Sweetpotato in South Asia:

Postharvest Handling, Storage, Processing, and Use

T.R. Dayal, G.J. Scott, G.T. Kurup, C. Balagopalan

International Potato Center (CIP)

Central Tuber Crops Research Institute (CTCRI)

Sweetpotato comes in all colors and shapes, from bright purple to pale yellow and from roots that are long and slender to round. As varied as its appearance, the sweetpotato's potential contribution to food, feed, and industrial processing in developing countries is only recently being fully explored.

The purpose of this report is to encourage debate and advancement of knowledge about production, distribution, and use of sweetpotatoes in food systems of developing countries. The views expressed are those of the author (s) and do not necessarily reflect the official position of the International Potato Center (CIP) or the Central Tuber Crops Research Institute (CTCRI).

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Foreword

Sweetpotato is the seventh most important food crop in developing countries, producing more edible energy per hectare per day than rice, wheat, maize, or cassava. Most varieties are high in beta-carotene. Although the crop originated in the Americas, current global production is concentrated in Asia. India produces over one million tons annually; Bangladesh roughly half that amount. Despite its importance at the farm level, sweetpotato has considerable untapped potential for food, feed, and industrial uses. Achieving that potential requires a better understanding of users' needs, including existing production patterns and, in particular, current storage, processing, and utilization practices.

In this publication, International Potato Center (CIP) scientists join with national researchers to analyze recent trends in sweetpotato postharvest storage, handling, and utilization in Bangladesh, India, Nepal, Pakistan, and Sri Lanka. This type of baseline information is an indispensable first step toward eliminating barriers to crop improvement and identifying research areas with potential for future impact. It also provides a basis for more effective collaboration among interested scientists and should serve to stimulate the interest of research directors and policymakers in this long-neglected crop.

CIP and the Indian Council for Agricultural Research (ICAR) — Central Tuber Crop Research Institute (CTCRI) — , are pleased to co-publish these findings. We believe that the information will be useful in India and elsewhere in Asia where sweetpotato postharvest issues are also of major interest.

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In Lima, P.I. Ferguson, the editorial consultant for this publication, did a very dedicated job of editing, formatting, and designing the layout of the publication. Anselmo Morales of CIP's Art Section was extremely helpful in redrawing all the figures and maps for publication purposes. The cover design and color scheme were the work of Cecilia Lafosse, head of design in CIP's Graphic Arts Section. To these and several other individuals who provided their time and creativity to preparing and printing this publication, our sincere thanks go out to you all.

The Editors

Acronyms and Abbreviations

AAU	Assam Agricultural University
AICPTC	All India Coordinated Project on Root Crops
AICRP	All India Coordinated Reseach Projects
BARI	Bangladesh Agricultural Research Institute
CIP	International Potato Center
CTCRI	Central Tuber Crops Research Institute
DCS	Department of Census and Statistics (Sri Lanka)
GDP	gross domestic product
IARI	Indian Agricultural Research Institute
ICAR	Indian Council for Agricultural Research
JNKVV	Jawaharlal Nehru Krishi Vishwa Vidyalaya
NGO	Nongovernmental organization
NPSC	National Planning Commission Secretariat (Nepal)
NSC	National Seeds Corporation
R&D	research and development
RH	relative humidity
SPFMV	sweetpotato feathery mottle virus
TCRC	Tuber Crops Research Centre

Weights and Measures

ha	hectare (2.47 acres)
IU	international unit
kg	kilogram (2.2 lbs)
km	kilometer (.68 mile)
q	quintal (220.46 lbs)
t	ton (1000 kg/2,204.6 lbs)

Global Perspectives on Sweetpotato Production and Use

T.R. Dayal, S.K. Mehra, and Gregory J. Scott

Sweetpotato is the world's seventh most important food crop after wheat, rice, maize, potato, barley, and cassava. More than 95% of the global sweetpotato crop is grown in developing countries. Per capita incomes in relation to commodity production are the lowest for sweetpotato among the world's twenty major food crops (Figure 1). Yet, its potential benefit to poor farm households and urban consumers is only now being considered.

Sweetpotato is thought to have originated in the Americas, although the precise location remains unknown. The crop was reportedly introduced into China in the late 16th century (Ge 1992). Because of its hardy nature and broad adaptability, and because its planting material can be rapidly multiplied from a very few roots, sweetpotato spread throughout Asia, Africa, and Latin America during the 17th and 18th centuries. Japan and the United States are the only industrialized countries that grow appreciable amounts (>50,000 t) of sweetpotato today (Table 1).

Annual global production of sweetpotato currently exceeds 124 million t. China is the world's largest producer. It accounts for more than 90% of global output. Vietnam, Indonesia, and Uganda all grow more than two million tons per year. India and Rwanda each harvest more than a million tons annually. Of the 82 developing countries where sweetpotatoes grow in Africa (36), Asia (22), and Latin America (24), 40 countries count sweetpotato among the five most important food crops produced on an annual basis.

At the farm level, sweetpotato is nearly always grown by small farmers with limited land, labor, and capital. The cost of planting material is minimal. Farmers use only vine cuttings rather than seed. The crop is often planted in more marginal fields—poorer soils with limited water supplies. Despite these conditions, sweetpotato can produce remarkable amounts of energy quickly. In fact, sweetpotato produces more edible energy per hectare per day than any other major food crop (Figure 2). These factors explain the sharp increases in sweetpotato production in heavily populated sub-Saharan African countries in recent years.

Sweetpotato for Food, Feed, and Processed Products

Sweetpotato has a cornucopia of uses. These range from consumption of fresh roots or leaves to processing into animal feed, starch, flour, candy, and alcohol. In recent years, sweetpotato's versatility has facilitated major changes in the importance of these various uses around the world in response to shifting supply and demand for food and feed in many developing countries.

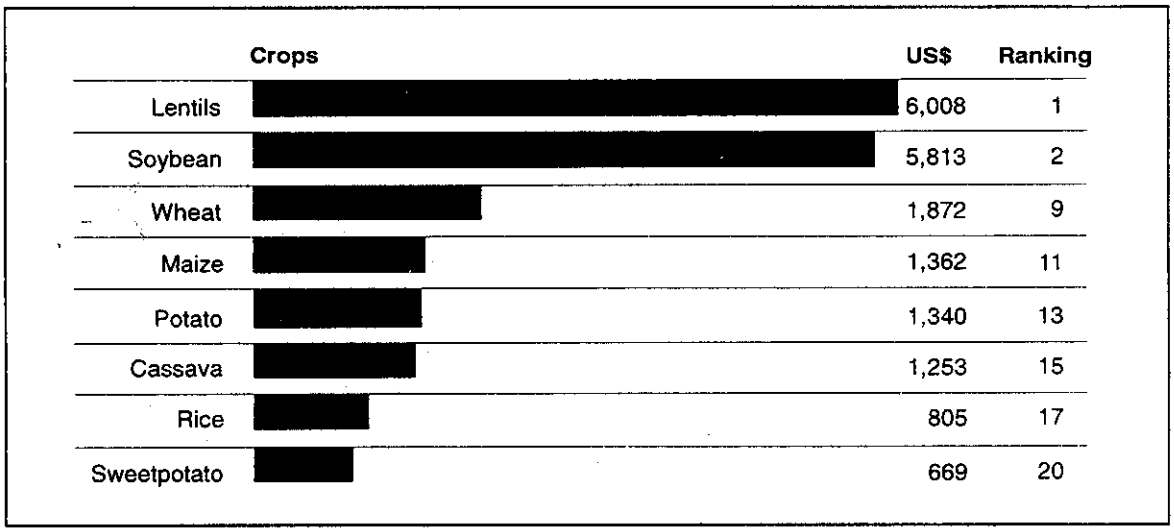

Figure 1. Average income per capita and commodity ranking in relation to major food crop production in developing countries.

Note: Average income per capita = the average, over all developing countries, of proportion of overall production of the crop in each country multiplied by that country's per capita GNP.
Source: Constructed from annual data for production and per capita GNP for 1993 from FAO Faostat-PC 1995, unpublished statistics, and the World Bank 1995 World Development Report.

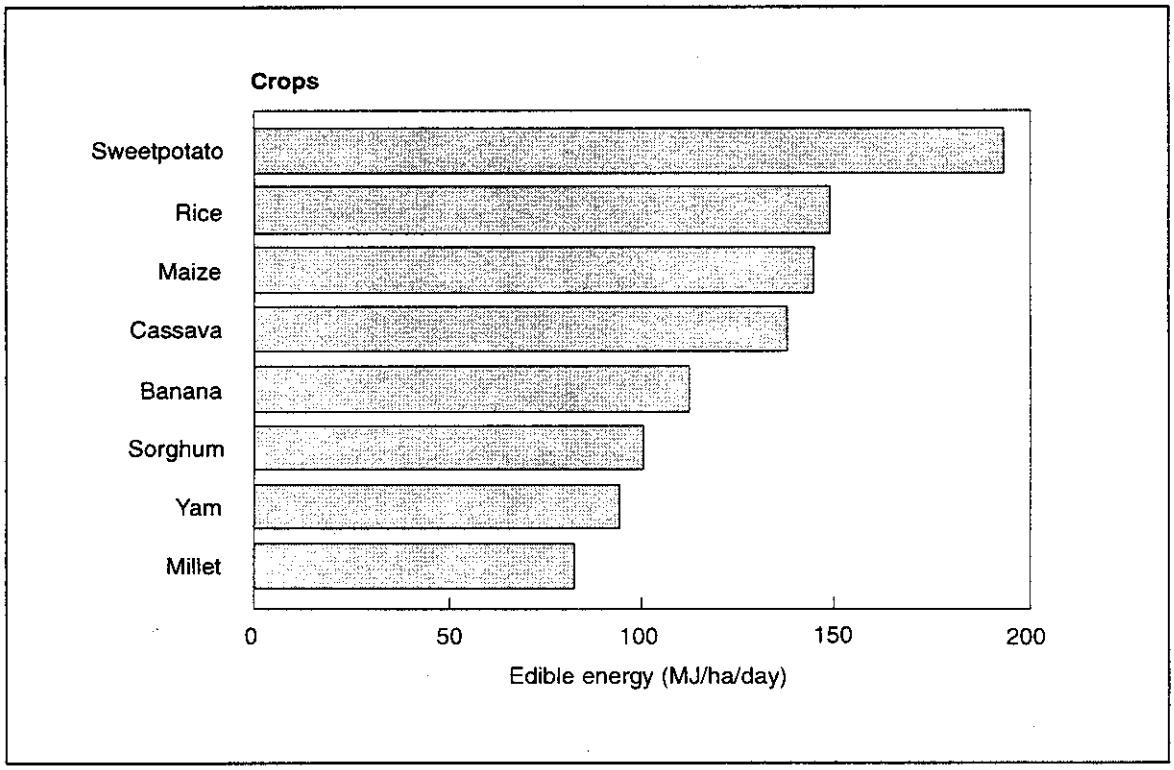

Figure 2. Comparative energy yield of sweetpotato and other major crops.
Source: Woolfe 1992.

