

JAPANESE VEGETABLE FARMING AS A SOURCE OF APPROPRIATE TECHNOLOGY FOR INCREASING FOOD PRODUCTION IN DEVELOPING COUNTRIES

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I. *Introduction*

A need exists in many developing countries for agencies concerned with agricultural development to help low-income farmers raise the levels of crop production on their farms (i) to produce more food for continuously rising populations and (ii) to alleviate poverty. The need is perhaps greatest in densely populated areas, where there is little or no scope for extending the area of agricultural land, that is, for bringing new land into cultivation.

Promoting the use of modern, industrial, agricultural technology to meet this need often increases levels of crop production but also, at the same time, leads to several inter-related problems. These problems include:

- (a) increasing dependence of poor farmers, and hence poor food consumers, on fossil fuel energy, in the form of expensive agricultural machines and chemicals;
- (b) decreasing employment opportunities for poor rural people, resulting from the use of these labour-saving machines and chemicals; and
- (c) increasing risk of environmental pollution, associated with the residues of chemical fertilizers and pesticides.

Hence, an alternative type of agricultural technology is required to meet this need. Such an agricultural technology must be characterized by:

- (a) high levels of crop production per unit area of land;
- (b) low, or negligible, use of fossil fuel energy;
- (c) high use of labour; and
- (d) low, or negligible, risk of environmental pollution.

The traditional agricultural technology of the intensive, i.e. high output and high input, crop production systems of Japan appears to have these four characteristics (as does similar technology in China). Thus, a study of the nature of this technology, made from the viewpoint of its appropriateness, that is, its relevance and possible transferability to poor farmers in developing countries, can make a useful contribution to agricultural development planning in these countries.

Multiple cropping sustained by organic recycling is the traditional basis of the high levels of crop production in many Japanese agricultural systems. Intensive year-round vegetable farming, in locations with mild winter climates, is certainly one of the most intensive of all these systems. The intensive vegetable farming system in its traditional form involves the growing of several crops per year on the same piece of land and the application of large

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amounts of night-soil, animal manures, composts and various other fertilizing materials. Hence, by focusing this study on the multiple cropping and organic fertilizing component technology of the intensive vegetable farming system, it is possible to identify the nature of a very good example of the traditional, intensive, agricultural technology of Japan.

As very little detailed information on Japanese vegetable farming has been published in the English language, this study was conceived as being mainly a fieldwork study, primarily concentrating on a vegetable farming area near Tokyo. The site chosen for the fieldwork was the large vegetable farming area of Miura Peninsula, which is currently one of the most intensive vegetable farming areas in the vicinity. This area has been a site of year-round vegetable production for over 100 years and is thus an ideal area for studying both the traditional as well as the modern methods of vegetable farming used. During the field study, information was gathered, with the help of interpreters, directly from vegetable farmers, including older ones with first-hand experience of using some of the traditional farming methods which are no longer used. Information was also gathered from staff of local government and agricultural cooperative offices, from staff of the local horticultural experiment station and from geographers in Tokyo. Where possible, this information was supplemented by reviewing relevant literature obtained during the course of the fieldwork. Many field trips were made to the farming area over a period of one year, from January to December 1984.

In this paper, the detailed findings of the field study are presented first. The physical environment and the historical development of vegetable farming in Miura Peninsula are described and the methods of multiple cropping and organic fertilizing are examined in detail. Then, on the basis of these facts, a discussion on the appropriateness of the farming methods used in Miura Peninsula for increasing food production in developing countries is presented.

II. *Field Study*

Miura Peninsula is located at 35°15'N and 139°40'E on the Pacific coast of central Japan, in the southern part of the Kanto region. The Peninsula juts out some 25 km into the Pacific Ocean, separating Sagami Bay on the West side from Tokyo Bay on the East side. The vegetable farming area is located at the southern end of the Peninsula, at a distance of some 60 km from the centre of Tokyo. The principal characteristics of the area's physical environment are as follows.

Geologically, the southern end of Miura Peninsula consists of Tertiary sedimentary rocks, in the main overlain with Quaternary wind-blown volcanic ash (Geographical Survey Institute of Japan, 1977: 9-16). The ash is variable in thickness, but in most places it is at least several metres thick. In some locations, alluvial deposits of recent origin also occur. The principal landform of the area is a gently undulating coastal terrace, ranging in elevation from 30 to 60 metres above sea level. The terrace is dissected by a number of steep-sided valleys containing small streams. Natural drainage on the terrace is good but tends to be poor on the flatter valley floors.

The climate of the southern end of Miura Peninsula is monsoonal, with warm wet summer and cool dry winter seasons. It is a climate which is basically favourable to year-

TABLE 1. SUMMARY OF CLIMATIC DATA FOR MIURA CITY

Month	Temperature, °C (29 year average)			Rainfall, mm (26 year average)
	Max	Min	Ave	
January	10.2	2.1	6.1	58.5
February	10.0	2.1	5.9	70.0
March	12.8	4.6	8.6	124.5
April	17.6	10.0	13.7	145.0
May	21.7	14.0	17.7	158.5
June	24.3	17.6	20.7	176.2
July	27.4	21.3	24.1	145.0
August	29.4	22.9	25.9	128.1
September	26.3	19.7	22.8	164.2
October	21.0	14.2	17.5	198.7
November	16.6	9.3	13.0	114.0
December	12.5	4.7	8.7	63.3
Total				1,546.0
Mean	19.2	11.9	15.4	

Source: Miura Branch of the Kanagawa Horticultural Experiment Station (KHES) (1984a: 100).

round vegetable production. Average temperature and rainfall figures for Miura City, located at the southern end of the Peninsula, are given in Table 1. Owing to the moderating influence of the warm Japan Current (Kuroshio), which flows past the Pacific coast of Japan, the vegetable farming area of Miura Peninsula experiences mild winters with little frost. Cool season vegetable crops can be grown there in winter in open fields, that is, without the protection of heated greenhouses, which are necessary for winter vegetable production in many other parts of Japan. Rainfall is concentrated in the warm summer months, in a slightly bimodal pattern, when potential evapotranspiration is high. In general, the rainfall is adequate in amount and frequency for year-round vegetable cropping, although supplemental irrigation is required during occasional dry spells. Strong winds are an important feature of exposed terrace areas, where windbreaks are necessary to protect easily damaged vegetable crops. In addition to these winds, which occur throughout the year, typhoons, with their very destructive high winds and torrential rains, occasionally hit Miura Peninsula during the late-summer typhoon season.

