PN-AAP-035

White Potato Production in Taiwan: A Farm Survey

TECHNICAL BULLETIN #10 (78-81), SEPTEMBER, 1978

ASIAN VEGETABLE RESEARCH & DEVELOPMENT CENTER

White Potato Production in Taiwan
a Farm Survey

by

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About this report

Data in this report are presented in metric units. Monetary values have been converted to U.S. dollars at the current (May, 1978) exchange rate.

A double asterisk (**) means significant at the 1% level; a single asterisk (*) means significant at the 5% level; and a cross (†) means significant at the 10% level.

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Correct citation: Calkins, P.H., and Su-hua Tu 1978. White potato production in Taiwan: A farm survey. AVRDC Tech. Bull. #10 (78-87). Shanhua, Taiwan, Republic of China.

Published by the Office of Information Services

at AVRDC, Sep 1978

Introduction

The white or Irish potato (*Solanum tuberosum*) is a cool-weather crop. Its cultivation has traditionally been confined to either the temperature zone or the cool season in the subtropics and highland tropics. Yet, as Table 1 shows, white potato is the highest producer of food energy per ha per day of any crop and the fourth highest producer of protein.

If heat tolerant varieties and appropriate cultural management practices can be developed, cultivation of this high food-value crop may be extended to the lowland tropics and the warm season in the subtropics. This would not only allow greater food production in the subsistence regions of the world, but would also expand the range of profitable crops from which farmers in the tropics could choose.

To meet this need, scientists at the Asian Vegetable Research and Development Center are working to develop cultivars with high levels of heat-tolerance and disease resistance. They also are developing improved cultural practices for the hot conditions into which the new varieties will be introduced. To measure and identify which improvements can be made and where, it is important to understand the present state of potato production in the subtropics and tropics. The present study aims to investigate the current productivity and profitability of white potato production in Taiwan, one area where the introduction of heat-tolerant varieties of potato could have a great impact on both producers and consumers.

Table 1. Rank of main crops by calorie and protein production.[a]

	Calorie		Protein	
	Per unit area	Per unit area/day	Per unit area	Per unit area/day
1	Sugarcane	White potato	Soybean	Soybean
2	White potato	Corn	White potato	Beans
3	Sugarbeets	Sugarcane	Corn	Peas
4	Corn	Rice	Peanut	White potato
5	Rice	Sugarbeets	Sorghum	Corn
6	Sorghum	Sorghum	Peas	Sorghum
7	Sweet potato	Barley	Beans	Peanuts
8	Barley	Sweet potato	Rice	Spring wheat
9	Peanut	Beans	Barley	Barley
10	Winter wheat	Soybean	Winter wheat	Rice

[a]Ref. 7.

Current Production Patterns in Taiwan

At present, more than 80% of area planted to potato in Taiwan is concentrated in Taichung District (Fig. 1) during the cool season between harvest of monsoon crops and planting of spring crops the following year. Potato is a major catch crop in Taichung because the weather is dry in