Table 1. Sweetpotato production, area, and yield in selected countries, 1961-94.

Major sweetpotato-producing countries	1992-1994			Average annual growth rate[1]			Rank
	Production (000 t)	Area (000 ha)	Yield (t/ha)	Production (%)	Area (%)	Yield (%)	In order of importance vs. other crops[2]
Asia & Oceania[a]	113,642	7,490	15	0.9	-1.4	2.3	4
China	105,004	6,328	17	0.9	-1.6	2.5	2
Vietnam	2,525	392	6	2.5	1.6	0.9	3
Indonesia	2,038	217	9	-1.3	-2.5	1.1	5
India	1,155	138	8	0.5	-0.1	0.6	16
Philippines	690	145	5	-0.2	-0.1	-0.1	5
Korea DPR	501	35	14	2.5	2.5	0.0	5
Papua New Guinea	480	106	5	1.6	1.2	0.4	2
Bangladesh	444	46	10	0.8	0.6	0.2	5
Korea Rep.	305	15	20	-4.3	-5.2	0.9	5
Laos	112	14	8	8.7	6.9	1.7	2
Africa[b]	6,730	1,352	5	2.2	2.4	-0.2	11
Uganda	2,011	460	4	4.2	3.5	0.7	3
Rwanda	1,021	161	6	2.2	2.5	-0.3	2
Burundi	629	103	6	1.6	1.8	-0.1	2
Kenya	627	64	10	4.6	2.9	1.7	3
Madagascar	504	90	6	1.6	1.4	0.1	3
Zaïre	384	82	5	0.9	1.6	-0.7	7
Tanzania	261	201	1	0.7	6.1	-5.4	7
Angola	181	20	9	1.8	0.8	1.0	4
Cameroon	165	31	5	1.3	-1.0	2.3	6
Ethiopia	154	19	8	2.1	2.1	0.0	9
Guinea	127	22	6	1.4	2.6	-1.2	5
Egypt	124	5	27	1.3	0.2	1.1	11
Latin America	1,779	251	7	-1.4	-1.0	-0.4	12
Brazil	619	60	10	-2.7	-2.9	0.1	10
Argentina	279	22	13	-0.9	-1.6	0.7	10
Cuba	213	55	4	0.3	0.7	-0.4	5
Haiti	192	62	3	0.0	1.6	-1.6	6
Peru	146	10	14	-0.1	-1.5	1.4	6
Paraguay	97	12	8	1.0	1.4	-0.4	6
Dominican Republic	59	9	7	-0.8	0.1	-0.9	6
Uruguay	52	7	7	-1.3	-2.2	1.0	7
Europe	61	5	12	-3.7	-4.1	0.4	14
Japan	1,197	53	23	-5.5	-5.9	0.5	4
USA	546	33	17	-0.8	-2.6	1.9	12
World	124,053	9,199	13	0.7	-1.1	1.8	7

Source: Production: FAO Faostat-PC, unpublished statistics, 1995.

a. Asia - (Japan, Israel) + Oceania - (Australia, New Zealand); b. Excludes South Africa.

1. 1961-63 - 1992-94. 2. On a fresh-weight basis.

Per capita consumption of fresh roots during 1990-92, according to the Food and Agriculture Organization of the United Nations, averaged as follows: Africa, 9 kg; Asia, 19 kg; Oceania, 79 kg; Latin America, 3 kg; Japan, 5 kg; and the United States, 2 kg. Unlike that of other major food crops, consumption of sweetpotato in Europe is minimal.

Within these regions, sweetpotato consumption varies tremendously. In Africa, for example, average consumption is 84 kg in Uganda, 110 kg in Rwanda, and 114 kg in Burundi. Similarly, sweetpotato consumption far exceeds annual national averages in centers of peak production and at times of the year when the seasonal supply of traditional staples is depleted.

Sweetpotato is almost always used, in some form and amount, as an animal feed wherever it is produced in developing countries (Table 2). Sweetpotato use for animal feed currently totals an estimated 42% of production in China, 40% in Brazil, 30% in Madagascar, 11% in North Korea, and 10% in Vietnam, Cuba, and Peru (Table 3). In the case of the Philippines, the potential may be greater for expanded use of sweetpotato as animal feed through the use of improved varieties (Cabanilla 1996). In virtually every instance, small farmers or the local community use sweetpotato for animal feed to raise rural incomes, improve yields, and add value to the raw material close to the center of production. In Kenya, small farmers are increasingly using sweetpotato vines in zero-grazing/intensive milk production systems as a high-quality, protein-rich supplement to fodder grasses (Semenge et al. 1992).

Sweetpotato processing into starch, flour, and noodles, among other products, is also growing (Scott et al. 1992). Recent reports from China indicate that 30% of sweetpotato output goes to processors in Shandong, the largest sweetpotato-producing province. Sweetpotato processing has recently attracted attention in a variety of countries in Africa and Latin America where knowledge of commodity-specific processing techniques, products, and equipment is less widespread.

Sweetpotato-Producing Regions

Sweetpotato supply and demand trends have varied in the past 30 years. Area planted has declined in Asia and Latin America. Production and planted area have expanded in Africa. Hence, analysis by region is necessary to clarify these differences.

Asia. Sweetpotato production in Asia has continued to increase modestly over the past three decades. The annual average growth rate of 0.9% reflects a situation in which increasing yields more than offset the declining planted area (Table 1). These trends are dominated by China. According to local statistics for the early 1990s the decline in area planted in Sichuan—China's second-largest sweetpotato-producing province—appears to have bottomed out. Pressure on local feed supplies accounts for these recent developments as sweetpotato often replaces maize in a feed ration for pigs. Other countries in Asia and Oceania where production, area planted, and yields all have positive trends are Vietnam, North Korea, Papua New Guinea, and Laos. In Vietnam

Table 2. Sweetpotato utilization and consumption in selected countries, 1990-92.

Major sweetpotato-producing countries	Utilization					Consumption
	Food	Feed	Seed	Processing	Other	kg/per capita/yr
Asia & Oceania[a]	51	40	0	4	5	19/79[1]
China	48	42	0	5	5	44
Vietnam	85	10	0	0	5	26
Indonesia	88	2	0	0	10	10
India	94	0	0	1	5	1
Philippines	90	5	0	0	5	9
Korea DPR	77	11	2	0	10	17
Papua New Guinea	85	0	0	0	15	100
Bangladesh	90	0	0	0	10	4
Korea Rep.	50	10	5	25	10	4
Laos	83	7	0	0	10	29
Africa[b]	87	3	0	0	10	9
Uganda	85	0	0	0	15	84
Rwanda	94	0	0	0	6	110
Burundi	95	0	0	0	5	114
Kenya	90	0	0	0	10	21
Madagascar	58	30	0	0	12	23
Zaïre	83	2	10	0	5	8
Tanzania	95	0	0	0	5	18
Angola	90	0	0	0	10	16
Cameroon	88	2	0	0	10	12
Ethiopia	100	0	0	0	0	3
Guinea	85	0	0	0	15	13
Egypt	89	0	0	0	11	2
Latin America	72	16	0	0	12	3
Brazil	50	40	0	0	10	2
Argentina	92	0	0	0	8	8
Cuba	80	10	0	0	10	19
Haiti	80	0	0	0	20	34
Peru	80	10	0	0	10	6
Paraguay	83	6	0	1	10	16
Dominican Republic	89	0	0	0	11	7
Uruguay	73	10	7	0	10	14
Europe	15	62	0	22	1	0
Japan	45	7	4	39	5	5
USA	90	3	7	0	0	2
World	53	37	0	4	6	13

Source: FAO, Faostat-PC, Food Balance Sheets, unpublished statistics 1994.

a. Asia - (Japan, Israel) + Oceania - (Australia, New Zealand); b. Excludes South Africa.

1. Asia and Oceania, respectively.

Table 3. Sweetpotato use as animal feed in Asia, Africa, and Latin America.

Country	Plant part	Form	Animal(s) fed
Asia			
Bangladesh	Vines	Green	Cattle
China	Roots	Sliced, dried, ground, cooked	Mainly pigs, but also cattle and poultry
Taiwan	Roots	Fresh, sliced and dried	Pigs
India	Vines	Green for ensilage	As above
Indonesia			
Java	Roots, culls, vines	Fresh	Cattle
Irian Jaya	Roots	Fresh	Pigs
Korea, Rep.	Roots, culls, stored roots	Fresh, stored, limited quantity for high-carbohydrate feed	Pigs, poultry, and other domestic animals
Papua New Guinea	Roots	Fresh, stored	Pigs
	Leaves, vines	Green	Pigs
Philippines	Roots	Cooked, dried chips, composite feed	Pigs mainly, also poultry
	Vines	n.a.	Pigs, carabao
Vietnam	Roots	Fresh, sliced and dried	Pigs
	Vines	n.a.	Pigs
Africa			
Egypt	Vines	Green fodder	Cattle
Kenya	Vines	Green fodder	Cattle, pigs
Mozambique	Vines	Green fodder	Small animals
Rwanda	Damaged roots, vines	Fresh	Livestock
Uganda	Surplus roots and vines	Fresh	Livestock, pigs
	Leaves	n.a.	Fish
Latin America			
Argentina	Roots, vines	Fresh	Pigs, cattle
Brazil	Roots, vines	Fresh	Dairy and beef cattle, pigs
Ecuador	Roots	Fresh	Pigs, goats, beef cattle
Dominican Republic	Roots	Fresh	Pigs
	Vines	Green, ground	Cattle
Haiti	Culls, roots left in the field after harvest	Fresh	Pigs
Jamaica	Roots	Fresh	Pigs
	Vines	Fresh	Pigs, cattle, and other farm animals
Peru	Roots	Fresh	Cattle, pigs, rabbits
	Vines	Fresh	Fodder for dairy cattle and small ruminants
Venezuela	Roots, vines	Fresh	Livestock

n.a. = not available.
Source: Boy et al., 1988; CIP 1988a, 1988b, CIP 1989; Mackay et al., 1989.

increased use for feed drives this growth. Strong demand for food has spurred output increases in the other countries mentioned.