Soils formed on the volcanic ash of the terrace areas are andosols. They are thickly developed, fine-textured, have a fairly high humus content and are reddish brown to almost black in colour. They are considered to be loams (Kanto Loam) with a high natural fertility. Under intensive vegetable cultivation though, especially with chemical fertilizers, their acidity increases, so making regular application of lime necessary. Alluvial gley soils are found in the valley floors. In the past, though to a lesser extent today, these gley soils were nearly always used for paddy rice production in summer. Potential natural vegetation at the southern end of Miura Peninsula is evergreen broad-leaved forest; the area is located in the Camellietea Japonica Region (Geographical Survey Institute of Japan, 1977: 17-19).

Intensive, commercial, vegetable farming began in the southern part of Miura Peninsula at about the time of the Meiji Restoration in 1868. It is very likely that it developed there for two main reasons. First, the area was located close to a large, growing and accessible urban market, encompassing Yokosuka, Yokohama and Tokyo. Secondly, the area

enjoyed a favourable climate, with a year-round growing season and adequate rainfall. It should perhaps also be added that the development of vegetable farming was not constrained by infertile soils or poor natural drainage.

The historical development of intensive, commercial vegetable farming appears to have taken place in two distinct stages: (i) the development of a traditional system, from the 1870's to the 1940's, and (ii) the modernization of this traditional system, from the 1950's to the 1980's. Of course, these dates are somewhat approximate. The traditional system may well have started before the 1870's, but the writer has been unable to discover any evidence to indicate that. Also, although the modernization took place after the end of the Second World War, it is clear that some modern methods were introduced, to a limited extent, before the War, e.g. the use of chemical fertilizers. Thus, it could be argued that the period from the 1930's to the 1950's was something of a transitional period, but this unnecessarily complicates an otherwise fairly clear distinction between the two stages, or between a traditional and a modern system. The modernization of vegetable farming, which started in the 1950's, reflects the rapid economic growth of Japan as a whole during the post-War period.

The main characteristics of the traditional system may be considered as follows. First, from a socio-economic viewpoint, are characteristics relating to the organization of farming. In the traditional system, the farms were small and, in the main, owner-occupied. They were also mixed, that is, relatively unspecialized; both vegetable and cereal crops were grown and farm livestock were kept for draught power and manure. All farm work was carried out by hand or with the help of animals. The economic wealth of the farmers was strictly limited but the manpower available for farm work was plentiful. In other words, the land and capital resources of the farmers were scarce, but the labour resource was plentiful. This is the same situation that exists in many densely populated parts of developing countries today. Moreover, there was very little institutional support of farmers in terms of financial or technical assistance.

Secondly, from a technical viewpoint, are characteristics relating to the methods of farming. Multiple cropping was practised, mainly double cropping at first but triple cropping in later years. The multiple cropping techniques of continuous sequential cropping without fallow periods, transplanting and relay interplanting were all used. Soil fertility under multiple cropping was maintained by applying large quantities of organic fertilizers, particularly night-soil, animal manures, oil-seed cakes, fish meal and bone meal. Cultivation of the soil was carried out by hand with hoes or with animal-drawn equipment. Fields were weeded by hand. Seeds were selected and saved on the farms which resulted in the development of locally adapted crop varieties with a significant level of resistance to local pests and diseases. Sloping land was terraced, where necessary, to control excessive runoff during heavy rains. In exposed areas, windbreak plants were grown, in temporary or permanent hedges, to protect crops from strong winds. Finally, transportation was based on hand carts and animal-drawn carts; bamboo baskets and wooden buckets were also used.

During the modernization of the traditional system a number of changes have taken place. These changes may be considered also from separate socio-economic and technical viewpoints. From the socio-economic viewpoint, the changes have been associated, fundamentally, with increasing industrialization and urbanization in Japan in general. First, as Takeuchi (1968: 24) has pointed out, with particular reference to Kanagawa Prefecture,

the extension of industry outwards from the metropolitan zone (including Tokyo) has resulted in the development, in adjacent agricultural areas, of specialized intensive forms of farming. In Miura Peninsula, the intensive mixed farms have become even more intensive specialist vegetable farms. In addition, a few separate specialist intensive livestock (pigs, poultry and cattle) farms have been established.

Agricultural land use survey data for the southern end of Miura Peninsula, namely, the Miura City and Yokosuka City districts, show that by 1980 the area of vegetable fields was 1,266 hectares (ha), whereas the area of rice fields was only 258 ha, the area of citrus orchards only 57 ha and the area of greenhouses (by 1982) only 12 ha. Livestock populations and farm numbers in the same two districts, in 1983, were: 6,100 pigs on 29 farms, 150,000 chickens on 17 farms and 1,200 head of cattle (beef and dairy) on 46 farms (Miura Branch of the Kanagawa Horticultural Experiment Station, KHES, 1984b: 3-4). Average arable farm size in 1980, in the Miura City district, which contained 67% of the total vegetable area, was 0.9 ha (Miura City Government, 1981: 4-5).

