Shen and Yuan (1964), and Feng and Kuo (1965) for potassium fertilizer. No significant difference was observed between the basal and split application of phosphorus fertilizer (Matsuo, 1948). Mitsui (1954) also suggested that sufficient amount of phosphorus fertilizer applied to rice as a basal dressing would be enough to cover the need for a maximum yield production.

An experiment designed to furnish information on the most favorable time of applying nitrogen and potassium fertilizers at various places of the island, was initiated in 1965 under the sponsorship of the Joint Commission on Rural Reconstruction with Chiayi Agricultural Experiment Station and all the 7 District Agricultural Improvement Stations cooperating. The purpose of this paper is to pressent a brief summary of the significant results obtained at this Station.

MATERIALS AND METHODS

Yield data were obtained for 4 successive crops, 1965 to 1966, inclusive, from an experiment in which a given amount of nitrogen and potassium fertilizers were applied to rice in a single application or in different combinations of split application as listed in Table 1.

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Table 1. Treatments of fertilizer application*

Treatment	Element	Easal dressing	First top-dressing	Second top-dressing	Third top-dressing	Fourth top-dressing (Panicle fertilizaton)	Fifth top-dressing (Grain fertilization)
A	N**	100	—	—	—	—	—
B	N	50	50	—	—	—	—
C	N	25	—	—	75	—	—
D	N	34	33	33	—	—	—
E	N	30	—	40	—	30	—
F	N	25	—	—	40	35	—
G	N	25	—	—	40	25	10
H	N	25	—	—	40	25	10
	K	50	—	—	50	—	—
I	N	25	—	—	40	25	10
	K	25	—	—	50	25	—

* Basal dressing: One day befor transplanting.
First top-dressing: 10 days (1st crop) and 7 days (2nd crop) after transplanting.
Second top-dressing: 20 days (1st crop) and 14 days (2nd crop) after transplanting.
Third top-dressing: 30 days (1st crop) and 21 days (2nd crop) after transplanting (maximum tillering stage).
Fourth top-dressing or panicle fertilization: Panicle initiation stage of about 58 days (1st crop) and 37 days (2nd crop) after transplanting.
Fifth top-dressing or grain fertilization: Heading stage or about 86 days (1st crop) and 63 days (2nd crop) after transplanting.

** The whole amount of P_2O_5 was used as a basal dressing, and the relative amounts (%) of N and K_2O applied at different times were shown in Table 1.

The trial was located in Tai-tou-ken Farm of Chiayi Agricultural Experiment Station on silty clay loam, a light colored, moderately heavy-textured soil of typical rain-fed paddy in Chianan area. Soil samples were taken before each trial and the analysis was made by Taiwan Agricultural Research Institute. Table 2 shows the result of the analysis.

Chianung 242, a typical panicle weight type of Japonica rice variety was used in the test. The plant spacing was 22.5 by 22.5 cm, (approximately 20 hills per square meter), with 5 seedlings being transplanted at each hill. Ammonium sulphate, calcium superphosphate, and potassium sulphate were used as carriers of N, P_2O_5, and K_2O which were applied at the rate of 100, 50, and 50 kg per ha respectively. Climatic conditions were favorable for good rice growth during the test period.

The design of the experiment was a randomized complete block with 4 replications. Each plot consisted of 13 rows 20 hills long or an area 3 by 4.5 m from which 11 rows of 18 hills each or an area 2.5 by 4 m (10 m^2 or 1/1,000 ha) was hervested for yield determination. Plot borders were not included so that border effects could be minimized. Besides grain yield, data for heading date, plant height, number of panicles per hill, panicle weight, panicle length, weight of 100 grains, number of grains per panicle were also taken for the analysis of variance. Since data on four crops in two years were available, combined analyses were also made for the recorded traits so that their interactions between treatments and years in both the first and the second crops could be determined.

Table 2. Result of soil analysis

	Organic matter (%)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	pH
First crop. 1965				
Surface soil	0.94 (low)	145 (high)	90 (low)	6.6 (medium)
Subsoil	0.38 (very low)	45 (low)	88 (low)	7.2 (high)
Second crop, 1965				
Surface soil	1.64 (low)	242 (high)	149 (medium)	5.6 (low)
Subsoil	0.06 (very low)	65 (medium)	116 (medium)	6.7 (medium)
First crop, 1966				
Surface soil	1.40 (low)	210 (high)	88 (low)	5.7 (low)
Subsoil	1.20 (low)	123 (high)	60 (low)	6.9 (medium)
Second crop, 1966				
Surface soil	1.80 (low)	229 (high)	98 (low)	5.8 (low)
Subsoil	1.46 (low)	134 (high)	85 (low)	7.0 (medium)

RESULTS AND DISCUSSION

Effect of Time of Fertilizer Application on Grain yield and Its Components.

The average grain yields for the 2-year period are given for each treatment in Table 3. Combined analyses of variance made on the 2-year summary of data in both crops indicated that differences in treatment means were highly significant. Treatments F and C gave the highest yields in the first and the second crops respectively, whereas treatment D, the lowest in both crops. The curves of grain yield were, as shown in Figure 1, generally in parallel with those of panicles per hill, indicating that the increase in grain yield was caused primarily by the increase of panicles per hill. The combined analyses of variance for yield

Table 3. Effect of time of fertilization on grain yield and its components.

Treatment	Grain yield (kg/ha)		Number of panicles per hill		Nummber of grains per panicle		Weight of 100 grains (g)	
	First crop	Second crop	First crop	Second crop	First crop	Second crop	First crop	Second crop
A	5,868	4,492	12.2	8.5	135.0	156.5	2.92	3.02
B	5,352	4,493	11.1	8.5	139.0	154.5	2.98	3.11
C	5,975	5,135	12.4	10.4	133.3	147.2	2.93	3.06
D	5,227	4,430	10.6	8.3	132.9	152.6	3.01	3.04
E	5,658	4,652	10.5	9.7	141.1	164.8	2.99	2.95
F	6,065	5,125	12.3	10.8	144.7	162.1	2.91	2.94
G	5,646	5,028	10.3	10.1	142.7	156.0	2.86	2.99
H	5,742	5,071	11.4	10.1	137.9	164.3	2.98	2.97
I	5,624	5,052	10.8	9.9	136.5	162.6	3.01	2.99
Mean	5,684	4,831	11.3	9.6	138.1	157.8	2.96	3.00
LSD 5%	311	300	0.3	1.1	—	9.3	0.10	0.09
1%	415	400	0.4	1.5	—	12.5	—	—

* Data are means of 1965 and 1966 Crops.

components (Table 3) showed that differences in panicles per hill among treatments were significant at 1% level in both crops. Grains per panicle and 100-grain weight were not in close association with grain yield. However, treatments with top-dressings at panicle initiation stage and heading stage produced more grains per panicle, especially in the second crop.

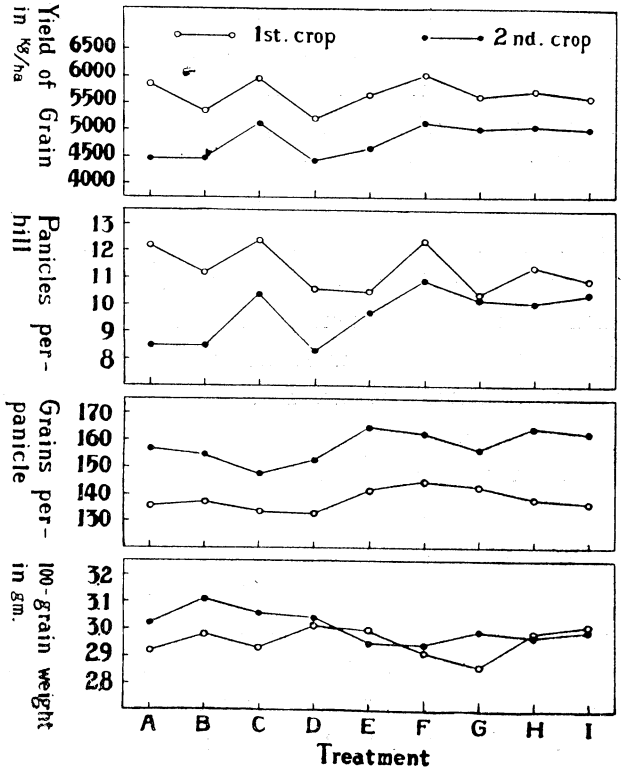


Figure 1. Effect of time of fertilization on yield and its components.

Treatment F produced 838 kg or 16.03% more grains per ha than that of treatment D in the first crop, whereas treatment C outyielded treatment D by 705 kg or 15.91% per ha in the second one, differances being significant at 1% level. The highest yield increases previously recorded for split application of fertilizers at Wang-tien-Li Farm of this Station were 5.69% and 6.36% for the first and the second crops respectively (Chang and Yang, 1966). Since soil fertility of Tai-tou-Ken Farm is lower than that of Wan-tien-Li Farm, split application of fertilizers appears to be more effective under the lower fertility conditions.

The differences in yields between treatments C and F were not significant, suggesting that both treatments had almost the same yielding ability. Treatment C had only one top-dressing of nitrogen at maximum tillering stage, whereas treatment F top-dressed twice at both maximum tillering stage and panicle initiation stage. The lowest yielding treatments B and C had one and two top-dressings of nitrogen respectively before maximum tillering stage which are very much similar to the conventional method of fertilization generally practiced by

farmers in Chianan area, and their yields are considered to be the typical ones for Chianung 242 obtainable at Tai-tou-Ken Farm. It appears, therefore, that yield increases of treatments C and F may be attributable to their proper timing of applying nitrogen fertilizer, and top-dressing of nitrogen at maximum tillering stage and panicle initiation stage are apparently necessary for increasing grain yield production. Similar results were also reported previously (Chang and Yang, 1966). As shown in Table 3. top-dressing of nitrogen at maximum tillering stage generally resulted in more panicles per hill, whereas that at panicle initiation stage or so called "panicle fertilization" appeared to produce more grains per panicle. This observation well agreed with those of Matsuo (1948). and Matsushima *et al.* (1964).

Top-dressing of nitrogen at heading stage or so called "grain fertilization" was practiced in treatment G, H, and I. Since grain yields of these treatments were all lower than that of treatment F, it seems likely that top dressing of nitrogen at heading stage may be unnecessary provided a sufficient amount of nitrogen is top-dressed at panicle initiation stage. Although nitrogen application at milk ripe stage was reported to be effective for yield increase (Matsuwura, 1962), it may be useful only under certain growing conditions as pointed out by Matsushima *et al.* (1963). The top-dressing of nitrogen at full heading stage was recommended by Matsushima and Tanaka (1967) to increase the percentage of ripened grains if the supply of nitrogen is withheld during the growing stage from 69 to 92 in leaf number index or about 42 to 18 days before heading. As shown in Table 5 the fertility percentages of treatments with nitrogen top-dressing at heading stage were not significantly higher than those without grain fertilization in this experiment. Nevertheless, the quality of rice grains can be greatly improved by top-dressing of nitrogen at heading stage. Tsai *et al.* (1965) reported that nitrogen or crude protein content of brown rice and milled rice increased 10 to 15% when the nitrogen fertilizer was applied at heading stage.

It is interesting to note that treatment A which applied all nitrogen as a basal dressing yielded as high as the two top yielding treatments C and F in the first crop whereas its yield was as low as the lowest yielding treatment D in the second crop. The seasonal difference in yield response of treatment A was further demonstrated by the partitioning of the treatment effect on grain yield as shown in Table 4. The component of the treatment effect, single versus split applications of fertilizers with one degree of freedom was not significant in the first crop, suggesting that nitrogen applied at one time during planting or split twice or more did not cause any significant difference in yield in the first crop, but in the second crop, the difference between single and split applications of nitrogen was significant at 1% level, indicating that split application of nitrogen was effective in increasing grain yield in the second crop. Moomaw (1965) also reported that Chianung 242 did not show any significant response to variously timed nitrogen applications in the 1963 and 1964 dry seasons (an equivalent of the

Table. 4. Mean squares and significance of F-values in the combined statistical analysis of data for the effect of time of fertilization on grain yield and its components.*

Certain degrees of freedom partitions		Grain yield (kg/ha)				Number of panicle per hill				Number of grains per panicle				Weight of 100 grains (g)			
		First crop		Second crop		First crop		Second crop		First crop		Second crop		First crop		Second crop	
Source	d.f.	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.
Treatments	8	591,999	1%	746,235	1%	5.46	1%	6.97	1%	136.99	—	287.63	1%	0.0225	5%	0.0025	5%
Single vs. split	1	304,934	—	1,034,204	1%	6.96	5%	11.59	1%	82.36	—	16.57	—	0.02	—	0	
Within split	7	633,008	1%	705,097	1%	5.25	1%	6.31	1%	144.79	—	326.35	1%	0.0229	5%	0.0257	1%
Years	1	559,858	—	164,642	—	46.56	1%	8.89	1%	2,278.13	1%	35.84	—	0.32	1%	0.09	1%
Treatments x Years	8	137,909	—	414,028	1%	1.15	—	4.39	1%	179.17	5%	80.03	—	0.0075	—	0.0025	—
Single-split x Years	1	2,504	—	786,843	1%	0.26	—	3.23	—	0.09	—	37.16	—	0.01	—	0	—
Within split x Years	7	157,252	—	360,768	1%	1.27	—	4.52	1%	204.75	5%	86.15	—	0.01	—	0.0014	—
Error	48	96,464		89,773		1.00		1.22		71.99		87.11		0.0096		0.0081	

* Analysis was based on data of the same crop seasons of 1965 and 1966.

first crop in Taiwan). The similar observation was also made by the writers in the previous report (Chang and Yang, 1966). Since panicles per hill is the most important component influencing grain yield, and rice plants generally produce more panicles per hill in the first crop, it appears necessary that more nitrogen should be applied at the early stage of growth in less splittings in order to prevent a drastic decline of effective tillers in the first crop. In the second crop, however, the environmental conditions are not favorable for rice plants to produce more panicles per hill, but are rather favorable for producing longer and heavier panicles with more grains per panicle, it seems desirable that nitrogen should by applied in more splittings with more emphasis placed at the late stage of growth.

Combined analyses of variance for grain yield and its components in Table 4 showed that differences between years were not significant in grain yields in both crops but they were mostly significant at 1% level in yield components. Interactions between treatments and years were highly significant only in grain yield and panicles per hill of the second crop, indicating that treatment effects on grain yield and panicles per hill varied with years. It seems reasonable, therefore, to suggest that environmental factors and nutritional status of rice plants should be taken into consideration when application of fertilizers is to be made.

Potassium fertilizer was split applicated in treatments H and I which gave slightly better yields than of treatment G which applied all potassium as a basal dressing, showing that split application of potassium fertilizer was slightly effective. Treatment I which applied more potassium fertilizer in top-dressings did not produce higher yield than that of treatment H which applied more potassium fertilizer at the basal dressing was found to give better yield by Feng and Kuo (1965). The grain yields of the treatments H and I, however, were all lower than those of treatments C and F, suggesting that the effect of split applicaton of potassium fertilizer is negligible when application of nitrogen fertilizer is not properly practiced.

Effect of Time of fertilizer Application on the Growth of Rice Plant and Some Agronomic Traits.

Plant height, number of tillers per hill, and leaf area were measured bi-weekly to determine the effect of time of fertilizer application on the growth of rice plant. Figure 2 shows that plant height increased as rice plant grew older. Plant height was not greatly affected by the time of fertilizer application in the early stage of growth, but it appeared to be closely associated with grain yield at the late stage of growth. Treatment means as shown in Table 5 differed significantly in both crops.

Rice plant showed a better growth with more tillers per hill in the early stage of growth up to heading stage when more nitrogen was applied at or before

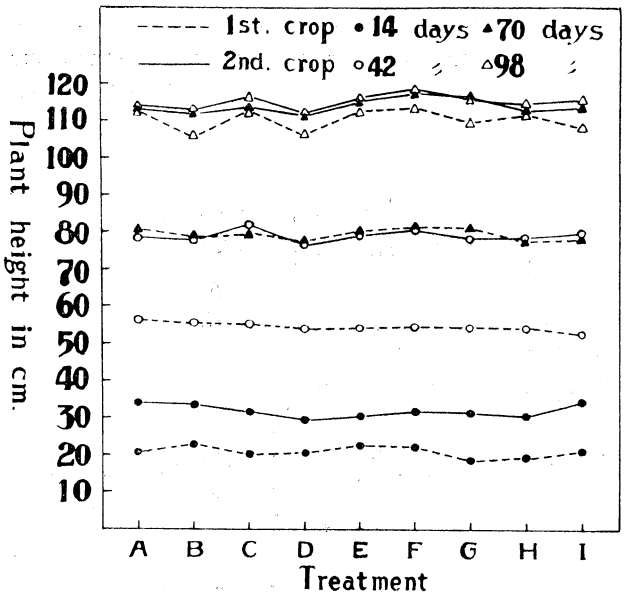


Figure 2. Effect of time of fertilization on plant height at different stage of growth.

Table 5. Effect of time of fertilization on some agronomic traits of rice.

Treatment	Heading date		Plant height (cm)		Panicle length (cm)		Panicle weight (cm)		Fertility (%)	
	First crop	Second crop	First crop	Second crop	First crop	Second crop	First crop	Second crop	First crop	Second crop
A	86	63	103.7	114.5	22.5	24.2	3.9	4.6	95.7	93.4
B	86	62	100.5	113.1	22.8	24.1	3.9	4.6	96.0	93.8
C	87	63	102.8	117.0	22.2	23.8	3.8	4.3	95.5	92.6
D	86	63	99.0	113.1	23.1	24.0	4.0	4.5	96.2	92.8
E	85	63	103.0	115.5	24.1	23.6	4.3	4.4	95.9	89.6
F	86	63	104.0	119.1	24.0	24.0	4.1	4.5	95.9	89.3
G	86	63	101.9	117.3	23.3	23.5	4.1	4.5	96.3	91.9
H	86	63	104.0	114.2	23.4	24.2	4.1	4.6	95.5	91.0
I	86	64	102.7	115.4	23.5	23.8	4.1	4.6	94.7	91.5
Mean	86	63	102.4	115.5	23.2	23.9	4.0	4.5	95.7	91.8
LSD 5%	—	0.6	2.7	3.7	0.5	—	0.2	—	—	2.0
1%	—	0.8	3.5	—	0.7	—	0.3	—	—	2.7

* Data are means of 1965 and 1966.

maximum tillering stage in the first crop as indicated in Figure 3. However, percentage of effective tillers was apparently lower in the treatments with early application of nitrogen as compared with that of the treatments which applied nitrogen lately. In the second crop, early application of nitrogen did not result in good tillering of rice plant, and treatments with nitrogen top-dressed at the late growing stage generally produced more tillers and panicles per hill. It is conceivable that early application of nitrogen is not effective in producing tillers and panicles which is the most important factor influencing grain yield in the

second crop, since tillering is largely controlled by water temperature (Matsushima *et al.*, 1964), and it is not unusual for water temperature during the tillering period in the second crop to outreach 31°C, the optimum temperature for maximum tillering.

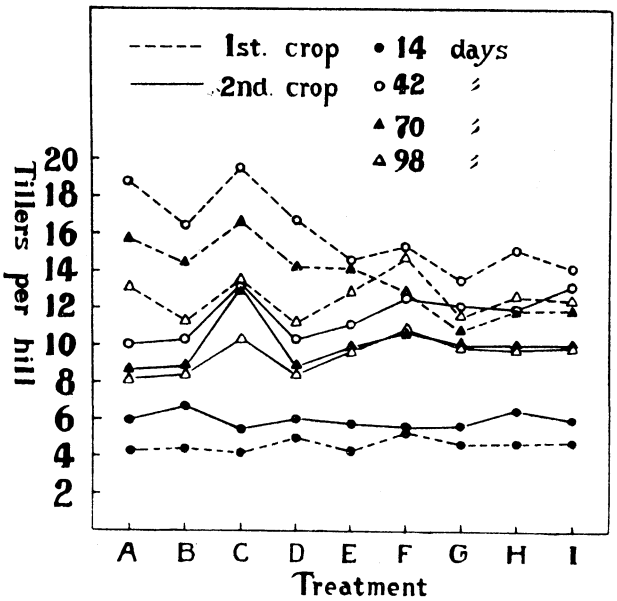


Figure 3. Effect of fertilization on tillers per hill at different stages of growth.

Figure 4 shows that leaf area index (LAI) increased as rice plant grew bigger, and reached its maximum somewhere around heading stage in both crops. The curves of LAI in Figure 4 were very much similar to those of number of tillers as shown in Figure 3, indicating that changes in LAI resulted primarily from changes in tiller number. Tanaka *et al.*, (1964) also reported that the tiller number per unit area was the major factor controlling LAI. It was observed that early application of nitrogen generally resulted in larger LAI in the second crop. The maximum values of LAI before heading were approximately 6 and 4 in the first and the second crops respectively, which were considered to be the right sizes for maximum dry matter production (Tanaka *et al.*, 1966). The optimum LAI for the rice plant has been reported to be between 4 to 4.5 by Kanda and Sato (1963) and 7 to 8 by Matsushima *et al.*, (1964). It seems highly likely that the response of LAI to the time of fertilizer application may have a great impact on the yield response, since treatments with larger LAI generally produced higher grain yield.

