

Role of tomato in multiple cropping systems.

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Summary

(1) As development of heat-tolerant and disease-resistant cultivars with the improved technology, (as hormone treatment, pruning or topping, use of raised bed), it makes tomato can be grown in any season around the year and the harvest duration can be adjusted from one to five months. (2) Short (determinate) or tall (indeterminate) plant type of tomato will increase the crop intensification in both time and space dimension by intercropping or relay-intercropping. (3) Labor intensive and even distribution of seasonal labor on growing tomato will absorb more family labor than other crops. This will give high return per unit of land and continuous income for several months.

Such advantages prove tomato is the most suitable crop for inclusion in intensive multiple cropping system, especially for the small farm with the surplus family labor.

Tomato is one of the most popular vegetables in Taiwan. Although wild tomato was found on this island for a very long time, the improved commercial cultivars were first introduced from Japan in 1895 and the research and extension program have been carried out by experiment station since 1909. The acreage of tomato in Taiwan have increased steadily from 500-600 ha in 1940's to more than 8,000ha in the 1970's. The acreage of tomato was 8,146 ha and the total production was 199,391 ton in 1976. Most of the fresh market tomato is growing in winter to spring on the paddy fields, but the processing tomato is growing mainly on the upland field in southern Taiwan. With the increasing demands in local and foreign markets and the success in improved techniques (varieties and cultural practices), the summer and autumn fresh market tomato are increasing on cool highland or shifting paddy rice field by the skilled farmers. Recently, a strong export market also brings the rapid expansion of processing tomato on the upland rotated with sugarcane or sweet-potato in southern Taiwan.

This report will introduce the present crop seasons of tomato with cropping patterns in Taiwan, and discuss the problems on adopting the tomato in multiple cropping systems.

1. Crop seasons and cropping patterns of tomato in Taiwan.

We classified the crop seasons based on the fruit producing periods, that is, producing fruit during February–April, May–July, August–October, and November–next January, are defined as

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spring crop, summer crop, autumn crop, and winter crop, respectively. Transacted volume and average price of fresh market tomato in different season are as following table.

Table 1. Transacted volume and average price in different season.
(Average 1972-1977)

	<i>Transacted volume</i>		<i>Average price</i>
Spring Crop	8,799t	41.15%	0.066 US\$/kg
Summer Crop	2,041	9.54	0.152
Autumn Crop	2,164	10.12	0.233
Winter Crop	8,380	39.19	0.109

(Source: Taiwan agricultural products wholesale market yearbook. 1978)

(1) Spring tomato:

Sowing seed : Early October

Transplanting: Early November

Harvesting : Mid January-early March or mid April

Mos fress market tomato is commonly produced in this season. Japanese or local bred, medium to large size, tomato cultivars, as Hokan 3, Nongyou 505, are adopted by the farmers. since the suitable cool-dry weather makes tomato grow without too much difficulty, high yielding and good queality and the low market price are the characteristics of spring tomato in Taiwan.

There are two cropping patterns, as (1) on the double cropping rice field, and (2) on the single cropping rice field for spring fresh market tomato. On the double cropping rice field, tomato is transplanted after rice harvesting or relay-interplanted before the harvesting of 2nd rice crop, and is terminated the harvesting before the transplanting of 1st rice crop. Moreover, the harvesting of spring tomato may prolong to mid-April at the time of good market price. In such a case, the rotation pattern will change as follwos: 2nd rice crop (July–October)-spring fresh market tomato (November-mid April)–cucumber, kidney bean, or cabbage (mid April–June). This cropping pattern is as same as the single rice and tomato pattern. So, these two patterns can be used freely according to the favorable market price.

(2) Summer tomato:

	Lowland	Highland
Sowing seed :	Mi Feb. –Early Mar.	Late Mar.
Transplanting:	Mid Mar. –Early Apr.	Late Apr.
Harvesting :	Early May or Early Jun. or Early Aug.	Early Jul. –Late Aug. –Late Jun.

