Present and Future Outlook for Sweet Potato in Asia Research and Development Needs

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Abstract

Cereal crops have fed the world population for a number of years. Still, the world is confronted with an increasing population with an increasing need for food. The sweet potato is being considered as a valuable crop to answer the world hunger problem because one hectare of sweet potato can feed more people from any other crop.

The paper outlines the present and future status of sweet potato production and utilization in Asia. Development programs and research needs and goals for the production of high quality sweet potato are discussed and identified.

Introduction

Sweet potato *(Ipomoea batatas)* originated in tropical America and the West Indies, where it was used as a food crop by prehistoric cultures (Cobley, 1956). It was introduced in Europe before the white potato, and was widely distributed in Asia and Africa in the 15th Century. It is now grown in every part of the tropics and in latitudes 40^{o}N and S of the equator.

An early world traveler, sweet potato had reached New Guinea and New Zealand before the time of Columbus and played an important role in the colonization and welfare of the Pacific Islands.

In 1974, the Food and Agriculture Organization estimated that approximately 84% of the world's sweet potato production was on the Chinese Mainland.

Crosby (1963), in his study of the organic constituents of food, reported that the sweet potato was originally called "Spanish potato" to distinguish it from Irish potato. In the southern part of the United States, sweet potato is generally known as "yam", although it has no botanical relation to the true yam (*Dioscorea spp.)*

Sweet potato has not yet achieved its rightful place as a vegetable or as a food crop and too little research attention has been given to its improvement. A possible reason for this is that its value as a food for humans and animals and as a cash crop for farmers was not fully appreciated in the past (Strydom and Hyman, 1965).

Sweet potato should not be regarded as just another starch food. It is also rich in nutrients, particularly carotene and a precursor to vitamin A, in the case of yellow or orange varieties. Sweet potato contains as much vitamin C as tomatoes, considerable quantities of the B vitamins and minerals. Some varieties have been shown to contain substantial amounts of protein, up to 7% on a dry weight basis.

There probably are several reasons why the sweet potato is not fully appreciated as a food for human beings, particularly among Asians. Prejudice against it may be the result of ignorance, and unpalatable fibrous and unripe sweet potato varieties often are offered commercially. Historically, the sweet potato has been a famine food, a food of last resort, and commonly the characteristic diet of poor people. The low esteem of sweet potato and the strong preference for rice among Asians are perhaps its biggest drawbacks.

Often considered a poor man's spinach, sweet potato leaves have high protein content which supplements the low protein content of the roots. In West Africa, sweet potato greens are particularly important, and varieties with leaves high in calcium and vitamin A (AVRDC, 1975) have been developed.

Tropical root crops such as sweet potato have traditionally been regarded as inferior foods and less worthy of attention than the cereals. Huge amounts of research have been done on staple cereals, but root crops have been seriously neglected (AVRDC, 1975).

In recent years, however, the production of sweet potato has attracted considerable attention in some countries. The reason for the increasing interest in sweet potato is readily apparent in light of the food shortage. The sweet potato represents an inexpensive, concentrated source of food energy.

Research Status and Agricultural Problems

Sweet potato produces a good yield throughout the year. Although the crop tolerates most soil types, it prefers the lighter, sandier soils. It grows equally well under irrigation in the drier areas. Sweet potato is of great value throughout the tropics as a vegetable root crop. When fermented, the roots yield a high proportion of alcohol. Young leaves can be used as green leafy vegetables and the fresh vines are used as fodder for all classes of livestock (Cobley, 1956).

The sweet potato is grown on a variety of soils, including soils of low fertility and pH. The plant has good drought tolerance and produces high amounts of dry matter (per hectare per day) under adverse conditions (Hahn, 1977). National average yields of 20 tons per ha fresh weight have been achieved in several countries, with 30 to 40% dry matter. Some sweet potato growing areas regularly produce 30 tons per ha and yields of 60 tons per ha in 5 months have been produced experimentally (AVRDC, 1979).

The drought tolerance of sweet potato has been tested by reciprocal grafting (IITA, 1975) and it has been shown to be readily subject to improvement through breeding. Sweet potato cultivars are known to be highly variable in their interaction with environment. This genotype x environment interaction means that much local testing and selection is required to produce best adapted lines. This interaction is high among seasons, climates, soils and locations and emphasizes the need for selection of the most stable lines in breeding for cultivars with wide adaptability and consistent performance.

Germplasm resources of sweet potato are great and varied. About 400 identified cultivars are in the AVRDC collection, but few accessions have been obtained from the large numbers known in China and Papua New Guinea. International plant quarantine regulations greatly restrict the movement of vegetatively propagated crops such as sweet potato.

Good seed, regardless of the crop, is one of the most important factors in crop production. This is especially true of sweet potato, owing to the fact that mutations occur frequently. Approximately one visible mutation occurs in sweet potato for every 10,000 plants.