Table 5 shows that time of fertilizer application did not cause a significant difference in heading date in the first crop. However, late application of nitrogen significantly delayed heading date in the second crop. The fourth top-dressing of nitrogen or so called "panicle fertilization" was applied 58 days and 37 days after transplanting or 28 days and 26 days before heading in the first and the

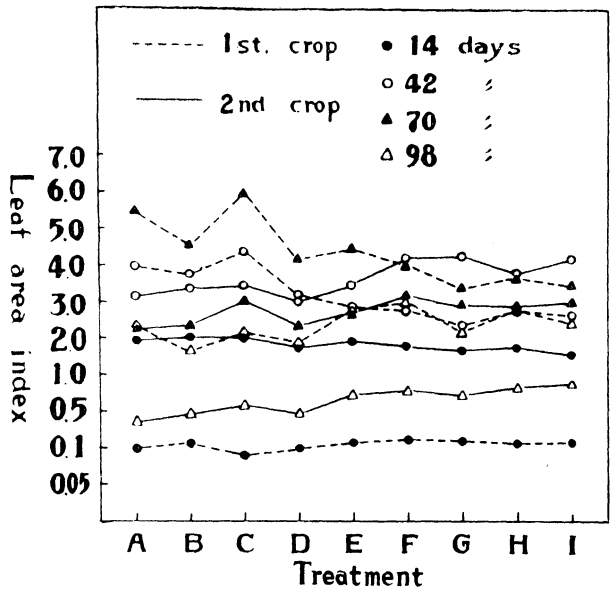


Figure 4. Effect of time of fertilization on leaf area index at different stages of growth.

second crops respectively. Matsuo (1966) also suggested that the suitable date for top-dressing at the time of ear-formation stage seems to be from 18 to 25 days before heading, depending upon the fertility of soil. The average length of young panicles at these stages were about 1 to 3mm as shown in Figure 5 which are in

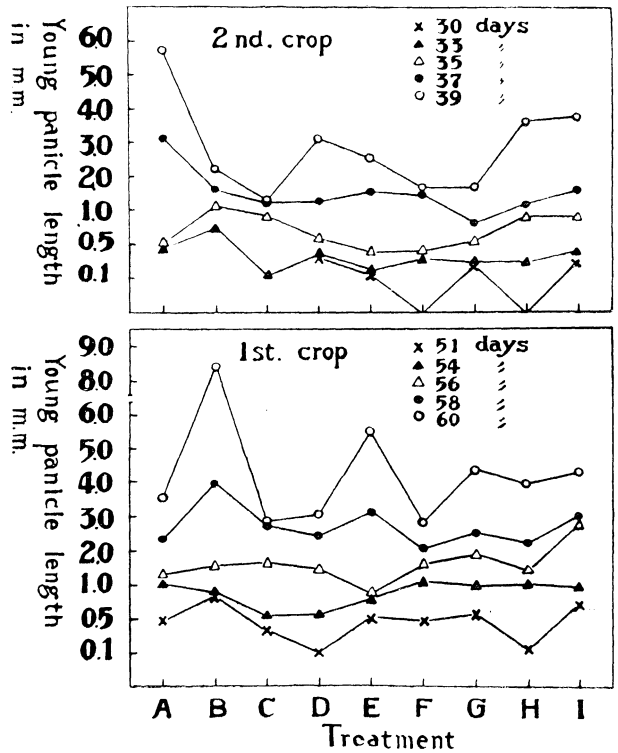


Figure 5. Growth of young panicles at their early initiation stage.

the early to middle spikelet differentiation stages (Matsustima, 1966). The stage when the length of young panciles nears 1mm is generally termed the beginning of panicle initiation, and the application of nitrogen at this stage has been proved to be highly effective in increasing grain yield production (Matsuo, 1948; Suzuki, 1958; Mitsui, 1964).

Nitrogen top-dressed at the later stages of growth produced longer and heavier panicles in comparison with the early top-dressings of nitrogen in the first crop, differences among treatment means being significant at 1% level. In the second crop, however, time of fertilizer application did not cause any significant changes in both panicle length and panicle weight. Combined analyses of variance given in Table 6 indicated that mean squares associated with years were highly significant in heading date, plant height, panicle length, panicle weight and fertility percentage in both crops. Interactions between treatments and years were not significant in most of the traits.

Table 6. Mean squares and significance of Fvalues in the combined statistical analysis of data for the effect of time of fertilization on some agromic traits of rice.

Certim degrees of freedom partitions		Heading date		Plant height (cm)		Panicle length (cm)		Panicle weight (g)		Fertility (%)	
Source	d.f.	M,S.	F.	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.
First crop											
Treatments	8	2.17	—	22.93	1%	3.3985	1%	0.1371	1%	3.5465	—
Single vs. Split	1	1.18	—	16.17	—	4.8473	1%	0.1882	5%	0.14	—
Within Split	7	2.31	—	23.90	1%	3.1916	1%	0.1298	1%	4.0331	—
Years	1	308.35	1%	352.45	1%	22.1002	1%	9.5557	1%	41.7698	5%
Treatments x Years	8	0.88	—	6.21	—	1.0286	1%	0.0471	—	6.8168	—
Single-split x Years	1	1.77	—	8.35	—	1.1165	5%	0.0158	—	0.1540	—
Within spli tx Years	7	0.75	—	5,90	—	1.0161	1%	0.0516	—	7.7687	—
Error	48	1.10		6.99		0.2633		0.0414		5.8651	
Second crop											
Treatment	8	1.55	1%	32.66	5%	0.51	—	0.12	—	21.38	1%
Single vs. Split	1	2.13	5%	7.80	—	0.64	—	0.14	—	26.87	5%
Within Split	7	1.46	1%	36.21	5%	0.49	—	0.12	—	20.60	1%
Years	1	51.68	1%	1,932.35	1%	16.62	1%	0.25	—	117.68	1%
Treatment x Years	8	0.71	—	20.44	—	0.67	—	0.07	—	5.68	—
Single-split x Years	1	0.09	—	3.18	—	3.03	1%	0.05	—	4.94	—
Within split x Years	7	0.80	—	22.90	—	0.30	—	0.07		5.79	—
Error	48	0.38		13.67		0.38		0.09		4.12	

* Analysis was based on data of the same crop season of 1965 and 1966.

It should be pointed out that the results summarized in this paper are indicative of the effect of time of application of fertilizers on one rice variety grown under one set of conditions. The Chianung 242 variety might respond differently on different soil types and under different climatic conditions.

SUMMARY

The effects of time of fertilizer application on yield, components of yield, and some important agronomic characters of rice evaluated in 1965 at the Chiayi Agricultural Experiment Station are summarized.

Treatment C with nitrogen fertilizer top-dressed at maximum tillering stage and treatment F, at both maximum tillering and panicle initation stages produced the highest yields in both crops. The yield increases appeared to be due largely to the increase of panicles per hill. Top-dressings of nitrogen fertilizer before maximum tillering stage did not contribute to yield increase. The effects of applying nitrogen fertilizer at heading stage and split application of potassium fertilizer were not evident in this experiment.

Early application of nitrogen fertilizer generally produced more tillers per hill and larger leaf area index in the first crop whereas late application of nitrogen fertilizer resulted in better growth of rice plant in the second crop. There was an indication for a tall and late heading plant to be associated with high yielding ability.

Significant interactions between treatments and years were observed in panicle length and number of grains per panicle in the first crop, and grain yield and number of panicles per hill in the second one.

LITERATURE CITED

1. Chang, W. L. and S. C. Yang. 1964a. Effects of split application of fertilizer and planting density on yield, components of yield, and other agronomic characters of rice. Jour Taiwan Agr. Res. 13(1): 16-27.
2. Chang, W. L. and S. C. Yang. 1964b. Effects of split application of fertilizer and planting density on yield, components of yield, and other agronomic characters of rice (II). Jour. Taiwan Agr. Res. 13(4): 1-10.
3. Chang, W. L. and S. C. Yang. 1966. Effects of split applicatien of fertilizer and planting density on yields, components of yield, and other agronomic characters of rice (III). Jour. Taiwan Agr. Res. 15(1): 1-7.
4. Feng, M. P. and K. E. Kuo. 1965. Experiment on timing of potash fertilization in rice. Sci. Agr. 13(9, 10): 286-288.
5. Kanda, M. and F. Sato. 1963. On the relationship between leaf area index and population growth of rice plants. Sci. Rep. Res. Inst. Tohoku Univ. 14: 57-73.
6. Matsuo, D. 1948. Observation on panicle fertilization (1). Agr. and Hort. 23(7): 403-406.
7. Matsuo, H. 1966. Fertilizer application techniques and water management for rice. Development of Paddy Rice Culture Techniques in Japan. Assoc. Agr. Rel. Asia. pp. 104-130.
8. Matsushima, S. 1966. Crop Science in Rice—*Theory of Yield Determination and Its Application*. Fuji Co., Ltd., Tokyo. pp. 365.
9. Matsushima, S., G. Wada, T. Tanaka, and T. Hoshino. 1963. Analysis of yield determining process and its application to yield prediction and culture improvement of low land rice. 67. Studies on the principles for maximizing yield and their demonstration. (1). Proc. Crop Sci. Soc. Japan. 33(1): 48-52.
10. Matsushima, S., G. Wada, T. Tanaka, A. Matsuzaki and T. Hoshino. 1964. Analysis of yield determining process and its application to yield prediction and culture improvement of low land rice. 72. Effects of top-dressing with ammonium sulfate on the grain yield and its components of directly sown rice plant at critical stages relating to determination of each yield components. Proc. Crop. Sci Soc. Japan. 33(2): 141-144.

11. Matsushima, S., G. Wada, and A. Matsuzaki. 1966. Analysis of yield determining process and its application to yield prediction and culture improvement of low land rice. 74. Studies on the principles for maximizing yield and their demonstration (3). Proc. Crop. Sci. Soc. Japan. 34(3): 321-328.
12. Matsushima, S. and T. Tanaka. 1967. Decreasing basal dressing of nitrogen in accordance with increasing planting density of rice. Agr. and Hort. 42(2): 373-374.
13. Matsuwura, A. 1962. Theory and practice of split application of fertilizers in rice (3). Agr. and Hort. 37(12): 1898-1902.
14. Mitsui, S. 1964. Nutrients absorption and panicle fertilization of rice Agr. and Hort. 29(1): 123-126.
15. Mitsui, S. 1964. Inorganic Nutrition Fertilization and Soil Amelioration for Lowland Rice. Yokendo, Tokyo, pp. 107.
16. Moomaw, J. C. 1965. Time of nitrogen application. Ann. Rep.. Int'l Rice Res. Inst. (1964) pp. 94-96.
17. Shen, C. Y. and W. L. Yuan. 1964. Effect of split application of potash on paddy yield. Jour. Agr. Assoc. China, New Series. 45:41-45.
18. Suzuki, S. 1958. Split application of nitrogen and panicle fertilization of rice in south western Japan. Agr. and Hort. 33(6): 941-944.
19. Tanaka, A., S. A. Navasero, C. V. Garcia, F. T. Parao, and E. Ramirex. 1964. Growth habit of the rice plant in the tropics and its effect on nitrogen response. IRRI Tech. Bull. 3:1-80.
20. Tanaka, A., K. Kawano, and J. Yamaguchi. 1966. Photosynthesis, respiration, and plant type of the tropical rice plant. IRRI Tech. Bull 7:1-46.
21. Tsai, w. F., C. S. Chen, and C. I. Lin. 1965. The effect of late-application of nitrogen fertilizer on the grain yield and somd other characters of paddy aice. Jour. Assoc. China, New Series. 49:65-72.
22. Tsai, W. F. and C. S. Chen. 1966. Effect of application of nitrogen fertilizer at panicle initiation stage and heading stage on yield and components of yield of paddy rice. Sci. Agr.14(1,2): 53-54.

肥料分施對水稻產量，產量構成因素，及其他農藝性狀之效果(四)

張萬來　楊遜謙　趙政男

摘　要

本文係報告嘉義農業試驗分所於民國54年第1期作起至民國55年第2期作承辦全省性水稻肥料分施試驗之綜合結果。

在水稻分蘗盛期施用氮肥1次之處理3及在分蘗盛期及幼穗分化期各施用1次氮肥之處理6，其產量在第1、2期作均較其他處理爲高，其增產原因爲每株穗數之增加。在分蘗盛期前之追施氮肥，效果甚微。又在齊穗期之氮素追肥及鉀肥之分施，在本試驗亦未見成效。

在第1期作早施氮肥能增加每株分蘗及葉面積指數，而在第2期作，則以後期追施氮肥之稻株發育較佳。稻株高，而生育日數長之處理，似較高產。

第1期作之穗長與每穗粒數，其處理與年份之交感作用達顯著水準，而第2期作之產量及每株穗數之交感亦極顯著。餘外性狀，均未見有顯著交感作用之存在。

東南亞引進稻種之研究

許東暉　馮朝程　楊方平　鄧耀宗

緒　言

提高水稻單位面積之產量，品種改良爲最有效之途徑。稻種改良之過程中，「引種」爲最基本而不可缺少的一項工作，因爲從事育種工作人員不能憑空製造新品種，必須先蒐集世界各地之品種，經過觀察比較，然後選擇最適於育種之材料。本省在來種，大部份在 200～300 年前，由中國大陸人民遷臺時所引進，及一小部份係山胞栽植之山地稻種，日本種爲 1896—1899 年之間由日本殖產局所引進。單就水稻來講，本省蓬萊稻之育或，應歸功於當時由日本引入之龜治，神力等優良品種作爲雜交育種材料所致。

本所於民國46年由東南亞產稻區引入水稻品種一批，筆者等爲徹底瞭解其經濟價值所在，曾於民國50、51、52年進行該稻種之調查及研究工作，希望根據所得結果，能够在其多數品種中發掘其寶藏。俾供今後從事稻作改良上的材料。本文承農藝系謝順景主任及黃眞生博士校正，請致謝忱。

試驗材料及方法

供試之品種有 278 種，此些品種爲民國46年分別由日本加茂、磯、安部、與岡彥一諸博士先後自低緯度地帶之東南亞諸國家引入者。茲將品種來源以及品種數列如第一表：

表一　供試品種數及其來源

Table 1. The number and origin of rice varieties used

分類代號 Classification	原產地 Origin	品種數 Number of Varieties	分類代號 Classification	原產地 Origin	品種數 Number of Varieties
PH	Philippineo	38	LO	Lombock	1
SO	Soembawa	39	Fl	Flores	9
佛	Indochina	45	Ba	Bali	14
CE	Celebes	50	印度	India	41
T	Tailand	2	其他 外國	Others	8
Ma	Malaya	1	其他 新來南洋		18
Ja	Java	12	合計		278

上述品種於民國47年至49年栽培於臺灣省農業試驗所之試驗田。第一年探討南方稻對於本省日照長短，溫度高低之反應，根據初步試驗結果，發現有部份品種，只能於二期作出穗，而一期作則不能抽穗，部份品種在一、二期作均不能正常抽穗。第二年將一、二期作不能出穗之品種作「中間作」栽培，卽本試驗之所謂第二、三期作，結果除極少數之品種外，其他均能抽穗。第三年將所有供試品種，按期作性不同分別在 4 月 3 日，5 月28日，7 月 2 日及 7 月23日四期移植，擧行特性調查，各期種植之品種分別爲31、82、97與67種。每品種栽植三行，每行十株，單本植，行株距各爲25公分，本田之肥培及一切管理均按照慣例實施。

調查工作，分別於田間與室內進行，其項目及方法如下：

(1) 植高 (Plant height):

於成熟期調查，由地面量至穗頂之高度，如有芒者，芒長不計算在內，用公分表示，10株平均之。

(2) 葉長 (Length of leaf):

於稻穗變黃，而葉尚未枯萎前，在田間調查主莖之劍葉長度，10株平均，以公分表示。

(3) 葉幅 (Width of leaf):

利用(2)材料調查劍葉最濶部份之寬度，10株平均，以公分表示。

(4) 劍葉角度 (Angle of flag leaf):

使用(1)材料，用量度器，測量劍葉與穗稈間角度之大小。

(5) 稈粗細 (Size of straw):

收穫後携回室內調查，由稈上部第一節至第二節間，卽在第二節上部約3公分處，剝去鞘葉，用測莖器量其粗細，用公厘表示，10株平均。

(6) 稈强 (Strength of culm to prevent from breaking):

利用(5)材料，同樣在第一節與第二節間，用莖稈强度測定器測定莖之載重力，用克表示，10株平均。

(7) 有效分蘖 (Number of tillers):

於成熟期調查之，數其每株之穗數，10株平均。

(8) 穗重 (Weight of ear):

成熟後，從小區之中間一行採收10個主穗，帶回室內，秤其重量平均之，用克表示。

(9) 穗長 (Length of ear):

用(8)材料，量其穗頸至穗頂之長度，（芒不計算），用公分表示，10穗平均。

(10) 一穗粒數 (Number of grains per ear):

用(9)材料，計算每穗之穀粒數，不稔粒亦計算在內，10穗平均。

(11) 着粒密度 (Number of grains per unit length of ear):

用(10)項求得之一穗粒數除以穗長，再乘以10，（卽10公分的粒數），10穗平均。

(12) 一株穗重 (Panicle weight per plant):

以求得的平均穗重與有效分蘖之相乘積卽爲一株理論穗重，用克表示。

(13) 穀千粒重 (Weight of 1,000 grains):

乾穀用數粒板數出千粒，秤其重量，5次平均。

(14) 穀--升重 (Weight of one liter of grains):

用清淨之乾穀，量出一升，然後稱其重量，用克表示，5次平均。

(15) 結實率 (Fertility):

利用 (10) 材料 $\frac{\text{一穗粒數}-\text{不稔粒數}}{\text{一穗粒數}} \times 100$ 用%表示。

(16) 糙米長度 (Length of kernel):

用乾穀10粒，以手剝去外殼，用測微器量糙米之長度，以公厘表示，10粒平均。

(17) 糙米寬度 (Width of kernel):

用(16)材料，測量其寬度，10粒平均，用公厘表示。

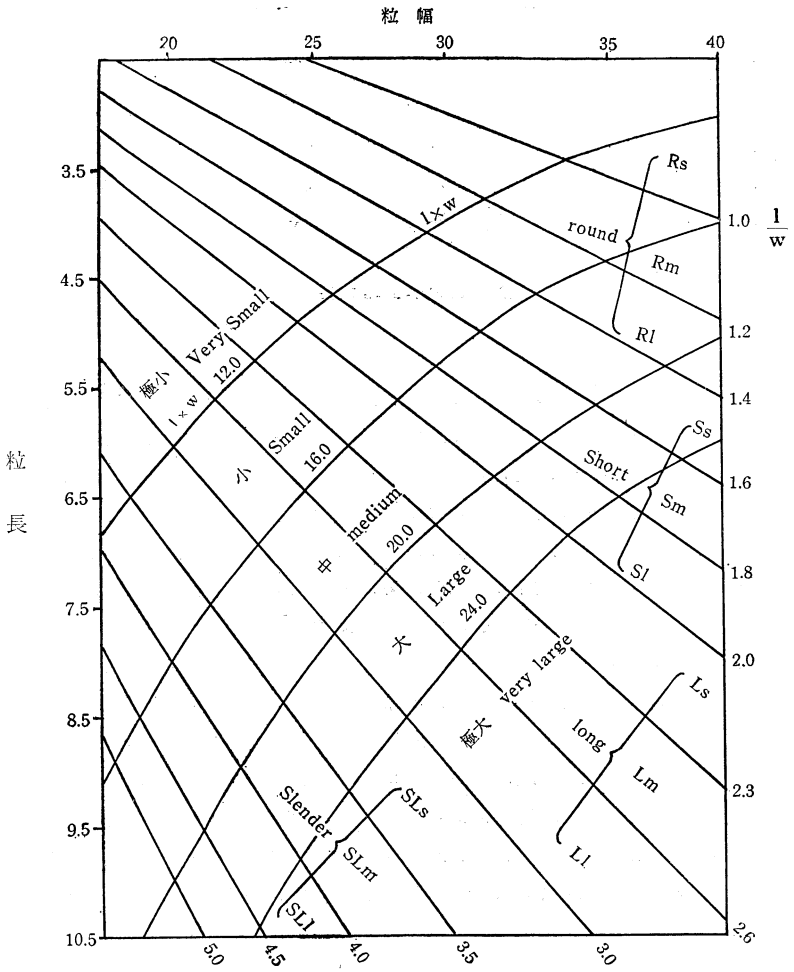
(18) 糙米長幅比（糙米形狀 Sharp of kernel):

由上述材料，糙米長度除以糙米寬度，10粒平均。

(19) 糙米大小 (Size of kernel):

用上列求得之糙米長度乘寬度，以10粒平均。

糙米形狀與大小之標準分類如圖一。



圖一：米粒形狀及大小之分類標準

Fig. 1. The product of length and breadth of kernals (curve lines) and the ratio of length and breadth of kernals (straight lines)

表示糙米長之縱與米幅之橫二軸略形成45° 之直線爲表示長幅比之分類境界線，與達此直線直交的曲線爲表示長幅積之同値線，卽構成米粒大小分類上之基準線，長幅北先依，3.0，2.0，1.4 及 0.8 分爲狹長，長，短與圓四大類，然後依0.5，0.3，0.2 與 0.2之增減每類再細分爲長、中、短三類，故米粒形狀可分爲12型。糙米積卽糙米大小，依24、20、16與 12mm² 區分爲極大，大、中、小與極小 5 種。米粒形狀與大小配合共可分爲60種。

⑳ 出穗期 (Date of heading):

出穗達50%時，記載其出穗日期，然後換算生育日數（自移植至出穗日數），其出穗期早晚之標準如下：

		第一期作	第二期作	第三期作	第四期作
早	早	80日以下	85日以下	60日以下	
	中	80— 85	86— 90	61— 65	
	晚	86— 90	91— 95	66— 70	70— 75

中	早：91— 95	96—100	71— 75	76— 80
	中：96— 100	101—105	76— 80	81— 85
	晚：101—105	105—110	81— 85	86— 90
晚	早：106—110	111—115	86— 90	91—100
	中：111—115	116—120	91— 95	101—110
	晚：116以上	121—125	96 以上	111 以上