Summer fresh market tomato is mainly distributed on the paddy field of highland area. As difficulties to grow tomato in hot-wet summer on lowland area, the farmers in cool highland will replace the paddy rice with the summer tomato for the more benefit than rice. Hot-tolerant and disease-resistant cultivars, ad Paisu, Nongyou 4, Kyokuko, are adopted on summer crop. After one year of summer tomato (late Apr. –late Aug.) –corn, cabbage, sweetpotato (Sep. –Dec. or next Feb.) pattern the field will be put back to the double cropping rice for two or three years in order to control the soil borne diseases. However, it is also planted on the lowland paddy field in Changhua area. but the planting time is about one month earlier than highland area. Because of high temperature and excess moisture during the fruit setting period, the abovementioned cultivars with application of plant growth regulators are required for growing summer tomato on lowland area. The hormones, as para-chlorophenoxy acetic acid (Tomatotone) or 2, 4-D, are sprayed on flower cluster at the time of blossoming. Besides, growing as sole cropping on paddy field, some summer tomato is interplanted on the perennial leek filed by the specialized vegetable growers in Changhua county.

(3)Autumn tomato:

	Lowland	Highland
Sowing seed :	Late May-mid Jun.	Late Jun.
Transplanting:	Mid Jun. –mid Jul.	Late Jul.
Harvesting :	Mid Aug. or mid Sep.	Late Sep. –Mid Nov. –Early Nov.

In contrast with summer tomato, the autumn tomato is adversely affected by high temperature and/or excess moisture before the fruit setting. Some cultivars and special culturl practices with plant growth regulator are adopted in autumn crop. Instead of planting 2nd rice crop, autmn tomato is grown on paddy field of both lowland and highland as growing period mentioned above. sometimes, the harvesting period would continue to next January on lowland, whenever the price is high. Newly developed determinated cultivars by AVRDC can be transplanted in mid-June and has short harvesting duration, about 35 days from mid–Aug. to early sept.

The most common cropping patterns with autumn tomato are (1) first rice crop (Feb. –Jun.)–autumn tomato (Jun. –Early Nov. or prolong to late Jan.), and (2) first rice crop (Feb. –Jan.)–autumn tomato (Jan. –Oct.)–winter vegetables (Nov. –Feb.). Autumn tomato interplanted with other vegetables as green pepper and cauliflower simultaneously in row are carried out on the raised bed vegetable farm in Changhua area. The field should be put back to paddy field after one or two years of tomato in order to restore soil fertility or control the diseases.

(4) Winter tomato:

	Fresh market	Processing
Sowing seed	: Mi Aug.	Late Jul. -Late Sept.
Transplanting	: Mid Sept.	Late Aug. -Early Nov.
Harvesting	: Mid Nov. -Late Jan. or Mid Mar.	Early Dec. -Mid May.

Figure 1. spring tomato and cropping patterns.

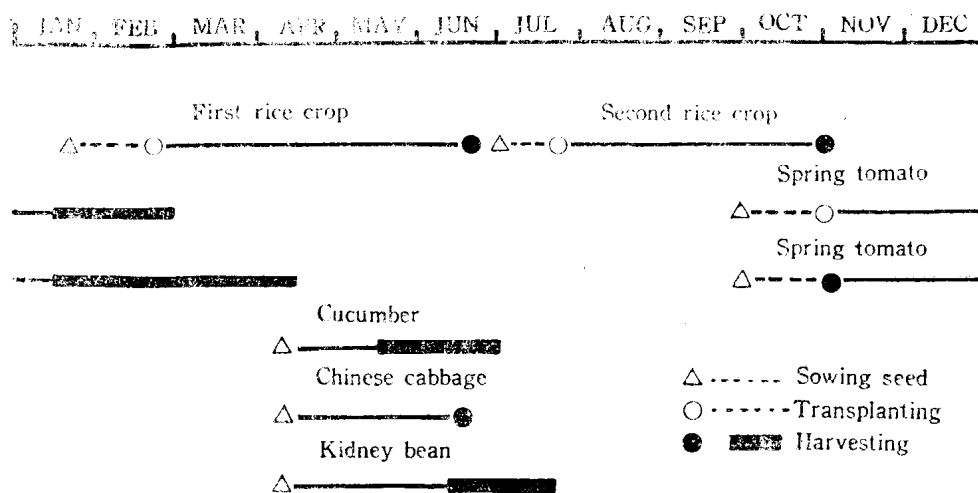


Figure 2. Summer tomato and cropping patterns.