In studies made in 1934 with Unit I Puerto Rico at the Louisiana Agricultural Experiment Station, 6 mutants were found per 100 roots produced. The Unit I Puerto Rico, selected from 16,000 hills, is an example of improvement in flesh and skin color.

It usually requires 8 to 10 years from the time a new cultivar is first grown until it is released as a named variety. No cultivar is introduced or named unless it possesses one or more characters superior to any existing variety (Miller, et al., 1959).

Cobley (1965) states that not only do sweet potato varieties differ in their leaf form, but the leaves of the same plant can show considerable variation. This gives us a clear idea of how much variation there is in the sweet potato plant. Plant breeders experience great difficulty in developing uniform "varieties" and in maintaining them when produced.

Variety "Julian" proved to be well adapted to production for canning because of its high carotenoids, low fiber, firmness, high production of medium sized roots and resistance to internal cork and stem rot (Louisiana Agr. Expt. Sta., 1964).

In a study to determine carotene content in parental varieties and their offspring in the sweet potato, Wang and Lin (1969) concluded that there were great differences among varieties and clones. None of the varieties or clones with white flesh were found to have any carotene content. The more the carotene content, the deeper yellow the flesh color. The use of available breeding lines, either variety or clone, with high levels of carotene as breeding parents may be expected to raise the tendency for the higher carotene content of the sweet potato.

Li, in his study on the variation in protein content and its relation to other characters in sweet potatoes concluded that protein content in roots of the various sweet potato cultivars ranged from 1.27% to 10.07% (dry basis) and the effective protein content of stem and leaves from 12.1% to 25.7% (dry basis). Therefore, a wide range of protein content exists in the various sweet potato cultivars.

Varieties vary to a considerable extent in their protein levels, but it should be possible through breeding programs to select new clones for both high root yield and high protein content (Li, 1974).

The sweet potato is an efficient converter of solar energy into carbohydrate. The photosynthetic production of dry matter is strongly influenced by mineral nutrition, soil moisture, solar radiation, temperature and other environmental elements. Correlation studies of mineral nutrition with photosynthesis (Tsuno and Fujise, 1965) showed high correlations with potassium, low with phosphorus and a negative correlation with carbohydrate in the leaf blade. High positive correlations were shown between the three nutrients.

Morita (1971) in his study of the effect of nitrogen applications on the rate of nitrogen absorption as related to top growth and formation and thickening of tuberous roots in sweet potato, found that applying nitrogen at about 30 days after planting in sandy soils was unfavorable to tuberous root formation during the one month period from mid-July to mid-August, because the higher rate of nitrogen absorption produced vigorous vine growth.

However, the marked absorption of N during the period of thickening growth after tuberous root inflation was favorable to the increase of tuberous root yield.

In clayey soil, the application of nitrogen 10 days after planting favored both formation and thickening of tuberous roots because the virogorus growth of vines resulted in the high rates of nitrogen absorption throughout the growing season. Such a nitrogen status caused a higher yield of tuberous roots.

Aerobic conditions were more favorable for tuber formation than high temperature and non-exposure. Non-aerobic conditions and exposure to sunlight were unfavorable to tuber formation. Meristematic activity of primary cambium was high and the degree of lignification of stele cells as small in the roots under favorable conditions (Kumano & Fujise, 1971).

It is well known that potassium affects the root yield of sweet potato more than other elements by increasing photosynthesis per unit of leaf area. When high levels of N are applied, the leaf area expands rapidly and net assimilation frequently declines owing to mutual shading, even with extended leaf area duration. High K levels also increase leaf area duration, but excessive leaf growth is suppressed, resulting in higher root yield (Hahn, 1977). Key factors for increased sweet potato yield are the careful regulation of N levels and a liberal supply of K to increase sink capacity and photosynthesis (Tsuno and Fujise, 1968).

Sweet potato yields are generally limited by the sink capacity, i.e., formation of roots, their rate of expansion and the ratio between leaf (or vine) and root. Where soils are poor, or long, continuous production has limited vine (source) growth, the source may be inadequate, but under moderately favorable combinations of temperature, moisture and soil fertility, especially in the lowland tropics, sink capacity is probably inadequate. Management practices should generally be directed toward this factor.

Using reciprocal grafting and other techniques, a number of workers (Hozyo and Park, 1971; Hahn, 1977) have shown that in most cases a good sink source produced high root yield with both low and high productivity vines.

Sweet potato varieties have been screened by Sadik (IITA, 1973) to identify plants with high photosynthetic efficiency or low CO_2 compensation points. Successful plants showed no consistent improvement in biomass yield, although their photosynthetic efficiency was high. There has been little success in identifying useful higher photosynthetic efficiency plants, since it is generally found that the storage and mobilization of the assimilates so universally limiting (IITA, 1974).