試驗結果與討論

一、出穗期之變異

檢討本省一般之第一、二期作水稻生長期間之環境，尤其是在北部水稻區域，無論是氣溫及日照時間的變異，均有不同，第一期作水稻生長的初期，溫度較低，每日日照時數亦短，其後由分蘖經孕穗期，溫度逐漸升高，每日日照時數亦隨之增加。這種環境，一直延續第一期作水稻的成熟期。第二期水稻生長期間之環境，恰與第一期作相反，其生長初期即營養生長時期，無論氣溫與日照，均爲一年中最高及最長者，但當由營養生長期進入生殖生長期後，氣溫隨逐漸低降，每日日照時數，亦漸減短，直到成熟期。此類屬低緯度之東南亞水稻，由於其基本營養生長長，對於日照時數長短的反應比較敏感，同時在生長期間需要比較高溫及較長的時間，始能正常出穗，因此此類品種在本省一年二期的水稻生長環境下，尤其在北部，一部份品種受氣溫與日照的限制，其生長日數較一再般本省栽培者爲長，常影響其正常出穗。本試驗的出穗期先分爲早，中與晚三大羣，然後各羣，細分爲早，中與晚共九個時期。試驗的結果如表二，自早一早至晚一晚品種間變異甚大，2/3 以上品種皆屬晚熟者。以期作別而論，屬第一期作者有 4/5 品種爲早熟，其餘爲中熟種，其中以印度與爪哇品種居多數。所有第二期作品種均爲晚熟種，而第三期作中有 85% 爲晚熟稻，此些品種中以佛，CE，SO者佔多數。第四期作品種，自早一早至晚一晚之變域雖大，但印度與菲律賓種屬中或早熟羣較多，而 CE 與 SO 則多屬晚熟羣。對照品種，臺中 65號，於一、二期作均屬中熟，而第三、四期屬早熟者。

表二　供試品種出穗期早晚之頻度分佈表

Table 2. Variation in heading date of rice varieties from Southeast Asia

出穗期 \ 來源別			印度	PH	SO	佛	CE	T	Ma	Ja	Lo	Fl	Ba	其對照他種品	合計	百分率(%)
早	早	I	4					1		4					9	3.23
		II														
		III														
		IV														
	中	I	2											2	4	1.43
		II														
		III														
		IV	1	1										1	3	1.07
	晚	I	4		1		1			2				3	11	3.95
		II														
		III														
		IV	5	2	1	1								2	11	3.95

中	早	I		2	2								1			5	1.79
		II															
		III															
		IV	4								2				1	7	2.51
	中	I															
		II															
		III															
		IV	2					1					1			3	1.07
	晚	I	1					1								2	0.71
		II															
		III	7			2									4	13	4.67
		IV		13	1								2		2	18	6.46
晚	早	I															
		II															
		III	3	1	1	4			1	1					4	15	5.38
		IV		1	10		3						2			16	5.74
	中	I															
		II															
		III	7	5		16	3								2	33	11.87
		IV					6									6	2.15
	晚	I															
		II	1	9	12	22	17			2	1	3	11	4		82	29.49
		III		3	11		18			1			3	1		37	13.26
		IV		1			2									3	1.07
合 計			41	38	39	45	50	2	1	12	1	9	14	26		278	100

二、葉之變異：

所有供試品種中葉長之變異不大，但葉幅以及劍葉與莖稈所成的角度，品種間變異甚大，在所有產地中，以 SO 區的品種具有較長的葉片，其中以 Semora mangga, Gadi 與 Fl 區之 Djamboe 等品種最長，皆爲 53.9 公分，但是非律賓的 Macan Barret 與爪哇 47 號等品種最短，僅有 26公分。劍葉角度變異範圍分佈在10度與117度之間，平均55.6度，以產地別 SO，Ba 與佛三地區的品種劍葉角度較大，例如 SO 區之 Montja mangge 與 Kariiranga 品種皆爲 116 度以上，其次爲CF，菲律賓與印度品種，最小爲爪哇之爪哇45號，只有12.1度。Ba 與非律賓區之品種葉幅較他區品種爲寬，一般約在 1.8公分以上。而佛與印度地區之品種的葉幅較狹，多數在 1.0—1.5 公分之間，供試品種中葉幅最大有 Ba 區 Dari djawa, Poetih menlk Don 1 與 SO 區之 Keta mee 等品種，均達2.4公分左右，最狹爲佛區的 70^{b}som Câu 與印度的印度7號品種，均不超過0.9公分。以葉整個面積而言 SO 與 Ba 區之品種較印度或佛以及其他地區之品種爲大。

表三　劍葉長度、寬度及角度頻度分佈表

Table 3. Variation of characteristics of flag leaf

葉長（公分）Length (cm)	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	總計 Total	平均 Mean
頻度 Frequency	3	5	7	13	36	35	31	38	45	18	25	5	7	3	3		278	39.5

葉幅（公厘）Width (m.m.)	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	總計 Total	平均 Mean
頻度 Frequency	2	8	29	28	31	28	30	40	27	29	27	18	2	5	2	2		278	1.8

劍葉角度 Angle of flag leaf to ear	8	17	27	37	47	57	67	77	87	97	107	117	總計 Total	平均 Mean
頻度 Frequency	5	14	24	53	52	48	45	27	8	1	1		278	55.6

三、植高之變異

所有供試品種之植高差異不大，除少數品種外，大多數品種的稈長均在130公分以上，其中145公分左右者佔多數。最高品種計有菲律賓之 Linleng，印度18號與佛區之 R.T.S. 3 號等品種均達169公分以上，最低爲印度11號與佛區之R.T.S. 26 號僅有 112公分。莖稈粗細，品種間差異小，其變域雖然於3.4至5.7公厘之間，但大多數品種分佈於4.7公厘左右，其中菲律賓區之品種，莖稈較粗大，共有72%以上之品種超過4.9公厘，其次爲 CE，SO 與 Fl 區之品種。所有供試品種中，以 SO 區之 Montja mangge 種不但劍葉角度最大，同時莖稈亦很粗大，其與菲律賓之 Davaol 與 CE 區之Atji品種莖徑均爲5.8公厘左右，而印度區之印度17與 8 號莖稈最細只有 2.9公厘。供試品種間莖稈强度雖然差異頗大，但莖稈强度大的品種佔多數，其中 73% 之品種莖强超過 300克以上，平均爲363.5克。依地區言，Ba，So，CE 與菲律賓等區之品種具有强狀之莖稈，尤其 Ba 區之 Dari djawa, Del idjogading 與 SO 區之 Montja naq 等品種其稈强分別爲727，662與555克之多。供試品種之有效分蘖，品種間變異不大，平均爲 15.9本，其中佛區的品種分蘖較多，平均20本，例如 33 bgie n'oi R.T.S. 15 與 17號等品種之分蘖均達29本之多，其次爲印度、爪哇 SO 與菲律賓品種。最少者爲 SO 區的 Montja mangga與菲律賓的 Kinan Kuda 等穗重型之品種，僅有 7 本。稈長、莖稈粗細，强度與有效分蘖之品種間頻度分佈示如表四：

表四　各供試品種間稈長，稈粗，稈强及有效分葉頻度分佈表

Table 4. Variation of characteristics of culm

稈長（公分）Plant height (cm.)	110	115	120	125	130	135	140	145	150	155	160	170	175	185	總計 Total	平均 Mean
頻度 Frequency	3	11	20	19	30	38	53	49	30	17	4	2	2		278	140.6

稈粗細（公厘）Diameter of Stem (m.m.)	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	總計 Total	平均 Mean
頻度 Frequency	2	8	47	109	82	26	4		278	4.4

有效分蘖（本）Number of effective tillers	7	9	11	13	15	17	19	21	23	25	27	29	31	總計 Total	平均 Mean
頻度 Frequency	2	13	50	59	65	40	20	14	4	6				278	15.9

稈强（g）Strength of Culm fo prevent from breaking	110	150	200	250	300	350	400	450	500	550	600	650	750	總計 Total	平均 Mean
頻度 Frequency	4	12	28	27	43	58	56	29	18	1	1	1		278	363.5

四、穗之變異

供試品種間有關穗長，穗重，一穗粒數，着粒密度以及稔實率之頻度分佈示如表五。除佛區極少數之品種外，其他各地區之品種穗長皆爲 22公分以上，多數分佈在 27公分左右，其中Ba地區絕大多數品種其穗長均超過30公分以上，其次爲 SO、CE 與菲律賓區品種，Ba 區之 Dari djawa 與 SO 區之 Semora mangga 品種，不但具有最寬的葉幅，最大稈强度及葉長同時其穗叫

均達36公分之長。穗重與一穗粒數品種間變異甚大，穗重最高爲 4.9克，但最輕者不及 1.3克，例如非律賓之 Linleng, SO 區之 Montja mangge 與 CE 區之 Poeloet oelan 等品種之穗重有4.6克之多，但佛區之 II Danh 僅有1.23克。所有品種中以SO，CE與非律賓區之品種其穗重較可觀，供試之品種由於其穗較長，因此一穗粒數亦隨之增多，共有 70%之品種其一穗粒數超過 140粒以上，其中非律賓之 Pulot, Caranglan 與印度18號等品種均高達205粒之多。着粒密度與結實率各地區品種間差異較小，着粒密度雖然分佈在30—95粒之間，但45—75粒之間者據多數、平均爲 55.7粒，其中以非律賓與CE兩區品種之着粒密度較大，如非律賓之 Pulot 、印度18號與佛區之 558 giou nghê 等品種分別有96.0，95.1與92.7粒。

結實率常受外界氣候環境之影響，據觀察結果，印度之印度26， P.T.B. 16號以及爪哇45號等品種之結實率最高，有96%之多，相反的 SO 區之 Bako, Dewa 與 Mantja 等品種，却不超過40%，此等結實率甚低之品種，是否對感溫，感光特別敏感有待以後進一步之研究。

表五　供試品種間穗長、一穗粒數、着粒密度及稔實率之頻度分佈表

Table 5. Variation of characteristics of ear

穗長（公分）Length of ear (cm.)	18	20	22	24	26	28	30	32	34	36	38	40		總計 Total	平均 Mean
頻度 Frequency	6	31	57	63	55	24	18	13	7	2	2			278	26.1
穗重 (g) Weight of ear (g.)	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0					總計 Total	平均 Mean
頻度 Frequency	1,4	4,7	6,4	7,8	4,8	1,9	5	3						278	2,6
一穗粒數 Number of grains per ear	70	80	90	100	110	120	130	140	150	160	170	180	190	200以上	總計 Total	平均 Mean
頻度 Frequency	2	5	8	16	23	35	48	38	38	17	12	8	9	14	278	140,3
着粒密度 Number of grains per unit length of ear	30	35	40	45	50	55	60	65	70	75	80	85	90	100	總計 Total	平均 Mean
頻度 Frequency	2	8	22	49	59	57	38	25	7	2	6	1	2			
稔實率 (%) Fertility	30		40		50		60		70		80		90	100	總計 Total	平均 Mean
頻度 Frequency		2		8		39		55		102		69		3	278	71,8

五、穀粒之變異：

穀千粒重與一升重，各地區之品種間變異甚大。尤其非律賓區品種更爲顯著，例如該區之 Linleng, Balid 與 Kinan Kudo 等品種之千粒重均爲 33.2 克之多，相反同區之 Milagrosa 與 Kosungsung 品種却不及12克。此爲品種本身特性之外可能尚受環境影響很大。供試材料中 SO 與 F1 區品種之千粒重較均勻，且亦較其他地區爲優，其次爲非律賓與印度地區之品種。穀粒一升重平均爲54.9克，其中以非律賓，印度，佛與 CE 等區之品種較佳，例如非律賓之 Kinan Kuda，不論千粒重或一升重均冠於所有供試品種。

一株穗重，供試品種間之差異頗大，其分佈在19—72克之間，平均 35.4克，其中佛區品種之一株穗重較可觀，如 R.T.S. 17, Quang nghê 等品種多達70克以上，其次爲 CE，SO 與印度區之品種。穀千粒重，穀粒一升重及一株理論穗重之變異情形，有如表六。

表六　品種間穀千粒重之頻度分表

Table 6. Variation of weight of 1,000 grains

穀千粒重（克）Weight of 1,000 grains (g,)	14	16	18	20	22	24	26	28	30	32	34	36	總計 Total	平均 Mean
頻度 Frequency	5	26	39	68	49	42	29	11	6	2	1		278	18,8
穀粒一升重（克）Weight of one liter of grains (g,)	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	總計 Total	平均 Mean
頻度 Frequency	10	5	13	15	21	30	31	28	28	35	26	4	5	1	2		254	54,9
一株穗重（克）Panicle weight per plant	10		20		30		40		50		60		70		80		總計 Total	平均 Mean
頻度 Frequency		1		79		129		51		14		3		1			278	35,4

六、糙米之變異

糙米之大小與形狀隨品種與原產地之不同而差異很大，佛區的 R.T.S. 4 號與 R.T.S. 3 號等品種的糙米粒長有8.1公厘，爲供試品種中最長者，其次爲菲律賓Davao 3，其粒長有7.8公厘，以產地別而論，菲律賓、佛、SO、CE 與 Fl 等地區之品種，其米粒長多數分佈在 6 公厘左右，印度與爪哇種則分佈於 4—6 公厘之間，平均爲5.5公厘，米粒寬度 CE 區之 Haloes Koening 種最狹僅有 1.7公厘，最寬有菲律賓 Kinan Kuda, Balid 與 Linleng 等品種均達 3.1 公厘以上，所有產區中屬 CE 與佛區品種之米粒寬度似較狹，分佈於 1.7 與2.6之間，其平均爲2.3公厘，而菲律賓與印度種有較寬之趨勢，平均爲 2.7 公厘。米粒形狀，即長與幅之比例，依產地別之分佈，其變異情形如表 7 與圖二。供試品種中有77%的品種屬長粒型，其長幅比爲 2—3，此類型品種於佛與 CE地區佔多數，其他19%其長幅比爲1.4與2.0之間屬短粒型，其餘少數 4 %的品種屬狹粒型，其長幅比爲 3.0 以上，供試材料中尚未發現屬圓粒型品種。所有供試品種中有關米粒大小（米粒長×米粒寬）之變異情形示如表七。計有 56% 的品種屬小粒型，38.1%爲中粒型，僅有 5.8% 爲大粒型，至於極大與極小之品種尚無發現，其中菲律賓種屬中粒者較多，但該區 Linleng Balid 與 Sinaguiug 等三品種却屬大粒者。糙米形狀與大小組合之變異情形，依地區分別列於圖二。米粒大小之五個等級（極小、小、中、大與極大等）與米粒之12形狀組合爲60個變級，除品種較少之幾個產地外，自圖中不難看出菲律賓、佛、CE 與其他等區域之品種間變異較大，其次爲 Ja 與 Fl 區，變異較小爲 SO 區與印度之品種。

表七　供試品種間糙米粒長、粒寬、長幅比與長幅積之頻度分佈表

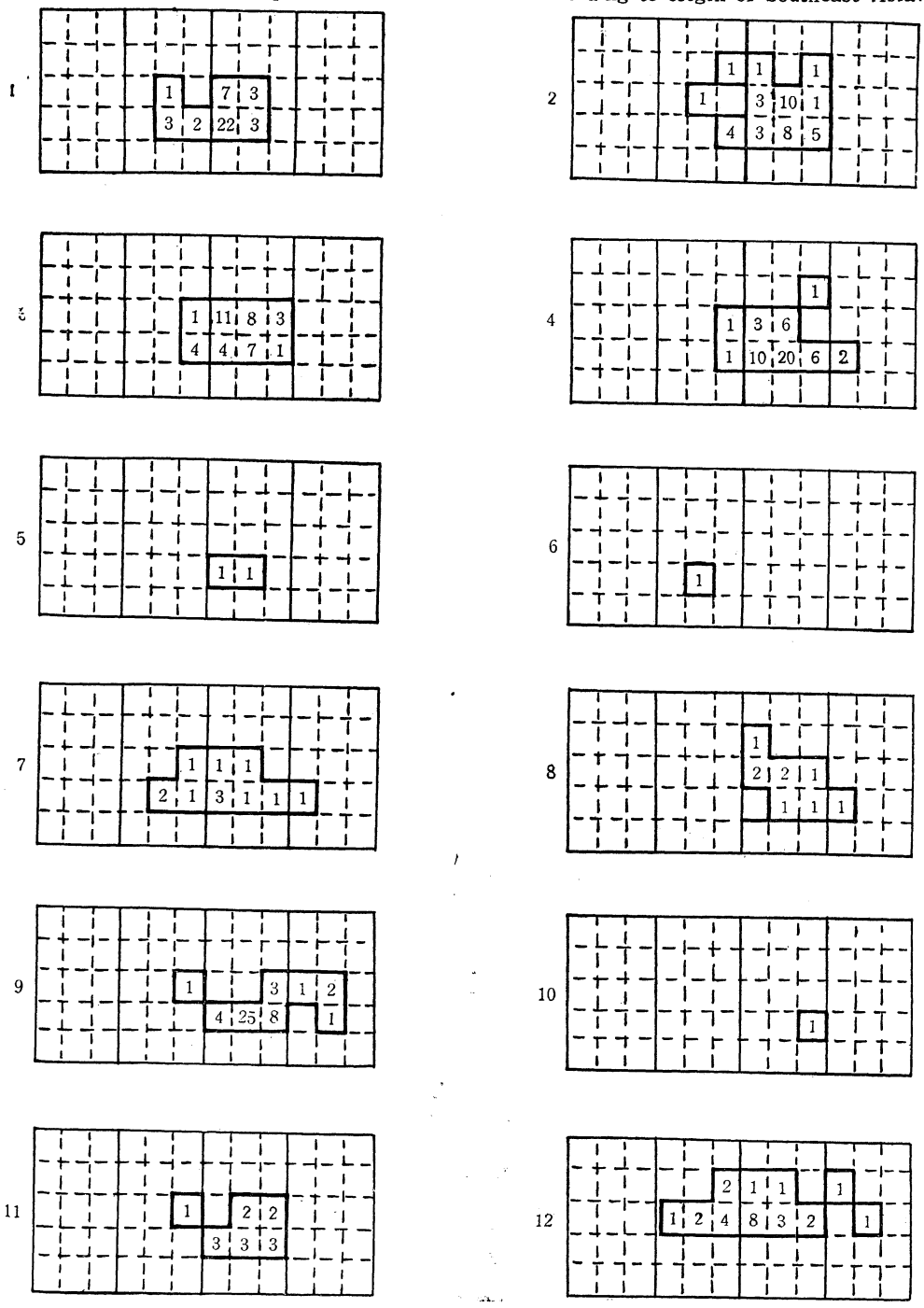
Table 7. Variation of characteristics of brown rise

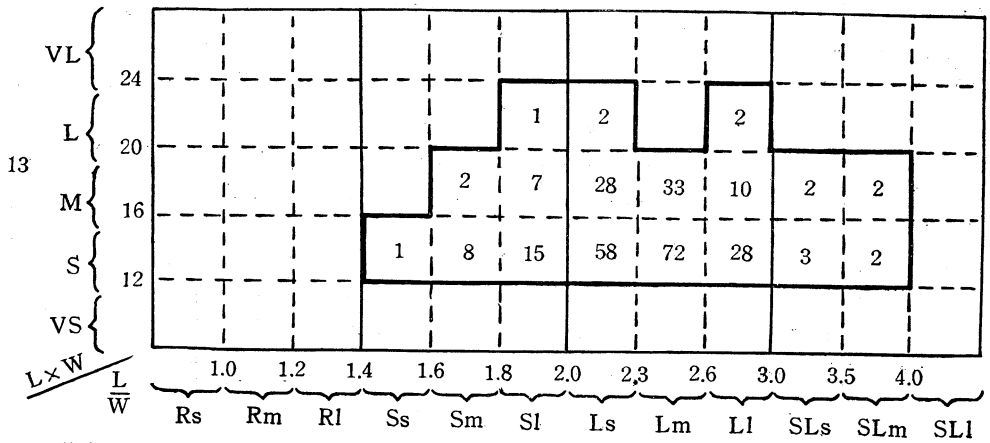
糙米長（公厘）Length of kernel (m,m,)	4,2	4,4	4,6	4,8	5,0	5,2	5,4	5,6	5,8	6,0	6,2	6,4	6,6	6,8	7,0	7,2	7,4	8,2	總計 Total	平均 Mean
頻度 Frequency	1	4	2	7	17	17	30	48	45	30	28	18	10	6	7	2	6		278	5,8
糙米寬（公厘）Width of kernel (m,m,)	1,7	1,9	2,1	2,3	2,5	2,7	2,9	3,1	3,3	3,5	3,7								總計 Total	平均 Mean
頻度 Frequency	2	11	36	48	125	42	9	4	0	1									278	2,5
長幅(糙長/粒幅) Ratio of length to width of kernel (length/width)	1,4	1,6	1,8	2,0	2,3	2,6	3,0	3,5	4,0										總計 Total	平均 Mean
頻度 Freqcency	4	11	38	99	78	37	7	4											278	2,0

長幅積(粒長/粒幅) Size of kernel (length x width of kernel)	12	16	20	24	總計 Total	平均 Mean
頻度 Frequency	175	98	5		278	15,5

圖二：供試品種依產地別，米粒形狀及大小之類度分佈表。

Fig. 2. Variation of sharp and Size of brown rice according to origin of Southeast Asia.





附註：1. 印度種　2. 菲律賓種 (pH)　3. 森巴華種 (SO)
4. 西伯斯島種 (CE)　5. 泰國種 (T)　6. 馬來半島種 (Ma)
7. 爪哇種 (Ja)　8. 佛羅勒斯 (Fl)　9. 佛領印度支那 (佛)
10. Lombock (Lo)　11. 巴里島 (Ba)　12. 其他東南亞種
13. 合　計

糙米大小之類別與其代號：
VL：極大粒　L：大粒　M：中粒　S：小粒　VS：極小粒
糙米形狀之區分：
R：圓粒　S：短粒　L：長粒　SL：狹長粒
(Rs：圓小粒　Rm：圓中粒　Rl：圓長粒　餘此類推)

七、幼苗稻熱病抵抗性之變異

本項調查工作由於種子量與病圃的關係，僅於玻璃室內行幼苗人工接種檢定，根據檢定的結果，有15%免疫，41%的品種具有抗病性，21%屬中等抗病，其餘 20.6%屬感染者。供試品種中印度，菲律賓、佛、CE與Fl 區之品種似有較多抗稻熱病品種，例如印度 1 號以及 Indochina. R.T.S. 4 與 11 具有高度抗病性。各供試品種間之變異情形如表八。

表八　幼苗稻熱病，抗病性之變異

Table 8. Variation of seedling blast resistance

程度 Degree	無反應	極強	強	中	弱	極弱	總　計
頻度 Freguency	44	94	22	60	19	39	278

表九　供試品種各性狀之最大與最小品種名表

Table 9. The names of varieties showing extreme expression each of 20 plant characteristics among 278 varieties introduced from Southeast Asia.