Secondly, there has been the development of a very high degree of institutional support of farmers. In the current modern system, Government provides guaranteed prices for the major vegetable crops, namely, Japanese radish and cabbage, technical advice through research (at the Miura Branch of the KHES) and extension services, and grants for building farm roads, irrigation systems, manure sheds and for converting rice fields into vegetable fields. In addition, local agricultural cooperatives support farmers by (i) marketing vegetable produce, viz. about two-thirds of the vegetables grown in the Miura City district in 1984, (ii) purchasing farm inputs from agricultural supply companies, e.g. machines, chemical and organic fertilizers, chemical pesticides (biocides) and hybrid seeds, (iii) purchasing animal manure from specialist livestock farmers, and (iv) providing technical advice, e.g. on fertilizer application rates.

Thirdly, there has been a steadily increasing injection of capital into vegetable farming, largely to reduce the labour input. The economic need to save labour has arisen as alternative, well-paid job opportunities have become available in nearby urban areas. The use of labour-saving machines and chemicals on the farms is now universal. Associated with this, and with the small and fixed size of farms, has been the significant development of part-time farming; by 1980, 49% of the farmers in the Miura City district were part-time farmers (Miura City Government, 1981: 4). Along with these changes in capital and labour inputs in vegetable farming, there has been a very marked rise in the standard of living of farmers, who today are just as prosperous as city workers, and very wealthy in comparison to small farmers in developing countries.

From the technical viewpoint, three major changes have taken place during the modernization of the traditional system. First, there has been an increasing, followed by a slightly decreasing, chemicalization of farming. In the case of fertilizers, a trend from the 1870's involving four stages may be identified, as follows:

- (a) 1870's-1920's: use of night-soil and oil-seed cakes, mainly;
- (b) 1930's-1950's: use of night-soil and oil-seed cakes, mainly, plus some chemical fertilizers;
- (c) 1960's : use of chemical fertilizers, mainly; and
- (d) 1970's-1980's: use of chemical fertilizers, plus oil-seed cakes, plus cattle manure.

Worries about deteriorating soil fertility when chemical fertilizers only were applied resulted

in a renewed emphasis on the use of organic fertilizers. In the case of biocides, a similar trend may be identified. Traditional non-chemical methods of weed, pest and disease control have been replaced by chemical biocides. However, recently, attempts have been made to introduce biological control methods wherever possible, in order to reduce the dependency on chemicals, which can be dangerous in the long run to human health and which can become ineffective as insects become resistant to them. Some examples of the methods that have been introduced are the application of bacterial spores and toxins of *Bacillus thuringensis* to control diamondback moth in the cabbage crop, the growing of marigold crops (*Tagetes* spp.) to control nematode worm in the Japanese radish crop and the grafting of watermelon plants onto resistant rootstocks to control Fusarium wilt disease in that crop.

Secondly, there has been an increasing mechanization of farming. Hoe cultivation has been almost entirely replaced by tractor-powered, rotary cultivation. Figures derived from 1980 census data for Miura City district (Miura City Government, 1981: 35) show that there was an average of 1.3 hand tractors and 0.8 4-wheel tractors on each hectare of farm land in that district; this certainly represents a very high density of tractors per hectare even in intensive farming. Hand carts and animal-drawn carts have been replaced by small pick-up

TABLE 2. VEGETABLE CROPS GROWN IN MIURA PENINSULA, 1984

English name	Japanese name	Scientific name
<i>Main commercial crops</i>		
Japanese radish ^(a)	“daikon”	<i>Raphanus sativus</i> L. var. <i>longipinnatus</i> BAILEY (var. <i>acanthiformis</i> MAKINO)
Cabbage ^(b)	“kyabetsu”	<i>Brassica oleracea</i> L. var. <i>capitata</i> L.
Watermelon	“suika”	<i>Citrullus lanatus</i> MATSUM. et NAKAI
Pumpkin	“kabocha”	<i>Cucurbita pepo</i> L.
Sweet melon	“meron”	<i>Cucumis melo</i> L. var. <i>reticulatus</i> NAUD. and var. <i>makuwa</i> MAKINO
<i>Other (minor) crops:</i>		
Potato	“jagaimo”	<i>Solanum tuberosum</i> L.
Chinese cabbage	“hakusai”	<i>Brassica campestris</i> L. (<i>B. pekinensis</i> RUPR.)
Lettuce	“retasu”	<i>Lactuca sativa</i> L.
Welsh onion	“shironegi”	<i>Allium fistulosum</i> L.
Carrot	“ninjin”	<i>Daucus carota</i> L.
Broad bean	“soramame”	<i>Vicia faba</i> L.
Pea	“endomame”	<i>Pisum sativum</i> L.
Eggplant	“nasu”	<i>Solanum melongena</i> L.
Maize, sweet corn	“tomorokoshi”	<i>Zea mays</i> L. var. <i>saccharata</i> BAILEY
Soya bean	“daizu”	<i>Glycine max</i> MERR.
Groundnut	“rakkasei”	<i>Arachis hypogaea</i> L.
Sweet potato	“satsumaimo”	<i>Ipomoea batatas</i> POIR.
Taro	“satoimo”	<i>Colocasia esculenta</i> SCHOTT
Tomato ^(c)	“tomato”	<i>Lycopersicon esculentum</i> MILL.
Cucumber ^(c)	“kyuri”	<i>Cucumis sativus</i> L.

Source: Fieldwork, 1984.