Present Production and Utilization

The world distribution of sweet potato acreage and production in the last 17 years (1961-1977), according to FAO Production Yearbook (FAO, 1978), clearly shows the dominance of Asian production, i.e., Asian countries have from 88 to 92 percent of total world sweet potato acreage and production; Africa ranks second, South America third, North and Central America fourth, Oceania and Europe are insignificant.

In general, the acreage and unit yield from 1961 to 1977 showed some increase around the globe. The world sweet potato acreage in 1961-65 was 13 million hectares, compared with 14 million hectares in 1977, a 10.5% increase; the world production of 108 million m/t in 1961-65 compared with that of 138 million m/t in 1977, an increase of 19%. The increase in world production of sweet potato was achieved less from the expansion of planted area than from increased unit yield, i.e., the average yield in 1961-65 was 8.3 t per hectare and the yield in 1977 was increased to 9.6 t per hectare, representing an increase of 15.8%.

Table 1. General review of world production of sweet potato (FAO, 1978)

	Area (1,000 ha)		Unit yield (kg/ha)		Production (1000 m/t)	
	(1961-65)	1977	1961-65	1977	1961-65	1977
World	12,977	14,334	8,320	9,638	107,964	138,148
Africa	1,016	829	4,512	6,336	4,585	5,253
N.C. America	181	160	7,169	7,625	1,297	1,219
S. America	247	248	9,689	10,443	2,397	2,592
Asia	11,433	12,978	8,671	9,982	99,139	128,337
Europe	11	13	13,326	10,385	151	134
Oceania	88	106	4,507	5,376	396	572

Philippines – Sweet potato can be grown throughout the year in a very wide range of soils. They are raised for home consumption as well as for commercial purposes. The average yield of 3.1 t per hectare in the Philippines suggested the need to introduce new technology in the production of sweet potato, such as the use of high-yielding varieties, use of appropriate kind and amount of fertilizer and protection chemicals (Cruz, et al, 1977). The crop would also benefit from the use of better quality soils.

None of the farmers surveyed used fertilizer for sweet potato. Encouraging farmers to use the appropriate kind and quality of fertlizer should increase production. Unless the use of plant protection chemicals is stressed, higher production in the Philippines may not be attained.

Farmers reported a lack of production technicians who could provide necessary assistance in improving the production of sweet potato. Sweet potato production on small and medium farms and on low and medium yield farms was not a profitable agricultural enterprise. Improved storage techniques and alternative uses for the crop would improve profitability.

Republic of S. Africa – In recent years the production of sweet potato has expanded rapidly, due partly to the appreciation of its nutritive value. Sweet potatoes make a particularly large contribution to the daily nutritional requirements of an adult as far as vitamin A and C are concerned. This is to say, if a man eats a portion of sweet potato daily, he need not supplement his diet in any way to obtain an adequate supply of vitamin A (Strydom and Hyman, 1965).

Consumption of sweet potato is limited mainly by prejudice, poor quality and poor keeping quality. Irish potatoes are inferior to sweet potato in vitamin A and calcium, but for many other factors there is a great similarity between them (Strydom and Hyman, 1965).

The United States of America – In 1962, sweet potato ranked 7th by weight in per capita consumption of major food crops in the United States. The total world production for 1961 was some 208,300,000 metric tons. Of this U.S. produced 701,000 tons; Republic of China, 2,979,000 tons; Indonesia 2,790,000 tons and Japan, which led world production, 6,277,000 metric tons. Sweet potato represents an inexpensive and nutritious

Table 2. Principal nutritional composition of sweet and irish potatoes

	Vit. A. IU/lb.	Vit. C. mg/lb.	Protein	Fibre	Calcium	Calories
			– – – – – – – Constituents in grams			
Irish potato	180	82	8.2	2.3	59	347
Sweet potato						
Yellow var.	10,000	91	7.3	3.6	109	423
White var.	230	91				

food crop (Crosby, 1963).

A survey for a number of years has shown that up to 40% of the total sweet potato crop of the southern United States is lost due to diseases, late harvesting, poor storage, or rough handling. In Georgia alone, this loss is calculated at US$6,000,000 annually.

Storing sweet potatoes for the fresh market is difficult. Temperatures below 50°F cause internal discoloration, while storage at 65°F or above permits excessive sprouting and respiration at such a rate that pithiness and other evidences of loss of quality develop in two to four months, depending largely upon the extent of the temperature increase, relative humidity, and the variety (Woodroff, Dupree and Cecil, 1955).

In Louisiana, storing sweet potato is necessary in order to spread consumption of the crop over a relatively long period. To attempt to force consumption of the entire production during a short period would result in disastrously low prices. However, from the standpoint of individual growers, the object of storing marketable sweet potatoes is to make more money than could be made if the crop were sold at digging time (Miller and Woodin, 1944).

Dehydrated sweet potatoes retained by farmers were used on the farms to feed dairy cattle and other classes of livestock, including beef cattle, chickens, hogs, and work stock. Dehydrators sell their product mainly to dairymen, and to a less extent to feed dealers and feed mills.