來源 (Origin) / 性狀 (Characteristies)		India	Philippineo	Soembawa	Indochina	Celebes	Java	Flores	Bali	Others
植高	最高	印度18	Linleng		R,T,S, 3					
	最低	印度11			R,T,S, 26					新來南洋 63
葉長	最長			Semora mangga, Gadi			Djambo-e			
	最短		Macan barret	Karike			爪哇 47			

葉寬	最寬			Keta mee				Dardja-wa, Poetih menlk Donl,	
	最狹	印度7			70b Sòm Câu, lV Tâm lùn,				
劍葉角度	最大			Montja mangge, Karriranga					新來南洋 72
	最小				R.T.S. 15		爪哇 45		新來南洋 68
稈粗細	最粗		Davao 1	Montja mangge		Atzi			
	最細	印度17 印度8							新來南洋 60
稈強	最强			Montja naq				Daridja-wa, Delidjo-gading	
	最弱	印度17 印度13							
有效分蘖	最多				R.T.S. 17, 33hgie noi, R.T.S. 15				
	最少		Kinan Kuda	Montja mangge					
穗重	最重		Linleng	Montja mangge		Poeloet oelan			
	最輕		Pauning gavierns		II Dành	Maraja			
穗長	最長			Semora mangga, Mojor,				Daridja-wa	
	最短				II Dành			Ketan Poetih	新來南洋 68
一穗粒數	最多	印度18	Pulot						
	最少	印度17			70b Sòm Câu	Bekka			
着粒密度	最大	印度18	Pulot		558 giau nghê				
	最小		Binangh, 菲律賓39	Monda					
一株穗重	最大				125 Quang nghê, 547 Jàm mùou, R.T.S. 17				
	最小					Maraja		Ketan Poetih	
穀千粒重	最大		Soumiguel, Balid, Linleng, Kinan Kuda						
	最小		Milagrosa, Kasungsung						
穀一升重	最大		Kinan Kuda			Poetih No, 2, Banda, Poenoet, Poeloe Bolong			
	最小			Montja Loi					
結實率	最高	P.T.B.16 印度26					爪哇 45		
	最低			Bako, Dewa, Montja,					

糙米長度	最長		Davao		R.T.S. 4 R.T.S. 3					
	最短		Milagrosa				爪哇 44			新來南洋 68
糙米寬度	最寬		Kinan Kuda Balid, Linleng,							
	最狹					Haloes Koening Mepan-ga,				新來南洋 64
長幅比	最大				R.T.S. 4, 19 Tam xocm	Haloes Koening				
	最小									新來南洋 68
										新來南洋 63
糙米大小	最大		Linleng, Balid,					Ladang		
	最小		Milagrosa			Tjina				新來南洋 60
幼苗稻熱病檢定	最抗	印度1			R.T.S.11, R.T.S. 4					
	最感			Montja, Bakatoi, Monda		Poeloe bolong	爪哇 1			

摘　　要

1. 本試驗爲採討來自東南亞之水稻品種之特性與其經濟價值，逐自民國47至49年，就引進之278品種，於農業試驗所進行調查與研究，並以所得結果，供今後稻作改良上之與材料參考。

2. 根據第一年觀察結果，第二年將所有供試品種，依其適宜栽培時期分別於4月3日，5月25日，7月2日與7月23日等四個時期插秧，供試品種數第一期爲31品種，二期作82品種，三期作97品種，四期作67品種。根據試驗結果，此類品種對於日照長短的反應較敏感，同時在生長期間需要較高溫及較長的時間，故其生育日數較本省一般栽培稻爲長，甚至有少數品種在本省一年兩期的水稻生長環境下，不能行正常抽穗，必須在「中間作」始能開花結實。

3. 供試稻種劍葉長度，平均爲 39.5公分，其中以 SO 區之品種較長，如 Semoro mangga 和 Godi 種，其 長度均達53.9公分；最短者爲菲律賓的 Macan Barrel 與爪哇47號只有 26 分公。劍葉寬度平均雖然爲1.8公分，但菲律賓與 Ba 地區之 多數品種均在平均寬度之上，佛與印度區之品種較狹，分佈僅在 1.0—1.5 公分。劍葉角度變異性頗大，其分佈在 10—117 度之間，平均爲 55.6 度，其中以 SO 區品種之角度較大，其次爲 Ba與佛，印度種則最小。

4. 植株高度， 多數均在 145 公分左右， 共有 82％的品種超過 130公分， 最高有菲律賓之 Linleng，印度18號與佛區之 R.T.S. 3 號，均達180公分，最低者有印度11號與 R.T.S. 26 號，不及115公分。莖稈粗細平均爲 4.4公厘，較一般本省栽培稻粗大，同時具有較大之稈强，尤其菲律賓有72％品種的莖徑超過 4.9公厘，並且有73％之品種莖强在300克之上。

5. 供試品種之穗長，平均雖然是25.9公分，但是 Ba 地區絕大多數品種均達30公分以上，其一穗粒數多達176粒，其次菲律賓、SO 與 CE 等區品種之穗長平均爲27公分，一穗粒數均在150粒以上，並且該地區有一半以上之品種其穗重超過 3 克，着粒密度爲60粒以上。

6. 各品種之千粒重變異很大，最重者有34克，最低僅有15克左右，一升重平均爲54.9克，其中菲律賓之 Kinan Kuda 不但具有最高千粒重，同時一升重及糙米千粒重均冠於所有供試品種。一株穗重分佈於72克 (R.T.S. 17) 至19克 (Maraja) 之間，平均爲35.4克，其中佛區品種不但具有較多的有效分蘗，同時一株穗重亦大。

7. 糙米長度，平均爲 5.8公厘，較一般本省栽培種與日本稻爲長，尤其菲律賓、佛與 SO 等區品種之粒長均有 6 公厘以上。粒寬却介於本省蓬萊稻與在來稻之間，平均爲 2.7 公厘。米粒形狀絕大多數屬長粒型(2～3) 少數爲短粒與狹粒型，圓粒型 (1.4以下) 於本試驗中無發現。米粒大小，多數品種屬小粒與中粒者 (12～20) ，兩極端之品種亦無發現。

8. 幼苗稻熱病之檢定結果，供試之品種中，一半屬抗病與免疫者，21%爲中等抗病，其餘20%屬感染者。

9. 本試驗引進之東南亞稻種，目前於本省似不能直接栽培，但有關數量性狀等因子，却可供本省改良稻種之良好材料。

參 考 文 獻

1. 王 俠 (1951) ：甘藷新引進品種特性觀察。農業研究，2(3)91—116。
2. 永松土巳 (1942)：栽培稻の地理的分化に關する研究。日本作物學會紀事，14卷2號。
3. 永松土巳 新城長有 (1960)：沖繩在來稻の分類に關する研究。琉球大學農家政工學部，學術報告，第7號。
4. 永松土巳 (1964) 在來稻之特性 (予報)。日本九州大學，農學部。
5. 黃正華 (1967) 臺灣本地稻栽培品種之研究。中華農學會報，新20期24—58。
6. 黃正華 (1956) 臺灣水稻品種改良之現狀及其趨向。科學農業4：6。
7. 張德慈 (1951) 今後臺灣水稻品種改良之草議。中華農學會，報新36期。
8. 臺灣省農業試驗所保存稻種誌。臺灣省稻作改進會出版。

STUDIES ON THE VARIETIES OF RICE INTRODUCED FROM SOUTHEAST ASIA

by

T. H. Hsu, C. C. Phong, F. P. Young and Y. C. Teng

SUMMARY

1. Two hundred and seventy eight varieties of rice introduced from the rice producing countries of Southeast Asia, such as Philippineo, Soembawa, Indochina, Celebes, Tailand, Malaya, Java, Lombock, Flores, Bali and India etc. were studied in order to get informations to be used for breeding purposes. Various morphological as well as physiological characteristics such as plant height, length and width of leaf blade, tiller and panicle numbers per plant, the strength of culm to prevent from breaking, number of grains per panicle, shape and size of grains, weight of 1,000 grains, blast disease resistance and date of maturity etc. were studied.

2. The varieties which did not head when planted in the regular 1st and 2 nd crop seasons, due to different photoperiodic responses, were further planted in four different seasons i. e. April 3, May 25, July 2 and July 23. It was found that the majority of vatieties tested were late in heading as compared with Taiwanese varieties. The days from transplanting to heading of the varieties tested were 79—91 days (89 days in check) in the 1st crop, 135—150 days (105 days in check) in the 2nd crop, 87—138 days (64 days in ceeck) in the third crop and 64—98 days (69 days in check) in the fourth crop. Some early maturing varieties were found

in India and Java groups, while most of late-maturing varieties were found in Indochina, Celebes and Soembawa groups.

3. The length of flag leaf as an average of all varieties investigated was 39.5 cm.; Semora mangga and Gadi from Soembawa had the longer flag leaves, while Macan Barret from Philippines and Java 47 had the shortest flag leaf. The average width of leaf blade was 1.8 cm. in those varieties, Philippines and Bali varieties such as Keta mee, Dari djawa and Poetih menlk Don 1 etc. had wide leaf blade, While some Indochinese and Indian varieties such as 70[b] sóm câu, IV Tàm lun and India 7 etc. had leaves as narrow as 1.0—1.5 cm. in width. The angle of flag leaf to ear was found to be quite variable, as from the widest Soembawa group to narrowest India group.

4. The plant height was 145 cm.; Linleng, India 18, R.T.S. 3 etc. had the tallest plaht height (180 cm.) while that of India 11 and R.T.S. 26 etc. was shortes (114 cm.). The stem of the majority of Philippino varieties was generally bigger with 4.9 mm. culm diameter and had 300 g. of culm strength to prevent from breaking. The ear length as an average of all varieties concerned was 26 cm.; but the varieties from Bali, Philippines, Soembawa and Celebes had longer and heavier panicles when compared with other varieties.

5. The weight of 1,000 grains and the weight of one-liter brown rice varied greatly wider, the average of 15—35 g. and 48—63 g. respectively. The yield of single plant ranged from 19. (Mraja) to 72 g. (R.T.S. 17); the average being 35.4 g.

6. Except a few varieties which showed short or medium in grain length, most of varieties tested within the present study had long grains. The average length and width of brown rice were 5.8 and 2.7 mm., respectively. The average ratio of length/width and value of length x Width of grains were found to be 2.5 and 15 respectively.

7. It was found that 59% of the varieties testaed in seedling stage showed either non-infection or resistant reaction to blast disease, while 21% and the remaining 20% of the varieties tested showed intermediate and susceptible reactions respectively.

8. It was concluded from the present observation that although the majority of varieties from the Southeast Asia were not suiteble for the imediate cultivation in Taiwan, however, there were many desirable characters can be introduced into Taiwanese varieties through hybridization breeding, such as panicle numbers, lenght of panicles, number of grains per panicle, size of grain and blast disease resistance etc.

薄荷銹病藥劑防治試驗（二）

吳　福　壽

一、緒　　言

筆者曾在初報[9]（1963）中敍述，幾種殺菌劑對在田間爲害劇烈之薄荷銹病之防治效果及防治處理與薄荷產量之影響，結果在實際上應用時，以 Dithane M-22 之 1：400 稀釋液較妥。

本文係檢討此防治薄荷銹病有效藥劑 Dithane M-22 之適當撒佈時期及撒佈次數之結果。玆將所得結果列述如下，以供參考。

本試驗承蒙所長徐水泉博士指示與鼓勵，當試驗進行時，蒸溜器及薄荷油之蒸溜，承本所農藝系楊永裕先生惠予供借並示教，試驗區之栽植、管理、病害調查、收穫等，多承雲林縣虎尾鎮北溪厝16號鄭錦聲先生及本系黃添福先生鼎力協助，特此謹致謝忱。

二、試驗材料及方法

1. 試驗材料：

A. 供試薄荷品種爲岡交1號。

B. 供試藥劑爲 Dithane M-22〔有效成分：80% Maneb(Manganese ethylene-bis-dithiocarbamate)〕，供試濃度爲 1：400。

2. 試驗方法：

本試驗田間採取隨機區組法，6重複，每小區面積 4×2.5 公尺（10m²），每一小區一處理，各種植8行，田間管理與常法相同。

藥劑撒佈時期，按薄荷栽植後之經過日數分爲52日、62日、72日，間隔爲10日，並分成1次、2次、3次撒藥，分別進行，另設無撒藥區爲對照，藥劑撒佈量每公頃 800～1,200公升。

表一　栽植後日次及撒藥次數表

Table 1. Days after planting and application frequencies.

撒藥次數 Application frequency ＼ 栽植後日次 Days after planting	52	62	72	處理代號 Treatment Number
無撒藥 None	—	—	—	CK
	—	—	—	
1	●	—	—	1
	—	●	—	2
	—	—	●	3
2	●	●	—	4
	—	●	●	5
3	●	●	●	6

註：●係示撒藥，—示無撒藥

Note:●=Showed spray,—=Show not spray

病害調查在藥劑撒佈完成後，防病效果顯明時進行，每小區中間4行調查發病株率，同時取其20株調查記載，據其發病情形分成被害狀況等級11級，其標準如下：

0……無病葉　　6……落葉約佔10%
1……時能見及病葉者　　7……落葉約佔30%
2……病葉約佔30%　　8……落葉約佔50%
3……病葉約佔50%　　9……落葉約佔70%
4……病葉約佔80%　　10……落葉約佔90%
5……時能見及病葉落下者

計其各等級別之株數，然後據下列公式求其被害程度：

$$\text{被害程度}=\frac{0A^{*}+1B+2C+3D+4E+5F+6G+7H+8I+9J+10K}{N}$$

A. B. C.……等係示該被害狀況等級別之株數

N……調查總株數

藥害調查，當調查病害狀況時，同時調查藥斑之有否，據如下之標準記載。

－……無藥斑　　＋……各分枝之 1–2 葉生有藥斑者
±……時能見及藥斑者　　＋＋……各分枝之 3–4 葉生有藥斑者

生長狀況調查，在各處理薄荷收割之前進行。

產量在收割之後調查每 10m² 之鮮草重，催乾蒸溜後調查收油量。

三、試 驗 結 果

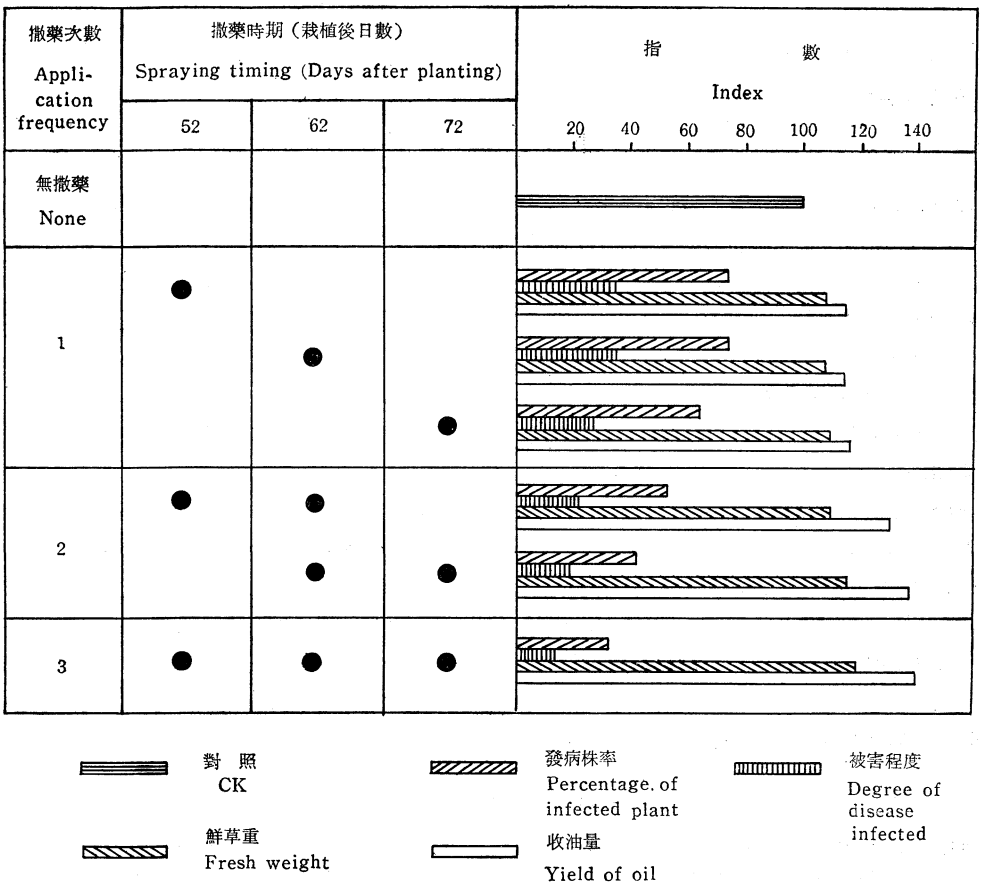
本試驗於民國54年2月23日栽植，因經久乾旱無雨生長頗爲徐緩，第一次施藥於4月16日（栽植後經52天），第二次施藥於4月26日（栽植後經62天），此時僅保護行部份稍有發病，第三次施藥於5月6日（栽植後經72天），此時試驗區內各處已開始發病，5月18日開始調查發病程度，5月21日收穫調查產量。生長稍不齊。其結果列於表二及圖：

表二　薄荷銹病藥劑撒佈時期及撒佈次數試驗結果

Table 2: Effects of maneb sprays with different timing and applications on the rust occurrence and yield of mint.

處理 Treatment	發病調查 Disease investigated					藥害 Phytotoxicity	產量調查 Yield investigated			
	*發病株率 Percentage of infected plant (%)	指數 Index	**被害程度 Degree of disease infected	指數 Index	防治率 Percentage of disease control (%)		***鮮草重 Fresh weight kg/10 m²	指數 Index	***收油量 Yield of oil g/10 m²	指數 Index
1	67	74	0.77	35	65	—	18.3	108	46.6	114
2	67	74	0.76	35	65	—	18.4	108	46.8	114
3	58	64	0.59	27	73	—	18.5	109	47.3	116
4	48	53	0.48	22	78	—	18.7	110	53.2	130
5	38	42	0.41	19	81	—	19.6	115	55.9	137
6	29	32	0.29	13	87	—	20.2	119	57.4	140
CK	90	100	2.20	100	0	—	17.0	100	40.9	100

L. S. D. *0.05=20.2838　0.01=27.2183　**0.05=0.9057　0.01=1.2153
***0.05= 2.3799　0.01= 3.1936　***0.05=6.1886　0.01=8.3042



圖：不同撒藥時期及撒藥次數對防病效果及產量之影響。

Fig.: Effects of maneb sprays with different timing and applications on the rust occurrence and yield of mint.

四、討　　論

本試驗於栽植後，因經久乾旱無雨，生長頗爲徐緩，於植後經52天始行第一次施藥，其後直無發病，於第三次施藥時，試驗區內方開始稍有發病，各處理經施藥後，植株葉上均無藥斑之發生。

據表（二）及圖所示，在田間將 Dithane M-22 之 1：400 稀釋液分三種不同撒藥時期，並分成1次、2次、3次分別撒佈藥劑試驗之結果，加以統計分析，檢討各處理間之差異。各處理對薄荷銹病，除在一次撒藥時，栽植後經52日及62日撒藥者之發病株率外，其餘各處理與無施藥區之間，其發病株率、被害程度均有極顯著之差異。就撒藥時期而言，在一次撒藥時，栽植後經52日、62日、72日等，其撒藥時期前、後之間及二次撒藥時之前、後期之間，其防病效果均無顯著之差異。就撒藥次數而言，則以撒藥三次及二次之效果爲優，其發病株率及被害程度與無施藥者相較，差異均極爲顯著，而三次撒藥與二次撒藥間之差異不顯著。

各種不同撒藥時期及撒藥次數對產量之影響，據表（二）及圖即可知對產量，除其收油量在一次撒藥時，栽植後經52日、62日撒藥者外，其餘各處理與無施藥區之間，均有極顯著之差異，而效果良佳。就撒藥時期而言，在一次撒藥時，雖以栽植後經72日撒藥者爲稍佳，惟與栽植後經62日，栽植後經52日撒藥者相較，其間並無顯著之差別，在二次撒藥時，以後期撒藥者之效果爲佳。就撒藥次數而言，亦以撒藥三次及二次之效果爲優，撒藥一次者次之，而撒藥三次與二次之間無顯著之

差異。

總而言之，施藥區對薄荷銹病之防治效果及對產量之影響，均較無施藥區爲佳。在實際應用上，自栽植後經62日開始，隔10日撒藥一次，而連續二次爲宜。

五、摘　　要

本試驗係繼薄荷銹病藥劑防治初步試驗[9] (1963)，檢討防治薄荷銹病之有效藥劑 Dithane M-22 (1：400 稀釋液) 之適當撒藥時期及撒藥次數，以供推廣之參考。

本年度曾分三種撒藥時期（栽植後經52日、62日、72日），並分成 1、2、3 次共六種處理，分別撒佈藥劑，所得結果概述如下：

1. 供試之六種處理，除在一次撒藥時，栽植後經52日、62日撒藥者外，其餘各處理與無施藥區之間，均有極顯著之差異，而經施藥後均無藥害之發生。

2. 供試處理中，在一次撒藥時，栽植後經52日、62日、72日等，其撒藥時期之前、後之間及二次撒藥時之前、後期之間，其防病效果均無顯著之差異。撒藥次數則以撒藥三次及二次之效果爲優，撒藥一次者次之，而撒藥三次與二次之間差異不顯著。

3. 各處理對產量之影響，除其收油量在一次撒藥時，栽植後經52日及62日撒藥者外，其餘各處理較無施藥區，均有極顯著之良佳效果。

4. 供試處理中，在一次撒藥時，撒藥時期前、後之間，其增產效果均無顯著之差異，二次撒藥時，以後期撒藥者之效果爲優。撒藥次數則以撒藥三次及二次之效果爲優，而兩者之間差異不顯著。

5. 在實際應用上，自栽植後經62日開始，隔10日撒藥一次，而連續二次爲宜。

六、參 考 文 獻

(1) 明日山秀文・河田　黨等：　作物病蟲害ハンドブック　養賢堂　2-7,323-324,1958.
(2) _____・向　秀夫等：　植物病理實驗法　日本植物防疫協會　279-315,322-327,1962.
(3) Brooks, F. T.: Plant diseases. Oxford University Press. 265-266, 1953.
(4) Dietz, S. M., A.P. Steenland, and C.E. Hornner: Mint rust (*Puccinia menthae*) epiphytotic in the North west (Abstr.) Phytopathology 44:938, 1951.
(5) 北海道農業敎育研究會：　薄荷の栽培法　淳文書院　62-63,1943.
(6) 中田覺五郎：　最新改訂作物病害圖編　養賢堂　596-598,1960.
(7) 瀧元清透：　改編微生物學及植物病理學實驗法　養賢堂　263-268,1958.
(8) 渡逖龍雄：　實驗防除工藝作物病害篇　養賢堂　98-101,1950.
(9) 吳福壽：　薄荷銹病藥劑防治試驗（初報）　農業研究　12(4)：42-47,1963.
(10) 山本　亮：　新農藥研究法　南江堂　404-423,435-449,1962.