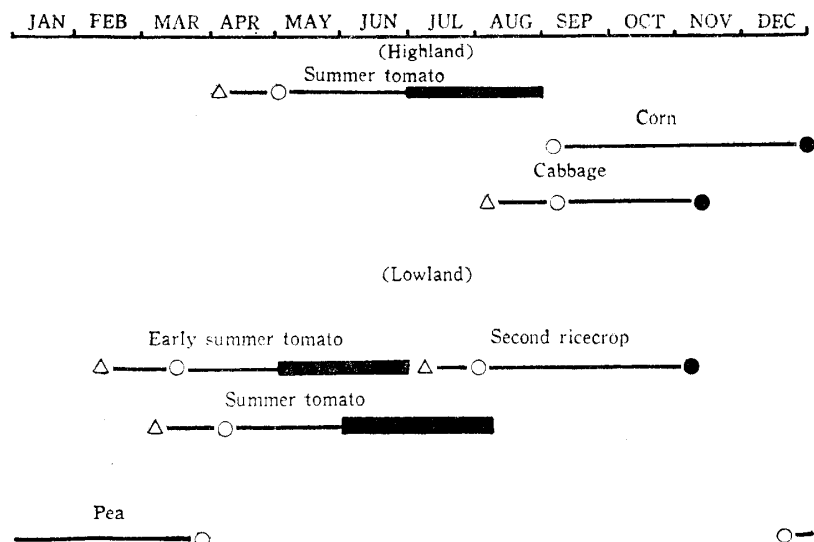


Figure 3. Autumn tomato and cropping patterns.

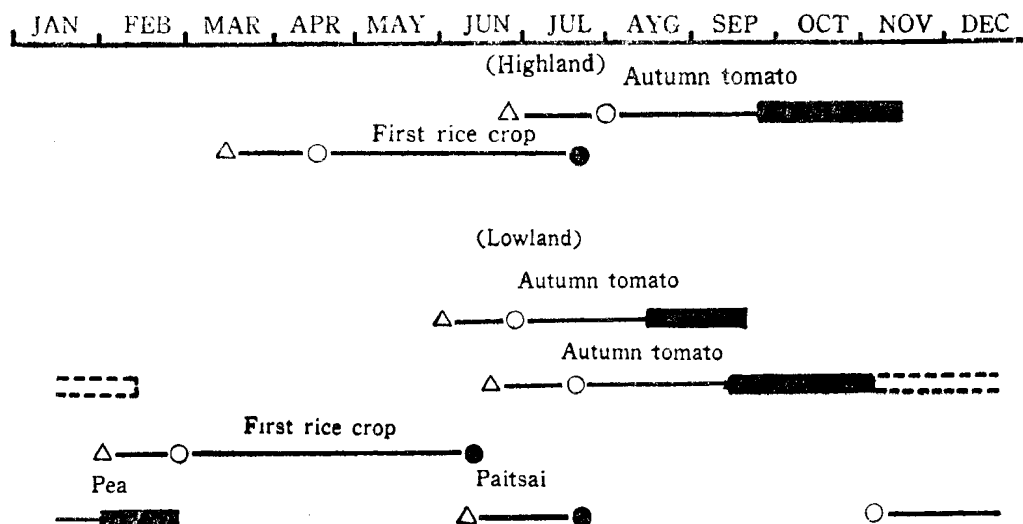
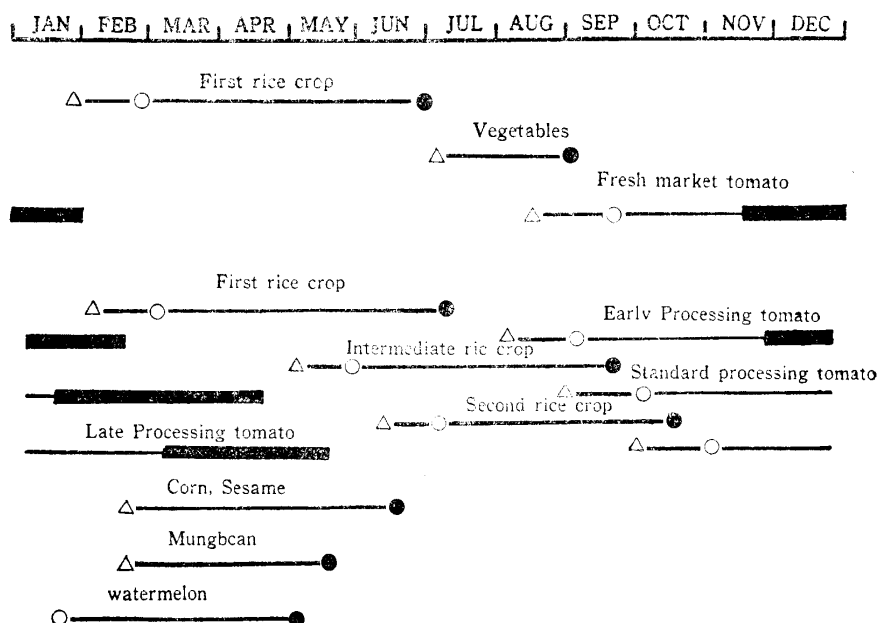