Although dehydrated sweet potatoes compared favorably with corn and other carbohydrate feeds in feeding value, it is uneconomical at existing levels of production and dehydration costs for most farmers to grow sweet potatoes primarily as a feed crop. The major role of dehydration was for some time of a salvage nature in the commercial production of sweet potatoes for table use (Miller, Ford and Woodin, 1949).

Sweet potato production in Taiwan

The importance of sweet potato in the overall field crops production in Taiwan is next only to rice. Before 1979, sweet potato was commonly used as feed (63%), table use (30%) and for starch processing (7%). This crop can be grown all year round. For adaptation to the existing cropping patterns, in 1970, 13% of the annual sweet potato planted area was distributed in the spring season (March-April), 14% in the summer (May-June) and 73% in the autumn season (September-October), mainly along the west coast of southern Taiwan.

Table 3. **Changes in sweet potato acreage and production in Taiwan. (1968-1977).**

	Harvested area (ha)	Yield per hectare (kg)	Production (m.t.)
1968	240,316	14,334	3,444,619
1969	232,726	15,906	3,701,769
1970	228,713	15,044	3,440,639
1971	225,293	15,053	3,391,354
1972	210,609	13,901	2,927,708
1973	200,746	15,959	3,203,778
1974	180,152	15,476	2,788,096
1975	156,705	15,337	2,403,440
1976	123,735	14,959	1,850,992
1977	108,990	15,551	1,694,782

Ref.: Taiwan Agricultural Yearbook, 1978.

Within a decade, both the acreage harvested and total production have shown a sharp decline. This situation is entirely due to the high labor cost resulting from rapid industrialization and the availability of inexpensive imported feedstuffs on the local market.

Most of the spring and summer crops are grown on dryland and seldom intercropped with any other crops, while the autumn crop is raised on either double-cropped or single-cropped paddy fields and sometimes intercropped with rice, corn, sugarcane, soybean or peanut.

This multiple and interplanting pattern developed in each district constitutes one aspect of the intensive land utilization in Taiwan.

Among the cultural methods adopted, relay-interplanting of sweet potato in double-cropped paddy fields deserves special mention. Cuttings are planted beside every 4th or 5th row of the rice plants about 40 days prior to harvest of rice. This simultaneous growth of both crops enables the sweet potato cuttings to have a longer growing period before the land is used again for transplanting the next rice crop, while the remaining soil moisture and the residual fertilizer can be utilized for an early and better development of the young cuttings. The recommended planting distances of sweet potato are 0.8 to 1.0 m x 0.20 to 0.25 m with an approximate density of 45,000 to 50,000 plants per hectare, to be harvested after 5 to 6 months.

Surveys conducted in Taiwan in 1977 by AVRDC (Calkins, et al.) disclosed the following:

1. The fall crop has the highest yield and summer crop the lowest.
2. Yields in areas with irrigation systems are better than those in rainfed areas.

3. Loam and sandy loam soils are the most suitable for sweet potato production.
4. More economical use of fertilizer is needed.
5. The yield of mono-cultivated sweet potato is greater than that of intercropped sweet potato.
6. Both overall investment and net profit by season are positively correlated with agronomic yield potential.
7. Because of other more desirable alternatives, area planted to sweet potato in best areas for their production is decreasing most rapidly.
8. The switch of hog producers to use of concentrated feed and the presence of starch factories are major stimuli to marketing of sweet potato. The crop was once used mainly on the farm as feed.
9. Profitable alternatives are few without irrigation.
10. Current producers have more land and face more natural constraints than former producers.

    (Ref: AVRDC Tech. Bull No. 4 – Farmers' Viewpoint of Sweet Potato in Taiwan, AVRDC, 1977).

Highlights of AVRDC Research Findings on Sweet Potato

The increase in total population with proportionately fewer people remaining in the rural areas will place an increasingly heavy burden on the small farmer to produce more food. Research must not only be focused on production increase to meet the demand from population growth, but also to meet the growing demand of an ever expanding, non-food-producing urban sector. Root crops such as sweet potato are better able to meet the needs of the present farmer for a crop that yields well with relatively few inputs, and to meet the needs of low income people for an inexpensive source of calories (AVRDC, 1975).

AVRDC's sweet potato research objectives include selecting for high yield under tropical conditions, high protein content, high B-carotene (precursor for vitamin A) content, resistance to weevil (*Cylas formicarius*) infestation and tolerance to the witches' broom disease.

Asian generally prefer a hard, white, dry sweet potato, which is high in starch, low in protein, and contains almost no B-carotene. The cultivars from the United States are generally high yielding and contain greater amounts of protein and B-carotene. Such cultivars are generally too moist for Asians. Crosses made between the U.S. and Asian cultivars attempt to develop lines that are richer in protein and B-carotene with high yields, yet retain some degree of the drier texture and superior keeping quality preferred by Asians (AVRDC, 1975).