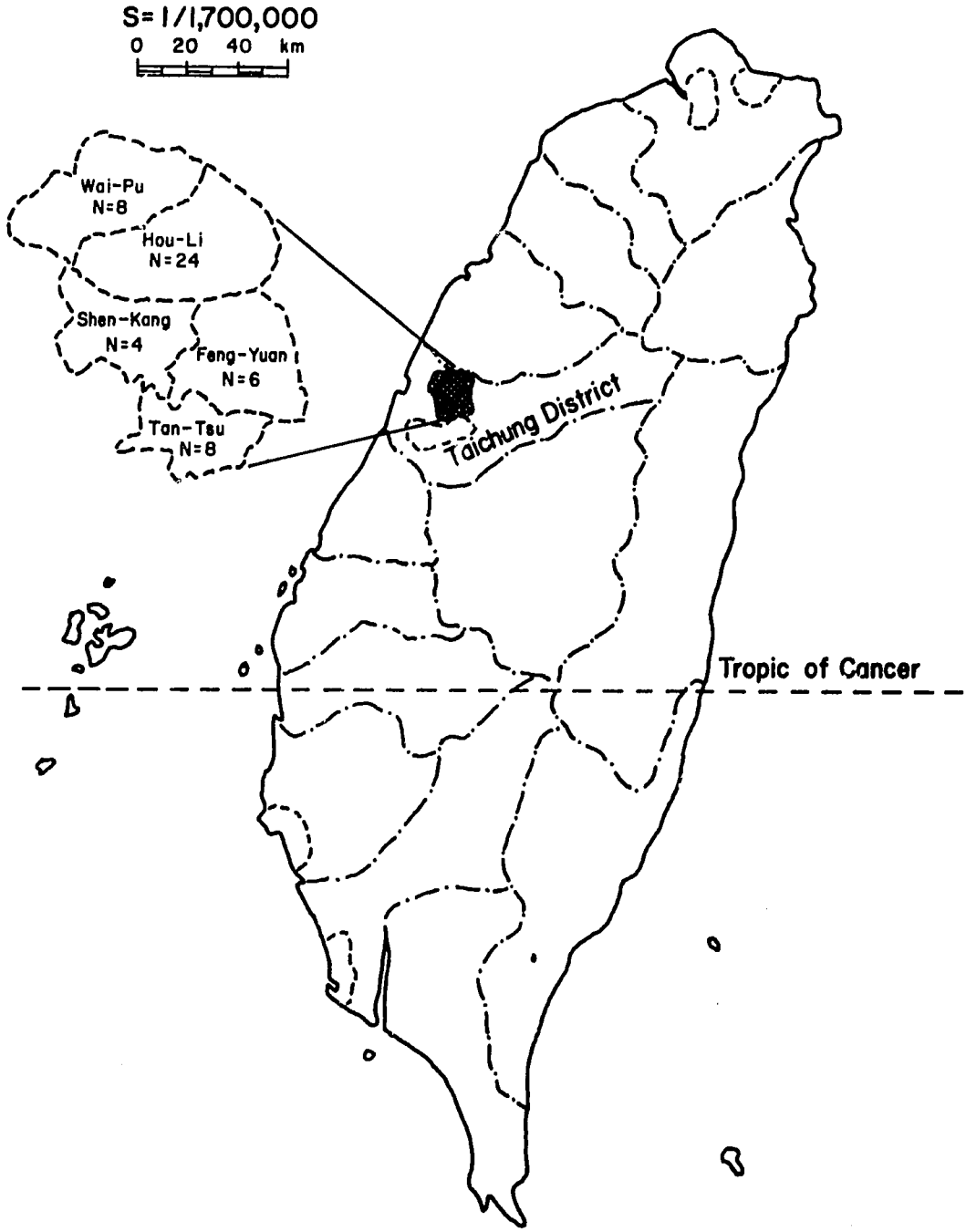

Fig. 1. Sample distribution of interviewed potato farmers in Taiwan. Total N=50

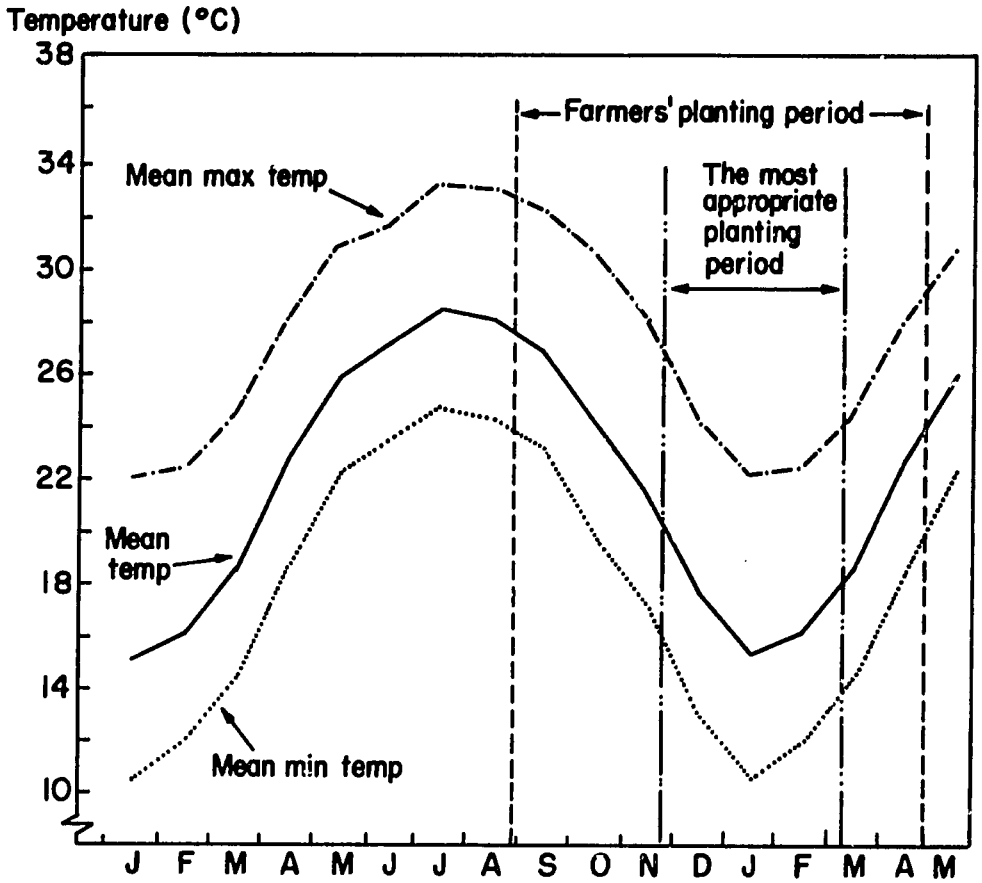

Fig. 2. Annual temperature patterns in Taichung district

SOURCE: Summary report of meteorological data in Taiwan vol. III, 1961-1970.

winter and early spring. In addition to short daylength, high light intensity and cool temperature, low rainfall restricts the growth of stems and leaves and allows for tuber enlargement. The optimal temperature for stem and leaf growth in potato is 18-20°C, while that for tuber enlargement is 15-18°C (1). Fig. 2. shows that the most appropriate planting period for white potato in central Taiwan is from late November to early March. However, because of differences in cropping patterns, farmers are able to plant as early as mid August and harvest in late April. Potato has a short enough growing period that it may be grown twice during this period. Even by planting at less than optimal times, cool season white potato production can allow farmers to fully use their land and farm labor in the slack season to increase farm income.

Fig. 3 shows that the rainfall pattern in the period of optimal temperature is low and reaches a peak in the middle of March. Even at this time however, rainfall is only 92.4 mm per month. Fog and frost reach an annual peak during this period. These conditions can lead to high incidence of late blight if a large population of susceptible host plants exists and the causal organism is present.

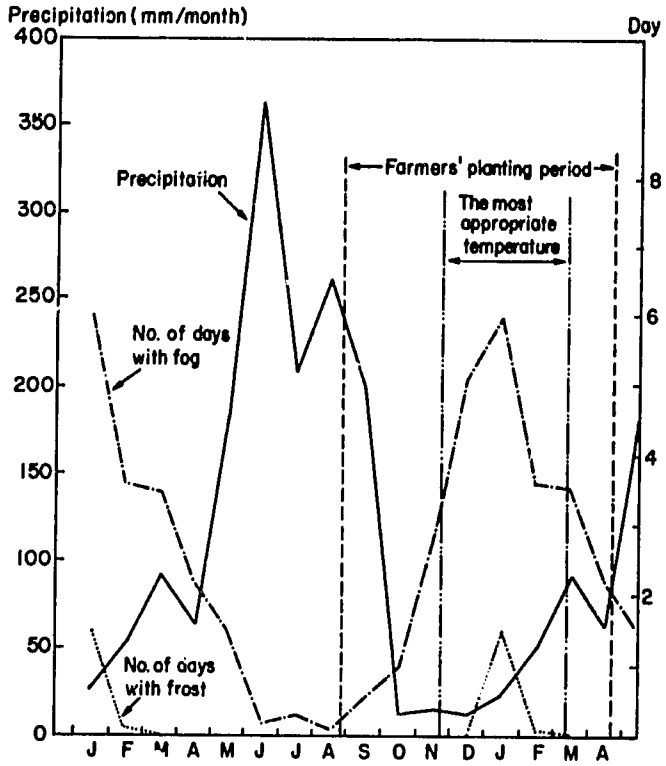

Fig. 3. Annual precipitation patterns in Taichung district.

SOURCE: Summary report of meteorological data in Taiwan vol. III 1961-1970

Trends in Production and Consumption

From 1968 to 1976 the area planted to potato increased from 2,000 to 4,000 ha (Table 2). Still, this area is much less than for other vegetables (Table 3). The potato production per capita for Taiwan remained fairly stable through 1974. After that time increases in production far outstripped the rate of population growth (Fig. 4). Thus,

Table 2. Trends in potato planted area by district, 1967-76.[a]

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	% of total 1976
Taiwan province total	1847	1988	2323	2408	2912	2296	2179	2328	3638	3962	100.0
Miaoli prefecture	27	31	33	8	48	37	41	60	243	238	6.0
Taichung prefecture	1753	1877	2226	2361	2772	2112	2020	2064	3097	3248	82.0
Changhua prefecture	-	-	-	-	-	-	-	-	-	51	1.3
Nantou prefecture	22	32	29	-	27	28	26	85	105	92	2.3
Yunlin prefecture	0	0	2	2	1	-	1	1	3	90	2.3
Chiayi prefecture	-	-	-	-	-	-	-	-	6	67	1.7
Pingtung prefecture	-	-	-	-	-	-	-	-	2	48	1.2
Taichung City	31	36	19	25	50	98	86	115	180	102	2.5
Others	14	12	14	12	14	21	15	3	2	27	0.7

[a]Ref. 6.

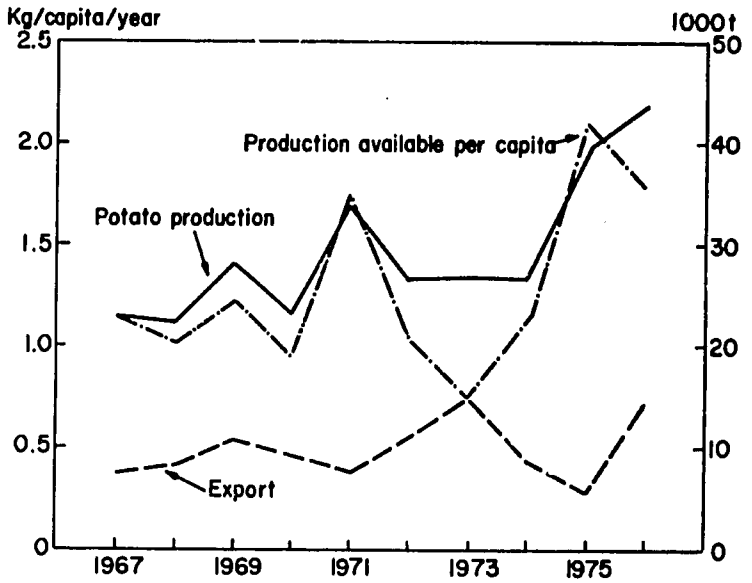

Fig. 4. Potato production, production available per capita, and export in Taiwan; AVRDC, 1978.[a]

[a]Refs (4), (6)

production available per capita increased steadily except when influenced by variations in export volume.