Figure 4. Winter tomato and cropping patterns.



There is no tomato growing in highland area during winter season due to the low temperature. As the period of fruit setting in winter are under relatively low temperature (15-20°C), and in order to obtain large, high quality fruit, the Japanese cultivars, as Hokan No. 1-2, Kyokuko, Hikari or local bred cultivars, as Nongyou 707 or 505, are planted extensively.

For fresh market tomato, the production areas are distributed on the paddy field of the central Taiwan. It follows the first rice crop or summer vegetables and plants on mid-Sept. instead of the growing of second rice crop. Following the harvesting of first rice crop or summer vegetables, the winter tomato are transplanted on double rice cropping area instead of second rice crop. Therefore, the cropping pattern is the first rice crop (Feb. –Jun.)-summer vegetables (Jul. –Aug.)-winter tomato (Sept. –Jan.). The tomato will be harvested from mid-Nov. to late-February or extend to mid-Mar., while the marketing price is good.

In the three year rotation area, the cropping pattern of processing tomato is as (1) first rice crop (late-Feb. to late Jun.)-early processing tomato (Sept. to mid-Feb.), (2) intermediate rice crop (late-May to mid-Sept.)-standard processing tomato (early-Oct. to mid-Apr.) and (3) second rice crop (early-Jul. to mid-Oct.)-late processing tomato (early-Nov. to mid-May). However, in the upland area of Southern Taiwan, the farmers grow processing tomato as sole crop rotated with other upland crops, such as corn, mungbean, sesame or watermelon, or interplanting between the rows of sugarcane. For extending the supply of raw materials to tomato processing factories, the planting time may adjust from early Sept. to early Nov. As a result, the harvesting of processing tomato will extend to six months (Dec. to May) compared with three months period in standard crop season (mid-Jan to mid-Apr.). The cultivars, Morioka No. 7, Roma, TK 2, Chico No. 3 and newly developed AVRDC strains as CI 11-0-2-2-0-3, are commonly employed by farmers.

2. Role of tomato in multiple cropping system

(1) Crop season and duration of tomato and selection of sequence in multiple cropping.