SCREENING TEST OF FUNGICIDES FOR CONTROLLING OF MINT RUST (II)

by

F. S. Wu

SUMMARY

This paper deals with the results of maneb spray test on mint rust control for its effective spraying timing and application frequencies.

The maneb dilution was applied on mint with six treatments of spray timing and application frequency combinations.

Results obtained were summarized as follows:

1. With exception of treatment with one application on 52 or 62 days after planting, all treatments showed significant control effects on mint rust control. In addition to it, no injuries by chemical were observed.

2. There were no differences among the treatments with one application of the different spray timing. It was also the case in the treatments with two applications. However, treatments with two or three applications showed the superior effect on rust control to the treatments with one application. There were no significant differences among the treatments with two and three applications

3. With exception of treatments with one application on 52 or 62 days after planting, all treatments showed a significant increase of mint yields.

4. Among the treatments, one application treatments of different spray timing showed no difference among them, while between two twice application treatments, the later spray was superior to the earlier spray.

5. Generalizing the results, the treatments of three applications and two applications of the later spray showed the significantly economical increase of the yield. So, for the practical control of mint rust the two applications of maneb spray initiated on 62 days after planting could be recommended.

AN OBSERVATION ON ECOLOGY OF *Stephanitis typica* DISTANT (HEMIPTERA, TINGIDAE) ON BANANA

By

C. H. CHENG

INTRODUCTION

Banana lace bug, *Stephanitis typica* Distant, which were originally described in Ceylan in 1903. In 1914, it was first recorded in this inland. Later, Takahashi (1936), Shiraki (1937) and others etc. reported that this bug mainly attacked languas (*Alpinia galanga*, Zingibraces) in Taiwan; whereas it feeded on banana and other plants in the southern part of China, Java and India. Subsequently, this bug was recognized to be a pest of banana in this island by Miwa (1943).

Since 1963, the bug has been found to be aboundant on banana orchard and caused a serious damage by its infestation in Chia-yi and Kaohsung districts. In the following years, it rapidly distributed to every banana plantation throughout this island. Under requiring, a test of chemical control was carried out by Chein & Huang (1965). The present study was conducted during the years of 1965 to 1966 to investigate some ecological aspects of this bug that might be helpful to field control of this pest.

MATERIALS AND METHODS

Life history study: This study was carried out near our laboratory where thirty banana-plants were grown for rearing of lace bug. One portion of a banana leaf on each plant was caged with wire-cage of 25 cm in each side. A pair of freshly emerged adults were then placed in this cage. After the adults oviposited readily in the tissues of banana leaf, then they were removed to the another cage for determination of their longevity and the fecundity of female adult. On the other hand, as the nymph hatched, they were transferred individually to another cage for the investigation of the duration of each stage and survival rate. Twenty five pairs of lace bugs were observed in each generation.

Field observation: This observation includes habits, seasonal succession, proportion of sexes, distribution and naturl enemies of this bug. Two banana orchards were chosen for this study, one was at Chiayi Agricultural Experiment Station, the other was in the suburb of Chiayi. On each of banana orchard, forty plants were marked for the observation, and each leaf of plants was taken three parts and each was 10 cm in length for sampling (Fig. 1). The survey was by means of counting the number of the insect pest per sampling part on each leaf

of a plant. The various damages by this pest on each banana variety, on different height of banana-plant were also noted in this study. All the available data were recorded and analyzed statistically.

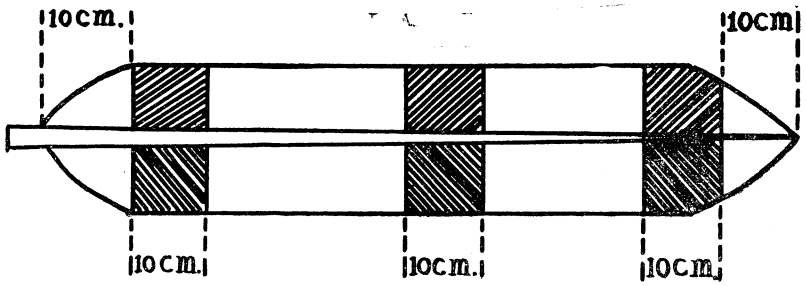


Fig. 1. Banana leaf showing the sampling parts for an investigation of lace bug population

Natural enemy study: This study was performed in the laboratory for investigating the life history, feeding behavior and feeding capacity of the predator. The adult of predators were collected from the field and confined individually in the glass tube, 3 cm in diameter and 13 cm in height, containing a section of banana leaf infested with lace bugs. The predators oviposited readily in the tissues of a leaf, then the leaves with eggs were removed daily and placed into another glass tubes. As the nymph hatched, they were transferred individually to another tube contaning a section of banana leaf infested with the lace bugs. The leaves with preys were renewed daily, and the duration of each stage and the number of lace bugs preyed were also recorded.

In the whole period of observations, the climatic data at Chiayi Agriculutral Experiment Station were also recorded.

RESULTS AND DISCUSSION

1. Character of injury

Both adults and nymphs infest plants by sucking the sap from the underside of the leaves. This withdrawal of plant juice causes the leaves become mottled with grayish-yellow blotches which, when aboundant, result in complete blanching.

The lower sufface of infested leaves is discolored by numerous flattered, black, shinym molasses-like spots of excrement. Its ecdysis may be seen adhering to the underside of the leaves until the leaves wilted. Badly damaged plant would wilt early, and then retarded the growth of plant at last.

2. Life history

The banana lace bug was known to have 9 generations from July 1965 to July 1966 in this area, Eight stages: egg, five instars and adult were found in a life-cycle. Data of the interval of each stage and generation were shown in Table 1.

Table 1. Records of observation on the life history of *Stephanitis typica* Distant on banana from July, 1965 to July, 1966

No. of gener.	Date conduct	Mean temp.	Preovip. (days)	Duration (Days)						
				Egg	Nymph (Inatar)					One lifecycle
					1st	2nd	3rd	4th	5th	
	1965									
6	20/7-10/8	27.95	3.54	8.70	2.36	2.10	2.22	2.56	3.29	24.36
7	16/8-10/9	27.27	5.63	13.45	2.33	2.33	1.62	2.10	3.14	30.20
8	20/9-19/10	26.75	6.72	11.91	3.00	2.55	2.52	3.24	4.06	34.20
9	22/10-3/12	23.44	7.36	13.67	4.36	3.05	2.55	2.98	6.24	40.88
1	12/12-19/2	18.56	9.87	31.45	6.90	5.90	6.25	6.00	6.20	73.72
	1966									
2	24/2-6/4	21.99	4.13	16.37	4.58	4.43	4.00	3.93	4.64	44.06
3	13/4-17/5	26.03	3.02	13.40	3.60	3.40	2.93	4.93	3.60	35.22
4	23/5-25/6	26.18	3.17	11.38	3.75	3.13	2.75	2.58	3.75	31.55
5	27/6-23/7		3.46	9.39	2.30	2.22	2.09	1.87	4.91	26.20
Average			5.21	14.30	3.69	3.23	2.99	3.35	4.43	37.82

The egg, which is approximately 0.39 mm. in length, 0.12 mm. in width, is like a pearl in color, but smooth, ovoid-clliptical and with a cap at the top end. The eggs were deposited in cluster in the tissues of banana leaf, and on each egg's cap where was covered with an excrement immediately after the egg has been deposited. The duration of the incubation period varied with the temperature. Observation (Table 2) indicated that the mininum time required for its incubation was 7 days at the average temperature 28.53°C; while at 17.10±0.23°C, it lasted 23.10±0.59 days in average.

Table 2. Effect of temperature on incubation of egg

Mean Temp. (°C)	Incubation of egg (Days)		
	Maximum	Minimum	Average
17.30±0.23	33	29	32.10±0.59
22.19±0.34	20	16	17.75±1.39
25.24±0.34	16	11	14.08±1.62
26.07±0.21	16	10	14.04±1.09
26.47±0.89	14	11	12.67±1.07
28.06±0.38	16	7	11.92±2.43

The newly-hatched nymph, average 0.68 mm. in length and 0.31 mm. in width, is yellowish-white in color. After they sucked the sap from plant, the color of head, end of antenna and abdomen change into brown. They generally got together and lived on the underside of a leaf, they also crawled short distance from where they were hatched or molted but never migrated from a leaf to another, excepting the leaves were wilted. In the nymphal stage, it molted 4 times. When they took the first step for molting, the insects standed with two

pairs of final leg, it lasted 4 hours to 12 hours and then emerged from the caronal suture. The wing-bud and paranotun was found to develope in th third instar, and especially noticeable in the fourth and fifth instar. The length of the nymphal stage was about 12 day in summer, and about one month in winter. The relation between the temperature and duration of nymphal stage were presented in Table 4. The survival rate of nymphal stage in each generation ranged from 59.86 to 88.24 per cent with an average of 71.16 per cent in the field (Table 5); while they were protected against the natural enemies attack, the survival rate nearly reached to 100 per cent.

Table 3. Characteristics on external feature of *Stephanitls typica* Distant

Stage	Body length (mm.)	Body width (mm.)	Color	Other
Egg	0.39	0.12	Pearl in color	Ovoid-ellipticul, with an cap at the top end.
1st instar	0.64	0.31	Head brown, other yellowish white	Paranotum undevelopment, without wing-buds.
2nd instar	0.93	0.43	5th segment of antenna, head, abdomen brown; other yellowish white.	Similar to 1st instar.
3rd instar	1.19	0.53	Similiar to 2nd instar.	Wing-buds and paranotum start to develop.
4th instar	1.53	0.68	Similiar to 2nd instar.	Wing-buds reach to 2nd segment of abdoment, paranotum develop.
5th instar	2.21	0.93	Both end of wing-buds slight brown, other similar to 2nd instar.	Wing-buds reach to 5th segment of abdoment, Parantum very development.
Adult female	2.14 3.36*	1.15 2.0 *	Wings have two brownish spots, body heavy brown.	With a pair of full-growth wing, head with hood, paranotum with median and lateral carian. The end of abdomen like V in form.
Adult male	2.20 3.43*	0.85 2.10*	Similiar to female	All similar to female excepting the end of abdomen like U in form.

The asterisk is shown the length or width with wings.

Table 4. Effect of temperature on the length of nymphal stage

Mean temp (°C)	Duration (Days)		
	Maximum	Manimum	Average
20.26±0.28	38	29	33.10±2.96
21.96±0.59	26	23	24.00±1.73
22.26±0.14	25	20	22.83±1.64
23.20±0.08	24	20	21.40±1.69
25.64±0.03	21	16	18.79±2.07
26.22±0.05	17	15	16.50±0.17
27.63±0.07	16	15	14.88±2.06
28.18±0.03	13	10	12.00±1.05

Table 5. Survival rate of *Stephanitiss typica* Distant

No. of gener. obs.	Mean temp. (°C)	No. of colonies obs.	No. of nymphs hatching	No. of adults appear.	Survivor per cent
6	27.95	10	83	50	60.24
7	27.27	17	64	84	75.00
8	26.75	27	238	210	88.24
9	23.44	35	183	115	62.84
1	18.56	15	142	85	59.86
2	21.99	10	91	62	68.13

The newly-emerged adult is white with a pair lace-like wings. After 2-3 hours, the body changed into heavy-brown in color. It was difficult to find their flying freely except they were disturbed or when they felt the places for oviposition. Although the flying capacity of this insect was very poor, but if they lean upon the help of the wind, they could be distributed to a great distance. Mating process usually accomplished in 1-2 days after the last molt of the female. As they were mating, the male and female were at an angle from 45 to 80. The mating act lasted from 50 seconds to 4 hours, and may be repeated.

Longevity of Adult: The longevity of adult was found to vary with the season, when the newly emerged adult was reared in the wire-cage containing a portion of a banana leaf, it took 11 to 73 days with an average of 31.44 days in male and 33.8 days in female during the cold season (18-20°C); while it took 2 days to 19 days with an average of 6.48 days in male and 7.1 days in female in summer, 1966 (27-30°C). However, the newly emerged or old adults were placed in the glass tube, 3 cm in diameter, 10 cm in length, with or without food, they only lived 2-3 days.

Proportion of sexes: In order to determine the sex ratio of the lace bug, the adults were collected every other days in September 1966, from a banana plantation in the suburb of Chiayi, and examined in laboratory with a low-power binocular microscope. The results were summarized in Table 6.

Here the sex ratio appeared to be slightly different, the number of the males were more than that of the females at the beginning of emerged period. Thereafter the famales were more than the males. It was possible that the males developed more quickly and lived shorter than females. The overall sex ratio in the entire period of 17 days was approximately 3:2.

Fecundity of the female: Thirty pairs of adults were observed in this study, each pair of newly emerged adults were placed in a wire-cage, 20 cm in each side, containing a portion of growing banana leaf. Observation was made daily till all the insect was dead. The results indicated that the number of eggs laying by each female adult was 36.8 in average, ranged from 0 to 71 in the period from January to Feburary, 1966. Another test took place in the period of July to August 1966, and adult laid 0 to 55 eggs with an average of 31.75. However

in these two tests, many adults died within 3 to 5 days after they were caged in the wire-cage, therefore the fecundity of a female was probably more than that has been shown in our study.

Table 6. The sex ratio of *Stephanistis typica* Distant

Date of obs.	No. of obs.	Sexiratio		Note
		Female	Male	
Sept.				
4	158	46.20	53.80	At the beginning of emergence
7	586	45.95	54.10	At one-third of emergence
9	765	53.69	41.31	At the maximum emergence
11	433	67.90	32.10	At the end of emergence
13	539	65.20	34.80	At the period of 1st to and instar
15	597	75.21	24.79	At the period of 2nd to 3rd instar
17	443	73.82	26.18	At the period of 3rd to 4th instar
19	195	62.05	37.95	At the period of 4th to 5th instar
21	373	60.05	39.95	At the period of 5th instar
Average		62.53	37.42	

Length of life-cycle: The life-cycle was determined as the interval from the parent adult to the appearance of next adult generation. From the data presenting in Table 1, the minimum period from the parent adult to the next generation adult was found in the 6th generation, which averaged 24.36 days, and ranged from 17 days to 26 days; while the maximum period was found in the 1st generation, it lasted 73.72 days in average, ranged from 69 days to 80 days. Total of 9 generations, the average duration of a life-cycle was found to be 34.82 days.

FIELD OBSERVATION

1. Observation on the location of eggs laid and number eggs in each egg-mass: The eggs of lace bug were laid together in the tissues of banana leaf. Generally an egg-mass was laid by a female adult, but it was found that two or more adults oviposited their eggs together in the period of high population density. However, a few adult females were found to lay their eggs in more than one place when they were disturbed in the midst of oviposition. It is easy to distinguish where the eggs were laid by many irregularly arranged excrements, which were used to cover on the top of the eggs.

In the period from August to September, 1966, the egg-masses on 10 banana plants were measured and collected from fields, and examined under low-power binocular microscope in the laboratory. The location of egg-mass on each leaf or a plant and the number of eggs were determined. The results were presented in Table 7 to 8 respestively.

Table 7. Location of egg-mass on a banana leaf

Distance from midrib (cm.)	Apical part		Middle part		Basal part	
	No. of eggs	percentage	No. of eggs	percentage	No. of eggs	percentage
0–10	290	90.91	219	63.85	327	72.51
10–20	29	9.09	124	36.15	123	27.27
Over 20	0	0	0	0	1	0.22
Total	310		343		451	
Percentage	28.66		30.82		40.52	

Table 8. Location of egg-mass on each leaf of a banana-plant

Leaf order	Number of banana-plant observated											
	1	2	3	4	5	6	7	8	9	10	Total	Percentage
1	0	0	0	0	0	0	0	0	0	0	0	0
2	1	8	1	4	1	1	5	1	6	2	30	7.91
3	9	21	6	15	13	27	7	4	12	11	125	32.93
4	11	24	12	15	8	18	11	12	3	16	130	34.30
5	0	9	10	8	8	11	8	11	0	7	72	19.00
6	1	2	—	1	1	—	3	2	1	1	12	3.17
7	—	3	—	1	2	—	1	—	2	1	10	2.64

From the data of Table 7 and Table 8, it indicated that lace bug laid their egg-mass mostly on the 3rd and 4th leaves in a plant and about 67.28 per cent out of the total located in that place. The egg-mass was scarcely found to lay on the newly grown leaf. The old leaves which had been deposited a great number of eggmasses by lace bugs before the last generation were not a preferential place for oviposition.

As a leaf was transversely divided into three part; namely basal part, middle part and apical part, then about 40.52% of egg-masses was laid on the basal part, another 30.82 per cent of egg-mass laid on the middle part of leaf, and only a few egg-masses was laid on the apical part. On the other hand, if the leaf was based on the midrib and perpendicularly divided into three parts of each side, then about 72.71 per cent of egg-mass was found to be laid on the place within 10 cm from midrib. The range from 10 cm to 20 cm away from the midrib was laid only 27.27 per cent, and the marginal zone was rarely laid.

The number of eggs containing in an egg-mass was quite uneven. The data indicated that the most egg-masses contained 10 to 15 eggs. The lowest number of eggs in an egg-mass was 1; the highest was 232; the average number of eggs of 589 egg-masses was 33.93.

2. The distribution of lace bug in a banana orchard: In order to determine the distribution of lace bug in a banana orchard, the number of adults and nym-

phs on each sampling place of a plant were counted and recorded. The results revealed that there were more lace bugs settling on the banana plants of 1-2 m. in height than those below 1 m. or over 2 m. in height, except in the period of adults in their maximum emergence. Generally, most adults would fly to the leaves of apical part for oviposition after they were emerged from nymphal stage, so that, at that time the population on the higher plant was higher than those on the lower one. It was especially noticeable on the plants of wind-sheltered plots. While, on those of no sheltered plots, the adults population on the plant of 1-2 m. in height was higher because the upper leaves would be blown to pieces (See Table 9-11).

Table 9. Distribution of *Stephanitis typica* on different height of Banana-plants in 1966

Date of obs.		Height of plant						Total
		Over 2 m.		1--2 m.		Below 1 m.		
		No. of bugs	Percentage	No. of bugs	Percentage	No. of bugs	Percentage	
Jan.	7	6.39	31.14	10.05	49.98	4.08	19.88	20.52
March	23	61.71	69.37	22.72	25.54	4.55	5.09	88.96*
June	26	18.65	32.97	20.35	35.98	17.56	31.05	56.16
Sept.	24	8.09	8.88	70.43	77.30	12.59	13.82	91.11

The asterisk is shown the adults in their maximum emergence.

Table 10. Distribution of *Stephanitis typica* on various part leaves of banana plants

Date of obs.		The leaves of upper part		The leaves of middle part		The leaves of low part		Total
		No. of bugs on the sampling place of a leaf	Percentage	No. of bugs on the sampling place of a leaf	Percentage	No. of bugs on the sampling place of a leaf	Percentage	
1965				Adult				
Apr.	15	2.65	40.90	2.37	36.57	1.46	22.53	6.48
May	19	7.04	63.03	2.90	25.96	1.23	11.01	11.17*
	29	13.63	66.75	5.57	27.28	1.22	5.97	20.42*
June	24	1.21	50.63	0.67	28.03	0.51	21.34	2.39
July	7	11.56	47.06	8.04	32.74	4.96	20.20	24.56*
	19	4.91	50.00	3.26	33.20	1.65	16.80	9.82
Aug.	2	2.15	37.99	2.00	35.34	1.51	26.68	5.66
	16	4.45	41.55	3.95	33.52	8.67	24.93	10.71*
Sept.	1	1.69	31.47	0.93	17.32	2.75	51.21	5.37
	14	10.35	40.91	9.91	39.17	5.04	19.92	25.30*
Oct.	1	1.60	44.69	1.27	35.47	0.71	19.83	3.58
	15	6.55	20.20	20.74	63.43	5.42	16.55	32.71*
Nov.	1	1.59	18.01	4.39	49.66	2.86	32.33	8.84
	16	4.00	56.74	2.12	30.07	0.93	13.19	7.05
Dec.	3	65.44	51.26	28.21	22.96	34.01	25.78	127.66*
	18	20.53	29.03	33.47	47.33	16.71	23.64	70.71

1966								
Jan.	1	5.77	34.22	7.93	47.03	3.16	18.74	16.86
	14	1.86	8.86	10.85	51.69	8.28	39.44	20.99
Feb.	1	3.93	39.30	3.43	34.30	2.63	26.40	10.00
	14	4.95	20.30	12.41	50.88	7.03	28.82	24.49
Mar.	1	38.58	76.61	6.09	12.09	5.69	11.30	50.56*
	15	16.91	40.67	19.99	48.08	4.68	11.25	41.58
Apr.	2	14.43	28.30	22.83	44.77	13.73	26.93	50.98
	15	16.39	20.28	40.00	59.25	11.12	16.47	67.51*
Total		263.17	40.02	252.97	38.61	139.97	21.37	655.11
1965				Nymph				
Apr.	15	0.39	1.95	11.08	55.26	8.58	42.79	20.05
May	19	21.33	19.44	65.27	57.50	23.10	21.06	109.70
	29	2.34	11.56	14.15	69.91	3.75	18.53	20.24
June	24	5.68	5.76	9.60	81.29	1.53	12.95	11.81
July	7	8.31	30.27	16.07	58.52	3.08	11.22	27.46
	19	10.91	33.24	20.42	62.22	1.49	4.54	32.82
Aug.	2	1.29	3.84	27.96	83.29	4.32	12.87	33.57
	16	1.55	9.90	12.98	83.00	1.11	7.09	15.65
Sept.	1	0.61	1.10	44.71	80.39	10.32	18.54	55.64
	14	1.20	5.21	17.69	76.85	4.13	17.94	23.02
Oct.	1	2.72	7.16	27.40	72.11	7.88	20.73	38.00
	15	2.96	6.42	39.16	84.89	4.01	8.69	46.13
Nov.	1	0.07	6.24	1.01	90.01	0.04	3.57	1.12
	16	6.56	5.95	55.87	50.68	47.82	43.37	110.25
Dec.	3	3.10	17.03	14.98	82.31	0.12	0.66	18.20
	18	1.98	5.71	22.21	64.08	10.47	30.21	34.66
1966								
Jun.	1	0.01	0.19	1.61	30.67	3.63	59.14	5.25
	14	0	0	11.68	41.26	16.63	58.74	28.31
Feb.	1	3.72	11.29	12.91	39.18	16.32	49.53	32.95
	14	1.61	2.17	51.96	69.98	20.68	27.85	74.25
Mar.	1	3.15	30.11	7.28	69.50	0.03	0.29	10.46
	15	6.68	13.26	33.55	66.61	10.14	20.13	50.37
Apr.	2	7.28	3.34	167.73	76.90	42.93	19.70	217.94
	15	6.99	3.83	157.25	86.25	18.07	9.92	182.31
Average		95.44	7.95	844.54	70,37	260.18	21.68	1200.16

The asterisk is shown the adults in their maximum emergence.