Although different varietal response to fertilizer application levels was observed during different seasons of AVRDC, increasing levels of nitrogen required proportionally larger levels of potassium for maximum sweet potato yields.

During both the summer and winter seasons of 1975-76, some of AVRDC's better table type breeding lines were tested and selection 35-2 (HDK 6/B6708) performed very well in both plantings (AVRDC, 1976).

In a series of trials, sweet potato yield and protein content were generally negatively correlated among cultivars. However, when root analysis was made from the line 35-2, which had been grown in a management trial under 15 different fertilizer treatments, a positive correlation was obtained between yield and protein content. This result indicates that both yield and protein content might be improved through such management practices as nitrogen application (AVRDC, 1976). A significant correlation (r = 0.92) between the protein content of sweet potato roots and trypsin inhibitor activity was found at AVRDC (AVRDC, 1975). To determine whether or not the above findings can be satisfactorily applied certainly requires further research.

From cool season trials and during the typhoon season, AVRDC scientists observed that cultivars with high yields had considerably lower vine/root ratio than the low yielders. In general, perhaps it is true that the high yielding selections had lower vine/root ratio – the ratio of the fresh weight of the vines to fresh weight of the roots. Exceptions also were observed at AVRDC. The variety Centennial had an extremely low vine/root ratio along with a low yield. Therefore, the real picture concerning the relationship between vine/root ratio and yield also needs further research.

In 1977 a cool, dry season trial indicated that rototilled land, compared with rice-stubble culture, produced highly significant increases in average root yield, and a highly significant decrease in vine/root ratio. Fertilizer and weed control significantly increased total root yield, vine weight and number of roots. Vine turning had no effect. Banking, compared with no banking, significantly increased total and marketable root yields.

During the wet season in 1977, sweet potatoes exhibited excessive vine growth and failed to produce large, fleshy roots. Pruning at one month produced the highest root yields (33% greater than the check). The vine to root ratio for this treatment was 31% lower than the ratio for the check.

In a study of the effect of top-growth retardation on sweet potato yield, pruning at 20 cm length appeared to increase root yields during the wet season.

Research workers at AVRDC assumed that soil compactness affected root initiation and enlargement of sweet potato roots. An experiment indicated clearly that there was a highly significant difference in root yield between levels of soil compactness. There was a highly significant interaction between soil texture and compactness. Both AVRDC 35-2 and Tainung 57 cultivars yielded better on compact rather than non-compact sand, but a non-compact loam gave the highest root yield.

Table 4. Mean root weight (g/flat) as affected by soil texture and compaction, AVRDC, 1978

Cultivar	Sand[1/]			Loam		
	Compact	Non-compact	g/flat	Compact	Non-compact	Mean
Tainan 57	228	134		144	356	215
AIS 35-2	297	276		161	406	285

[1/] Bulk density of the two soils without compaction were 1.6 (sand) and 1.4 (loam).

Chemical analysis of sweet potato quality conducted at AVRDC provided preliminary but dependable information. Scientists found that sweet potato nutritional qualities have wide genetic variability even within the same root A distinct varietal difference was found for most characteristics analyzed. Ranges of several characters were as follows:

Items	Range*
Dry matter	12 - 36%
Crude Protein	2 - 12% (dry weight)
B-carotene	0 21 (mg/100 g fresh weight)
Starch	30 – 48% (dry weight)
Sugar	8 – 40% (dry weight)

*228 cultivars were analyzed in this study.

Chemical analysis also shows that sweet potato tips are highly nutritious and valuable as a green leafy vegetable, especially during the summer season when fresh leafy vegetables are not available on the market in most Southeast Asian countries. Sweet potato tips have a high content of vitamin B_2, calcium and iron, besides vitamin A and C. The eating quality can be improved through breeding. There is higher protein content and low oxalate in the first 14 cm of the tips. This part is, therefore, recommended for human consumption. The range and mean of some selected nutrients in sweet potato tips are shown in Table 5 (AVRDC, 1977).

Improved analytical techniques for screening purposes have been developed at AVRDC. Analysis of B-carotene by AOAC method is found rather slow and expensive. A modified and efficient method has been developed using the Hunter colorimeter to determine orange color values of ground, dry, root tissue. The essential advantages of this modified method are o two kinds, namely:

1. Substantial reduction of cost and time.
2. Reduction of variability from different roots by using a mixture of several root samples.

The regression urve between the standard AOAC method and the modified method is shown in Figure 1 (AVRDC, 1977). The basic technique is described in the reports.

On the basis of production budgets and simple regression analysis from a survey of sweet potato farmers in three townships in Taiwan conducted by AVRDC agricultural economists, the following facts were established:

1. The higher the yield, the higher the net return.
2. Inputs contributed to increases in yields; however, over-investment by many farmers caused negative or low correlations between capital inputs and yields.
3. The higher the investment in human labor, the higher the yield.
4. The most labor-intensive operations are planting and harvesting, regardless of cultural method employed.
5. Regardless of cultivation method, sweet potato is less labor and capital intensive than alternative vegetable crops which may be grown in the fall.
6. Highest net and farm return are associated not with high yield but with low cost. With the falling demand and declining price of sweet potato in Taiwan, low input and/or low cost technology is essential to growers.
7. Sweet potato yield and profitability were distinctly different in each area studied.