In the period 1968-1974, supply was low because:

1. It was difficult to get good seed potatoes, and farmer-retained seed degenerated rapidly. Nor could seeds from the Farmers' Associations be relied upon because they once were infected with virus. Seed importation from Japan was entirely prohibited after the golden nematode was discovered in Hokkaido.

2. The export market was very narrow and stable (Table 4).

Table 5. Planted area of main vegetable crops in Taiwan, 1976.[a]

Crop	Planted area	Individual crop/total vegetable planted area
	1000 ha	%
Bamboo shoot	18.5	9.6
Asparagus	13.0	6.8
Cabbage	11.0	5.7
Radish	10.5	5.5
Head cabbage	8.4	4.4
Tomato	8.1	4.2
Chinese cabbage	7.4	3.9
Pea	5.4	2.8
Cauliflower	4.7	2.5
Potato	4.0	2.1

[a]Ref. 6.

Table 4. Destination and amount of potato exported from Taiwan.[a]

Nation	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	C.V.
	t										%
Singapore	1303	1743	3757	1205	3211	4629	8004	4944	3664	8927	64
Hong Kong	3384	3349	4319	4666	3973	5052	6689	3118	2114	4364	30
Malaysia	40	45	239	524	387	722	389	360	136	188	72
Other countries[b]	2612	3092	2183	3062	248	288	11	-	0	124	119
Total	7765	8229	10498	9457	7819	10691	15093	8422	5914	14168	30

[a]Ref. 4. [b]Other countries include: the Ryukyus, Japan, Thailand, Oman, Indonesia, United Arab Emirates.

3. Farmers lacked good cultivation techniques and their potatoes were threatened with late blight infection. Demand was also low because the inhabitants of Taiwan accepted potato as a vegetable only gradually, and as a staple food, not at all. Since there are many substitute vegetables in Taiwan, few people desired to eat potato. Consumption followed production closely because total export volume was fairly stable.

In 1975-76, however, a government extension effort encouraged both greater production and consumption of the crop. Such efforts emphasized that while the price of potato was not high, it was very stable (Table 5). The government is as yet unwilling to establish a guaranteed price for potato, but is hoping to capitalize on its high yield potential with technology to maintain or lower costs. Researchers in plant breeding, plant pathology, crop management, and other areas at AVRDC seek to discover how this may be accomplished.

Table 5. The level and variability of monthly farm prices of main vegetable crops in Taiwan, 1976.[a]

Month	Celery	Cauliflower	Head cabbage	Cabbage	Onion	Chinese cabbage	Cucumber	Radish	Potato
	US$/t								
Jan	56	103	87	20	134	51	88	48	134
Feb	88	203	99	36	107	78	156	63	114
Mar	85	98	86	38	67	66	191	55	82
Apr	104	144	148	31	41	75	134	59	89
May	168	153	102	41	45	88	81	94	91
Jun	355	388	421	237	117	228	213	204	128
Jul	451	338	384	301	146	206	227	203	143
Aug	585	413	392	391	215	339	362	221	177
Sep	533	544	254	252	264	87	157	167	143
Oct	371	392	185	149	319	112	95	95	165
Nov	156	71	60	49	316	54	98	44	179
Dec	106	42	44	21	86	60	114	30	196
Mean	255	241	189	131	155	120	160	107	137
C.V. (%)	75	69	74	100	65	75	51	66	28

[a]Ref. 3.

Objectives and Hypotheses of the Survey

In our study, we sought to:

1. Determine the present yield and profitability of white potato.

2. Understand why farmers plant potatoes even with current low prices.

3. Compute a rational price level that would stimulate farmers to increase their potato cultivated area.

4. Determine the extent of blight incidence and resulting yield loss.

5. Explore the effect of planting date on yield and price.

6. Determine an appropriate level of production technology to maximize profits.

7. Suggest how planted area in Taiwan could be increased to meet consumer demand.

At the same time we set out the following hypotheses for testing:

1. Soil type, season and cultivar all significantly influence yield.

2. Producers of seed potato have greater production costs than producers of edible potato.

3. Small-scale potato plantings involve higher production costs and net returns.

4. The order of field preparation and plowing significantly influences yields and profit.

5. The more pesticide, fertilizer, and total pre-harvest capital inputs farmers apply, the higher their yields and returns.

6. Farmers consider disease the most serious production problem.

7. Most farmers grow white potato because they lack alternatives.

Sampling Procedure

Since more than 80% of the area planted to potato in Taiwan is in Taichung district, we decided to choose farmers only from this area. The Feng-yuan Farmers' Association provided us with a list of areas planted to potatoes in the neighboring townships. We chose five with the largest planted areas, Hou-li, Wai-p'u, T'an-tzu, Feng-yuan, and Shen-kang, in that order (Fig. 1). We allocated a total of 50 sample households on the basis of proportionate planted area in each township. Households were chosen randomly from the list of potato growers in each township.

Table 6 shows the distribution of the potato farmers surveyed. Three households were discovered to produce potatoes exclusively for seed, and we analyzed them separately.

Table 6. Potato farmer survey distribution, 1977; AVRDC, 1978.

Township	Seed potato	Table potato	Total
	----------	farmers	----------
Hou-li	0	24	24
Wai-p'u	0	8	8
T'an-tzu	0	8	8
Feng-yuan	3	3	6
Shen-kang	0	4	4
Total	3	47	50

Results and Discussion

The Influence of Soil Type on Yield by Season

Some farmers in the sample planted as early as the end of August and some harvested as late as the end of April. In order to determine the influence of season on yield and profitability, we divided the 50 farms into three seasons by planting date: early (Aug 15-Nov 1), Middle (Nov 2-Dec 9) and late (after Dec 9). Table 7 shows that most farmers planted in the middle season.

Although potato can be grown on almost any soil type, the most suitable is a deep, well-drained loam or sandy loam. Poorly-drained soils are unsuitable because they lack sufficient aeration for rapid tuber enlargement. Of the 3 soil types planted to potato by the Taichung farmers in our sample, a full 66% planted on sandy loam (Table 7). Table 8 shows that sandy loam yielded the highest output per ha on average, and that all farmers producing seed potatoes chose sandy loam

Table 7. Sample distribution by soil and season, 1977; AVRDC, 1978.

Soil \ Season	Table potato			Seed potato		Total
	Early	Middle	Late	Middle	Late	
	farmers					
Sand	5	5	4	0	0	14
Sandy loam	6	17	7	1	2	33
Loam	2	1	0	0	0	3
Total	13	23	11	1	2	50

Table 8. The influence of soil type on yield[a] by season, 1977; AVRDC, 1978.

Soil \ Season	Table potato			Seed potato		Mean
	Early	Middle	Late	Middle	Late	
	t/ha					
Sand	(216) 14.5	(191) 18.7	(205) 16.2	-	-	(204) 16.5
Sandy loam	(232) 19.0	(162) 17.3	(191) 15.8	(314) 24.2	(209) 16.1	(188) 17.4
Loam	(212) 15.8	(131) 13.0	-	-	-	(185) 14.9
Average	(223) 16.8	(167) 17.4	(196) 16.0	(314) 24.2	(209) 16.1	(192) 17.0

[a]Figures in parentheses are kg/ha/day.

Table 9. Potato production cost by season, 1977; AVRDC, 1978.