Latin America and the Caribbean. Latin America produces 1.8 million t of sweetpotato annually. The crop tends to be more important relative to other food commodities in smaller countries such as Cuba and Paraguay, which have more modest levels of total production. In these cases, output has continued to expand at very modest rates over the past three decades in response to a steady increase in demand for food. For large producers such as Brazil and Argentina, production and area planted have contracted sharply. Alternative uses in the form of animal feed, however, have gained in importance to offset the decline in human consumption, particularly in Brazil. These developments portray a sweetpotato sector that is reorienting itself toward alternative market outlets.

Africa. Every country in sub-Saharan Africa produces sweetpotato. Production expanded all across the continent during the past 30 years. Production growth rates in Kenya (4.6%) and Uganda (4.2%) were spectacular. Trends in area planted were equally impressive, particularly in Tanzania (6.1%), Uganda (3.5%), Kenya (2.9%), and Rwanda (2.5%). In North Africa, production growth was also positive, but slower, as in the case of Egypt (1.3%). Trends in yields were not impressive. This points out the great potential for increased production through intensification and research.

Sweetpotato is ideally suited to African agriculture in several respects. It requires no heavy doses of chemical inputs. Planting material can be easily and rapidly reproduced locally. Cultural management practices are basic. These factors, combined with a mushrooming demand for food, particularly in densely populated rural areas, have provided strong impetus for the increases in production and area planted. Sweetpotato has also served extremely well as a famine relief crop in those parts of the continent adversely affected by natural disasters, civil wars, or severe economic hardships (Doku 1989; Behehu 1989).

Sweetpotato and the Environment

Sweetpotato is an environmentally friendly crop in a number of increasingly important respects. Production takes place frequently—almost always in sub-Saharan Africa—without the use of large quantities of chemical fertilizers and pesticides. Some farmers in developing countries also use sweetpotato as a quick cover crop to minimize soil erosion. In West Africa, sweetpotato is frequently grown before rice to avoid exhausting soil nutrients (Gura 1991).

Sweetpotato and Global Food/Feed Requirements

Most projections for population growth in developing countries suggest that food requirements cannot be met by relying on increased production of cereals alone, particularly in the poorest regions of Africa, Asia, and Latin America. Recent trends in sub-Saharan Africa and the growing importance of sweetpotato as a food crop there indicate the crop's potential contribution.

Crop production needs of developing countries are also becoming more complex. In Asia and parts of Latin America, the need to generate rural jobs and improve incomes for the poor to buy food coincides with a growing demand for livestock feed as consumers seek to add more protein to their diets with meat and dairy products. Sweetpotatoes increasingly serve as a local feed source while providing employment and earnings where they are desperately needed.

Sweetpotato Postharvest in South Asia

In light of these global trends for sweetpotato production and utilization, the remainder of this volume focuses more closely on postharvest constraints and opportunities for this commodity in South Asia. Postharvest topics merit high priority in this region for two reasons: Most scientists would agree that considerably more sweetpotato could be produced, but then the questions emerge as to how this increase in production will be consumed or marketed? And in what form? Moreover, relatively little is known about existing postharvest practices for sweetpotato in South Asia and how improvements—whether already available or yet to be developed—might build on them. Given sweetpotato's agronomic and nutritional potential, answers to these questions are likely to be of interest to farmers, rural development specialists, and policymakers as well.

The remainder of this volume is organized into three parts. Part one consists of country reports on sweetpotato postharvest handling and its use in Bangladesh, Nepal, Sri Lanka, and India. Each of these papers provides a national overview of these topics and in so doing sets the stage for the more in-depth coverage that follows. Part two includes ten papers which each focus on sweetpotato production, handling, and use in a different state in India. Finally, part three looks more carefully at the specific issues of storage.

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Country Reports

Postharvest Handling and Utilization of Sweetpotato in Bangladesh

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Abstract

Sweetpotato is gaining importance in both production and utilization in Bangladesh, although work in the area of postharvest handling and utilization of sweetpotato has been limited. Technologies for storage and utilization of sweetpotato are being refined, as new technological innovations are made. However, diversified use of sweetpotato can only be sustained through increased acreage and production. Carotene-rich sweetpotato varieties have been developed which are suitable for processing into various value-added products such as jam, jelly, chips, and fruity foods. Non-conventional uses of the crop and crop products such as leafy vegetables, green fodder, and processed animal feed (peels) are being researched.

Key words: Harvesting, utilization, processing, infestation.

Introduction

Sweetpotato (with a 0.36% share of the cropped area) ranks fourth after rice, wheat, and potato in Bangladesh. It is one of those neglected food crops generally grown on marginal land with minimum care. Sweetpotato is a cheap, nutritious food, yet its social status is low in the country. Under optimum growing conditions, sweetpotato can give much higher dry matter yields than rice and wheat. At present, the area is 52,000 ha (Figure 1), production 500,000 t, and yield 10 t/ha. This low yield is the result of limiting factors such as the lack of suitable high-yielding short-duration varieties, unimproved cultural practices, diseases, and inadequate insect pest management. Sweetpotato is cultivated in winter and used as supplementary food and snacks. It is found in almost every area of Bangladesh but is intensively grown in Comilla, Kishoreganj, Jamalpur, Barisal, Patuakhali, Dhaka, and Noakhali. These districts include more than 50% of the country's sweetpotato acreage.

Since 1980, systematic research on sweetpotato has been done in the area of germplasm collection, varietal improvement, standardization of production practices, postharvest handling, and utilization. Five improved varieties, Kamlasundari, Tripti, Daulatpuri, BARI sweetpotato-4, and BARI sweetpotato-5, have been developed for commercial cultivation. Though Tripti (300 IU/100 g) and Kamlasundari (10,000

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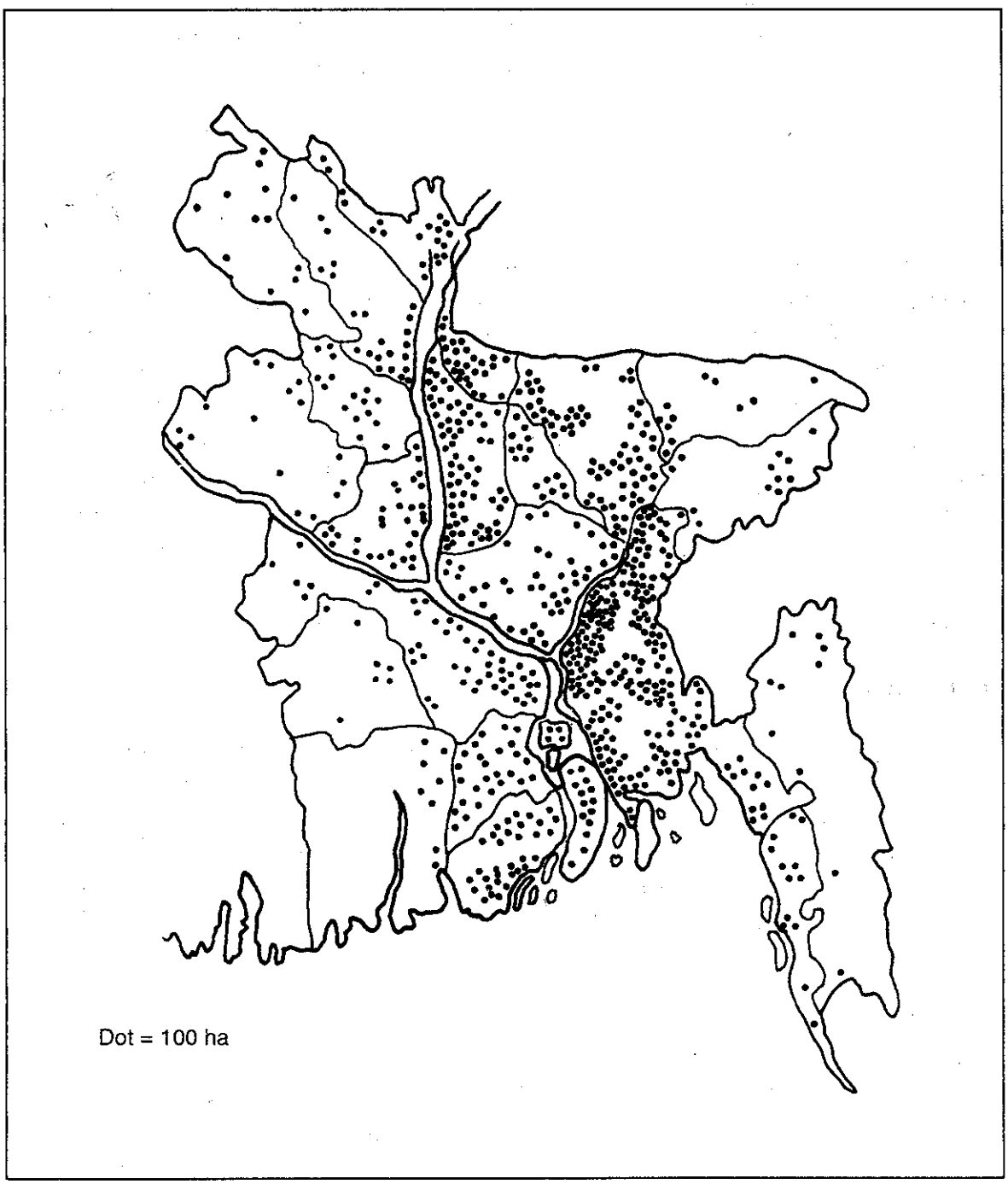

Figure 1. Sweetpotato-growing areas in Bangladesh.

IU/100 g) are rich in carotene, some consumers dislike them because their flesh is soft, moist, and less sweet. Leaves of these two varieties can be consumed as vegetables. In Bangladesh, consumers prefer dry and sweet-fleshed varieties like Daulatpuri. Indigenous sweetpotato varieties are poor in food value whereas improved varieties are higher-yielding, as well as nutritionally richer.

Therefore, any attempt to increase crop production in the country would not be effective unless suitable and practical methods at the farm level are made available for postharvest handling of the roots. Results of some important surveys and studies conducted in Bangladesh on postharvest handling and utilization of sweetpotato are briefly discussed below.