- Notes: (a) two varietal types are grown (i) the traditional “Miura” type and (ii) the modern “Aokubi” or green neck type, which is currently the dominant type.
 (b) two varietal types are grown (i) winter cabbage, including a type known as early spring cabbage, and (ii) spring cabbage, which is currently the more important type.
 (c) tomato and cucumber are grown in greenhouses.

trucks for transportation. The degree of truck ownership was very high by 1984, with most farmers owning a truck of their own.

Thirdly, there has been an increasing use of purchased hybrid seed. In the case of Japanese radish, this has been associated with a decreasing use of locally selected seed and has resulted in some loss of adaptation to local weather conditions and in some loss of resistance to local pests and diseases, e.g. to virus disease spread by aphids and to bacterial disease which affects the crop after cold weather.

The foregoing paragraphs represent a general survey of the physical environment and the historical development of vegetable farming in Miura Peninsula. In the following paragraphs of this section of the paper the methods of multiple cropping and organic fertilizing are examined in detail.

When intensive, commercial, vegetable farming began in Miura Peninsula, in about 1870, Japanese radish was the main crop grown. It was grown as a winter crop, in a double cropping pattern with either broad bean or dryland rice as a summer crop. Later, sweet potato, potato or wheat were also grown as summer crops. Triple cropping began after the end of the Second World War, when cabbage was introduced and grown as a spring crop between the winter and summer crops. Later, cabbage was also grown as an alternative winter crop. In the late 1960's, watermelon, which had been grown for a number of years on a small scale, became the main summer crop, replacing the former summer crops. In the late 1970's, pumpkin and sweet melon were introduced as alternative summer crops (APAIMP, 1972: 15-25 and discussions with cooperative and experiment station staff).

In 1984, five main vegetable crops were grown commercially in Miura Peninsula. These were Japanese radish, cabbage, watermelon, pumpkin and sweet melon. A number of other vegetable crops were also grown, but to a much lesser extent, either for the market or for home consumption. A list of the vegetable crops grown, specifying their English, Japanese and scientific names, is given in Table 2.

In addition to the vegetable crops grown in 1984, a few rows of wheat were sometimes grown between the rows of watermelon and pumpkin crops to act, in exposed terrace locations, as temporary windbreaks. Similarly, rows of maize were occasionally grown around the edges of fields, for the same purpose. Some of the most exposed fields though were protected by permanent evergreen hedges on one or more sides, one to two metres in height.

The harvested areas of the five main crops in the Miura City district in the 1983-84 cropping year (9/83-8/84) were: Japanese radish, 581 ha; cabbage, 768 ha (including 253 ha of winter and early spring varieties and 515 ha of spring varieties); watermelon, 615 ha; pumpkin, 150 ha; and sweet melon, 70 ha (Miura Branch of the KHES, 1984b: 3). These harvested areas totalled 2,184 ha, in a total vegetable field area (in 1980) of 848 ha.

In 1984, three or less commonly two main vegetable crops were grown in the same field each year. These crops were grown on a continuous basis, without any fallow period between them. A simple kind of rotation was followed in which cool season crops of Japanese radish and cabbage (family: *Cruciferae*) were alternated with warm season crops of watermelon, pumpkin and sweet melon (family: *Cucurbitaceae*). Where possible, the main vegetable crops were sown in nursery beds and transplanted later, in order to save time and space in the fields. Cabbage, watermelon, pumpkin and sweet melon were transplanted crops, whereas the Japanese radish crop was directly sown in the fields, because transplanting damages its young tap-roots.

FIG. 1. TYPICAL VEGETABLE CROPPING PATTERNS IN MIURA PENINSULA, 1984

	9	10	11	12	1	2	3	4	5	6	7	8	Months
(a) 3 crops per year:													
(i) Japanese radish (directly sown), or winter cabbage (transplanted)		LP. S/T					H						
		/...../...../...../											
(ii) spring cabbage (relay interplanted between rows of (i))					RI			H					
					/...../...../...../								
(iii) watermelon or pumpkin (relay interplanted with (ii))							LP. RI				H		
							/.../...../...../						
(b) 2 crops per year:													
(i) Japanese radish (directly sown), or winter cabbage (transplanted)		LP. S/T					H						
		/...../...../...../											
(ii) sweet melon (transplanted after harvest of (i))							LP. T				H		
							/.../...../...../						

Key: LP, land preparation; S, direct sowing; T, transplanting; RI, relay interplanting; H, harvesting.
Source: Fieldwork, 1984.

Typical vegetable cropping patterns in 1984 are shown in Figure 1; they are shown as commencing in September, when the land is prepared for the cool season crops. In pattern (a), either Japanese radish or winter cabbage was the first cool season crop. During its growth, spring cabbage was interplanted between its rows. After its harvest, from December to March, the spring cabbage grew on and was in turn harvested from April to May. However, not all of the field was interplanted with spring cabbage. At regular intervals, gaps of about three rows were left unplanted. After harvest of the first cool season crop, these gaps in the spring cabbage crop were planted (interplanted) with watermelon or pumpkin, the warm season crop. After harvest of the spring cabbage in April and May, the watermelon and pumpkin plants spread out over the whole field. Thus, by interplanting the crops in relays (relay interplanting), three crops were grown in the same year in the same field. To further save space, seeds of spring cabbage were sown in narrow seedbeds between rows of Japanese radish and winter cabbage. Shortly before the latter crop plants covered the ground, the seedlings were transplanted. In pattern (b), only two crops were grown in the same year. Relay interplanted spring cabbage was not grown. As sweet melon does not spread over the whole field in the same way as watermelon or pumpkin, it was transplanted at a much closer row spacing than watermelon or pumpkin, leaving no space available to fit in a crop of spring cabbage.