Another investigation was used to determine the distribution of lace bug on a banana plant throughout the year. The plants of 1-2 m. in height were used for investigation and then the leaves of each plant were divided into three parts: Upper part leaves (From 2nd to 4th leaf in order), Middle part leaves (From 5th to 7th leaf), and low part leaves (Below 7th leaves). The number of bugs of on each part was recorded twice a month. The results were shown in Table 10. The data clearly showed that during the period of warm season, the most adults were actively on the upper part's leaves, especially on the 2nd and third leaf, but most of the colonies of nymph settled on the middle part's leaves. During the cold season, it was found that the most adults changed to live on the middle part leaves, and nymphs settled on the lowest part's leaves. It seems the longevity of adults and the duration of a life-cycle were longer in cold season

than in warm season; therefore, the upper or middle part's leaves which originally colonized by the most of adults or nymphs were changed into the middle or lowest part's leaves owing to the newly grown leaves. Cold and severe wind might be an another factor that forced the insects to live on the lower leaves.

3. Seasonal succession: This investigation were carried out from April 1965 to April 1966. The number of adults and nymphs on each sampling place of every one leaf of 25 banana plants were counted and recorded twice a month, respectively. The plant of 1-2 m. in height were chosen for this investigation. The results were summarized in Figure 2.

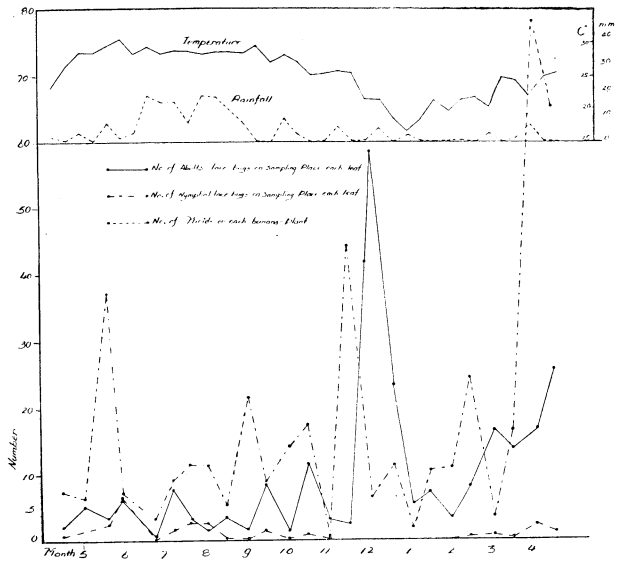


Fig. 2. Indicates a correlation between the seasonal fluctuation of lace bug and environmental conditions relative to clemate and natural enemies—*Stethocunus* sp.

According to the peak and tendency of the curve shown in Figure 2, the lace bug occured 9 generations in mid-south part of the island in a year round. The duration of the first generation began from the middle of December to the middle of February; of the second, from the end of February to the beginning of April; of the third, from the beginning of April to the beginning of May; of the fourth, from the beginning of May to the middle of June; of the fifth, from the middle of June to the middle of July; of the sixth, from the middle July to the middle of August; of the seventh, from the middle of August to the middle of September; of the eighth, from the middle of September to the middle of October; of the ninth, from the middle of October to the beginning of December. It took about 25-45 days to complete one generation in warm season, while it took about 60-75 days in cold season. All stages may be observed during the winter of that year.

The temperature at the area was favorable for the lace bug all the year round. The population density as shown in Figure 2 tended to be high during

the dry season, between September, October, November, December and the first five monthes of the next year. Rainy season seemed unfavorable for the lace bug, and was noted to have reduced the spring population and depressed a low population throughout the summer.

4. Geographic distribution: From October to December 1965 and in September 1966, the distribution of lace bug on various environment was investigated. The number of lace bugs on each sampling place of a leaf of 40 banana plants were counted and recorded. The data were shown in Table 11 which revealed that the banana plants which grew in the place of the wind-sheltered seemed to be infested more seriously than those of growing in the windswept areas. This case was particually noticeable in winter. Another inspection showed that there were no different in the population of lace bug if plants were cultured in the hillside, upland or on low land areas. In a banana orchard, generally, the population density of lace bug was higher in the side of shelter from wind than those in the sides of wind-received area.

Table 11. Geographic distribution of *Stephanitic typica*

Obs.	date	No. of Plants obs.	No. of lace-bug on the sampling place of a leaf (AV)			
			Windswept orchard	Environment	Wind-Sheltered orchare	Environment
Oct.	7	40	6.08	Up-land	10.63	Hillside
Nov.	15	40	0.86	Up-land	56.38	Up-land
Dec.	15	40	3.55	Low-land	251.88	Up-land
Dec.	16	40	30.15	Low-land	134.73	Low-land
Dec.	17	40	1.53	Hillside	141.18	Hillside

5. Preference on varieties of banana: 54 spacies of banana varieties in the orchard of Chiayi Agricultural Experiment Station were used for this study. The number of lace bugs on each sampling place of a varieties (1 to 5 plants (some varieties of banana were too high to be investigated, and some were absent)) were counted and recorded during the monthes of September, November and December in 1965. The data were shown in Table 12.

Table 12. The population density of lace bugs among 54 verieties of banana

Varieties	No. of plants obs.	Average number of lace-bugs on sampling part of a leaf				
		Sept. 15	Oct. 14	Dec. 15	Nov. 16	Total
Abaca Seedlin	3	8.36	51.12	297.00	173.00	529.48
Ai-Chueh Chiao	2	16.79	27.67	288.50	—	322.96
Ambon	3	2.34	49.47	46.00	561.50	659.31
Apple	3	1.56	7.00	2.50	474.00	485.06
Assam	3	0.63	4.14	28.00	386.00	418.77
Awak	3	1.00	21.12	73.00	45.50	140.62
Blue-Field	3	0	51.31	3.00	394.00	448.31
Boyang	2	2.23	14.69	3.00	—	19.92
Breazilian	5	0.63	25.86	24.40	28.50	79.39

Bungulan	2	0.17	7.67	3.67	275.50	287.01
Chung-Sheng-Pa Chiao	3	21.15	16.33	11.33	432.50	481.31
Cooking	2	0	2.67	112.00	5.00	119.67
Fen-Chiao	2	2.00	3.40	131.00	—	136.50
Golden-King	3	0	1.33	6.33	108.50	116.16
Golden-Beauty	3	3.49	5.86	5.67	116.00	131.02
Hsia-Li Yuan	3	31.14	43.67	26.00	352.50	453.31
Hsien-Jen Chaio	2	0	3.00	19.00	180.50	202.50
Hun-Mao Chiao	3	3.40	38.83	81.33	897.00	1020.56
Hung-Pi Chiao	2	0	7.75	18.23	26.34	52.32
Hung-Tao-Pei Chiao	3	0.80	3.23	17.67	49.00	70.70
Ice Cream	2	0.13	3.71	15.33	162.50	181.67
Idzo	3	0	3.46	2.00	5.50	10.96
Java	2	0	36.67	38.34	19.24	95.25
Kabok	2	0	20.19	1.33	200.50	222.02
Kanabu	2	0.62	22.07	32.33	251.00	306.02
Keelung-pei Chiao	1	0	39.41	16.00	182.00	237.41
Kiliang	2	2	39.20	36.00	163.23	240.43
Lacatan	2	0.86	9.92	81.43	98.26	190.47
Latundan	4	0.13	24.17	30.67	782.50	837.47
Lang-Yia Chiao	2	7.94	3.33	10.67	394.00	415.94
Lu-Sung Chiao	5	0	21.00	9.60	226.00	256.60
Malacca	1	0	22.00	2.00	85.00	109.00
Mas	3	0.33	7.57	13.33	260.50	281.73
Monkey	4	1.55	6.57	25.50	502.50	536.22
Nibak	2	0.13	2.38	73.50	218.00	293.93
Panchghol	2	2.69	13.64	34.51	83.27	134.11
Paruk	3	0.26	7.89	11.00	34.16	53.31
Peh-Chiao	2	0.11	5.64	4.67	279.00	289.42
Pendok	2	0	12.50	1.70	61.00	74.80
Pipon	3	0	11.01	171.00	221.00	403.00
Pitigo	4	0	0.83	103.67	—	104.50
Popul	2	—	—	195.00	337.00	532.00
Puerto Rice	2	0	10.00	6.67	275.50	292.17
Raja	2	1.24	5.20	7.33	559.00	572.77
Restali	2	12.44	10.38	12.50	185.00	320.32
Rilian	1	0	5.40	14.86	33.22	53.48
Saba	2	0.17	5.62	16.00	198.00	219.79
San-Chih Chiao	2	0.07	7.43	4.00	8.25	19.75
Saribu	2	8.20	9.62	27.00	47.50	92.32
Shuang-Sui Chiao	2	0	14.00	16.00	310.00	340.00
Spain	2	0.07	14.77	2.00	414.00	430.84
Su-Su	3	0	9.83	2.00	277.50	289.33
Tandok	4	0	3.75	12.00	108.00	123.75
Wei-Tsung Chiao	3	12.35	8.83	34.26	103.00	158.44

According to the data, some varieties such as Boyand, Idzo, Paruk, Rilian, Hung-Pi Chiao, San-chih Chiao and Shuang-Sui Chiao showed less injury by lace bug, and the varieties of Hung-Mao Chiao, Amban, Apple, Latundan, Monkey etc. seemed to be favourite host to the lace bug. Same observations were made by Chein & Huang (1965) at the southernpart of the island in 1964, they reported that no lace bug was found to injure the varieties of Latundan and Pipoh. However, the results of their observation disagreed with those reported in this report. Hence, it is necessary to have a further study on the field of resistance of banana to lace-bug.

NATURAL ENEMIES

During the investigations, a species of Mirid and several species of spider (Family *Salticide*) were observed to be associated with the lace bug. The later species were predacious on both of lace-bug and two-spotted spider mite (*Tetranychus urticae* Koch) on banana. The data about their biological studies were not observed here.

The Mirid which was identified as *Stethoconus* sp. was yellowish white in color with many dark-brown spotted in the body. According to the record of rearing in laboratory from March to May 1966, it took 14 to 17 days with an average of 15.13 days to complete a life-cycle at 27.03±1.63°C; while it lasted 19 to 24 days with an average of 22.13 days at 22.81±0.20°C (Table 13). It was about 8-18 days shorter in their whole development than that of the victims. The longivity of adult was 10.27 days in average, within a range of 4 to 10 days in summer. The average number of eggs laid by each female was 34, ranged 20 to 48.

Table 13. Effect of temperature on the incubation period and completed one life-cycle of *Stethoconus sp.*

Incubation period		Completed one life-cycle	
Mean Temp. (°C)	Days	Mean Temp. (°C)	Days
20.94±0.16	12.56±0.88	22.81±0.20	22.13±1.38
28.03±0.39	7.89±0.78	27.03±1.63	15.13±0.04

Both nymph and adult of Mirid were found to attack the nymph and adult of lace bug. Table 14, showed that the nymph of a Mirid destroyed 121 to 184 lace bugs (Including adult and nymph) with an average of 140.5, while in adult stage, it could prey 109 to 273 lace bugs with an average of 182.3; and therefore, a Mirid could prey some of 356 lace bugs in whole life.

Field observation indicated that the Mirid spent their winter with their egg stage. The adults of the first generation appeared in the middle of February in the area of the wind-sheltered; as to the area of the windswept, the appearance of the first generation of the Mirid would come to the beginning of April. Egg was deposited in the tissue of the leaf where the egg-mass of lace-bug was near

to. 2 or 3 of eggs were laid in a deposited site. After they hatched, the nymphs dispersed into the colonies of lace bug. Some lace bug population were quite seriously injuried by Mirid. However, Mirids caused a unevenly destribution of the population of lace bug sometimes. There were 0 to 187 mirids being found in the plant of the orchards.

Table 14. Duration of each stage of *Stathoconus sp.* and their predatory capacity

	Nymphal stage					Adult stage	Total
	1st instar	2nd instar	3rd instar	4th instar	5th instar		
Length of each instar or stage	2.06	1.38	1.50	1.75	2.88	13.14	23.28
(Days)	(2-3)*	(1-2)	(1-2)	(1-2)	(2-3)	(4-21)	(15-27)
No. of lacebugs were preyed	8.63	10.33	22.00	27.33	72.17	223.27	363.77
	(3-18)*	(5-19)	(11-32)	(14-38)	(58-100)	(109-273)	(233-396)

Note: The number in the parenthesis were shown the minimum and maximum.

SUMMARY

The observation on the ecology of banana lace bug (*Stephanitis typica* Distant) in laboratory and field during 1965 and 1966. The insect which we observed was a small bug about 0.40 mm. in length, and was a species of the family Tingidae. Both the adult and nymph of the insect injured the banana by sucking the sop of leaves under the surface, that caused the leaves to become mottled with grayish-yellow blotches and retarded the growth of plant consequently.

The result of the observation in laboratory indicated that, the bug took 9 generation in a year. The period of incubation lasted 11.92±2.43 days in summer and 32.10±10.59 in winter. The interval of nymphal stage ranged from 10 days to 38 days with an average of 17.69 days. The average number of days length of life for a female was 7.1 in summer and 36.8 in winter. The time for completing a life-cycle required 37.82 days in average, within a range of 17 days to 80 days.

The average number of the total eggs produced by one female was 36.8. The average survival rate from newly hatching nymph to adult was 69.05 per cent in field, and it reached 100 per cent if they were protected against the natural enemies. The sex ratio of adult was approximately 3:2.

Observation in field indicated that the bugs builded up some denser and larger colonies in the banana plantation where these plants were sheltered from wind than those on the wind sewpt orchard. There was no difference between the population size of the bug if the banana plants were cultured in the hillside, upland or on low land areas.

Most adults of the bug were actively on the upper part of the leaves (From

2nd to 4th leaf), and about 67.28 per cent out of the total egg-mass were found there. Nymph mainly settled on the middle part of the leaves (From the 5th to 7th leaf), about 70.37 per cent out of the total nymphs was found living on those place.

Temperature here, was favorable for the bug to propagate all the year round. The population of the bug tended to be high during the dry season, from September to May of the next year. Rainy season seemed unfavorable for the lace bug. It was noted to have reduced the spring population and depresed a low population throughout the summer. All stages might be observed during the winter.

Among 54 varieties of banana being planted in Chiayi Agricultural Experiment Station, no varieties had exactly shown resistant to the bug. The varieties such as Boyang, Idzo, Paruk, Rilian, Hung-Pi, San-chih and Shung-Sui shown less injured by lace bug.

One species of Family Miridae, *Stethocunus sp.* was found to attack both nymph and adult of lace bug. This predacious insect appeared in whole year except December and January of the next year, and they spent their winter with egg's stage. The average number of egg that was laid by each female was 34. The time for completing one life-cycle required 8-18 days. It was quicker than the victim of the insect in the same environment. A mirid could prey some of 356 lace bugs in its whole life.

LITERATURE CITED

1. Takahashi (R.) 1936. Food habits and new habitats of the Formosan Psyllidae, with notes on the peculiar food habits of some Formosan phytophagous insects (In Japosese). Kontyu 10(6): 291-296.
2. Shiraki T. & Soan J. 1937. Banana pests. Tropical Horticulture (4): 432-450.
3. Miwa Y. 1943. A list of insect pests in Taiwan.
4. Hòffmann (W. E.) 1935. Observation on a Hesperid leaf-roller and a lace bug, two pests of banana in Kwangtung. Lingnan Sci. J. 14(4): 639-649.
5. Ko R. S. & Chu Y. I. 1936. Ecological notes on *Stephanitis typica* Distant (Hemiptera, Tingidae) in Taiwan. Plant Prot. Bul. 8(2): 163-167.
6. Chein H. S. & Huang C. C. 1965. Banana lace wingbug (*Stephanitis typica* Distant) and its chemical control study. Plant Prot. Bull. 7(3): 126-134.

香蕉軍配蟲 (*Stephanitis typica* Distant) 之生態觀察

鄭　清　煥

中 文 摘 要

香蕉軍配蟲 (*Stephanitis typica* Distant) 爲本省近年來香蕉葉片之主要害蟲，全省各地蕉園均有分佈。其造成爲害係以成蟲及若蟲，羣集蕉葉背面吸取養液，致使被害蕉葉表面形成黃灰色之斑點，受害嚴重者，葉面整片呈蒼白狀，引起早期枯萎，終而影響蕉株之發育。

本蟲在嘉義地區，年發生九代，其完成一世代，最短須時17天；最長爲80天。在冬季除發育所歷時間較長外，並無嚴格之越冬現象，在田間各蟲期可同時發現。

按室外飼養結果：卵期在盛夏 (28.06±0.38°C) 平均爲 11.92±2.43 天，在嚴冬(17.10±0.23°C) 平均爲 32.10±0.59 天。若蟲脫皮四次共五齡，歷時 12—38天，平均爲 17.29 天。雌成蟲平均壽命：夏天爲 7.10 天，冬天爲 30.80 天。各世代各蟲期所歷時間之長短，均隨各季節氣溫之高低而不同。

由田間調查知悉，本蟲之卵成簇狀地產於蕉葉背面組織內，每一雌蟲平均卵數爲 35.80 粒，卵塊主要 (67.28%) 被產於第二片至第四片蕉葉（由上往下數）。以葉基主脈兩側10公分範圍內分佈最多。幼蟲(70.37%)（棲息於中部蕉葉第五片至第七片），其在田間之成活率平均爲69.05%，但若保護其免受天敵之侵害，則幾可這 100%。若蟲蛻變爲成蟲後，有飛往上部新葉產卵之習性，產卵時，有一隻產一處者，亦有數隻產於一處者。平時成蟲及若蟲均羣集於蕉葉背面，除非受到刺激，干擾或被害葉枯萎，甚少遷移或飛翔。成蟲之性比爲♀：♂＝3：2。

本省終年氣溫均適於香蕉軍配蟲之繁殖，棲羣密度，以乾旱季節（由九月至次年五月）較高，雨季似不適其生長。其棲羣密度在山坡地、烟地或平原水田地之蕉園，並無顯著之差異。唯其在避風蕉園之棲羣密度，往往較當風蕉園之密度高得多，在同一園蕉當中，亦以避風一方棲羣密度較當風之面爲高。

軍配蟲天敵，主要有雜食性蜘蛛類 (Family Salticidae) 及屬於盲椿象科之一種 (*Stethoconus* sp.)，前者除捕食軍配蟲外，並可捕食爲害馳蕉之二點紅蜘蛛 (*Tetranychus urtical* Koch)，後者專捕食軍配蟲，其完成一代，平均較軍配蟲快8—18天，一生可捕食軍配蟲約爲356隻左右，唯其分佈甚爲不均，對軍配蟲發生之抑制力不大。

誌謝：本試驗工作承外貿會香蕉小組補助經費，王所長茂康及陶主任家驊之鼓勵與指導及楊溫仁、賴清課兩位先生之鼎力協助。本文草成後，承蒙中興大學昆蟲系主任張教授書忱詳加斧正，感激甚深，謹誌於此，略申謝悃。

本省現有稻穀乾燥機性能試驗

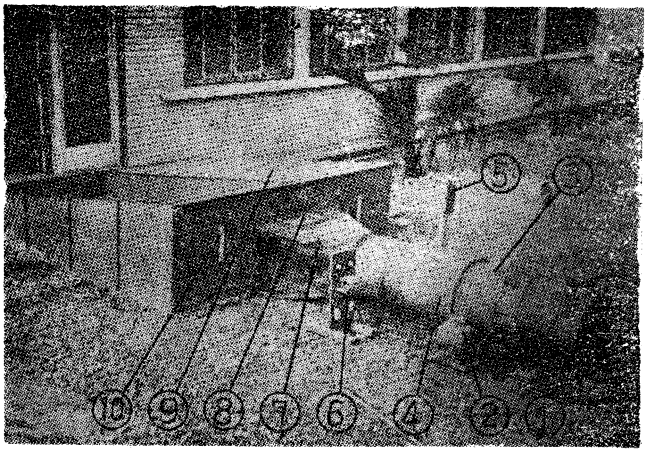
林 展 弘　　鄔 清 標

一、前　　言

由於本省氣候高溫，多雨濕度大，在農產水稻收穫期間且常連日陰雨，致使稻穀水分無法去除，而導致發芽發霉之損失，尤其本省中南部一期及北部二期水稻收穫期，所受影響最爲嚴重，爲了解決此問題，農林廳乃與中農設計一新式雨季稻穀搶救性乾燥機。