Harvesting and Storage

Harvesting

Sweetpotato vines are planted from October to November and roots are harvested from April to May. The cropping period is about 150-160 days. Harvesting is done manually with spades, and roots are transported to the markets or home using bamboo cases (*changari*) and gunny bags. Sometimes, early monsoon rains cause harvesting problems resulting in rottage of roots. In Bangladesh, the harvesting period cannot be extended due to environmental limitations.

Storage

Sweetpotato cannot be stored for more than 2-3 months, so the bulk of production is used within a short period after harvest, without considering the economic aspects of this practice. Most sweetpotato farmers prefer selling the roots immediately after harvest rather than storing them. If stored, most of the roots are stored on the floor of houses under *khatia, chowki,* etc. Sometimes *Machan* and *Dhol* (made of bamboo-thatched *chatai*) are used to store the roots along with sand and sawdust. Wet sawdust mixed with sand is used to preserve sweetpotato roots in order to minimize dehydration. Desprouting is also done. Pit storage and cold storage preservation of sweetpotato are not common practices in Bangladesh. However, sun-dried sweetpotato slices are sometimes preserved for future use in areas of Chittagong Hills.

Some attempts (BARI, 1980-88) have been made to study dehydration, sprouting, weevil control, disease, etc., in different varieties/lines of sweetpotato under indigenous storage conditions in Bangladesh (Tables 1, 2). The results of these studies indicate non-availability of a sweetpotato variety with good storage traits with respect to dehydration, sprouting, weevil resistance, and rottage.

Postharvest losses. Spoilage of sweetpotato is very high in Bangladesh. Roots are easily damaged during transport and storage. Although such losses vary by cultivar, mean weight losses in one study were found to be as much as 45% after 90 days storage.

Insect pests in storage. Sweetpotato weevil (*Cylas formicarius*) is the most serious sweetpotato storage pest in Bangladesh. Infestation varies from place to place and year to year. Complete spoilage is not uncommon if the roots are kept for 2-3 months under ambient conditions. Attempts have been made to manage the pest using a repellent water trap baited with synthetic pheromone (Figure 2) and storage manipulation

to year. Complete spoilage is not uncommon if the roots are kept for 2-3 months under ambient conditions. Attempts have been made to manage the pest using a repellent water trap baited with synthetic pheromone (Figure 2) and storage manipulation (Tables 3, 4, 5). Use of the botanical control, *Lantana camara* leaves, was found to be on a par with that of the control.

Table 1. Physiological change of different cultivars of sweetpotato under natural storage conditions after 90 days.

Variety	Stored in grass-roofed shed			Stored in galvanized iron shed			Open verandah	
	1[a]	2	3	1	2	3	1	2
BNAS-white	21	0	20	27	--	13	22	0
Cinjhi	28	0	33	29	--	20	18	7
Tripti	16	14	20	24	15	7	12	0
USA-1	15	15	20	28	15	7	12	0
Kamlasundari	17	0	13	22	0	0	15	0
SP 070	22	45	45	29	42	20	14	13

1 = Weight loss (%); 2 = time taken for sprouting (days); 3 = weevil infestation (%).
a. = No data available.

Table 2. Performance of different sweetpotato varieties/lines in natural storage.

Year	Varieties/ lines studied	Days to sprouting	Storage period (d)	Weight loss (%)	Weevil infestation (%)	Remarks
1981-82	38	9-38	75	29-77	--	28-32°C, 89-98% RH in Mymensingh, April-May
	63	0-48	42	17-86	7-77	28-37°C, 72-90% at Joydebpur
1982-83	24	--	56	26-83	7-100	Tin shed, 30-39°C
	24	--	56	24-69	14-79	Thatched shed, 27-37°C
1983-84	6	0-45	56	16-21	13-45	Glass-roofed shed
	6	0-42	56	23-29	0-20	GI sheet shed
	6	--	--	11-22	0-13	Open verandah
1984-85	10	--	28	14-28	--	--
1985-86	16	5-73	56	46-90	3-46	--

GI = Galvanized iron.

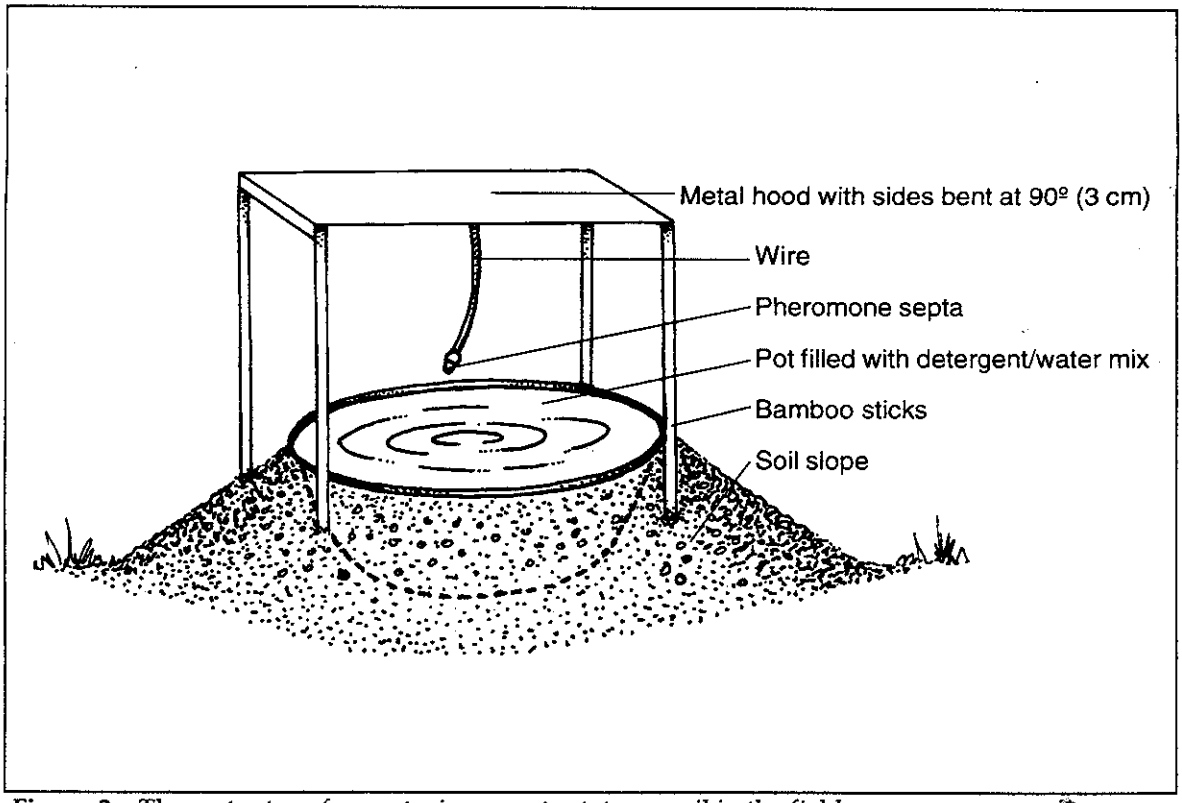

Figure 2. The water trap for capturing sweetpotato weevil in the field.

Table 3. Effect of different insect repellents on stored sweetpotato.

Treatment	Weight loss after 60 d (%)	Damage by insects and diseases (%)
Sand bed + tobacco leaf + sand	25	62
0 + insect repellents + sand	31	74
Neem leaf	30	16
Tobacco leaf	31	9
Sand bed + 0 + sand	rotten	100
Sand bed + 0 + 0	rotten	100
0 + 0 + sand	rotten	100
0 + 0 + 0	rotten	100

Table 4. Effects of storage with sand + botanicals on the floor.

Treatment	Weight loss after 60 d (%)	Weevil damage (%)
Dry sand + tobacco leaf powder	25	62
Dry sand + neem leaf	30	74
Dry sand	rotten	100
On floor (control)	rotten	100

Table 5. Effect of NAA and botanicals on the pit storage of sweetpotato.

Treatment	Good condition (%)		Remarks
	60 days	90 days	
NAA (20 ppm dip for 2 minutes)	5	0	No effect on sprouting
NAA + tobacco leaf powder	61	2 8	
Tobacco leaf powder	72	3 6	
Check		0	

Temperature = 26-29°C; relative humidity = 90-98%.

Storage diseases

Postharvest sweetpotato diseases cause a considerable loss in storage, during transit, and in the market. Important diseases are black rot (*Ceratocystis fimbriata*), soft rot (*Rhizopus stolonifer* and *R. oryzae*), Java black rot (*Botryodiplodia theobromae*), charcoal rot (*Macrophomina phaseolina*), surface rot (*Fusarium oxysporum*), black mold rot (*Aspergillus niger*), blue mold rot (*Penicillium digitatum*), punky rot (*Trichoderma* spp), and Sclerotium rot (*Sclerotium rolfsii*) (Talukdar 1974; Jenkins 1981; BARI 1991).

The frequency of Java black rot and soft rot has been found to be three times higher than that of other diseases. In one study, a 10-minute dip in hot water (40-45°C) was found to be better (10.3% rottage) than Tecto (14.8%) in reducing microbial rottage after 5 weeks in natural storage (Jenkins 1982) (Table 6).

Utilization

In Bangladesh, almost 100% of sweetpotato is consumed by poor people. There is no industry, large- or cottage-scale, which utilizes sweetpotato as a raw material. Recent research has been initiated at BARI (Bangladesh Agricultural Research Institute) to produce fruity foods from sweetpotato.

Consumption

Most Bangladeshis consume sweetpotato boiled, and to a lesser extent baked. Some mix

Table 6. Sweetpotato tuber rottage after 5 weeks in natural storage.

Treatments	Rottage	
	Complete	Partial
10-min. dip in hot water (40-45°C)	6.3	4.0
Tecto	12.2	2.6

Source: Jenkins (1982).

it with other vegetables in curry (*niramish*). Roots are also used as vegetables with fish and meat to prepare a delicious curry. Sweetpotato is very popular when cooked with prawns or hilsha fish in the Patuakhali and Barisal areas. Sometimes roots are chewed raw. Sweetpotato is occasionally baked or fried.