Cost \ Season	Table potato						Seed potato	
	Early		Middle		Late			
	US$	%	US$	%	US$	%	US$	%
Land preparation labor	86	5.2	88	5.9	89	5.9	132	7.1
Irrigation labor	76	4.6	46	3.1	68	4.5	63	3.3
Pesticide labor	112	6.8	116	7.8	83	5.4	157	8.4
Fertilizer labor	83	5.1	115	7.8	84	5.5	135	7.3
Other pre-harvest labor	290	17.7	267	18.1	242	16.0	279	15.0
Harvest labor	195	12.0	173	11.8	219	14.4	147	7.9
Total labor	841	51.4	805	54.5	785	51.7	912	49.0
Nitrogen	116	7.1	114	7.7	125	8.2	94	5.1
Phosphorus	70	4.3	55	3.8	72	4.7	68	3.7
Potassium	59	3.6	54	3.6	68	4.5	79	4.2
Total chemical fertilizer	245	15.0	223	15.1	265	17.4	241	13.0
Compost	173	10.6	126	8.5	165	10.9	132	7.1
Seedling	153	9.4	132	8.9	163	10.7	396	21.3
Pesticide	130	8.0	97	6.6	86	5.7	133	7.1
Other pre-harvest material	92	5.6	94	6.4	55	3.6	46	2.5
Total material	794	48.6	671	45.5	735	48.3	948	51.0
Total cost	1635	100.0	1477	100.0	1520	100.0	1860	100.0

soils. In the middle and late seasons, sandy soil yielded slightly higher, but this may well be the result of the limited differences between the three types of soil surveyed. In general, then, yields per ha were highest on sandy soils and during the middle season.

In terms of yield per ha per day, however, Table 8 shows that sandy soil and the early season gave the highest values because they allowed the potatoes to grow most rapidly.

One would expect that potatoes grown in the middle season would have higher yield, not only per ha but also per ha per day. This is because temperature and daylength are most favorable during the middle season. In a controlled experiment this would probably be the case; however, farmers in the middle season leave their potatoes in the field longer than in the other two seasons because of their cropping system. Unlike early season farmers, they in no hurry to harvest potatoes so that they may plant another potato crop; and unlike the growers of the late crop, they do not wait a month after the harvest of summer rice to plant potatoes before spring rice.

Production Costs and Net Returns by Cultivar and Season

Seed potato farmers invested more heavily in their crop than producers of edible potatoes (Table 9). This was in large part because of the strict regulations regarding blight and virus spreading aphids, which

meant that seed producers must use more fungicide and insecticide, and devoted more labor to applying them. They also must buy the best tubers for planting (more than 20% of their total costs). Land preparation and fertilizer investments also were higher, in expectation of higher yields and profits.

In the three seasons for table potato, production costs were highest in the early season and lowest in the middle. The major differences lay in levels of labor for irrigation and fertilization, and fertilizer and pesticide inputs. Farmers in the middle season invested less in these production factors because most other farmers planted in this season and they feared low price from excess supply. Indeed, as Table 10 shows, the middle season farmers incurred a negative net return per ha. Their motivation in planting potato as a winter catch crop was to achieve both better use of and higher return to their labor in the slack season. Thus, they were willing to use large quantities of non-cash family labor to earn positive farm incomes.

What is the effect of increasing levels of overall input on yield by season? The coefficient of correlation between pre-harvest cost and yield of table potato was non-significant for both the entire sample and for each season. That is, the current structure of pre-harvest costs is either inappropriate or the level too high to have significant effect on yields.

However, increases in yield have a positive impact on both net return and farm income. The relationship was significant at the 1% level both overall and in the middle season (Fig. 5), when an increase in yield of 1 t/ha increased net return by US$7.50. Similarly, Fig. 6 shows the relationship between yield and farm income, which was signi-

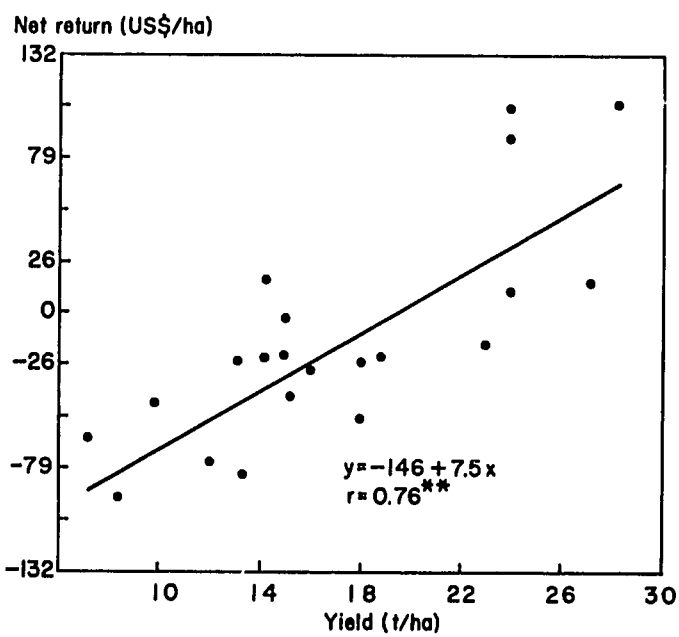

Fig. 5. The relationship between yield and net return of potato in the middle season, 1976/7; AVRDC, 1978.[a]

[a]Survey results, 1977.

Table 10. Production costs and returns by season and cultivar, 1977; AVRDC, 1978.

	Table potato									Seed potato
	Early			Middle			Late			
	Kennebec (n=9)	Wu-feng (n=3)	Average (n=12)	Wu-feng (n=16)	Norin #1 & Kennebec (n=8)	Average (n=24)	Kennebec (n=10)	Wu-feng (n=1)	Average (n=11)	Norin #1 (n=3)
Yield (t/ha)	16.0	20.4	17.1	19.3	13.8	17.5	16.0	16.2	16.0	18.8
Qualified potato ratio (%)	88	91	89	87	85	86	90	88	90	97
Price (US$/t)	106	72	96	74	98	80	100	70	97	163
Revenue (US$/ha)	1693	1476	1638	1427	1349	1401	1590	1132	1548	3053
Cash cost (US$/ha)	1037	698	952	782	967	844	870	815	855	1318
Non-cash cost (US$/ha)	628	848	683	707	484	633	641	793	654	542
Total cost (US$/ha)	1664	1546	1634	1489	1451	1477	1511	1608	1520	1860
Cash cost/ total cost (%)	62	45	58	53	67	57	58	51	57	71
Farm income[a] (US$/ha)	656	778	686	645	382	557	720	317	683	1735
Net return[b] (US$/ha)	28	-70	4	-63	-102	-76	79	-476	28	1193
Duration (days)	72.3	87.7	76.2	106.5	96.1	103.0	82.3	89.0	82.9	76.7
Yield/day (kg)	22.1	23.2	22.4	18.1	14.4	17.0	19.4	18.2	19.2	24.5
Farm income/day (US$)	9.06	8.88	9.01	6.06	3.98	5.41	8.75	3.56	8.23	22.62
Net return/day (US$)	0.40	-0.79	0.05	-0.58	-1.05	-0.74	0.96	-5.34	0.34	15.55

[a]Farm income = Total revenue - cash costs. [b]Net return = Farm income - non-cash costs.