Table 5. Nutritional constituents of leaf tips of 10 sweet potato cultivars[a] and of five common leafy vegetables[b].

AVRDC Acc. No.	Entry	Water	Protein	Fiber	Ash	Ca	Fe	Vit A	Vit B_2	Vit C	Oxalate
		– – –	– – % – –	– – –	– – –	mg/100 g	– – –	IU/100g	mg/kg	– – –	mg/100 g
112	PI 344120	87.1	2.8	1.8	1.41	67	3.4	5390	3.7	43	3.6
33	Earlyport	87.7	2.4	1.9	1.51	72	3.6	4870	3.6	41	2.8
119	PI 344138	86.8	2.7	1.8	1.51	72	3.9	5740	3.1	35	3.4
229	Kinangkong	87.1	2.9	1.9	1.63	71	3.4	5390	3.6	37	3.9
212	Dilaw	87.8	2.7	1.9	1.65	84	3.6	3520	3.1	33	3.9
1 (check)	BNAS-White	83.6	3.0	2.3	2.14	58	4.8	5290	2.9	39	3.3
8	Daja 380	86.3	2.4	2.0	1.63	72	3.6	4850	4.1	36	4.4
31	Rose Centennial	85.5	2.8	2.0	1.82	90	2.7	8320	3.6	73	4.5
127	HM 16	85.4	2.8	1.9	1.69	73	5.0	5780	3.4	32	3.0
104	PI 318856	83.9	2.8	2.2	1.79	87	4.4	6650	3.5	44	4.2
Mean		86.1	2.74	1.96	1.68	74.4	3.94	5580	3.5	41.07	3.7
LSD%		1 23	ns	0.28	0.26	ns	ns	ns	0.5	10.68	0.9
				Nutritional constituents of five common leafy vegetables[b]							
Water convolvulus (EP)		91.8	2.3	0.9	1.0	94	1.4	4200	2.0	43	
Spinach		92.3	2.3	0.8	1.7	70	2.4	10500	1.8	60	-10.0
Amaranth, green (EP)		87.8	1.8	1.3	21	300	6.3	1800	2.3	17	17.5
									Amaranthus hybrids		
Head lettuce		96.3	0.9	0.3	0.2	14	0.2	4300	0.3	6	–
Leaf mustard		91.7	1.6	0.6	0.8	138	0.7	2700	1.9	94	–

[a]10 cultivars were planted July 28, 1976 and 15 cm tips were harvested Sept. 6, 1976. All values are means of 3 replications.

[b]Adapted from T.C. Tung, P.C. Huang, H.C. Li., and H.L. Chen, "Composition of foods used in Taiwan"; from Sidki Sadik, "Oxalates contents of some leafy vegetables." Proceedings of Institutional Institute of Tropical Agriculture Seminar 1971.

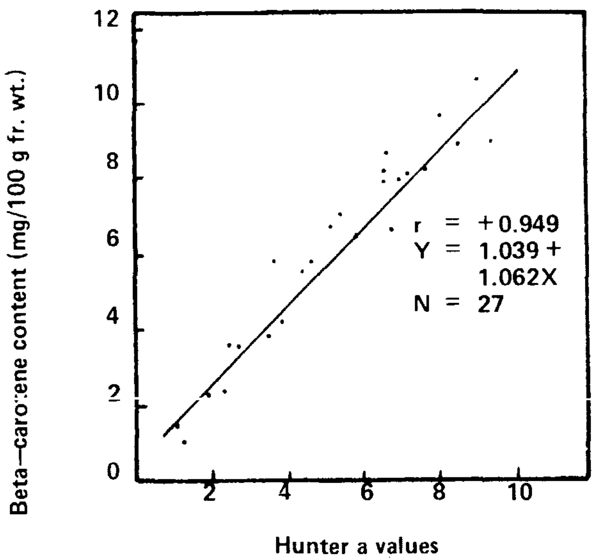

Fig. 1. Regression of Beta-carotene content in fresh sweet potato roots on Hunter a values of dried sweet potato powder.

Future Outlook – Research and Development Needs

Research needs. Germplasm resources of the sweet potato are incompletely collected and preserved. Despite large collections in AVRDC, the United States and Japan, much more material could be added from Latin America and especially from Papua New Guinea.

The true botanical ancestor(s) of the sweet potato is unknown at present and much basic work is needed before it can be identified. A complete cytological study of the genus *Ipomoea* followed by a whole series of hybridizational studies on the members of genus from the Central and South American regions is needed (O' Brien, 1972).