Young leaves are eaten as vegetables in parts of Sylhet, Chittagong Hills, and Dinajpur. In Comilla, sweetpotato is fed to animals. Following the root harvest, raw vines are sometimes used as animal feed and dried vines as fuel in rural areas. Local varieties grown by farmers are dry-fleshed with a sweet, floury texture. Two of the five varieties developed by TCRC (Tuber Crops Research Centre) are rich in carotene and moist-fleshed. These are not yet accepted by consumers, even though a 50 g root of these varieties is enough to meet the daily vitamin A requirement of the average person. These moist-fleshed varieties break easily, become mushy on boiling, and are also less sweet, but they can be easily used for making *halua*, jam, jelly, sweets, and *kalojam*. In Bangladesh, widespread child blindness prevails because of vitamin A deficiency. The rural poor could overcome this problem by consuming carotene-rich sweetpotatoes. Utilization of sweetpotato through processed products may improve its economic value and upgrade its status to that of a market-oriented crop.

Processing

Development of sweetpotato processing methods, preparation of recipes and their organoleptic tests, and chemical analysis of varieties have been reported (Chowdhury et al. 1991; Hossain et al. 1984, 1987; Hossain and Chowdhury 1991; BARI 1980-88). Results of some of these studies follow.

Chips

Sweetpotatoes were washed and peeled using knives. Chips (1-1.5 mm thickness) were made from the peeled sweetpotato using a manually operated chipper. The raw chips were blanched at 80°C for 1-2 min. Blanched chips were then dried using both a solar and a mechanical dryer. Drying chips in the sun took 10 hr and the mechanical dryer (65°C) took 7 hours. The final moisture content of chips was 6.5%.

Flour and *suji*

Studies of drying methods revealed that sweetpotato slices sun-drying for 10 hr contained the least moisture (10%) and most protein (1.7%), with the highest production of flour (91%) (Table 7). Chips in this experiment were 3-5 mm thick. To prepare flour and *suji*, dehydrated sweetpotato chips were placed in an oven at 80-85°C for 5 min and then poured into a blender before passing through a strainer; *suji* remained in the strainer, but the flour sieved off. The resulting sweetpotato flour was used in bread-making mixed in different proportions with wheat flour to make a loaf. The mixture of 30% sweetpotato flour and 70% wheat flour gave the best loaf with respect to appearance, odor, texture, taste, and volume (Table 8).

Table 7. Color, physical characteristics, and chemical composition of dehydrated sweetpotato chips.

Methods	Color/physical characteristics	Moisture	Protein	Flour	*Suji*
		(%)			
Blanching in hot water at 60-62°C for 10 min + immersing in 1.5% $KMnO_4$ for 10 min + sun-drying for 18 hr	White and uniform, soft	10	1.5	89	11
Sun-drying for 10 hr	Slightly brownish white, soft	10	1.7	91	9
Blanching in hot water at 83-85°C for 10 min + sun-drying for 18 hr	White-black, not uniform, completely hard	12	1.4	57	43

Table 8. Average score (of 10) on the organoleptic properties of sweetpotato/wheat flour bread.

Treatment	Average score				Loaf volume
	Appearance	Smell	Texture	Taste	
Loaf of 30% sweetpotato flour + 70% wheat flour (blanching 60-62°C)	5.5	5.2	5.5	5.5	Moderately satisfactory
Loaf of 20% sweetpotato flour + 80% wheat flour	3.2	3.2	3.5	5.0	Unsatisfactory
Loaf of 10% sweetpotato flour + 90% wheat flour	5.7	4.5	4.7	4.2	Fairly satisfactory
Loaf of 30% sweetpotato flour + 70% wheat flour (not blanched)	6.2	5.7	6.0	5.7	Satisfactory
Loaf of 30% sweetpotato flour + 70% wheat flour (not blanched)	6.0	6.5	6.5	3.6	--

Fruity foods

Jam, jelly, pickles, biscuits, and cakes have been successfully prepared from sweetpotato in the research laboratory. Among the recipes, those developed for jam, cakes, biscuits, and pickles appear to be promising. The cost of 500 gm of these products was Tk 20.00 (US$ 0.50).

Jam. Sweetpotato was washed, manually peeled, and cut into pieces. These pieces were steamed and pulp was made using a blender. Sugar, pectin, acid, flavoring, and

potassium metabisulphite were added and the mixture cooked to a desired consistency. Prepared jam was then poured into glass bottles and allowed to cool. Melted wax was used to seal the surface. After cooling, the lid was closed and the bottles of jam were stored in a dry, cool place. No sign of spoilage or discoloration was noted in the jam after three month's storage under ambient conditions.

Peels. Rehydrated peel was found to be an acceptable livestock feed. The peels obtained during preparation of sweetpotato chips and jam were washed and blanched. Blanched peels were dried in either a solar or a mechanical dryer. One kilogram of raw peel on drying yielded 180-200 g of dried peel. The rehydration ratio of peel was found to be 1:3. Dried peels were preserved in polyethylene packets.

Other products. In addition to dehydrated cubes, sweetpotato strips have been produced for future use and starch extraction. In general, 1 kg of sweetpotato gives 100 g of dried chips, 3-5 g of starch, and 10-15 g of dehydrated peel.

Chemical analysis of sweetpotato

Chemical analysis of 20 genotypes during 1984-85 and 11 genotypes during 1985-86 showed that dry matter varies from 11% (AIS-243-2-1) to 32% (SP-087). The value for ash ranged from 0.4% (AIS-243-2-1) to 1.7% (CI-489-1), and for crude protein from 0.44 mg (AIS-243-2-1) to 1.87 mg (SP-083) per 100 g. Carotene content varied from 0 (C1-478-9) to 6,528 mg per 100 g.

Future of sweetpotato utilization

Sweetpotato processing has potential in Bangladesh, but technically efficient, economically viable, and socially acceptable processing techniques, equipment, and products have yet to be fully developed and broadly disseminated. Preparation of value-added products such as jam and jelly will improve the economic and social value of the crop. The great crisis of animal feed in the country may be partially solved with sweetpotato peels obtainable as a by-product of processing. Moreover, processing will strengthen existing cottage industries and also promote more labor-intensive small food industries. Many institutions in the country, such as BARI, BAU, IFST, BIRTAN, BSCIS, IAT, IFRB, INFS, and MCC, are responsible for the development of appropriate postharvest technologies for agricultural products. These organizations could also contribute to the further development of sweetpotato processing in Bangladesh.

Major postharvest constraints to sweetpotato (storage, sprouting, rottage, and low market price) can be resolved if sweetpotato is consumed as a supplementary staple food for at least two months during harvest and if raw roots are transformed into processed foods and industrial products for future use. Mass media, extension agents, and some NGOs (non-governmental organizations) could help motivate the well-to-do to accept sweetpotato as a prestigious food. To a lesser extent, sweetpotato may also be used as animal feed in the country.

There should be a special project supporting development of new and innovative sweetpotato processing technologies suited to rural Bangladesh. Noodles are a very common food for urban people. Therefore, a sweetpotato-based noodle industry could be encouraged. Processing-oriented sweetpotato varieties should be developed. For use as a vegetable in curry, sweetpotato varieties should be developed with less or no sweetness at all. Technologies already developed should be transferred and the use of vines as vegetables needs to be promoted. Vines could be cultivated and made available throughout the year.

Acknowledgments

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Production, Postharvest Handling, and Utilization of Sweetpotato in Nepal

D.M. Gautam[1]

Abstract

Nepal has three distinct topographical belts: the *terai* (the plains), mid-hills, and mountains. Sweetpotato is grown throughout the mid-hills and *terai* region. It is grown on poor, neglected land that is newly deforested and cultivated for the first time. It is also grown in kitchen gardens for home consumption. The crop is generally grown without fertilizer or irrigation. Sweetpotato roots are mainly consumed during the *Makar Sakranti, Maha Shiva Ratri,* and *Acadashis* festivals. It is believed that sweetpotato is *prashad* of Lord Shiva and that it should be eaten during festivals. Sweetpotato roots are usually eaten boiled. They are used as a snack for poor people, field laborers, and load carriers in the hilly area. Sweetpotato tops are considered the best feed for milking animals. Sweetpotato roots are stored in the field unharvested, in bamboo baskets, in jute sacks, and in clamps (piles) in a shaded corner of houses. Statistics on cultivation, production, and utilization of sweetpotato are lacking. Government programs have paid little attention to sweetpotato. It is a neglected crop throughout the country despite its potential as one crop in a sustainable agricultural system. The introduction of high-yielding varieties that can be used both for vegetables and staple food can raise the economic and nutritional status of poor people. Sweetpotato could be a good supplementary food to help overcome the problems of malnutrition and under-nutrition in the country.

Key words: Topography, agroclimate, ecology, storage, utilization.

Introduction

Nepal is basically an agricultural country of which 91% of the population depends on agriculture and contributes 53% of total GDP (NPCS 1990).

Ecological distribution of the population shows that 10% of the population lives in the mountains, 52% in the mid-hills, and 38% in the *terai*. About 18% of the total land area (147,181 km) is in agricultural production. The 1990 population was 19 million with an annual growth rate of 2.6%. Land-holding availability was 1.13 ha per family.

Nepal can be divided into three well-defined agroclimatic topographical belts: the *terai*, plains area in the south with an elevation of 60-300 m; mid-hills, in the central area with an elevation of 300-5,000 m; and mountains, in the north with an elevation of

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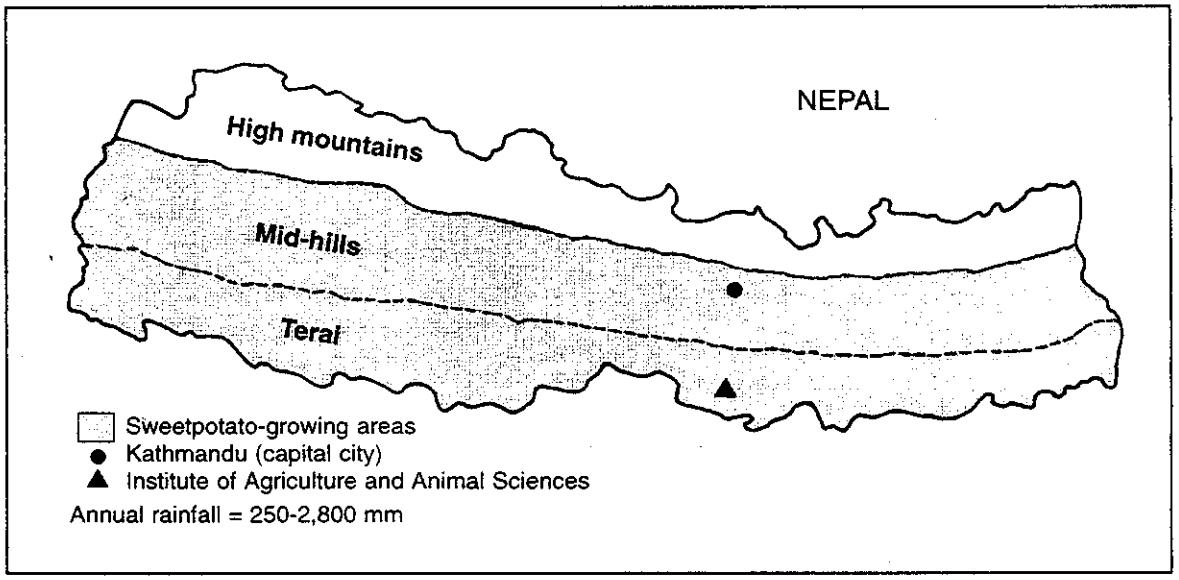

Figure 1. Sweetpotato-growing areas in Nepal.