農廳——中農高坂式乾燥箱專爲配合一般農村經濟及農民之需要而設計，其所採取熱風乾燥法，可說是一新穎且實用之方法，目前已有逐漸推廣之勢，在此我們對其乾燥時，在穀層中之水分變化情形及其可能產生之問題，應能作進一步之探討，以作將來稻穀乾燥方法之改良與發展之基礎。

二、農廳—中農高坂式乾燥箱構造簡介



① 焦炭爐
② ½馬力單相馬達
③ 鼓風機
④ 風量測定筒
⑤ 測定風壓用U形管
⑥ 安培計，伏特計，瓦特計
⑦ 通風帆布套
⑧ 進氣門調節桿
⑨ 穀箱
⑩ 箱底L型溫度計。

此熱風乾燥機，由二分之一馬力之單相馬達帶動一導翼式鼓風機，吸取焦炭爐燃燒之熱氣吹入穀箱，穀箱分成左右兩隔，各有進氣門調節左右箱風量之多少，當一隔換裝稻穀或攪拌時，可關閉氣門，另一隔可繼續進行乾燥工作。（如上圖）

三、稻穀火力乾燥原理

乾燥原理即爲利用各種機械使穀子內部水分蒸發，不論其所用之方法爲何，其作用均係相同，火力乾燥法即爲最常用之熱空氣乾燥法，係先使空氣加熱，降低其相對濕度，然後通過穀層帶走水分。

在熱風乾燥法中往往受到許多因素之影響，必須能將各因素控制得當，才能達到理想，配合不當，則效用不佳，減低乾燥效率，茲列舉幾種重要因素如下：

(1)風。包括風量與風速。
(2) 溫度。
(3) 濕度。
(4) 乾燥速度。
(5) 穀層厚度。

四、將以上各因素說明如下：

(1)風：包括風量與風速。

(A)風量：風量大則在同一時間所能吸收穀層之水分亦多，反之則少，故乾燥程度與風量之大小極有關係。

(B)風速：當空氣流動得快，促使稻穀層裡水分蒸發容易，同時也常可使空氣保持乾燥，以供穀層水分之蒸發，在乾燥過程中風速亦極重要。

(2)溫度：乾燥溫度的高低直接影響穀層水分變化，溫度太高有傷稻米粒的品質，溫度太低則熱空氣濕度太高，對穀層水分沒有吸收力，無法促使水分蒸發。

(3)濕度：整個乾燥問題，可說就是濕度問題，空氣愈乾溫度愈高，其吸收水分的能力亦強，反之則低，在亞熱帶的本省，空氣濕度很大，因此須運用高溫以求取濕度極低之空氣，但又受穀子品質之限制無法提高溫度。濕度問題具有多方面的相關性，如能控制得當則乾燥問題，就得解決。

(4)乾燥速度：在陰雨天實施搶救性稻穀乾燥時，我們不可忽略之問題爲稻穀米粒之胴裂問題，胴裂與熱脹冷縮有關，而乾燥速度卽爲其影響因子。

(5)穀層厚度：穀層愈厚空氣流通不易；太薄易使空氣流失消耗燃料，當求較適厚度，以合經濟要求。

上列乃乾燥過程中之五種主要因素，如能隨時控制得當，則效率自然提高成本減低。

五、茲將農廳一中農高坂式乾燥機之試驗記錄列於下表：

表　一

試驗日期		56年1月18日	試驗地點		農機系實驗工廠
天氣		陰	大氣濕度		乾球 15°C 濕球 13.5°C
稻穀品種		臺農 38 號			
乾燥前	稻穀重量	616公斤	乾燥後	稻穀重量	470.9公斤
	含水量	41.8%		含水量	表層 20.8% 底層 18%
穀層厚度		17.3公分			
動力機		單相馬達1/2馬力	鼓風機		導翼式推進型
馬達廻轉數		1720轉/分	鼓風機廻轉數		1500轉/分
電壓		112伏特	靜壓差		6.4公厘
電流		3.8安培	風量		0.8立方公尺/秒
本次總耗電量		1.5仟瓦，小時			
焦炭總消耗量		20.2公斤			

時間	溫度 °C 箱底	箱前段		箱中段		箱後段		含水率%		備註
	±2°C	表層	底層	表層	底層	表層	底層	表層	底層	
0.5小時	50	23.5	41	24.5	40	25	41	37	33.5	1.胴裂率：19%（包括未乾燥前已碎裂者）。 2.碎米率：6.4%。 3.乾燥中：每隔1小時攪拌一次。 4.胴裂率：係採用隨機取100粒剝殼在燈光上觀察斷裂計算。 5.碎米率：係用200公斤稻谷精白後取一公斤之白米其中斷一半之米粒計算。
1 小時	46	24.5	44.5	27	39.5	28	33	33	32.5	
1.5小時	30	20	38	21.5	30	22	32	27.7	31.7	
2 小時	52	27	54	26.8	53	27.5	55.5	28.5	23.4	
2.5小時	48	31.5	34	35	36.5	34.5	38.5	26	20.4	
3 小時	33	29.5	30	28	31.5	29	20.8	20.8	18	

表　二

試驗日期	55年1月19日		試驗地點	農機系實驗工廠	
天氣	陰		大氣濕度	乾球 19.5°C 濕球 17°C	
稻穀品種	臺農 38 號				
乾燥前	稻穀重量	480公斤	乾燥後	稻穀重量	323.5公斤
	含水量	40.4%		含水量	表層21.9% 底層18.9%
穀層厚度	12.5公分				
動力機	單相馬達1/1馬力		鼓風機	導翼式推進型	
馬達廻轉數	1720轉/分		鼓風機廻轉數	1500轉/分	
電壓	112伏特		靜壓差	5公厘	
電流	3.8安培		風量	0.84立方公尺/秒	
本次總耗電量	1.25仟瓦小時				
焦炭總消耗量	18.45公斤				

時間	溫度 °C 箱底	箱前段		箱中段		箱後段		含水率%		備註
	±2°C	表層	底層	表層	底層	表層	底層	表層	底層	
0.5小時	66		48	29.8	31.8		41	37.3	36.5	1.胴裂率18% （包括未乾前已碎裂者） 碎米率6.1%。 2.每隔1小時攪拌一次。
1 小時	60		52	27	50.5		53	33	27.6	
1.5小時	58		58	35	53.3		48	34.4	26.5	
2 小時	50		44	41	45		40	27.5	22	
2.5小時	40		31	28.5	33		30	21.9	18.9	

表　三

試驗日期	56年1月20日		試驗地點	農機系實驗工廠	
天氣	晴		大氣濕度	乾球 25°C 濕球 22°C	
稻穀品種	臺農 38 號				
乾燥前	稻穀重量	800公斤	乾燥後	稻穀重量	679.8公斤
	含水量	20.8%		含水量	表層13.65% 底層12.7%
穀層厚度	27公分				
動力機	單相馬達1/2馬力		鼓風機	導翼式推進型	
馬達廻轉數	1720轉/分		鼓風機廻轉數	1500轉/分	
電壓	112特		靜壓差	9.5公厘	
電流	3.8安培		風量	0.735立方公尺/秒	
本次總耗電量	1.5仟瓦小時				
焦炭總消耗量	10.2公斤				

時間	箱底溫度 ±3° °C	水分率 表層	水分率 底層	備註
30 分	37	18.15	17.00	1.未烘前胴裂率18% 烘後胴裂率28% 烘後碎米率9.4%。
1 小時	37	16.80	16.10	
1 小時 30 分	37	16.00	15.40	
2 小時	37	14.50	14.15	2.此次供試之稻穀係18,19,日搶救乾燥者。
2 小時 30 分	37	14.15	13.3	
3 小時	37	13.65	12.7	

表四　農廳一中農高坂式穀類乾燥機試驗記錄表（55年 2 期作）　測試員：林文雄

示範農戶或機關名稱	蔡陽力	地址	臺北縣五股鄉更寮村鴨母港31號						
供試品種	臺北三〇九號	乾燥前	稻穀重量	980公斤	乾燥後	稻穀重量	842公斤	精選後稻穀重量	810公斤
			發芽率	95%		發芽率	97%		
電氣用量	乾燥開始	126.9度	乾燥完畢	131.2度	所用電度數	4.3度	所用電費	4.1元	
碾米率	73%				碎米率	9.2%			

日/月	室內溫度	室內相對濕度	天氣	雨量	加熱後空氣溫度 右箱	加熱後空氣溫度 左箱	加熱時間	稻穀層溫度℃ 右箱	稻穀層溫度℃ 左箱	稻穀各層含水量% 上層 右箱	上層 左箱	下層 右箱	下層 左箱	燃料 種類	燃料 用量
25/11	22°C	95%	陰雨	0.7mm	55°C	50°C	12時46分			20%	20%	20%	20%		
					48	45	13時46分			15.5	15.5	15.5	15.5		
	22	95			48	45	14時46分			15.5	14.5	14.5	14.5		
					48	45	15時46分			15.5	14.0	14.0	14.0		
	22	95			48	45	16時30停	18時35	分開始	14.2	14.0	14.0	13.7		
					45	43	19時35分			14.0	14.8	13.4	13.3		
	18.5	94			38	43	20時35分			14.0	13.8	12.4	12.3		
					40	43	21時35分			13.4	13.2	11.5	11.5		
	18.5	94			38	40	22時35分			12.5	12.5	11.2	11.2		
計				0.7mm										黑色焦碳	34.2公斤

※黑色焦碳每公斤1.56元×34.2公斤=53.4元+電費4.1元=57.50元。

表五　農廳一中農高坂式穀類乾燥機試驗記錄表（55年2期作）　　測試員：林文雄

示範農戶或機關名稱	蔡連豹及蔡陽力	地址	臺北縣五股鄉更寮村鴨母港35及31號

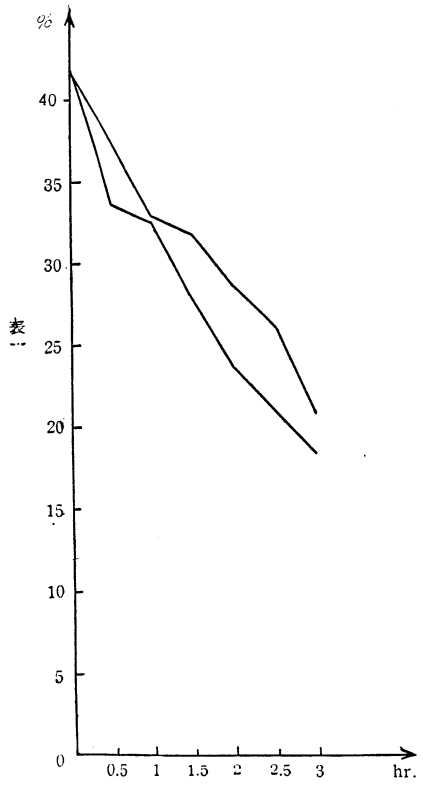
供試品種	臺北三〇九號	乾燥前 稻穀重量	蔡連豹547公斤 蔡陽力477公斤 計 1,024公斤	乾燥後 稻穀重量	蔡連豹449.0公斤 蔡陽力349.8公斤 計 796.8公斤	精選後稻穀重量	蔡連豹429公斤 蔡陽力329公斤 計 756公斤
		發芽率	96%	發芽率	95%		

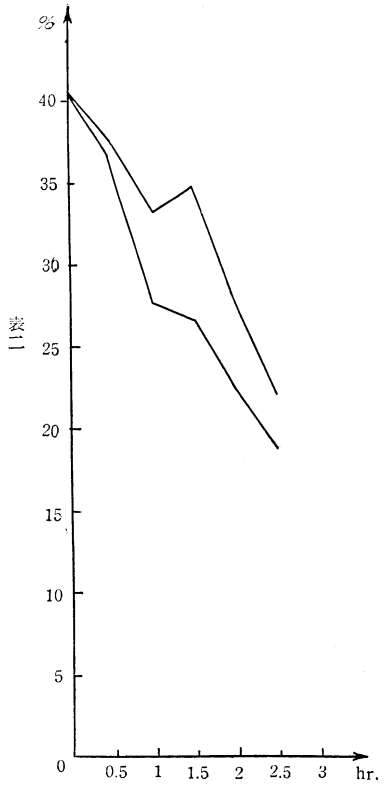
電氣用量	乾燥開始	131.4度	乾燥完畢	137.0度	所用電度數	5.6度	所用電費	5.3元

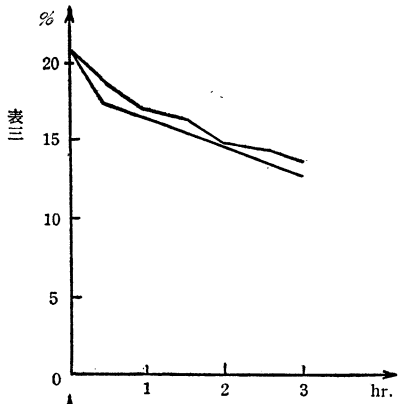
碾米率	76%	碎米率	8.8%

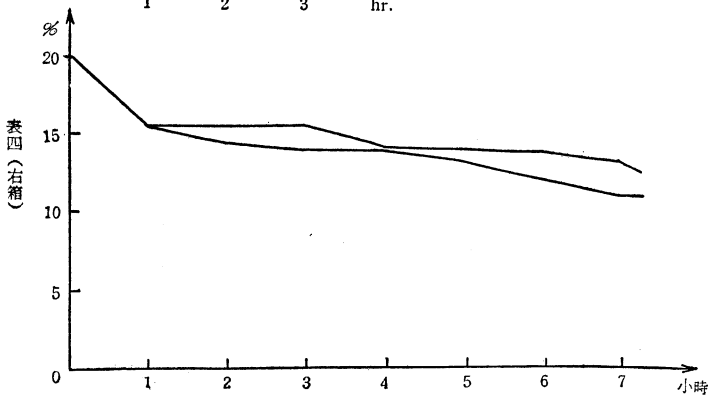
日/月	室內溫度	室內相對濕度	天氣	雨量	加熱後空氣溫度℃ 右箱	加熱後空氣溫度℃ 左箱	加熱時間	稻穀層溫度℃ 右箱	稻穀層溫度℃ 左箱	稻穀層含水量% 上層 右箱	上層 左箱	下層 右箱	下層 左箱	燃料 種類	燃料 用量
26/11	17°C	89%	陰雨		50	48	10時12分	36.0	39.0	20.09以上	20.0%	20.0%以上	20.0%		
					55	48	11時12分	37.0	39.0	18.0	20.0	18.0	20.0		
	18	89	〃		49	45	12時12分	41.0	37.5	18.0	18.5	17.0	17.5		
					49	45	13時12分	41.0	37.5	17.5	17.0	16.8	16.8		
	18	89	〃		48	45	14時12分	41.0	38.0	17.0	16.8	16.5	16.6		
					49	45	15時12分	41.5	38.5	16.7	16.4	16.2	16.3		
	17	89	〃		49	45	16時12分	42.0	41.0	16.3	16.2	15.7	15.7		
					49	45	17時12分	43.0	42.0	15.5	15.5	15.3	15.3		
	17	94	〃		48	43	18時12分	41.0	39.0	14.7	14.7	14.7	14 6		
					48	43	19時12分	41.0	39.0	14.0	13.9	14.0	13.8		
	16	94	〃		40	38	20時12分	34.0	32.0	13.2	13.0	12.4	12.1		
					40	38	20時21分	34.0	32.0	13.0	12.8	12.3	12.1		
計							10時09分							黑色焦碳	45公斤

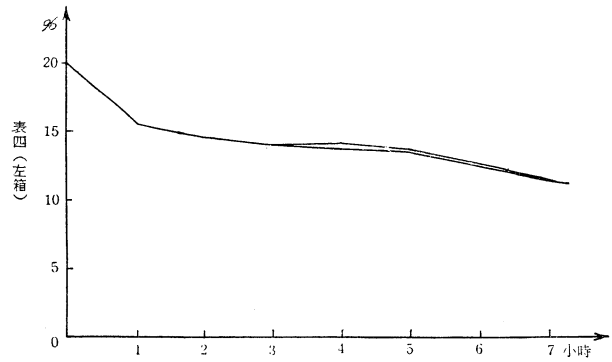
※黑色焦碳每公斤1.56元×45公斤=70.2元+電費5.3元=75.5元。


%
40
35
30
25
20
15
10
5
0
0.5
1
1.5
2
2.5
3
hr.
表一

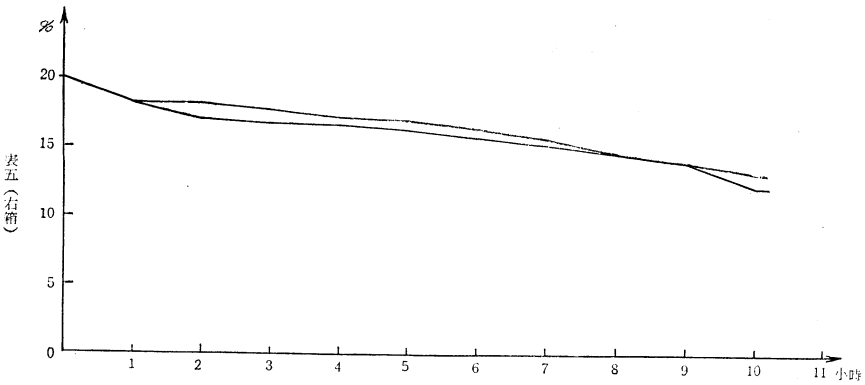

%
40
35
30
25
20
15
10
5
0
0.5
1
1.5
2
2.5
3
hr.
表二


%
20
15
10
5
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1
2
3
hr.
表三

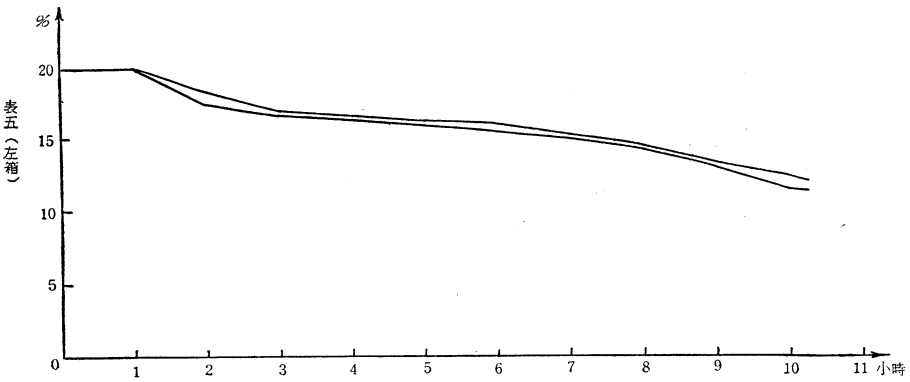

%
20
15
10
5
0
1
2
3
4
5
6
7
小時
表四（右箱）



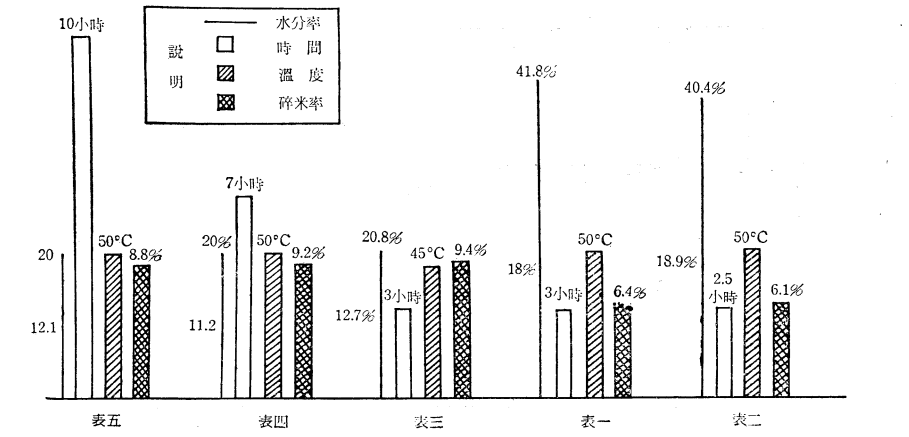
表四（左箱）



表五（右箱）



表五（左箱）



我們從水分率變動曲線圖表及統計圖表來看：

(1) 上下穀層水分率差距：

①水分率曲線表一及表二之最大差距爲表二之8％，此差距在有實施攪拌工作的乾燥過程不可能發生，此差距可能由於取樣時誤差。就理論上來說，在兩表之間表一比較正常。

就水分率高40％的稻穀乾燥過程來看，由於水份太多，底層穀乾燥後，水份漸蒸發，向上層穀移動，由於上層溫度較低，因此有一部份的水就再凝結，滯留於上穀層。形成底層穀的水份與上層穀水份差距增加。此種現象在乾燥過程極不經濟，必需時常翻動攪拌才能避免。尤其穀層愈厚者攪拌工作次數應增加。

②表一、表二，乾燥工作屬於安全乾燥，表三爲儲存乾燥。水分率曲線較前二者平均差距也小。同樣的表四、表五上下層水分率曲線差距亦甚小。這種現象係由於穀粒外殼水分已被乾燥，剩下來的都是稻穀粒內部水分之故。此現象的發生時期約在穀層水分率爲16％至18％之間。

③水分率曲線差距減小之原因：

稻穀外殼水分消失可能是曲線漸趨平穩的主要原因，在這個時期由於穀粒內部水分向外蒸發的速度較慢，另方面由於穀層水分漸少，空氣所受阻力也漸低。因此水分率曲穩漸平穩而水分率差距也大大的減少。