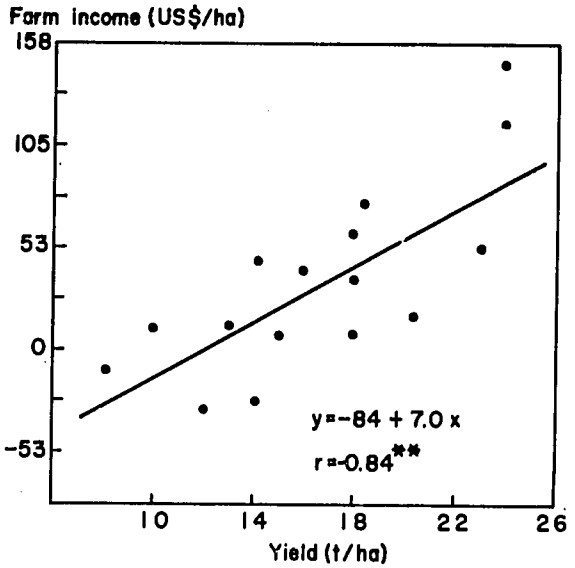

Fig. 6. The relationship between yield and farm income of potato in the middle season, 1976/7; AVRDC, 1978.[a]

[a]Survey results, 1977.

ficant at the 1% level both overall and in the middle season. An increase of 1 t/ha in that season increased farm income by US$7.00.

Partly because of the non-significant relationship between preharvest costs and yield, the correlation of total cost with net return or farm income was negative. That is, under current production technology, the more inputs applied the lower the return. Fig. 7 shows that for the middle season, as for the sample as a whole, the relationship between total cash and non-cash costs and net return was significant.

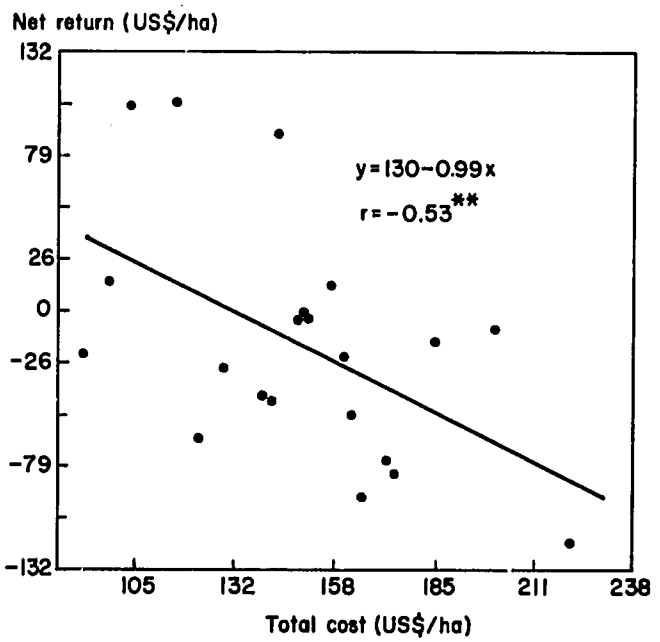

Fig. 7. The relationship between total (cash and non-cash) costs and net return of potato in middle season, 1976; AVRDC, 1978.[a]

[a]Survey results, 1977.

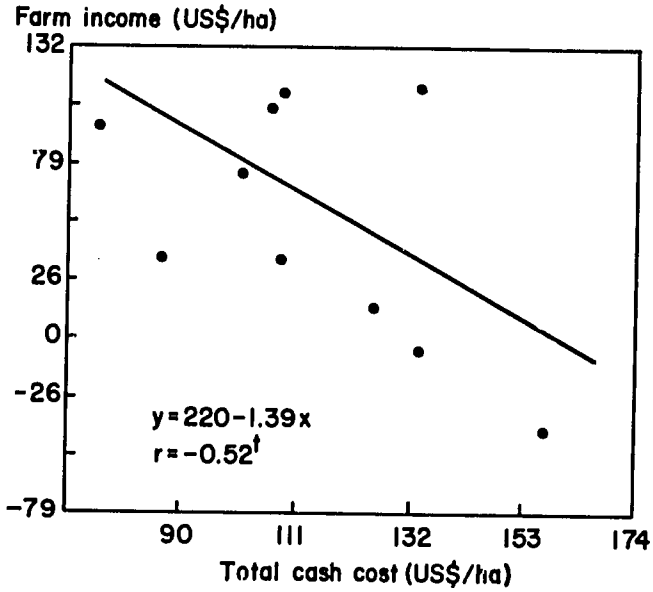

Fig. 8. The relationship between total cash costs and farm income of potato in the early season, 1976/7; AVRDC, 1978.[a]

[a]Survey results, 1977.

When total costs were reduced by $1/ha, net return increased by $0.99. Similarly, Fig. 8 shows that for the early season there was a negative relationship (significant at the 10% level) between total cash costs and farm income. In that season, an increase in total cash costs of $1 reduced farm income by $1.39. In the other two seasons and the sample as a whole, there was no significant relationship between total cash costs and farm income.

The preferred cultivar in the early and late seasons was 'Kennebec', and 'Wu-feng'[a] was preferred in the middle season. In the early season, Wu-feng had higher yield but lower price; indeed, its net profit was negative. If the quality and price of Wu-feng could be improved, it could be superior to 'K'o-nan' because of its high yield and short season.

In the middle season, Wu-feng still had the lowest price, but its significantly higher yields gave it the best net and farm income.

Therefore, we may accept hypothesis 1, that soil type, season, and cultivar all significantly influence yield.

Table 9 shows that we may also accept hypothesis 2: producers of seed potato had greater production costs than producers of table potato. All 3 seed potato farmers interviewed planted Norin #1, which, despite higher levels of input had good yields, high price, and hence high profit. In fact, farmers might plant more seed potato if they could, but the area is restricted through agreements between the Farmers' Associations and the farmers. Any seed potatoes not sanctioned by the Farmers' Associations cannot be certified and are therefore judged unreliable by potential buyers. The agreements contain the following provisions:

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[a]Hybrid offspring from Norin #1.

1. Other flowering crops such as maize may not be planted near the potato crop.

2. Farmers must let inspectors from the Hsinchu District Agricultural Improvement Station destroy any plantings infected by disease.

3. All harvests must be sold to the Farmers' Association at the contract price.

4. Farmers must accept the period limitation during which harvests will be accepted.

Production Costs and Returns by Scale of Planting and Seed Source

Farmers with small (less than 1.0 ha), medium (1.0-1.5 ha), and large (greater than 1.5 ha) areas planted to potatoes chose different production cost structures (Table 11). Medium plantings involved the lowest production costs. These farmers used less of their own labor and more hired labor because they preferred to earn income at higher wages off the farm. Farmers with small plantings did not pursue so much off-farm employment because of their small nuclear families, and those with large plantings were able to use all their family labor effectively on the farm.

Table 11. Per-hectare production costs by farm size of table potato, 1977; AVRDC, 1978.

Cost \ Farm size	Under 1.0 ha (n=32)		1.0-1.5 ha (n=12)		Above 1.5 ha (n=3)	
	US$	%	US$	%	US$	%
Land preparation labor	55	3.5	92	6.4	66	4.0
Irrigation labor	66	4.2	46	3.2	37	2.3
Other pre-harvest labor	532	34.3	423	29.2	493	30.1
Harvest labor	183	11.8	199	13.8	221	13.5
Total labor	835	53.8	760	52.6	818	49.9
Chemical fertilizer	237	15.3	249	17.2	261	16.0
Compost	149	9.6	116	8.0	204	12.5
Seedling	150	9.7	128	8.9	117	7.1
Pesticide	98	6.3	106	7.3	130	7.9
Other pre-harvest material	83	5.3	86	6.0	108	6.6
Total material	717	46.2	685	47.4	820	50.1
Total cost	1553	100.0	1445	100.0	1638	100.0
Non-cash labor	540	34.8	378	26.2	592	36.1

Table 12. Production costs and revenue by farm size and seed source on table potato, 1977; AVRDC, 1978.