5,000-8,848 m. The land area of these three zones consists of 23% *terai*, 43% mid-hills, and 34% mountains (Figure 1). The maximum temperature in the cultivated area ranges from 15 to 40°C. Annual rainfall ranges from 250 to 2,800 mm. Most of the rain falls from June to September.

Food consumption is 2,000 calories/day/person, which is 28% below minimum requirements. Cereals provide the majority of this energy. Vegetable consumption is only 125 g/day/person (Puh and Karmachary 1988), which is very low compared with the recommended level (350g/day/person). Malnutrition and under-nutrition are common problems in the country.

Production

Sweetpotato (*Ipomoea batatas*) is known in Nepal as *sakhar khand*. It is grown both in the *terai* and the mid-hills throughout the country. It is the second most important root crop -after potato- in terms of production and area. It is usually grown on newly cultivated or neglected land, and is grown to some extent in kitchen gardens for home consumption. Throughout the country it is grown under unirrigated conditions without fertilizer. Farmers usually plant local cultivars of the red and white types. The red type is preferred in mid- and western Nepal, while the white-type is preferred in eastern Nepal. These cultivars have been cultivated for a long time and are the long-duration type. In the *terai*, they are planted from July to September, and in the mountains from April to May. Planting is generally done by stem cuttings, and to some extent by roots and tip cuttings. In the mountains, sweetpotato is harvested in November, and in the *terai* in February. Harvest is done when needed. Nepal still lacks reliable statistics on area under sweetpotato cultivation and on production. Returns to sweetpotato,

compared with those to other vegetable production, seem to be higher. Production averages 5-6 t/ha.

Consumption

Sweetpotato is mainly eaten boiled or roasted. It is believed that during fasting in *Makar Sakranti* and *Shiva Ratri* people eat *sakhar khand* (sweetpotato) as *prashad* of *Shiva*. It is also used as a snack for field workers and load carriers in the mountain regions. Poor people sometimes depend on sweetpotato for their evening meal. Sweetpotato tops are considered the best feed for milking animals. In Taiwan and in the Philippines, sweetpotato tops are used as a vegetable (Villareal 1989); in Nepal, however, farmers have not adopted this practice.

Postharvest Handling and Storage

Sweetpotato roots are generally harvested as required during festivals. Farmers do not look for the characteristic signs of development for maturity. Three to four days before harvest, the foliage is cut and removed. Sometimes farmers wait till the festival begins for harvesting the crop to get a better price.

If roots are to be stored for a few days, they are dried for 1-2 days on the floor so that the adhered moist soil and surface moisture can be easily removed. These roots are thus cured so that they can be stored for a longer period without spoilage. The roots are usually stored in clamps (heaps), in bamboo baskets (*Thunse, Dali,* and *Kothi*), and in jute sacks in a shaded corner of the house (Figure 2). Storing of roots in rice or millet husks is common if they are to be stored for longer than a week. The use of straw-lined bamboo baskets facilitates storage and transpiration.

Constraints

As of this writing, the Government of Nepal had not given any attention to sweetpotato production and statistical records are not maintained. Because of urbanization and an increase in purchasing power, sweetpotato is rated as a neglected food. Demand for sweetpotato is decreasing day-to-day as a consequence of the easy availability of other foods. Despite the resolution passed in the 7th United Nations General Assembly (1975) to reduce postharvest losses of food crops by 50% in 10 years, nothing has been started in Nepal to achieve this goal.

Other constraints are the storage problems of shriveling, browning, loss of quality, loss of taste and texture, development of pithiness, and rotting. No serious insect pests or diseases have been reported. Rats, porcupines, and monkeys cause serious damage to sweetpotato crops in the hilly areas.

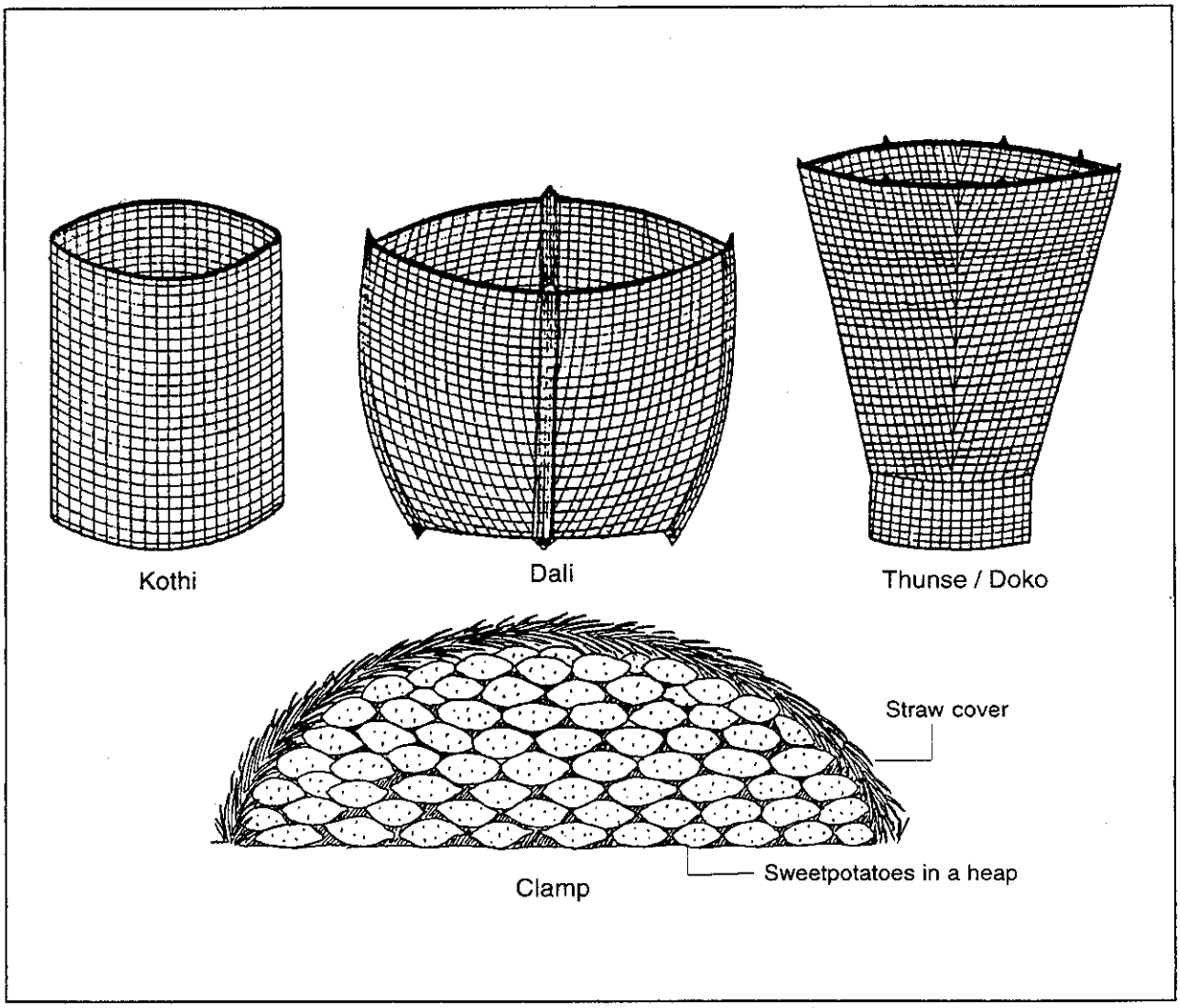

Figure 2. Sweetpotato storage containers and methods in Nepal.

Future Prospects

In developing countries like Nepal, where malnutrition and under-nutrition are common, sweetpotato can be used both as a staple food and as a vegetable. It could be used both as an important and nutritious supplementary food source and for fodder production. What is needed is to introduce new high-yielding varieties that can be used both as a vegetable (the tops) and as a staple food (the root) within a system of sustainable agriculture. The promotion of sweetpotato cultivation among small-holder farms can be a supplementary income source and thus contribute to poverty alleviation. Sweetpotato production will not pay much unless demand is promoted through the creation of industrialized uses of the crop. Along with production and postharvest handling, an industry based on sweetpotato should be encouraged in Nepal.

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Production, Postharvest Handling, and Utilization of Sweetpotato in Sri Lanka

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Abstract

Cultivated area under sweetpotato in Sri Lanka is about 7,000 ha. The crop is grown in the small-holding sector, mainly as rainfed cultivation in the highlands, as well as in the lowlands during the dry season. National sweetpotato production is about 70,000 t/yr. All of this production is used for human consumption. Sweetpotato is consumed as boiled roots, a cooked vegetable, or as fried chips. Cleaned fresh roots are packed in coir sacks and transported to the market either by farmers or by middlemen. Storage of sweetpotato is not practiced in Sri Lanka at present because the produce has a ready market as fresh roots. When consumers in rural areas sometimes need to store sweetpotato for a short period for their own consumption, they cover the roots with a layer of dry sand and store them for 2 to 3 weeks without any damage or weight loss.

Key words: *Maha* season (October-February), *Yala* season (May-September), bimodal, plantation crops, climatic zones.

Introduction

More than 70% of Sri Lanka's population of about 1.6 million depends entirely on agriculture. Land area is about 6.5 million ha, out of which nearly 970,000 ha are under major plantation crops such as tea, rubber, coconut, and other minor export crops. Paddy (rice) is grown on around 700,000 ha. Annual crops other than rice are grown on nearly 500,000 ha, mostly in the highlands (DCS 1986-90).

The country has a bimodal pattern of rainfall under the influence of northeast (October-February) and southwest (May-September) monsoons forming two distinct seasons known as *Maha* (October-February) and *Yala* (May-September). Based on annual rainfall, Sri Lanka is divided into three main climatic zones—the wet zone (1.5 million ha), the dry zone (4.1 million ha), and the intermediate zone (0.8 million ha).