Approximate crop yield figures for the main crops grown have been derived from data obtained in discussions with several farmers and with staff of the Miura City agricultural cooperative and from estimates published by the Miura Branch of the KHES for 1983-84. These yield data are shown in Table 3. It appears that in recent years the yields of some of these crops have risen a little. Yields during the late 1960's, as reported by APAIMP (1972: 28 and 34), were: watermelon, 3.2-4.0 tonnes per 10 ares per crop (t/10a/crop) and cabbage, 3.0-3.6 t/10a/crop. However, unfortunately, no yield data were reported for Japanese radish

TABLE 3. VEGETABLE CROP YIELDS IN MIURA PENINSULA, 1984

Crop	Farmers' ($\times 3$) yield estimates typical crops, t/10a/crop	Agric coop's yield estimate typical crops, t/10a/crop	MB of KHES yield estimate 83-84 crops, t/10a/crop	Derived approx. yield figures typical crops, t/10a/crop
Japanese radish	8.0-10.0 (3)	9.0	9.4	9.0
Cabbage, winter	4.5 (1)	4.5	5.3	5.0
Cabbage, spring	3.8-5.3 (3)	5.0-6.0	5.1	5.0
Watermelon	3.5-3.6 (2)	5.4	3.6	4.0
Pumpkin	2.0-3.0 (2)	2.5	2.5	2.5
Sweet melon	2.5-3.0 (2)	No data	2.4	2.5

Sources: (a) Fieldwork, 1984.

(b) Miura Branch of the KHES (1984b: 4).

Notes: (a) Number in brackets after farmers' yield estimates denotes number of farmers providing data for that crop.

(b) To obtain figures for yield per hectare, multiple by 10.

TABLE 4. VEGETABLE CROP YIELDS IN MIURA PENINSULA COMPARED TO THOSE IN JAPAN, ASIA AND THE WORLD

Crop	Yield, t/ha/crop			
	Miura Peninsula	Japan	Asia	World
Cabbage	50	36	19	21
Watermelon	40	30	16	13
Pumpkin	25	16	12	10
Sweet melon	25	21	14	14

Sources: (a) Table 3.

(b) FAO (1982: 145-163).

Notes: (a) Yield data for Miura Peninsula are for 1983-84.

(b) Yield data for Japan, Asia and the World are for 1981.

(c) No yield data are available for Japanese radish in the FAO source.

or other main crops; also, the writer has been unable to obtain any crop yield data for earlier years, particularly for Japanese radish before the Second World War.

A comparison of yields in Miura Peninsula with yields for four of the same crops in Japan, Asia and the World, based on FAO figures, is presented in Table 4. These data show that yields in Miura Peninsula are considerably higher than in Japan as a whole and much higher (2 to 3 times) than in Asia and the World. Clearly, the vegetable farming system in Miura Peninsula is highly productive. Even in the 1960's, the yields of cabbage and watermelon in Miura Peninsula were significantly higher than the yields of the same crops in Asia and the World in the 1980's.

The high productivity of vegetable farming in Miura Peninsula, and the maintenance of soil fertility under continuous multiple cropping, is based on a long history of organic recycling. Night-soil, which was the traditional fertilizer for the Japanese radish crop, was the major fertilizer used in Miura up until about 1955.

Night-soil was obtained by the farmers from both Yokosuka and Tokyo. Farmers, who travelled to Yokosuka to sell radishes, returned to their farms with night-soil collected from the city's houses. They transported it in buckets loaded onto carts, which were drawn either by hand or by horses or cattle. Farmers paid city householders for the night-soil, with

glutinous rice ("mochi"), wheat, vegetables or money. In the Meiji Period (1868–1912), two or three cups ("go") of rice (360 or 540 cubic cms) were exchanged for one load of night-soil (72 litres). From Tokyo, night-soil was transported to Miura by sea. According to contemporary estimates, in 1872, 27,720 litres per day of night-soil were shipped to Miura, representing 0.4% of Tokyo's output of night-soil of 7,029,000 litres per day. At the time, Tokyo had an estimated population of some 326,529 households and the Tokyo City Government, which had by then become very concerned about the problem of disposing of the city's night-soil, actively promoted the distribution of night-soil to farming areas around the city. The Tokyo City Government even built a ship for transporting night-soil to Miura and also constructed night-soil storage tanks in Miura, at the southern end of the Peninsula in the Kaneda, Matsuwa and Bishamon areas (APAIMP, 1972: 18, 19 and 77). Before the Second World War, according to old farmers interviewed by the writer, dealers with small sailing craft (motorized in later years) also shipped night-soil from Tokyo to Miura. The same craft returned to Tokyo loaded with vegetables.

Night-soil was stored on the farms in large wooden tubs of 720 to 930 litres in capacity, or, in more recent times, in concrete tanks of varying sizes which can still be seen on many of the farms. A local book on growing Japanese radish, published in 1936, recommended a night-soil application rate of 5,000 kg/10a/crop (i.e. 50 t/ha/crop). This amount was to be applied in separate dressings, as follows:

- (a) before soil cultivation, 2,000 kg/10a;
- (b) after sowing, 200 kg/10a;
- (c) during early growth, 1,200 kg/10a; and
- (d) half a month before harvesting, 1,600 kg/10a.

In addition, both the second and third dressings were to be applied with 80 kg/10a of mixed fertilizers, including among other things rice polishings and a little ammonium and potassium sulphate. The night-soil of the second, third and fourth dressings was to be applied to the crop rows. Prior to application, the night-soil was diluted with water (APAIMP, 1972: 18).

According to staff of the Miura City agricultural cooperative interviewed by the writer, night-soil was often mixed with cattle manure prior to application. The mixture was placed in holes in the soil and then covered with soil. Radish seeds were sown in the soil immediately above the fertilizer mixture. This was a common practice in the Taisho Period (1912–1926).