In addition to (1) the development of varieties to meet specific purposes of utilization (for table use, leafy vegetable, starch processing and animal feed, etc.) (2) the development of varieties resistant to major pests (potato weevil) and disease (witches' broom) and (3) the development of efficient cultural methods (low input and good fit with a changing cropping pattern), the following areas are also considered important:

(a) Plant and soil factors – The identification of self and cross incompatibility of sweet potato entries, the general and specific combining ability of different types of cross combination, the discovery of factors affecting flowering and seed setting and methods of promoting flowering, the analysis of yield components through correlation and path coefficients, improvement of field and sampling techniques for progeny selection, appropriate fertilizer recommendations, critical times for irrigation and soil moisture content in relation to yield and quality of sweet potato.

(b) Mechanization – The mechanization of major farming operations in order to reduce human labor and cost of production and also to improve the efficiency of farming.

(c) Post-harvest handling and storage – The identification of major areas of need, effective means of improvement in food conservation through food loss reduction from producer to consumer, understanding the post-harvest characteristics of new varieties developed by research centers, and the development of simple, inexpensive technology on post-harvest and processing for general application.

Development needs. Much development needs to be done and caution should be exercised in bringing this nutritious root crop to public attention. The development needs deserve a sequence of attention and support in order to reach the anticipated goal of success. The following topics are considered essential elements among development needs, namely:

1. Adequate supply of quality planting materials, to be propagated by dependable sources of named varieties, with varietal description as the first step of development.

2. A well organized scheme through which the transmission of research findings can be effectively applied for profitable crop production. Trained man-power, as well as information prepared in many forms, become indispensable to successful implementation.

3. The appreciation of food value of the sweet potato by the public through various educational processes is an important requirement for development. Nutritional education must be intensified, particularly among the poor and illiterate who depend on low-cost diets.

4. Re-evaluation of the sweet potato in the social and economic context of world hunger may reveal techniques useful to a successful development of the sweet potato around the globe.

Weather in most Southeast Asian countries is hot and humid in summer. Vegetable production is low and prices are high. Where varieties with abundant palatable leaves are developed and planted, as in the Philippines, sweet potato tips are an inexpensive leafy vegetable with high potential nutritive values and good market price in the long summer season.

Because the practice of including sweet potatoes, both roots and leaves, in the diet is still uncommon in Asian countries, the nutritive value of sweet potatoes and their contribution to human health should be made more widely known to the general public and the traditional attitude of regarding sweet potatoes as a low-status food for the poor, changed. Therefore, it is necessary and urgent to initiate a campaign to stimulate and promote the extensive planting of superior sweet potato varieties and to make the sweet potato a regular part of the human diet in order to enable people, especially children, to be adequately nourished by their daily diet.

Also, special effort and time should be devoted by food scientists, nutrition specialists, biochemists and home economists to create innovative ways to prepare more appetizing and appealing sweet potato dishes. This will undoubtedly help change people's attitude and encourage their acceptance of the sweet potato.

The improvement of shipping and marketing, another important aspect of development, must rely on the efforts of the agricultural economists and marketing specialists.

Conclusion

Cereal crops, the major staple foods, have fed the world population for thousands of years and received adequate research and development attention all over the world, especially in the recent past. On the other hand, the sweet potato, also with a long history of human use, has received relatively little research attention. Today, the world is confronted with a population explosion and seeking additional food supplies. The sweet potato, an efficient solar energy food convertor is being recognized as a valuable crop to answer the world hunger problem because one hectare of sweet potato can feed more people than any other crop.

The production of more sweet potato of high quality should be approached with active programs of both research and development. The research goal for varietal improvement is to develop lines which are high in protein content and with high yield, but low in sugar and intermediate levels of carotene in order to make the sweet potato a staple food crop. Varieties for animal feed should have the characteristics of high starch, high protein and high yield with improved storage and processing qualities. Varieties for use as dessert or confectionery should be high in sugar, carotene and protein content with an economic yield.

As to the development program, numerous phases of work shall be involved, such as pricing, farming systems, supply of planting materials of dependable quality, increase of acreage, change of food patterns and eating habits, and development of good shipping and marketing systems, etc. All deserve the full support of those who wish to solve the world hunger problem. In short, we now must realize that the sweet potato is one of the most productive, nutritious foods for the expanding world population.