Sweetpotato in Sri Lanka is a traditional crop grown mainly in the wet and intermediate zones. *Maha* is the major season for sweetpotato. In *Yala*, sweetpotato is grown mainly in well-drained paddy fields. Annually, sweetpotato is cultivated on about 7,000 ha in the small-holding sector, and is found mainly on highland homesteads as a rainfed crop.

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Expansion of the main rice crop has reached the saturation point in Sri Lanka. The potential to cultivate food crops in the highlands, however, remains unexploited. Therefore, root and tuber crops appear to have a great potential in the highlands and in rice fields where irrigation water is insufficient. Among root crops, sweetpotato has the greatest potential on small land holdings throughout the country.

Sweetpotato is produced in 8 Sri Lankan provinces. Of these, Sabaragamuwa, North Western, Central, Uwa, and Western provinces are highly productive, having the best-suited physical and socioeconomic environments. National yield of sweetpotato averages 10-12 t/ha and the current total production is around 70,000 t/yr.

Utilization

Compared with other root and tuber crops, sweetpotato ranks third after potato and cassava. Because consumers prefer sweetpotato to cassava, all the sweetpotato produced goes for human consumption. Sweetpotato is mainly consumed by low-income people because it is one of the cheapest substitutes for starchy staples such as rice, wheat, and potato (De Silva et al. 1989).

The major domestic pattern of human consumption of sweetpotato is boiling the roots. Boiled sweetpotatoes are commonly eaten at breakfast in rural areas in Sri Lanka. There is also a considerable demand in the urban market for lower-sugar types to be used as a vegetable. Sweetpotato roots are either cooked with coconut milk and spices as a curry, boiled and seasoned, or used as a filling for pastries. They are also fried as chips and used as a snack-substitute for potatoes.

After harvesting, farmers manually clean the roots and make them soil-free. Small-scale farmers supply their produce to local markets or to village fairs. They usually transport the produce in coir sacks. Because they transport clean roots directly to the market, they generally sell their produce at attractive retail prices of about Rs 7-8/kg. If the crop is large, farmers usually sell the produce at a low price to middlemen who harvest the sweetpotato and transport it for sale in the urban market. They also transport sweetpotatoes in coir sacks.

Storage

Sweetpotato storage is rarely practiced in Sri Lanka because fresh produce goes directly to the market, and because there is a considerable demand for fresh roots in the open market. In rural areas where consumers sometimes need to store sweetpotato for a short period, they lay the roots on the floor and cover them with a layer of dry sand. Fresh roots can be stored in this manner for 2 to 3 weeks.

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Sweetpotato Production, Postharvest Handling, and Utilization in India

G.T. Kurup and C. Balagopalan[1]

Abstract

India is the sixth-largest sweetpotato producer in the world, with an annual output exceeding 1.1 million t. Area planted and production are declining. A large variation in sweetpotato consumption exists between urban and rural areas. The bulk of production goes for human consumption. Current postharvest research emphasizes technologies for pest-free storage of fresh sweetpotato using sand, sawdust, wood ash, earth, and waste carbon paper in earthen pots. Current processing techniques, research priorities, storage techniques, improved technology for the separation of starch, diversification for value-added foods, and industrial products are described.

Key words: Sweetpotato, storage, starch separation, diversification, processing, food industry.

Introduction

India is the largest sweetpotato producer in South Asia and the sixth largest in the world. Current output exceeds 1.1 million t. Area planted is over 130,000 ha. Sweetpotato is believed to have been introduced to India by the Portuguese and is currently grown throughout the country as a secondary food crop. Sweetpotato has yet to be used in industry on any significant scale, but it is one of several tropical root and tuber crops that represent the third most important group of dietary staples used by low-income consumers. These crops are rich in energy and a source of some essential vitamins and minerals.

In times of seasonal or natural food shortages, those low-income groups most at risk nutritionally are the rural and urban poor, who have little or no land and whose limited resources do not meet their nutritional needs. Ensuring access to food supplies for such groups will help increase their income-earning capabilities and provide adequate supplies of basic needs at prices within their reach. Fluctuations in the prices for roots and tubers, however, have forced a shift to plantation crops. This shift in the cropping system will lead to further problems as it becomes more difficult for food production to keep pace with population increases. To keep root and tuber crops within the cropping system of marginal farmers, attention must be focused on better postharvest practices and development of novel value-added products.

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Area, Production, and Yield

Sweetpotato is grown mainly in Assam, Bihar, Karnataka, Madhya Pradesh, Maharashtra, Orissa, and Uttar Pradesh. These states account for 89% of growing area and 88% of production nationwide. Area planted and production of sweetpotato in India have recently declined. In 1981, the country had an area of more than 0.2 million ha in sweetpotato and production was 1.5 million t. By 1992-94, area fell to 138,000 ha and production to 1.1 million t. Sweetpotato productivity in India is less than 50% of the total world/Asian average (8.2 t/ha) and the crop occupies only about 0.11% of the total cropped area in India. Even though the crop is grown in most states and union territories, area and production are concentrated in Orissa, Bihar, and Uttar Pradesh (Tables 1 and 2 and Figure 1).

Table 1. Sweetpotato production in India by state.

State	Area (ha)	Production (t)
Andhra Pradesh	2,700	21,700
Arunachal Pradesh	300	1,400
Assam	8,558	27,363
Bihar	30,389	293,102
Gujarat	921	13,332
Haryana	703	7,236
Karnataka	6,672	43,999
Kerala	4,001	33,851
Madhya Pradesh	6,733	39,194
Maharashtra	5,400	78,400
Manipur	100	300
Meghalaya	3,900	13,000
Mizoram	312	2,211
Nagaland	40	600
Orissa	58,700	351,270
Punjab	116	673
Rajasthan	1,180	2,120
Tamil Nadu	1,958	42,530
Tripura	1,453	13,533
Uttar Pradesh	29,676	267,410
West Bengal	8,000	50,000
Andaman and Nicobar Islands	100	800
Pondicherry	14	175
All India	**163,926**	**1,254,179**

Table 2. Production projections and level obtained for sweetpotato, 1969-2000.

	Average of 1969-70	Estimate of NCA 1985	Obtained 1987-1988	Estimate of NCA 2000
Area (000 ha)	230	310	163	500
Production (000 t)	1,800	4,300	1,254	10,000
Productivity (t/ha)	8.0	14.0	7.7	20.0

NCA = national cropping average.

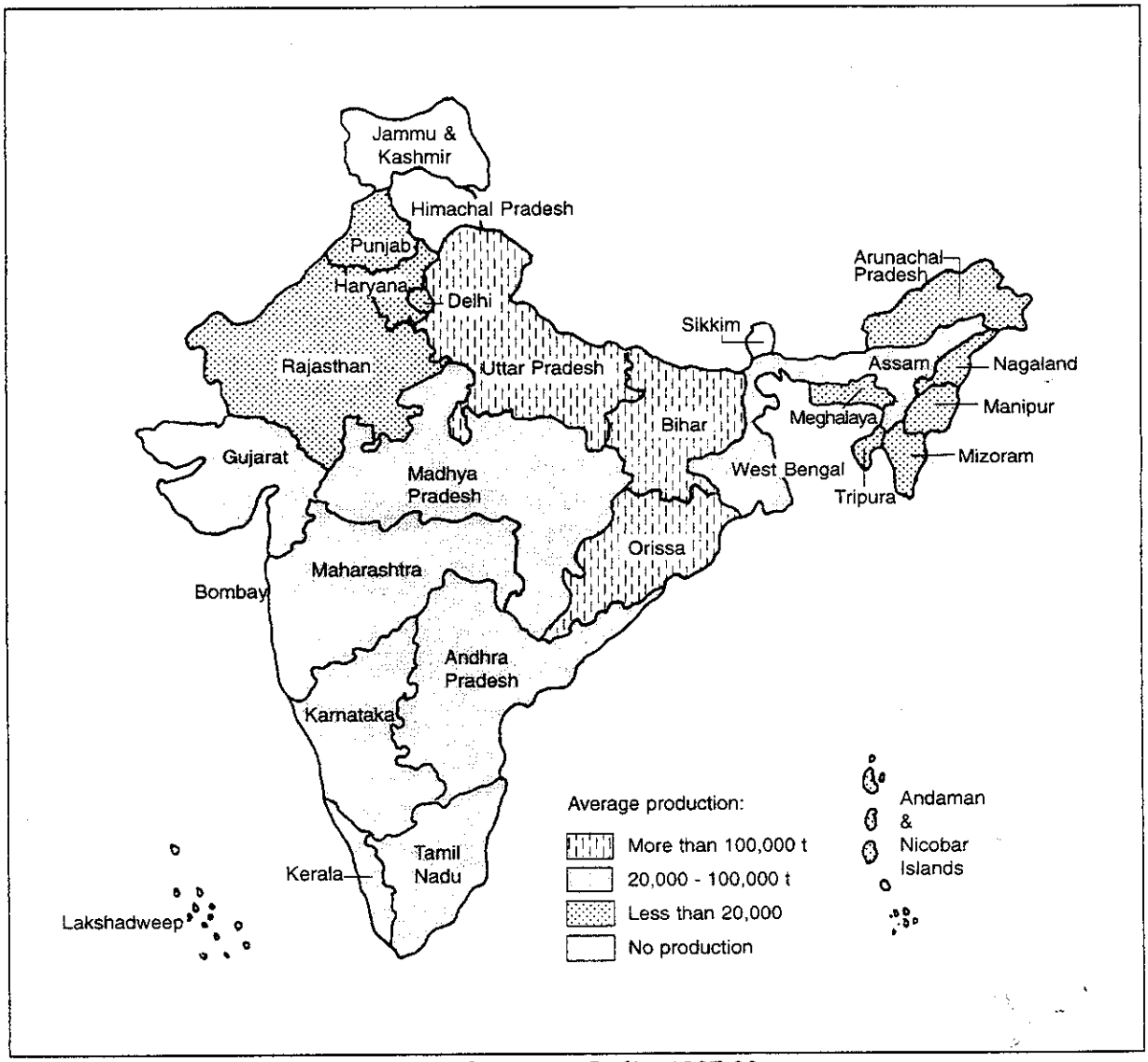

Figure 1. Average sweetpotato production in India, 1987-90.