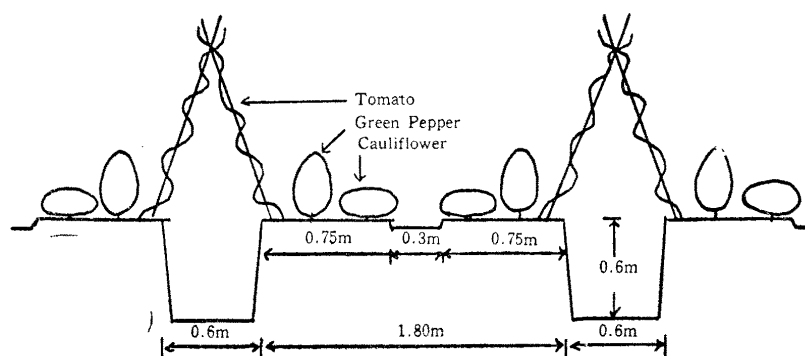
Favorable dry-cool weather from Oct. to next Mar. in Taiwan makes tomato production concentrated in the winter-spring season. As successful development of heat tolerant, disease resistant cultivars and intensive operations, as hormone treatment for promoting fruit set under high temperature environment or the use of raised bed for good drainage, tomato in Taiwan will be produced on commercial scale at anytime around the year.

Commonly the growing period of tomato requires about four months. But it will be able to extend the harvest duration from 45-60 days to 120-150 days by pruning and training the indeterminate cultivars or shorten by topping at the lower flower clusters or adopting determinate cultivars.

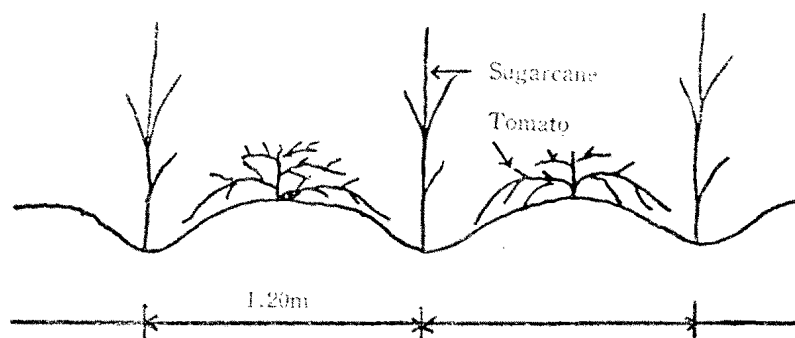
This means tomato can be programmed either as long duration crop or as short duration crop in sequential cropping.

Figure 5. Tomato intercropping.

a. Intercropping as tall plant.



b. Intercropping as short plant.



Different crop seasons and duration increase the possibility of introducing tomato to multiple cropping system, when maximum return can be obtained. Shifting the first rice crop to the summer tomato or the second rice crop to the winter tomato, and extending the harvest duration of winter tomato from Nov. –Jan. to Nov. –Mar. or Apr. are commonly adopted by the farmers.

(2) Intercropping makes crop intensification in both time and space dimensions.

As above mentioned cropping patterns, tomato are commonly interplanted between the rows of long duration crops as sugarcane on upland or leek on intensive vegetable farms at the beginning of growing period.

According to the results of Taiwan Sugar Research Institute (1970), it yielded not only about 40 MT/ha of tomato but also 2-10% increase in sugarcane yield by interplanting tomato induced by the residual stems and leaves returned back to field as manures were observed.

On leek vegetable farm, the tomato will be transplanted on the ridge of raised bed with stake covering the furrow as Fig. 5. In addition to gain 30-40 Mt/ha fresh tomato, there is no difference on yield of leek between intercropping and sole cropping leek.

The continuous vegetable production on the raised bed with furrow for in paddy drainage is usually adopted on the fully irrigated area in central Taiwan. Summer tomato are planted on both edges of raised bed by staking, pruning and training. Inside of this tomato (tall), one row of green pepper (medium) and one row of cauliflower are grown simultaneously to establish the better structure.

In the former case (intercropping in sugarcane), tomato plays as minor (short) crop to sugarcane, but in the latter case, tomato plays as major (tall) crop to green pepper or cauliflower.

In order to avoid delaying the planting of subsequent crops (the crops to be grown after tomato), the relay-interplanting of tomato have been adopted two weeks before rice harvest by farmers. Now, with the release of the early-maturity rice cultivars, as Tokyo No. 1, this kind of labor-intensive planting method are seldom observed. On the other hand, relay-intercropping in intensive vegetable farm are commonly adopted on the raised bed by farmers.