	Under 1.0 ha			1-1.5 ha			Above 1.5 ha
	R[a] (n=8)	P[b] (n=24)	Average (n=32)	R (n=1)	P (n=11)	Average (n=12)	P (n=3)
Yield (t/ha)	17.0	16.5	16.6	21.0	17.3	17.6	16.7
Qualified ratio (%)	84	88	87	100	86	87	87
Price (US$/t)	71	93	87	69	86	84	87
Revenue (US$/ha)	1213	1529	1450	1449	1485	1482	1458
Cash cost (US$/ha)	573	912	827	1291	911	943	842
Non-cash cost (US$/ha)	882	669	723	377	513	502	769
Total cost (US$/ha)	1455	1582	1550	1668	1425	1445	1638
Cash cost/total cost (%)	39	58	53	77	64	65	51
Farm income (US$/ha)	640	61[illegible]	622	159	574	540	617
Net profit (US$/ha)	-242	-53	-100	-219	61	38	-180
Cash cost (US$/t)	34	55	53	62	52	54	50
Total cost (US$/t)	86	96	94	79	82	82	98

[a]Seed retained by farmer. [b]Seed purchased outside the farm.

As farm size increased, so did the capital/labor ratio in potato production technology. In particular, capital investments in chemical fertilizer and pesticide increased. Interestingly, use of seedlings per ha decreased, showing that the farmers with small holdings opted for higher plant density on their limited land.

When farmers supplied their own seed (Table 12) they achieved higher yield, but of lower quality. By contrast, seeds bought from the Farmers' Association brought a higher price[a] and better revenue. The ratio of qualified to unqualified tubers was similar by farm size in table potato, but the proportion was much higher for seed potato growers.

Because of their high use of hired labor, medium holders had the highest net returns but the lowest farm income. Therefore we must reject hypothesis 3, that small-scale potato plantings involve higher production costs and net returns. One farmer interviewed said that the break-even price for net return was about US$111/t and for farm income $87. These prices exceeded costs in all seasons.[b]

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[a]One would expect that, other things being equal, purchased certified seeds would have not just higher price but also higher yield than seed retained by the farmer. However, of the 9 farmers in our survey who reserved seed potato, 6 reserved Wu-feng, the highest-yielding cultivar, in order to get good production. Thus, the influence of differences by cultivar is also at work.

[b]It should be noted however, that fixed costs such as interest on equity, land rental, and equipment depreciation have not been included in these computations.

Production Costs and Returns by Order of Field Preparation

Farmers prepared and planted their land in 3 different ways:

1. bed formation, planting, basal fertilization

2. planting, basal fertilization, bed formation

3. basal fertilization, bed formation, planting

Eighty-two percent of the farmers interviewed adopted the first method, and only seed potato producers followed the second. Although most producers of table potato adopted method 1, Table 13 shows that method 3 yielded superior net profit and farm income for table potato. This is because fertilizing before planting makes the best use of fertilizer, resulting in higher quality and price. Therefore we may accept hypothesis 4, that the order of field preparation and planting significantly influences yields and profit. The reason why so many farmers still use the first method is that they are in the habit, from their production of other crops, of forming the bed first.

Seed potato production differs from that of table potato in that small size can save labor without affecting yield or quality, the growing plant does not have to be trimmed; the small potatoes do not have to be cut.

Table 13. Potato production costs and returns by order of field preparation and planting, 1976-77; AVRDC, 1978.

Item	1[a] (n=41)	2[b] (n=3)	3[c] (n=6)
Yield (t/ha)	442	495	462
Price (US$/t)	85	163	99
	----------US$/ha----------		
Revenue	1418	3053	1738
Land preparation labor	63	132	77
Other labor cost	762	780	698
Material cost	716	948	682
Total cost	1541	1860	1457
Net profit	-123	1193	281
Non-cash labor	522	411	366
Farm income	545	1735	779

[a]Bed formation, planting, basal fertilization. [b]Planting, basal fertilization, bed formation. [c]Basal fertilization, bed formation, planting.

Table 14. The influence of pesticide level on yield and return from potato, 1976-77; AVRDC, 1978.

	Pesticide used (US$/ha)			
	Table potato			Seed potato
Range	0-100	101-202	203-285	101-202
Mean	69 (n=30)	140 (n=14)	253 (n=3)	133 (n=3)
Yield (t/ha)	16.5	17.6	16.9	18.8
Price (US$/t)	84	91	87	163
	US$/ha			
Revenue	1392	1595	1481	3053
Pesticide labor	104	102	147	157
Other labor	676	779	722	755
Pesticide cost	69	140	253	133
Other material	619	592	585	814
Total cost	1471	1613	1707	1860
Net profit	-79	-18	-226	1192
Non-cash labor	502	532	358	411
Farm income	581	637	234	1735

The Influence of Pesticides on Yield and Net Return

Table 14 shows a wide range in the use of pesticides per ha of potato. We divided the sample into 3 management categories and found that the middle one had the best yield and profit. Not only did higher investment in pesticide and pesticide labor reduce net and farm income, but it also had no positive effect on yield. Regression analysis showed no significant relationship between the level of pesticide costs and yield for either the sample as a whole or for the sample in any season. It seems that potato farmers in Taiwan are using pesticides at levels too high to have any meaningful impact on yields. This is not to say that pesticides when properly used do not control diseases and insects, but that farmers are currently either using inappropriate levels and combinations of pesticides, or trying to control pests which have as yet no known control.

The Influence of Fertilizer on Yield and Net Return

Table 15 shows the surprising result that the more fertilizer used, the lower the yield. As fertilizer value increased, there was a substitution of inorganic for organic sources of nutrients and a progressive reduction in net profit and farm income. Regression analysis showed that there was a significant relationship (at the 10% level) between fertilizer costs and yield only in the late season (Fig. 9).
An increase in overall fertilizer costs of $1 increased yield by 7.6 kg/ha. In the other two seasons there was no significant relationship between fertilizer expenditures and the level of output per ha.

Table 15. The influence of fertilizer on yield and return of potato, 1976-77; AVRDC, 1978.

	Fertilizer used (kg/ha)			
	Table potato			Seed potato
Range	0-44 (n=6)	45-88 (n=31)	89-115 (n=10)	61-115 (n=3)
Yield (t/ha)	20.7	16.6	15.3	18.8
Price (US$/t)	77	89	84	163
	US$/ha			
Revenue	1600	1487	1285	3053
Fertilizer labor	79	105	95	135
Other labor	668	706	772	777
Nitrogen	66	112	163	96
Phosphorus	27	64	82	68
Potassium	22	56	85	78
Chemical fertilizer	115	231	330	241
Compost	180	142	128	131
Total fertilizer	295	374	458	372
Other material	283	340	325	575
Total cost	1324	1525	1651	1860
Net profit	276	-38	365	1192
Non-cash labor	518	482	557	411
Farm income	974	586	320	1735

Optimal Levels of Pre-harvest Labor and Capital

All of the above production inputs taken together contribute to pre-harvest capital and labor input. What aggregate levels of these are most appropriate to achieving high yield and net return? Table 16 shows a total of 9 management cells for the producers of table potato, each representing a level of labor and capital input, and the average yields for the producers in each. Maximum yield was associated with the lowest levels of investment in labor and capital.

Of course, farmers are not interested in yield per se, but in profit. Table 17 shows the average net return to each of the 9 management cells. Again, cell IA had the best results. We concluded that many farmers invested too much labor and capital in their table potato production. Increases in not only pre-harvest labor but also pre-harvest capital had a negative influence on net return.