From the beginning of the Showa Period (1926 onwards), oil-seed cake, made from Manchurian soya beans (after oil extraction), was used as a fertilizer. Prior to its application in the field, the oil-seed cake was mixed with fish meal and compost. The fish meal was usually made from sardines. On the watermelon crop, the mixture was applied by placing it in trenches before planting. In the late 1960's, the method of applying mixtures of oil-seed cake, fish meal and compost was changed to broadcasting before planting, in order to save labour (APAIMP, 1972: 26 and 77).

Although chemical fertilizers were first used in Miura Peninsula before the Second World War, their availability was greatly restricted during and immediately after the War. Consequently, night-soil remained the most important fertilizer until well into the 1950's. At this time though, it seems that the use of night-soil declined for three main reasons: first, pumped sewerage was introduced in the cities; secondly, the cost of the large amount of

labour required for transporting it increased substantially; and thirdly, new generations of younger farmers preferred not to handle it. Nevertheless, old farmers, at least the ones met by this writer, still say that radishes grown in the past with night-soil as the main fertilizer were much tastier than those grown in recent years.

During the 1950's, the use of chemical fertilizers increased substantially and Miura became the first area in the whole of Japan to establish a system of supplying chemical fertilizers to farmers. This was apparently because Miura was a vegetable growing area as opposed to a rice growing area and because it already had an established vegetable marketing cooperative. In 1962, the use of chemical fertilizers, with their high nutrient contents, peaked and largely replaced the use of organic fertilizers. Quick acting types were used for winter crops and quick plus slow acting types were used for summer crops. However, it was generally observed that, after the widespread use of chemical fertilizers, the soil under vegetable cultivation was becoming exhausted. It was believed that insufficient organic matter was being applied to the soil. The farmers once again recognized the value of organic manures (APAIMP, 1972: 19 and 77-78).

In 1984, a combination of cattle manure, other organic fertilizers and compound chemical fertilizers was used for maintaining soil fertility. Additionally, some pig and poultry manure from local farms and some compost were also used. The cattle manure was obtained, through the agricultural cooperative, mainly from the cattle farming area of Yamakita, near Mt Fuji, in western Kanagawa Prefecture, about 100 km from Miura City, but some was also obtained locally in Miura Peninsula.

The Miura City Government has encouraged the use of cattle manure since 1977, by providing grants to vegetable farmers to cover half the cost of constructing a manure shed on their farms. By 1984, some 220 manure sheds had been constructed with the grants. Additional ones had been built without the grants, so that by 1984 about 50% of the farmers in the Miura City district had a manure shed.

The cattle manure obtained was mixed with sawdust and wood shavings, which are used on the floors of the cattle sheds as bedding materials. After transportation, by truck, to the vegetable farms, the cattle manure was stored in the manure sheds, sited beside the farm roads next to the fields, for two to three months prior to use. Typical application rates of cattle manure were 1, 1.5 or 2 t/10a/crop, before planting of both cool and warm season crops. Thus, 2-4 t/10a/year, or probably most commonly about 3 t/10a/year, were applied in two separate basal dressings each year; relay interplanted spring cabbage did not receive an additional dressing.

Other organic fertilizers applied in 1984 included fish meal, soya bean cake, rape seed cake, castor oil seed cake and bone meal. These are considered to be valuable fertilizers for the watermelon, pumpkin and sweet melon crops. They were usually applied in mixtures with compound chemical fertilizers. Specific mixtures for specific crops were blended by fertilizer companies and purchased by the farmers through their agricultural cooperative. The organic matter in these mixtures results in an overall slower release of crop nutrients in the soil, producing a generally milder effect than when the chemical fertilizers are applied alone. Lime was often applied with these basal dressings of blended organic and chemical fertilizers, and with cattle manure. It was incorporated into the soil with them through mechanized rotary cultivation. The lime regulates soil acidity and thus encourages biological decomposition of the organic materials in the soil.

In a new development in 1984, the Miura City agricultural cooperative started operating two factories itself to produce blended fertilizers consisting of cattle manure, wood chips and chemical fertilizers. Initially, the cooperative formulated 13 different blends to suit the different vegetable crops grown. The aim of the cooperative was to produce complete basal fertilizers for these crops. The method of preparing the blended fertilizers was as follows. First, logs and waste wood were brought to the factory by farmers and finely chipped by machine. The chips were then collected by cattle farmers and used as a bedding material in their cattle sheds. Later, cattle manure and wood chips, in approximately a 50:50 mix, were delivered to the factory and matured for a period of one month. After this initial maturation, the cattle manure and wood chips were blended in mixing tanks with chemical fertilizers, namely, ammonium sulphate, calcium phosphate and potassium sulphate, according to one or other of the 13 different formulae. The blended mixtures were then matured for another two months in wire crates lined with porous sheets, before being sold to the vegetable farmers. The cattle farmers were not charged for the wood chips nor paid for cattle manure they delivered to the factory. Thus, the cooperative has started to play a key role in integrating specialist, intensive cattle and vegetable farming, by promoting organic recycling to the benefit of both the farmers and the soil.

III. *Discussion*

Which of the farming methods used by vegetable farmers in Miura Peninsula can be identified as appropriate to poor farmers in developing countries, for the purpose of increasing local food production? To answer this question, it is necessary:

- (a) to clarify the meaning of the expressions used in the question,
- (b) to define the concept of appropriate technology underlying the question,
- (c) to identify which of the farming methods are appropriate according to this definition, and
- (d) to consider possible constraints on the transferability of the appropriate methods in different environments.