(2) 穀層厚度的影響：

穀層較厚時乾燥時間也較長，水分率差距也大。就水分率說：

①20％以下：表五穀層最厚，在表五的曲線裡，由於水分率已乾燥至20％以下，因此水分率差距極小。但在17％時由於穀層較厚之關係，差距一直維持在0.8％左右。

表四，左箱的情形，從水分率曲線的變化，可看出平穩且差距小，是爲乾燥曲線最理想的一個，然而由於乾燥速度較慢無法提高熱效率。

②40％時：穀層太厚時，易使曲線差距增加，同時曲線變動大。此時若不實施攪拌工作時易致乾燥時間增長，下層稻穀受熱過久或過度乾燥而發生胴裂現象，間接影響將來精白時之碎米率增加。

③攪拌工作：由表一、二，的實驗可知若攪拌次數增加確可使乾燥效率提高，但仍以每小時攪拌一次較適，否則即有濫用人工之損失。

(3) 乾燥速度：空氣溫度與風速直接控制乾燥速度而影響穀粒胴裂，但確能降低燃料之消耗，提高熱效率，但就碎米率來說，則殊不值得。故仍取適當之乾燥速度爲佳，將乾燥速度與碎米率列表如下：

	表　一	表　二	表　三	表　四	表　五
原水分率％	41.8	40.4	20.8	20	20
乾燥後水分率％	18	18.9	12.7	11.2	12.1
水分率差％	23.8	21.5	8.1	8.8	7.9
乾燥時間小時	3	2.5	3	7.23	10.15
乾燥速度％/小時	7.9	8.6	2.7	1.2	0.88
碎米率％	6.4	6.1	9.4	9.2	8.8％

① 在表一、二裡所示乾燥速度率在 8.6％/小時時並無影響，因水分高達40％，因此最初能以高溫，高風速乾燥10分鐘左右，再以50°C溫度繼續乾燥之。

② 表三、四乾燥速率在1.2與2.7％/小時之間並無甚大之分別，因之可在此範圍內，加以乾

燥可省時，省燃料，直接提高熱效率。

六、熱　效　率：

熱效率是衡量一部乾燥機在純水分乾燥方面優劣的方法，由熱效率可看出如何來改良熱風乾燥機，但一部乾燥機的性能，除了熱效率之外仍有許多因素與它發生直接間接之影響。

下列爲乾燥機各項試驗之熱效率計算：

表一，所除去之水分量爲 $616\times(0.418-0.18)=146.5$公斤

146.5公斤之水由氣溫 15°C 化成 50°C 之蒸氣需熱

146.5公斤$(50-15)+146.5\times568.92=83.300$卡……(1)

(50°C時水之汽化熱爲568.92卡/公斤，水的比熱爲 1)

燃料焦炭共消耗20.2公斤，每公斤熱量爲7,500卡。

所產生之熱量共爲 $20.2\times7,500=151,500$ 卡……(2)

故熱效率爲：$\frac{83,300}{151,500}=55\%$。

表二　所蒸發之水量爲$21.5\%\times480=96$公斤

所需之蒸發熱爲$66\times[30.5+598.92]=57,500$卡

焦炭所產生之熱量爲$18.45\times7,500=138,500$卡

熱效率爲$\frac{57,500}{138,500}=41.5\%$。

表三　所蒸發水量爲$8.1\%\times800=64.8$公斤

蒸發熱需量 $64.8(30+568.92)=38,300$卡

焦炭所產生之熱能量爲：$10.2\times7,500=73,500$卡，

熱效率$=\frac{38,300}{73,500}=52.1\%$。

表四　水份蒸發量$8.8\%\times980=81.3$公斤

水份蒸發需熱$81.3[30+568.02]=48,700$卡

焦炭所生之熱$34.2\times7,500=256,500$卡

熱效率$\frac{48,790}{256,500}=19\%$。

表五　水份蒸發量爲$7.9\%\times1024=81$公斤

水份蒸發需熱爲$81[30+568.92]=48,600$卡

焦炭所產生之熱爲$45\times7,500=337,50$卡

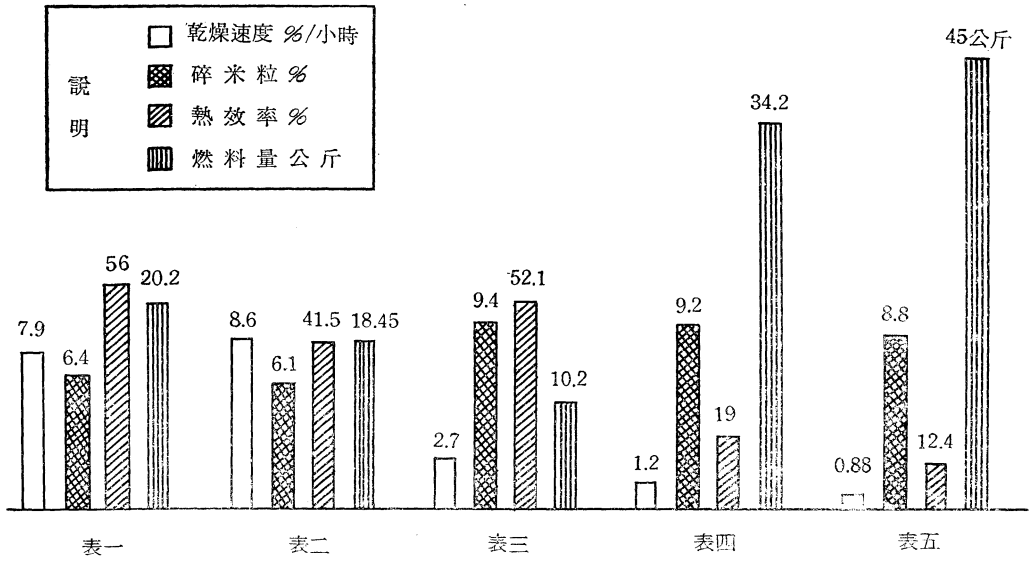
熱效率$\frac{48,600}{337,500}=12.4\%$。

(1)　由上表一、二我們可看出水分率在 40 %之穀層施以 8.6 %/小時之乾燥速度，溫度維持在 50°C 其所造成之結果是省時，且能提高熱效率。

(2)　表三、四、五的乾燥情形以表三最經濟，但碎米粒則較多其省時、省燃料實爲最佳處，因風量風速與溫度控制得當的結果，促使熱效率大爲增加。

(3)　熱效率在搶救性乾燥中並不是一很重要的困子，前述它在整個稻穀乾燥過程中指示出乾燥機在水份率與燃料量之關係，在純理論方面是一最基本的研究要項，但在搶救性乾燥中，時間與乾燥速度才成爲工作重點。

(4)　由熱效率高者可看出各項因子配合的情況較佳。



七、結　　論

(1) 要從熱效率的觀點來衡量這部乾燥機，在以上幾個試驗裡，我們是無法作詳盡的分析研討，但我們所知道的是一個良好的乾燥工作中是要能把各種影響因子適當的加以運用，而良好的運用就能提高熱效率。因此我們所能運用熱效率的是來衡量我們實施乾燥工作的優劣。在此我們是以熱效率來印證前面整個乾燥的工作過程，來判斷各項因子的控制與運用之是否得當。

(2) 再就從水分率的變動情形來看，在對穀層厚度與乾燥速度問題間應能有一適當的規則。一般穀層水分率的變動有如下圖。

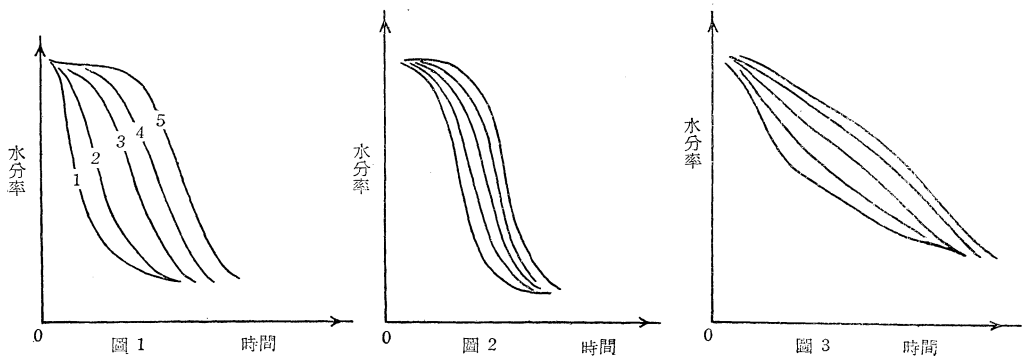


圖 1 在理論上若能隨時施予攪拌均勻，即能得如圖 2，上下層的水分率相差愈小對於我們急速乾燥愈有利；但如圖 3 則乾燥速度慢，其害處爲降低熱效率。由此，要能提高熱效率則有如下列二法則。

法則一，試從圖 1 由下而上，由內而外分成五層，其第一層之乾燥情形是爲最理想。試想若能隨時將第一層換下，再由上層進補而由第 5 層上面另外加添新穀，繼續乾燥時，那麼水分率變動曲線，只要能控制第一層，即可。這時我們可隨意調節或變動其他乾燥因子，而把穀層水分率變動、或差距等問題略去。此爲一理想之法則。

法則二，如圖 2，上下穀層水分率曲線差距逐漸減小，若能使此差距消失則必能達到乾燥理想。在

這裡我們可以以隨時不斷攪拌的方法求得之。但是不斷的攪拌所費人工太大，反而不經濟。因此我們必須自動攪拌方面着手，並要求精簡方便合乎經濟，始能收效。

以上二法則乃由以上各節的討論所演譯者。由於目前本省乾燥機工作情形通常以空氣乾燥固定穀層稻穀，因此不管燃燒部份如何改進，其水分率變化曲率所顯現的各種問仍然無法解決。如能打破此守舊形式則乾燥機的性能必然可改進，乾燥效率也可提高。

八、摘　　要：

(1) 穀層愈厚，上下層水分率差距愈大，乾燥時間較長。

(2) 水分率高且穀層厚時，常實施攪拌較爲有利，可提高乾燥效率。

(3) 水分率高達40%，而穀層厚度在17公分以上時，風速若保持0.86立方公尺/秒，則乾燥速率可高達8.6%/小時，而影響不大且提高熱效率。但必須限於搶救性乾燥時。

(4) 搶救性安全乾燥熱效率較高，而儲存性乾燥則一般較低。（碎米率不變的情形下）

(5) 熱效率可做爲衡量乾燥工作優劣之參考。

(6) 目前乾燥機應走向能控制水份率變化曲線的新途徑。

九、誌　　謝

本試驗承中農，高坂教授之指導及農試所農機系同仁之協助，另有臺北改良場提供之試驗資料，於此一併誌謝。

十、參 考 文 獻

1. Thermodynamics by George A. Hawkins
2. 農業機械實驗便覽，東京大學農業工學教室
3. 農廳一中農高坂式穀類乾燥機示範報告臺北區農業改良場

TESTING OF THE EFFICIENCY OF THE CURRENT GRAIN DRYER IN TAIWAN

by

C. H. LIN & C. P. WU

SUMMARY

1. The deeper the grain layer, the more the drying time needs and the more moisture contain difference between the top and the bottom of the grain layer.
2. As the moisture contain is high and the layer deep, it is better to mixture the grain layer occasionally to get the higher drying efficiency.
3. For a 40% high moisture contain of a more than 17cm. deep layer, and the air velocity maintain at 0.86 m/sec, it is still safe to operate in the drying speed of 8.6% per hour,
4. Rapid drying has higher heat efficiency than storage drying.
5. Whether it is good or not in the operation of drying can be checked by the heat efficiency.
6. A new dryer must be designed in such a new way as can control the change of the moisture contain in the drying.

文 獻 介 紹

ABSTRACTS OF LITERATURE

一、水稻在生育各期所同化之 ^{14}C 對穀實之運移〔大島正男 (1966) 日本土壤肥料雜誌 37(12):589～593〕

爲究明穀粒形成之動態用盆栽法自最高分蘖期每隔10日使水稻同化 $^{14}CO_2$ 以檢討 ^{14}C 對種子之運移及分布狀況，其方法則，一叢水稻中選取主桿一枝，將上位4張葉及莖部用玻璃管 (6×70^{cm}) 套上，兩端以橡皮塞塞住，管內懸掛之小燒杯中放含有 40μc $^{14}CO_2$ 的 IN NaOH 溶液 8月13日以後各次試驗均含 20μc，自上端橡皮塞注入10%過氯素酸使發生 $^{14}CO_2$，同化時間均在晴天上午11～12時，同化試料枝數出穗前各期5枝出穗後各三枝，結果而言各時期所同化之 ^{14}C 均能見於糙米粒中，而其分佈情形是出穗期前同化者不分穗之上下部位，以至粒子內乃均勻分布。出穗期至乳熟期同化者於上位粒爲多，其後漸移於下位粒。糊熟期者多集中於糙米粒子邊緣部位，^{14}C 對谷粒轉移率愈接近乳熟期愈多。就構成種實成分中之 ^{14}C 比放射能而言出穗期前同化者蛋白質多於澱粉，以後則相反。於最高分蘖期經同化蓄存於出穗期莖葉中蛋白質碳素，變爲種實蛋白之轉移率約有20%。同時間莖葉澱粉中之碳素變爲種實之轉移率高達90%。此事實指出，構成種實蛋白之胺基酸中大部分碳素係非出穗前蓄存於莖葉中胺基酸之碳素而係出穗後經光合成之碳素所製成之新胺基酸，種實澱粉之碳素係大部分爲出穗後光合成者，而一部分是出穗前蓄存於莖葉中澱粉之碳素轉移種實者。（吳啓東）

二、二氧化碳對薔薇生育之效應〔Lindstrom, R. S. (1965) Proc. Amer. Soc. Hort. Sci. 87:521～524〕

以薔薇 (Rosa hybrida, 品種 Better Times) 的自根苗種於兩座相同的溫室內，並將兩室內之 CO_2 含量調節成不同的濃度，即一爲高濃度者，含 CO_2 1200～2000ppm，另一爲低濃度者，只含 120～375ppm。然後觀察記錄此些薔薇之生長及產量情形；發現含 CO_2 濃度高者，其植株比低濃度者高大，生長勢亦較强，又生長於 CO_2 濃度高之溫室中者，普通產生粗壯的長花莖，且其開花數亦有顯著的增加，3個月內，生長於高濃度中者，每株平均開8朶花，而低濃度者只有5朶花。本試驗於北美洲大湖區之低光照（9～11小時）下進行，由高濃度溫室中植株生長情形得知，低光照並非限制生長之唯一因子，同時又得知，於低光照之下，其在低濃度之 CO_2 中生長者，很接近所謂之最低閾值的情形。（楊騰雄）

三、奇菌靈對薔薇開花技條之效應〔Mastalerz, J. W. (1965) Proc. Amer. Hort. Sci. 87:525～530〕

薔薇之切花在市場上之分級標準爲依據其花莖長度，花的大小，形狀及顏色，和葉片之情況等條件，其花莖愈長者價值愈高。本論文爲依據GA能延長細胞之長度之理論而探討其對花莖長度及品質所產生的影響。

以 10ppm, 50ppm, 及 100ppm 等三種不同濃度之GA鉀鹽水溶液，以不同之處理次數分別處理（噴霧）長度在3/4～1 in 的幼芽頂端，結果(1)用 10ppm 及 100ppm 只處理一次者，切花之鮮重及花莖長度均有顯著的增加，50ppm 者增加不顯著，但其鮮重與長度之比 (g/inch) 均大於 1.0，故均屬上品，經過一週後再處理一次者，各處理皆有顯著之增加，其中花蕾以下，葉片以上之無葉片之花梗部分之延長特別顯著，花梗以下之各節間亦比CK之長度有增加，唯各處理之間之差異不顯著，外面之花瓣常成萼片化 (Sepaloid)，老葉仍保有幼葉之微紅色，故其切花品質極劣。(2)以 10ppm 及 100ppm 每天處理一次共七次，隔天處理一次共四次及一週一次共四次等各處理，其花梗部分亦顯著延長，切花品質大

受影響。(3)以 50ppm 只處理一次或同第二法，發現只處理一次者，其變化只限於花梗部分之延長，連續處理數次者，花梗以下之花莖均有延長，但其鮮重與莖長比小於 1.0，且亦產生花瓣蕊片化之情形，因而減低切花價值。總之 GA 可以增加花梗及花莖之長度，但處理次數超過二次者，鮮重與莖長之比小於 1.0，花瓣蕊片化及老葉含有幼葉之顏色，以致減少切花之價值，唯有以 50ppm 或 100ppm 只處理一次者，對花莖之延長尚有一些經濟價值可言。（楊騰雄）

四、菇類之生化學研究（a有機酸代謝）〔橋本一哉等三人 (1966) 日本菌學會會報 7(1):20～24〕

有關菇類栽培法之參考文獻已發表者頗多，但關於其生理現象之生化資料却甚爲缺少，本文以液體培養之方法使用洋菇香菇及稈菇之三種食用菇之菌絲爲材料，測定其產生子實體時期之有機酸代謝情形，其結果如下：

1. 洋菇及稈菇之菌絲體量，在培養後20天達到最高重量，並由於有機酸的積蓄，培養液中的 *p*H一度下降，但因爲培養日數的進展菌絲就自己消化，液中之 *p*H 亦再度昇高，香菇菌絲體在培養後30天仍未達到最高，菌絲無自己消化現象，故 *p*H 無變動。

2. 在培養期間菇類菌絲所產生之有機酸均爲醋酸、蟻酸、琥珀酸、蓚酸及乙二醇酸。

3. 三種菇類中香菇之蓚酸分泌最旺盛。

4. 洋菇之蓚酸分泌雖然不多，但添加 $CaCO_3$ 時培養液中就含有多量之蓚酸。

5. 用稈菇爲材料測定其對蓚酸之分解能力結果，遊離型蓚酸比鹽類型之蓚酸有兩倍之分解能力。本文中有關圖片九個附英文摘要。（杜自疆）

五、草菇栽培觀察 〔Shin-Ling Chung & Robert Snetsinger (1966) Muchroom news 14(11):1～11〕

美國賓州大學昆蟲系近年來爲了菇蠅類研究上之需要，開始採用能適應較高溫度發生子實體的草菇。在此種試驗進行途中發現幾種有趣的問題，本文中報告使用中國式之老方法栽種草菇時，每 100 公斤稻草中只能收穫 10kg 之草菇，其產量約乾稻草之 10%，但在賓州大學溫室中之試驗結果每 100kg 乾稻草常常產到 50kg 到 120kg 之草菇，此記錄並不是奇蹟在該大學之最高產量曾經達到每 100kg乾稻草產到 220kg 之多。

著者認爲此成績在1956年間有多數之草菇文獻中大多數是根據中國之方法，如波蘭或菲州國家，但本方法係在玻璃室之條件下尤其控制溫度在 85°F (30°C) 並使用商業性之堆肥所培養出來之成績，本方法可能適合於美國式之大規模培養，但要普及到小菇農，目前尚屬困難。（杜自疆）

六、植物成熟度溫度與土粒濕度對 Grain Sorghum 的莖褐腐病之關係〔L.K. Edmunds (1964) Phytopathology 54(5):514～517〕

Grain Sorgum 植物對所有的環境中其成熟的範圍是 35° 到 40 度攝氏的土壤溫度，40 度日照氣溫與25及 80 % 的土壤濕度 (ASM)。在成熟 4 到 7 天前以穿刺接種器接種 Macrophomina phaseoli (Maubli) Ashby。結果在土壤濕度 80% (ASM) 以上者無感染，在 25% ASM 的植物接種 14～28 天開花者於 5～7 天或 3～5 天接種後土壤溫度是 35 度和 40°C，幾乎完全死去。在開花後少於13天的任何土壤溫度下接種沒有令人滿意的Stalk rot 發現，Rot的發展在莖內較快而漸向上發展，溫度在 40°C 優於 35°C。在各主幹中黑腐在節以上比較明顯，黑腐的終止與菌核快速的發生是由於帶有 M. phaseoli 的死株在多水份狀況下產生。

Threat of charcoal rot [Macrophomina phaseoli (Maubl) Ashby] 生長在 grain Sorghum 上只在局部地區發生，人工接種不易，只 Hsi, C.H. 1961 利用帶菌的 Soil 及Young, H.C. 1943，利用 toothpick method 可以得到 90%的成功率。

本試驗分離病株而得，M. phaseoli，引用 round toothpicks method，分三方面進行，第一求得植物 Rs610 的成熟度及感病率在 25% ASM 濕度下之關係。結果是80% 濕度以上無感染，35°C 單位時間的土壤溫度

褐腐病在開花 15～28天的植株上發生。但 40 °C 病菌發育於開花 13～32天的植株。

第二方面試驗 Rs610 在 25% ASM 之死亡率。在 35°C 大部份數目的植株接種後 5～7 天死亡。 40°C 多數在 3～5天死亡只有一株活 9 天 (35°C)，2 株活 7 天 (40°C)。

第三方面試驗在個別植株中 rot 的發展亦與兩土壤溫度有關， 35°C 褐腐發生幾乎均在第四、第五節以上，但在 40°C 黑腐極少發展至第三或第四節。

討論——典型的褐腐病在種苗繁殖溫室中得到，所以在田間該病的發現溫室爲病源地。故總感病數與總逃避感染數決定於適合於病菌的溫度環境，若適合的環境少則可逃避感染。田間無病栽植只是典型的無病處理而非奇跡。紅色或黑色的濕腐發生只須 24～48hr.即產生菌核，而褐腐被忽略亦不爲病原。因此之故觀念上 M. phaseoli 只是第二次寄生菌生存於濕度高的殘莖中。在目前的試驗結果知道主要的菌核形成時期在當植物死亡或稍後即發生。在田間菌核生長在不完全有褐腐的植株上，隱性的感染在冠上亦發生。死株產生菌核後營養菌絲收縮，在荒蕪地方久旱或延遲收割均爲該病發生的地方。

35°C 與 40°C 的單位時間土壤溫度，可提供病原菌的生長性能與植物的感性結果，利用不適環境以減少病菌發生。（張曉麟）

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