On the basis of the results in the last three sections, we must reject hypothesis 5, that the more pesticide, fertilizer, and total pre-harvest capital inputs farmers apply, the higher their yields and returns.[a]

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[a]Studies are also being done on the possibility of mechanization of white potato production in Taiwan. While conducted in farmers' fields, such studies are experimental and do not reflect general production conditions of white potato in Taiwan. See ref. 2.

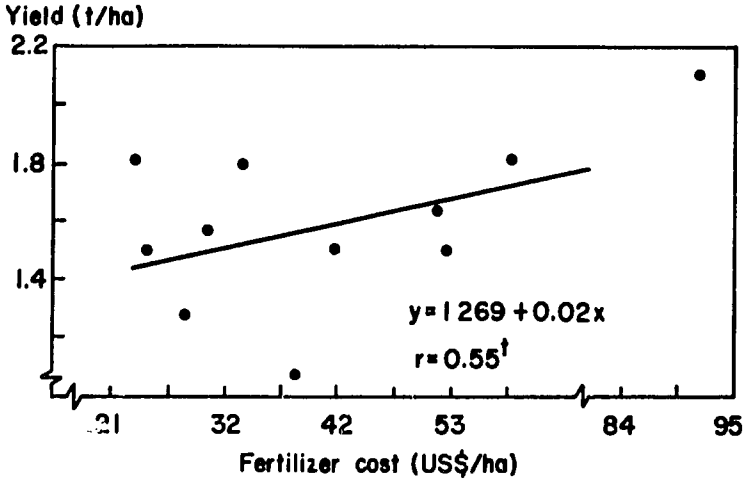

Fig. 9. The relationship between fertilizer costs and yield of potato in the late season, 1976/7; AVRDC, 1978.[a]

[a]Survey results, 1977.

Table 16. Potato yields as influenced by levels of pre-harvest labor and capital, 1976-77; AVRDC, 1978.

Pre-harvest capital (US$/ha) Range		Pre-harvest labor (US$/ha) I Range 360-556 (n=16)	II 557-685 (n=16)	III 686-1131 (n=15)
		---------- t/ha ----------		
A	399-580 (n=16)	19.4 (10)	17.5 (3)	16.9 (3)
B	581-738 (n=16)	13.2 (4)	16.1 (7)	13.8 (5)
C	738-1088 (n=15)	18.0 (2)	17.4 (6)	17.0 (7)

Table 17. Net return as influenced by levels of pre-harvest labor and capital, 1976-77; AVRDC, 1978.

Pre-harvest capital Range		Pre-harvest labor I Range 360-556	II 556-685	III 686-1131
		----------US$/ha----------		
A	399-580	351	-555	-366
B	580-738	341	-146	-358
C	738-1088	21	-259	-394

Post-harvest Handling and Sales

If potatoes are too small they have no market value and can only be used as hog feed. Table 18 shows that as farm size increased, the amount of table potato retained for seed also increased, thus accounting for the decline in percentage of qualified seed offered in the market. Seed potato had the highest percentage of qualified seed because size did not have to be too large, and none had to be retained for seed purposes on the farm.

Table 18. Ratio of qualified potatoes harvested, 1976-77; AVRDC, 1978.

	Qualified[a]	Unqualified	Retained for seed	Yield
	%			t/ha
Table potato				
Under 1.0 ha	87.3	12.4	0.3	17.1
1.0-1.5 ha	86.0	13.2	0.8	16.3
Above 1.5 ha	85.8	12.6	3.6	16.7
Seed potato	96.6	3.4	0	18.8
Total	87.3	12.1	0.6	17.0

[a]i.e. marketable; see text.

Table 19 shows the sales patterns of qualified table and seed potato. When farm size was large, farmers preferred to sell their entire harvest to local shippers, while in small and medium holdings, many farmers also sold to wholesalers. Only in the case of seed potatoes did farmers sell through Farmers' Associations, for reasons mentioned. Half of all potato farmers sold their crops right in the field to save marketing labor, and another three-eighths sold at home. This shows that farmers are not enterprising in taking over some of the early marketing operations to shorten their marketing channels. The average size of holding of the potato farmers sampled was only 0.73 ha, lower than the Taiwan average of about 1.0 ha but similar to farm sizes in specialized vegetable production areas in Changhua district.

Problem in Potato Production

Table 20 shows that we may accept hypothesis 6, that farmers consider disease the most important problem in potato production, especially in the middle season, when dense fog was common (Fig. 3). The second major problem was temperature and daylength. Late season farmers were most sensitive in this regard because high temperature and increasing daylength in March and April are not suitable for good tuber growth (Fig. 2). In the other two seasons temperatures were occasionally too cold for optimum growth. Insect damage was also worst in the late season.

Table 19. Sales patterns of qualified potatoes, 1976-77; AVRDC, 1978.

Farm size range	Mean	Potato sold to			Total production sold	Sold from	
		Shipper	Wholesaler	Farmers Association			
		%			t/ha		%
Table potato producers							
Under 1.0 ha	0.49	93.7	6.3	0	14.5	home	34
						field	53
						road	13
1.0-1.5 ha	1.09	58.3	41.7	0	15.5	home	33
						field	58
						road	8
Above 1.5 ha	1.90	100.0	0	0	14.6	home	33
						field	33
						road	33
Seed potato producers	0.63	0	0	100.0	18.1	home	100
All producers	0.73	80.0	14.0	6.0	15.0	home	38
						field	50
						road	12

Table 20. Problems of potato production by season, 1976-77; AVRDC, 1978.

Reason	Season			Total
	Early	Middle	Late	
	%			
Disease	29	56	29	40
Temperature	18	16	29	21
Insects	12	0	29	13
Bad variety	12	4	10	8
Wind damage	12	8	0	6
Harvest too early	6	4	5	5
Rot in storage	6	8	0	5
Bad germination ratio	6	0	0	2
Shortage of water	0	4	0	2
Total	100	100	100	100

Producer Attitudes

Table 21 shows the motivations of growers for producing potato. Twenty-three percent of farmers planted potato because they had no alternative and another 10% did so out of habit. Thus a full 33% of growers did not grow potato for any positive reason, and we may accept hypothesis 7, that most farmers grow white potato because they lack other alternatives. Continued government research and extension programs could help such farmers to be less pessimistic. Such farmers have often planted potato for more than 20 years, have found no profitable alternative crops, and are hence unwilling to change crops.

Income and revenue considerations ranked second in importance, with about 21% planting potato to increase their profit.

Table 21. Motivations for growing potato, 1976-77; AVRDC, 1978.

Reason	%
No other suitable crops to plant	23
High price and good variety	11
Increase farm income	10
Farmers are used to planting potato	10
Adquate labor in the slack season	9
Potato can serve as hog feed	9
Uses less labor than other crops	6
Land suitable for potato planting	6
Potato can be stored for a long time	5
Potato uses less fertilizer than other crops	4
Good quality	1
High production	1
Maintain land productivity	1
Short duration	1
Concentrated plantings convenient for sale	1
Planting potato is good for next crop	1
Total (N = 80)	100

Of the remaining reasons, some farmers wanted to fully use their idle family labor during the cool season, but also wanted a crop that did not have such high demand for labor and material that it required hiring inputs. For them, potato was an ideal crop.

Reasons for Changing Varieties

The reasons for changing cultivars were diverse (Table 22). There has been a shift over time from Norin #1 to Wu-feng, either directly or through Kennebec. Farmers were critical of Norin #1 because of its bad outer appearance, low price due to small size, and low revenue. Farmers believed that Wu-feng was least subject to these faults.

Table 22. Reasons for changing potato variety, 1977; AVRDC, 1978.