The expression 'increasing food production' refers not only to increasing the amount of food produced locally, just to keep pace with rising populations, but also to improving its dietary quality, in terms of its content of proteins, vitamins and minerals. The expression 'developing countries' means less developed or low-income countries in general, that is, the poorer countries of the Third World. In many of these countries, immense problems of poverty exist today and will very probably continue to exist well into the future. These problems involve, among other things, food shortage and malnutrition combined with unemployment and underemployment. The more densely populated areas of these countries have a strictly limited amount of cultivated and cultivatable land available for food production in relation to a high population dependent on that land for food. It is in these areas where the greatest long-term food supply problems exist. Such areas, which are usually characterized by their poor (small) farmers and landless farm labourers, are to be found in many parts of monsoonal South and Southeast Asia, for example, in India, Bangladesh and Indonesia (Java), in some parts of South and Central America and in a few parts of Central and West Africa. In Africa, these areas do not necessarily include the currently famine-affected areas where recent

severe food shortage has been caused by political unrest combined with severe drought.

In the densely populated parts of Asia, Latin America and Africa, some of the worst cases of poverty exist in the urban fringes of the great cities, such as Calcutta, where multitudes of displaced rural poor end up after leaving their land in rural areas. It is perhaps in these urban fringe areas where such traditional farming technology as developed in the densely populated parts of Japan, like Miura Peninsula, over many generations would be most useful. At this point, it may be noted that, as China's traditional farming technology is essentially similar to that of Japan, the densely populated parts of China are not considered in this paper as areas where traditional Japanese farming technology would be useful.

A comprehensive definition of the concept of appropriate technology in relation to less developed countries has been provided by Thormann (1979: 283), as follows. First, in terms of available resources, appropriate technologies are intensive in the use of the abundant factor, labour, economical in the use of the scarce factors, capital and highly trained personnel, and intensive in the use of domestically produced inputs. Secondly, in terms of scale of production, appropriate technologies are small-scale but efficient, replicable in numerous units, readily operated, maintained and repaired, low-cost and accessible to low-income people. Thirdly, in terms of the people who use and benefit from them, appropriate technologies seek to be compatible with the local cultural and social environments. Although not actually included in Thormann's definition, perhaps it should be added that appropriate technologies also seek to be compatible with the local natural environment, that is, with local ecological balance.

This concept of appropriate technology can be contrasted strongly with a comparable concept of modern industrial technology, which can be characterized by (i) its intensive use of capital, in terms of machines and chemicals based on fossil fuel energy, and highly trained personnel, (ii) its economical or minimal use of labour, and (iii) its large scale of production. In the context of less developed countries, its introduction may well increase production and create greater wealth for some, but its disruptive effects on local social and natural environments are often very marked. These effects are much more marked than in developed countries, where governmental social welfare and environmental protection services are much more organized.

The concept that traditional village technology can be appropriate and useful to poor (small) farmers in the developmental process, that is, in the economic development of less developed countries, has been considered by the United Nations University (UNU). At the outset of its Sharing of Traditional Technology (STT) Project in 1977, its Project Task Force (UNU, 1979: 3-4) defined traditional technology as basically non-industrial technology which has evolved out of generations of experience of village communities and which forms an integral component of the entire socio-economic, cultural and ecological complex of these communities. The STT Project Task Force considered that, in the developmental process, traditional technology has several important characteristics which make it particularly useful. First, its scale of production is usually small, requiring the labour of individuals or small groups, usually the family unit. This implies that it is capable of being used and controlled by small farmers. Secondly, it uses little capital, in terms of, for example, savings or farm machinery, as it is often based on natural elements in the environment. This implies that it is accessible to small farmers, who can easily obtain the materials and skills needed for its use. Thirdly, it is highly labour-intensive and this enables

the productive absorption of otherwise surplus and untapped labour. However, the development of traditional technology does not completely preclude the use of modern industrial technology, some elements of which could be adapted to help improve traditional technology. But, such modern technology is for most part beyond the reach of poor villagers, or small farmers, who live under preindustrial conditions.

A consideration of these concepts shows that appropriate technology for poor farmers in developing countries is likely to be traditional rather than modern technology. The traditional technology of the farmers of one country may well be an appropriate technology for poor farmers in another country, especially where there have been or still are similarities in either cultural, social or natural environments. Thus, some of the traditional farming methods developed in densely populated parts of Japan may well be appropriate methods for poor farmers in densely populated parts of some developing countries. Of course, some of the modern methods may also be appropriate in some circumstances, too.

To identify which of the methods of vegetable farming used in Miura Peninsula are appropriate for poor farmers in developing countries, for the purpose of increasing food production, the methods should show the following characteristics of appropriate technology:

- (a) they should be economical in their use of capital; their inputs should be low-cost and easily obtainable;
- (b) they should be labour-intensive, but their use should not entail a high level of training;
- (c) their scale of production should be small; equipment used should be readily operated, maintained and repaired by the labour of farm families; and
- (d) they should be compatible with local cultural, social and natural environments.

A number of the modern vegetable farming methods used in Miura Peninsula clearly do not show all these characteristics. These are (i) the use of tractors with rotary cultivators for soil preparation, (ii) the use of farm trucks for transportation, (iii) the use of chemical fertilizers for maintaining soil fertility, (iv) the use of chemical biocides (insecticides, fungicides, herbicides, etc.) and chemical spraying equipment for controlling crop pests, diseases and weeds, and (v) the use, in some circumstances, of expensive hybrid seed. These are the farm inputs provided by modern industrial technology. They all require substantial amounts of capital for their purchase. The first two are especially labour-saving and not readily operated, maintained and repaired by the labour of farm families. The use, or perhaps abuse, of the chemicals can lead to serious problems of environmental pollution. For example, the residues of chemical fertilizers and biocides can pollute water courses and result in the death of fish and fish-eating predatory birds. Also, the residues of the biocides may contaminate foodstuffs and result in human health problems.