Vine vegetable crops, such as pea, asparagus bean, kidney bean, etc. are interplanted at two weeks before the end of harvesting of tomato for utilizing the stakes already set. Other vegetables such as cabbage or cauliflower, are also relay-interplanted before the termination of tomato harvested.

(3) Intensive management on tomato enable the family labor be fully utilized.

According to the reports on the Agricultural Products Production Cost by Taiwan Provincial Department of Agriculture and Forestry in 1977 and the survey by the AVRDC in 1976-1977, tomato is one of the most labor intensive crop among the 42 crops in Taiwan. It requires about 5,000 man-hours per hectare to produce fresh market tomato in winter. This is about eight times of labor needed in the first rice crop, and about four times to competitive vegetables as cauliflower or cabbage.

As management of fresh market tomato needs skilled and persistent processes as staking, pruning, training or harvest every one or two days, it makes the labor distribution evenly through the whole growing period. The tomato growing will not cause the concentration of labor demand in a short period, in which the farmers' selfed family labor could meet the requirement. Such an intensive and even labor distribution enable the family labor be fully utilized. As in table 2, the components of labor are almost entirely family labor, and hired labor form only eight percent compared with total labors.

Table 2. Labor requirement and production cost among major crops.

	Labor requirement				Gross return	Total cost (US\$/ha)	Net reutrnr	Farm income
	Total	Seld Hired (hrs/ha)		Harvest				
Fresh tomato	4,815	4,415	400	1,467	4,857	4,657	200	3,000
Rice 1st crop	602	366	236	110	1,486	1,234	252	544
Soybean (winter)	470	226	244	101	706	682	24	158
Corn (winter)	543	371	172	170	799	797	2	223
Watermelon (summer)	1,277	1,043	234	157	1,826	1,379	447	1,069
Cabbage (winter)	1,265	1,101	154	698	1,760	1,786	-26	761
Pea (winter)	1,407	1,407	—	299	1,764	1,572	192	961
Cauliflower (winter)	1,597	1,420	177	1,420	2,244	1,976	268	1,191

Source: Reports on Agricultural Products' Production Cost. PDAF, 1977.

However, extensive managemet, short harvesting time and long interval of harvesting period (every 7 to 15 days) on the processing tomato, will reduce the labor requirements to 1,750 man-hours per hectare and increase the dependense on hired labor to 50.86%.

As above mentioned, the labor intensive and even distribution of seasonal labor on growing tomato will absorb more family labor than other crops and increase the farmily farm earning. Therefore, adopting the tomato in multiple cropping pattern will most suitable for small farmer with surplus of farmily labor.

(4) High return per unit of land and continuous cash income for several months.

According to the above mentioned PDAF reports in 1977, the net income of winter fresh market tomato is US\$ 200/ha. This value is not the most profitable among the annual crops growing in Taiwan. While the farmer earning by the selfed family labor is included to the net return, the farm income is amounted to US\$ 3,000/ha. This farm income is significantly higher than the other crops including rice, other field crops and vegetables.

Since the fresh market tomato set fruits over a period of two to four months and harvest every one or two days, the tomato grower can get the continuous cash income for several months. Such advantage will make the small farm adopt the tomato in the multiple cropping pattera. On the other hand, intercropping of tomato in sugarcane field, the farmers can get the extra income in

early growing stage of sugarcane instead of no income on monoculture of sugarcane for a period of 18 months later.

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摘 要

番茄在複作制度下之功能

蘇匡基*

- (1)由於抗熱、抗病品種之育成與改良技術如荷爾蒙處理，剪定或摘心，高畦栽培之配合，使番茄可在週年任何季節中栽培及調節收穫期間一個月至五個月。
 - (2)矮性或高性不同植採型態使番茄在時間上與空間上適合於間作或糊仔作之集的栽培。
 - (3)生長期中需要多量與平均分佈之勞力，使番茄較其他作物易於吸收家庭勞工，連續數月中有固定之收入及單位面積土地上獲高之利潤。
- 這些優點證明番多茄在集約的複作制度下，尤其是小農場有剩餘家庭勞力時為最適合之作物。

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