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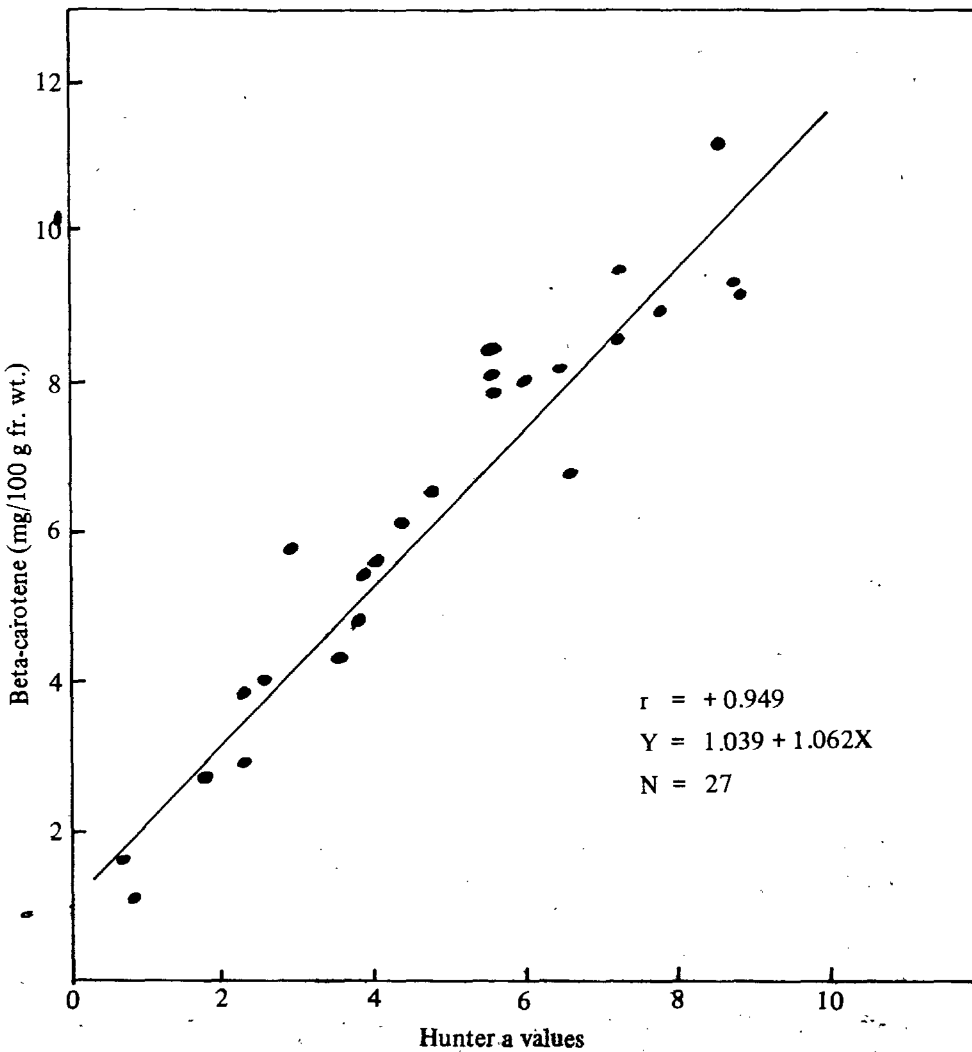

Figure 1. Regression of Beta-carotene content in fresh sweet potato roots on Hunter a values of dried sweet potato powder.

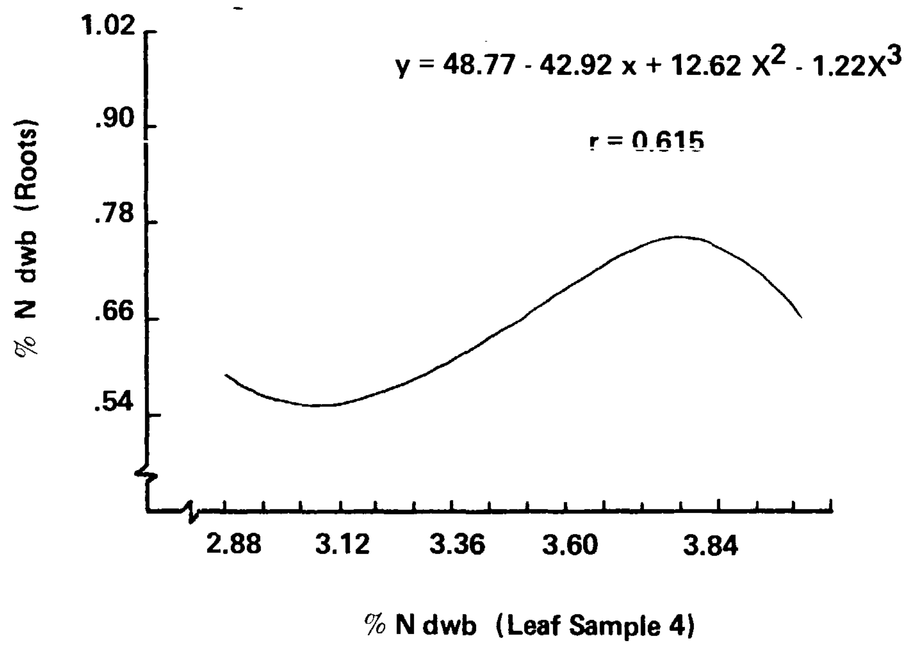

Fig. 2. Percent N dwb in the roots as predicted by % N dwb in the leaves.