In contrast, the methods of multiple cropping and organic fertilizing, the traditional basis of the intensive, commercial, vegetable farming system in Miura Peninsula, show all the characteristics of appropriate technology. These are the methods which could make it possible for poor farmers in developing countries to achieve high levels of crop production per unit area of land with a low input of capital and a high input of labour. Complementary, traditional farming methods, which also show the characteristics of appropriate technology, include (i) the use of hoes or animal-drawn cultivating equipment for soil preparation, (ii) the local selection and saving of seeds (of the best crop plants) on the farms to develop crop varieties adapted to local conditions, with occasional hybridization if it would greatly raise

crop yield or quality, (iii) the weeding of crops by hand, (iv) the terracing of fields where runoff problems are serious, (v) the planting of windbreaks where strong winds are a problem, and (vi) the use of hand carts and animal-drawn carts for transportation. Complementary modern farming methods, which show the characteristics of appropriate technology, include the use of biological methods of pest and disease control, where the cost of these is low.

Although these mainly traditional farming methods are generally appropriate to poor farmers in densely populated parts of developing countries, some constraints on their possible transferability do exist in certain particular types of cultural, social and natural environments. These constraints, which mainly apply to organic fertilizing and multiple cropping, may be considered as follows.

In the cultural environment, there are, first of all, the high aspirations of some people in positions of political leadership, i.e. the policy makers, who want to see the use of high technology rather than appropriate technology as a matter of principle. These people like to see, for example, the use of modern, brightly painted farm machinery and modern, chemical fertilizers on the farms as a sign of progress. Their aspirations can act as a constraint on the extension of appropriate farming methods to poor farmers. However, poor farmers are usually very practical people and not so easily moved by such romantic ideas of progress. Secondly, and rather more serious, are the taboos that exist regarding the handling of specific organic materials. Such taboos may constrain the use of night-soil and pig manure as fertilizers. Pig manure, for example, may not be handled by people of the Islamic religion. Fortunately though, such taboos rarely apply to more than one of the organic materials available for use as fertilizers in any one location.

In the social environment, there are, first of all, constraints on the use of some organic materials as fertilizers where these materials are needed for other purposes. For example, in many parts of India, cattle manure is needed as a fuel of cooking. However, this particular constraint can be overcome through the adoption of biogas technology, which enables the production of both methane gas for cooking and fermented cattle manure for soil fertilization, by a process of anaerobic fermentation of cattle manure in low-cost, purpose-built manure digesters. Also, although fish meal is a potentially useful fertilizer, its use as such should be constrained in areas with malnutrition problems, by considerations of the value of its protein content in human nutrition.

Secondly, in the social environment, there are the human disease risks associated with the use of night-soil as a fertilizer. Pathogens of one or more of the following human diseases may be present in a given sample of fresh night-soil: cholera, typhoid, paratyphoid A and B, bacterial dysentery, amoebic dysentery, hookworm and roundworm. However, storage and fermentation of night-soil over a period of time lasting from several weeks to several months, as was traditional in Japanese agriculture, kills or severely debilitates any of the pathogenic organisms that may be present (Swanson, 1949: 279). Assuming, then, that night-soil can be adequately treated prior to its use, it surely has a great potential as a fertilizer which is universally available. Its actual use as a fertilizer should perhaps be considered more realistically, that is from the viewpoint that its use can in fact aid sanitation in many instances. For example, Nicholson (1907: 58), a senior government official in India who visited Japan in 1906, contrasted the scrupulous collection, storage and field application of night-soil in Japan with the contemporary sanitary negligence in India, where human

excrements were left to fester on the soil around the houses and to pollute the drinking water in the villages.

In the natural environment, multiple cropping may be constrained by extremes in the water balance. In arid areas, or in semi-arid areas with long dry seasons, year-round multiple cropping is constrained by water shortage, unless irrigation water is available. Fortunately though, not a few of the more densely populated parts of developing countries are located in the humid tropics, where rainfall is spread more evenly over more months in the year. However, some locations in the humid tropics experience seasonal deep flooding, which constrains multiple cropping unless aquatic crops can be grown, such as deep water rice.

To sum up, there are some constraints on the transferability of certain of the appropriate farming methods of Miura Peninsula to poor farmers in developing countries, in particular environmental situations. However, these constraints are very specific in nature and can often be overcome, for example, by careful selection of alternative materials in the case of organic fertilizers. Hence, it can be reasonably maintained that, apart from some very specific exceptions, the appropriate farming methods are generally transferable to poor farmers in developing countries.

IV. *Conclusion*

The main finding of this study is that the Japanese vegetable farming system, as found in Miura Peninsula, does represent a source of appropriate technology for poor farmers in developing countries, for the purpose of increasing local food production. The methods of multiple cropping and organic fertilizing, which form the traditional basis of this highly productive system, are appropriate for poor farmers because they are (i) economical in their use of capital (ii) intensive in their use of labour (iii) small in their scale of production and (iv) compatible with, and generally transferable to, local cultural, social and natural environments in developing countries. A number of other methods used in vegetable farming in Miura Peninsula, complementary to multiple cropping and organic fertilizing, are also appropriate in the same terms. These methods include the use of hoes and animal-drawn cultivating equipment, the selecting and saving of seeds on the farms, the weeding of crops by hand, the use of hand carts and animal-drawn carts for transportation and the biological control of crop pests and diseases.

The conclusion to be drawn from this finding is that agencies concerned with increasing food production and alleviating poverty in developing countries should give special consideration to the transfer of a package of appropriate vegetable farming methods based on the traditional Japanese model as found in Miura Peninsula. Local studies and field trials could be set up in many different locations to adapt these methods to different environments and to help local farmers adopt those that would be most beneficial to them and to other people in their local communities.

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