Reasons	Norin #1 Kennebec (n=10)	Norin #1 Wu-feng (n=12)	Kennebec Wu-feng (n=7)	Total (n=29)
	%			
Size too small	26	27	30	28
Bad outer appearance	26	18	30	25
Unfavorable price	16	18	10	15
Low production	21	27	10	20
Shortage of seed source	11	9	20	13
Total	100	100	100	100

Farmers' Conception of the Ideal Potato

Table 23 shows that farmers preferred white, oval potatoes to round ones of other color. Ideal size was between 0.2-0.3 kg: either too small or too large was unwelcome.

Farmers cited the price they hoped to receive as US$55-77/t (Table 24). Interestingly, this price did not cover the total of both cash and input costs, but it did allow farmers to earn positive farm income. Moreover, the actual prices received by farmers have been higher than prices they felt would be satisfactory. Ideal yield, however (15 to 18 t/ha, Table 24) was higher than actual yield, with 16% of farmers not even achieving 12 t/ha. This reflects some of the problems in potato production noted, such as diseases, insects, and temperature damage.

Comparative Costs of Potato and Alternative Crops

Table 25 shows the comparative costs and returns of the major winter crops for which 1976-77 data are available. The area planted to potato in Taichung district was 3248 ha, far greater than that to radish (971), kidney bean (450) and tomato (129). The level of returns followed the revenue order, however. Two conclusions derive from the table:

1. Potato has the lowest farm income and net return of the four crops, showing again that farmers who plant potato often do so because they have few alternatives. That capital is not lacking is clear from the total cost figures.

Table 23. Characteristics of the ideal potato, 1977; AVRDC, 1978.

Characteristics	%
Appearance	
Round	27
Oval	61
Long	11
Total	100
Color	
White	67
Yellow	18
Pink	7
Red	4
White-yellow	4
Total	100
Size (gm/potato)	
Under 100	4
101-200	16
201-300	61
301-400	8
401-500	2
501-600	4
Above 601	4
Total	100

Table 24. Ideal and actual prices and production of potato, 1976-77; AVRDC, 1978.

	Ideal	Actual
	%	
Price (US$/t)		
Below 55	0	6
55-79	67	30
79-105	23	36
105-132	7	20
132-158	3	6
Above 158	0	2
Total	100	100
Production (t/ha)		
Below 12	0	16
12-15	23	26
15-18	33	26
18-21	6	12
21-24	23	14
24-27	0	2
27-30	8	4
Above 30	6	0
Total	100	100

2. While the net return of potato is a mere fraction of that from the other three crops, farm income is about 60% of that from radish and almost half that of kidney bean. This is further evidence that potato farmers are interested in return to their hired or purchased resources and are willing to take a low level of return to those owned inputs they supply themselves.

Table 25. Comparative costs and returns of major winter crops in Taichung district,[a] 1976-77; AVRDC, 1978.

		Potato	Radish	Kidney bean	Tomato
		US$/ha			
Revenue		1553	1889	2761	5078
Seed		158	46	88	85
Fertilizer	S[b]	143	50	-	248
	H[c]	241	250	280	195
Labor	S	496	642	389	1902
	H	324	376	410	-
Pesticide		104	163	262	355
Other material		83	16	412	129
Total cost		1550	1542	1840	2916
Non-cash cost		640	692	389	2150
Farm income		644	1039	1309	4312
Net return		4	348	920	2162

[a]Ref. 5. [b]Self-supplied. [c]Purchase or hired.

Summary and Conclusions

In December, 1977, the economics survey team of the Asian Vegetable Research and Development Center conducted a survey of 50 producers of cool-season white potato in Taichung district where over 80% of the area planted to potato in Taiwan is concentrated. Although AVRDC's long-range goal is to develop heat-tolerant cultivars so that white potato could be grown in periods other than the cool season, it was first necessary to understand the present productivity, motivations, and problems of farmers in the cool season.

Objectives of the survey were to:

1. Determine the present yield and profitability of white potato.

2. Understand why farmers plant potatoes even with current low price.

3. Estimate a rational price level that would stimulate farmers to increase their potato cultivated area.

4. Determine the extent of blight incidence and resulting yield loss.

5. Explore the effect of planting date on yield and price.

6. Determine an appropriate level of production technology to maximize profits.

7. Suggest how planted area in Taiwan could be increased to meet consumer demand.

Analysis of the results showed that the white potato has tremendous potential for supplying calories and protein to the people of Taiwan, but that it still occupies only 2.1% of the area planted to vegetables. A government effort in 1975 and 1976 increased production markedly, but higher levels of exports, largely to Singapore and Hongkong, resulted in a slight decline in production available per capita.

Yield of table white potato was highest in the middle season, when price was lowest, and on sandy loam soil. Total production costs were highest in the early season, when farm income was also highest. Net return, however, was greatest in the late season, because farmers in that season had proportionately higher non-cash costs.

Farmers plant potato largely because they lack alternatives and have experience in planting this crop in previous years. Although the price of potato is not high compared with other vegetables, it has the

greatest month-to-month price stability and is thus a "source" crop. This is one major reason farmers plant potato, even though its level of profitability is lower than that of cool-season tomato, kidney bean, and radish.

Two-thirds of farmers would respond positively to a price of US$55-79/t, but at present 96% of farmers interviewed were receiving that price or higher! The second most important reason for planting potatoes was high price and good quality cultivars. Therefore, adverse price does not seem a major factor in limiting the present area planted to potato. Efforts to stimulate greater planting of potato should logically be through elevating unit yields through plant breeding and improved management, rather than increasing output prices.

Disease was the major problem listed by farmers, with 40% of all responses. It was most severe in the middle season when fog caused blight damage on 56% of farms. Although we could not estimate the precise amount of yield loss from disease, we concluded that spraying pesticides as a whole was non-economical, perhaps because farmers inappropriately mix many kinds of pesticide together or spray for problems for which no control has been discovered. Yield loss from diseases may be unavoidable until disease resistant varieties are developed.

Overall production costs in potato should be kept down, since our analysis showed that increases in production costs had a negative effect on net return and farm income. The way to induce planting of more potatoes in Taiwan should, again, be through yield improvement (plant breeding and appropriate low- to middle-level cultural management) rather than through increasing levels of production inputs.

The three producers of seed potatoes interviewed differed from the producers of table potato in that they had higher production costs, price, farm income, net return, and percentage of qualified tubers. Thus, seed potato production is one potential way to improve profitability of production, particularly in the cool season; however, the regulations under which such potatoes must be grown are also stringent and require careful management.

The data also allowed us to accept the following hypotheses:

1. Soil type, season and cultivar all significantly influence yield.

2. Producers of seed potato have greater production costs than producers of table potato.

3. The order of field preparation and plowing significantly influences yields and profit.

4. Farmers consider disease the most serious production problem.

5. Most farmers grow white potato because they lack other alternatives.

However, the data led us to reject two hypotheses:

1. Small-scale potato plantings involve higher production costs and net returns. On the contrary, production costs per ha were highest on the largest farms and net returns were highest on the medium-sized farms.

2. The more pesticide, fertilizer, and total pre-harvest capital inputs farmers apply, the higher their yields and returns. By contrast, for the sample under study farmers seemed to be over-applying production inputs, so that higher input levels resulted in no significant increases in yield or profits.

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Editor--Grant I. Johnson
Artwork- Chang Foo-Fu
Typing- Mrs. Alice Shao
Printing- Tsai Jung-Huei
Photography- Shao Li-Ting

Published by the Office of Information Services, Asian Vegetable Research and Development Center, P.O. Box 42, Shanhua, Tainan 741, Taiwan, R.O.C.