Utilization

The bulk of sweetpotato production in India goes for human consumption. It is processed into different forms and consumed at the village or household level. Only the vines are fed to cattle. Since the technology to effectively separate starch from sweetpotato is still in the rudimentary stages, sweetpotato is unable to compete with other starch sources. Recent reports indicate that sweetpotato flour has started arriving in commercial markets in India. Its usefulness in pure form or as a blend in various flour preparations has to be explored and research is under way.

Sweetpotato roots are mostly eaten boiled, steamed, roasted, or baked. Another method is to roast them unpeeled in a low fire. Sometimes good-sized roots are placed in earthen pots and the mouth of the pot is securely covered with paddy straw. The pot is then turned upside down and covered with cow dung cakes or wood straw and a fire is built around the pot. After 3-4 hr of roasting, the roots are ready. Peeled roots are cut and cooked as vegetables. A delicious dish is prepared by cooking peeled roots with raw mango and *jaggery* (sugar cane syrup).

Boiled and peeled roots are crushed into pulp and mixed with wheat flour, and this dough is made into desirable shapes and then fried in vegetable ghee. The fried pulp is candied with syrup or syrup and milk to make *Gulab Jamoon, Rasavali,* and other desserts. Often, chips are prepared from sweetpotato roots using a potato chipping-type process and dried. Dried chips are fried in oil and eaten as snacks.

In northern India, roots are ground into flour and used for *chapatis* and confectionery. Boiled sweetpotato pulp is dried into shreds and used during feasts and festivals in Maharashtra. No attempt has been made in India to produce secondary processed foods from sweetpotato. One of the main constraints to sweetpotato utilization is the poor extractability of starch. Extraction of starch from sweetpotato has very seldom exceeded 50% of the total starch values recorded by chemical means. Phenolic oxidation and its effect on starch color is another minus in sweetpotato starch use. Novel methods for extracting a maximum amount of starch and removing unwanted color will enable its utilization in various food industries.

Postharvest Losses

Processing research

Sweetpotato is subject to several forms of postharvest loss: physical damage, weight loss, pathological decay, sprouting, and weevil infestation. Several fungi such as *Rhizopus* spp., *Aspergillus* spp., *Botryodiplodia theobromae, Penicillium* spp., and *Fusarium* spp. have been isolated from diseased tissue. *Rhizopus stolonifer* causes soft rot and *Pellionella indica* produces scurfy lesions in the roots.

In India, there is no systematic procedure or technique for long-term sweetpotato storage. Roots are mostly left in the field until needed. The traditional storage method consists of placing heaps of sweetpotato roots in pits. The heaps are then covered with paddy straw, mud, and cow dung slurry. Other sporadically followed methods are putting the roots in sand beds 4-6 inches deep, in earthen pots, or simply in heaps covered with a thin layer of paddy straw or dried grass in a dark corner of the hut. In this system, to withdraw roots, a small hole is made in the heap, or the mud plaster of the earthen pot is removed. The holes are then re-covered. Roots can be safely stored in this manner for 1-4 months. Under these storage conditions, temperatures mainly range from 25 to 38°C with relative humidity (RH) varying from 80 to 95%. Rodents cause considerable loss and damage to stored roots.

The best way to minimize damage in storage is to store healthy roots that are free from insect damage and mechanical injury. Such roots are heaped and covered with dry soil or wood ash for about two months. Keeping the roots in earthen pots sealed with fine net or cloth also prevents the entry of pests and prolongs storage for up to three months.

Storage and preservation

An estimated 24% of harvested sweetpotato roots are damaged during harvest. This enhances rotting during storage. Affected roots can be recognized easily by their water-soaked appearance and mushy decay, sometimes exuding a mild alcoholic odor. Storage rot is higher in enclosed storage than in ventilated yards. Attempts have been made to reduce damage during storage. In one experiment, sweetpotato roots were stored for 90 days in sawdust, red earth, earthen pots, wood ash, white sand, local earth, and waste carbon paper. Local earth was the most economical medium (Mukherjee and Prasad 1972).

In another experiment, uninfested and uninjured roots were stored in earthen pots, fine sand, laterite soil, wood ash, and sawdust and compared with exposed storage as a control. At day 50, there was no damage in the different treatments. In the control, 100% of the roots were damaged by pest infestation and drying was observed.

Sprouting and rot are common during sweetpotato storage. Storage studies have shown that the weight loss of sweetpotato roots stored for 30 days could be reduced from 25-73% to 8% by storing them in sand. After 60 days' storage, the weight loss was 42% under ambient conditions and 13% in sand. After 90 days, the weight loss was 50% under ambient conditions and 16% under sand storage (Dayal et al. 1990).

Sweetpotato weevil, *Cylas formicarius*, is a very serious storage problem. Harvested roots may contain weevil in any of its life stages that damage roots during storage. Affected roots taste very bitter and are unfit for consumption. Water loss and shrinkage are other changes caused by weevil infestation. Research at the Central Tuber Crops Research Institute (CTCRI) showed that sweetpotatoes heaped on the floor of a godown and covered completely with a 5-cm thickness of dried red earth (1:4 wt/wt) or wood ash (1:1 wt/wt)

were free from weevil infestation and dehydration for two months (Rajamma 1984). For this experiment, roots were free from weevil infestation, selected immediately after harvest, and cured in the sun for about 6 hours.

It was observed that the tribal people in Orissa store sweetpotato roots immediately after harvest in heaps and then cover them with a layer of straw. The straw heap is then plastered with a mixture of clay soil and cow dung. Roots stored in this manner remain fresh for as long as six months.

Areas of Research and Development with Potential

Major factors slowing growth in sweetpotato production are many and varied. They include the easy availability of cereals, increased standard of living, lack of an assured market, and high returns from cash crops. Sweetpotato diversification into industrial uses is the major development alternative. Therefore, research and development (R&D) for sweetpotato in India focuses on the exploitation of the crop for non-conventional food, feed, and industrial uses.

Starch separation

Poor recovery of starch is one of the main constraints to the use of sweetpotato in the food-processing industry. After starch recovery, a good percentage of starch retained in the pectino-cellulose matrix remains unrecovered. Novel methods of starch separation involving maceration of the tissue and disintegration of the root cell wall are reported by Kallanbinski and Balagopalan (1991). These techniques must be scaled up to produce starch on a commercial scale.

Diversification

Diversification of uses of sweetpotato in India will involve its exploitation for non-conventional food, feed, and industry.

Foods

Sweetpotato is directly consumed as a processed food item in India. No attempt has been made in the past to produce secondary processed foods. One of the main constraints to using sweetpotato is its poor extractability of starch, which seldom exceeds 50% of the values recorded by chemical means. Phenolic oxidation and its effect on starch color is another minus point. Novel methods for the maximum extraction of starch and removal of unwanted colors would enable its wider utilization in food industries.

Animal feed

Approximately 20-25% of total production is lost because of damage during harvesting or weevil infestation. Developing a proper ensiling technology to use damaged roots could ensure conservation and diversification of this produce for animal feeding.

Fermented products

Techniques for the production of novel products such as citric acid, monosodium glutamate, high-fructose syrup, vitamin C, and ethanol from sweetpotato need to be standardized for their use in industry.

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Indian State Reports

Sweetpotato in Andhra Pradesh

Abida Sultana[1]

Abstract

Sweetpotato in Andhra Pradesh occupies an area of 2,900 ha with an annual production of 27,400 t. It is consumed immediately after harvest without intermediate storage. Harvesting is done daily or at 2-3-day intervals based on demand. Sweetpotato is sold in local areas; very little of it reaches big wholesale markets because of high transport costs, perishability, and lack of storage facilities. Therefore, it is an inexpensive food in villages and a costlier commodity in cities. Sweetpotato use is largely confined to fresh consumption, with minor quantities going to animal feed and industry.

Research and development areas requiring more support through improved production technologies are to evaluate separate varieties for superior traits for food, feed, and industry; for supplying certified planting material; and for integrated pest management programs. On the postharvest side, needs are for proper storage, a reduction in the price by creating cooperative marketing societies, and use of sweetpotato in processed food products such as chips, wafers, and noodles. Sweetpotato as a component in animal feed and in industrial products (starch, glucose, and alcohol) can change its status from a subsistence to a market-oriented crop.

Key words: Postharvest, curing, energy, saprophyte, infection, and utilization.

Area and Production

In Andhra Pradesh, sweetpotato occupies an area of 2,930 ha with an annual production of 27,480 t, constituting 1.8% of total cropped area under sweetpotato in India and 2.15% of total production.

Area under sweetpotato (Table 1) decreased from 4,250 ha in 1975 to 2,930 ha in 1989. Production also fell from 21,250 t in 1975 to 18,230 t in 1986. But from 1987 onwards, production grew with no substantial increase in area, largely because of the use of high-yielding varieties and adoption of improved production technologies.

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Table 1. Area planted to sweetpotato and quantity produced in Andhra Pradesh between 1975 and 1989.

Year	Production	Area	Yield	Index (x)		
	(000 t)	(000 ha)	(t/ha)	Production (t)	Area (ha)	Yield (t)
1975	21.2	4.2	5.0	100	100	100
1980	24.4	4.1	6.0	95	115	120
1981	19.7	3.8	5.2	89	93	104
1982	16.9	3.4	5.0	79	79	100
1983	16.6	2.8	5.9	66	78	118
1984	15.8	2.9	5.5	68	75	111
1985	16.7	2.6	6.5	61	79	130
1986	18.2	2.9	6.3	68	86	126
1987	25.0	2.9	8.6	68	117	172
1988	20.2	2.8	7.1	67	95	142
1989	27.5	2.9	9.4	69	129	188

Source: Statistical abstracts 1975 to 1989, Directorate of Economics and Statistics, Government of Andhra Pradesh.

The reasons for the decrease in area may be:

- Rapid urbanization and rising income levels leading to changes in food habits, with an increased consumption of cereals, meat, and fruits.
- Marketing problems caused by sweetpotato's bulky nature, perishability, and high transport costs.
- Non-utilization of sweetpotato in processed foods such as canned sweetpotatoes, chips, flakes, wafers, and noodles; as a component of animal feed; and in industries (starch, glucose, and alcohol).

Nellore, Vishakhapatnam, Prakasam, and Guntur districts in coastal Andhra; Chittoor in Rayalseema; and Rangareddy district in Telangana lead in area and production. These districts can be referred to as the sweetpotato-producing belt of Andhra Pradesh (Figure 1). Guntur district, however, recorded the highest productivity (13.7 t/ha).

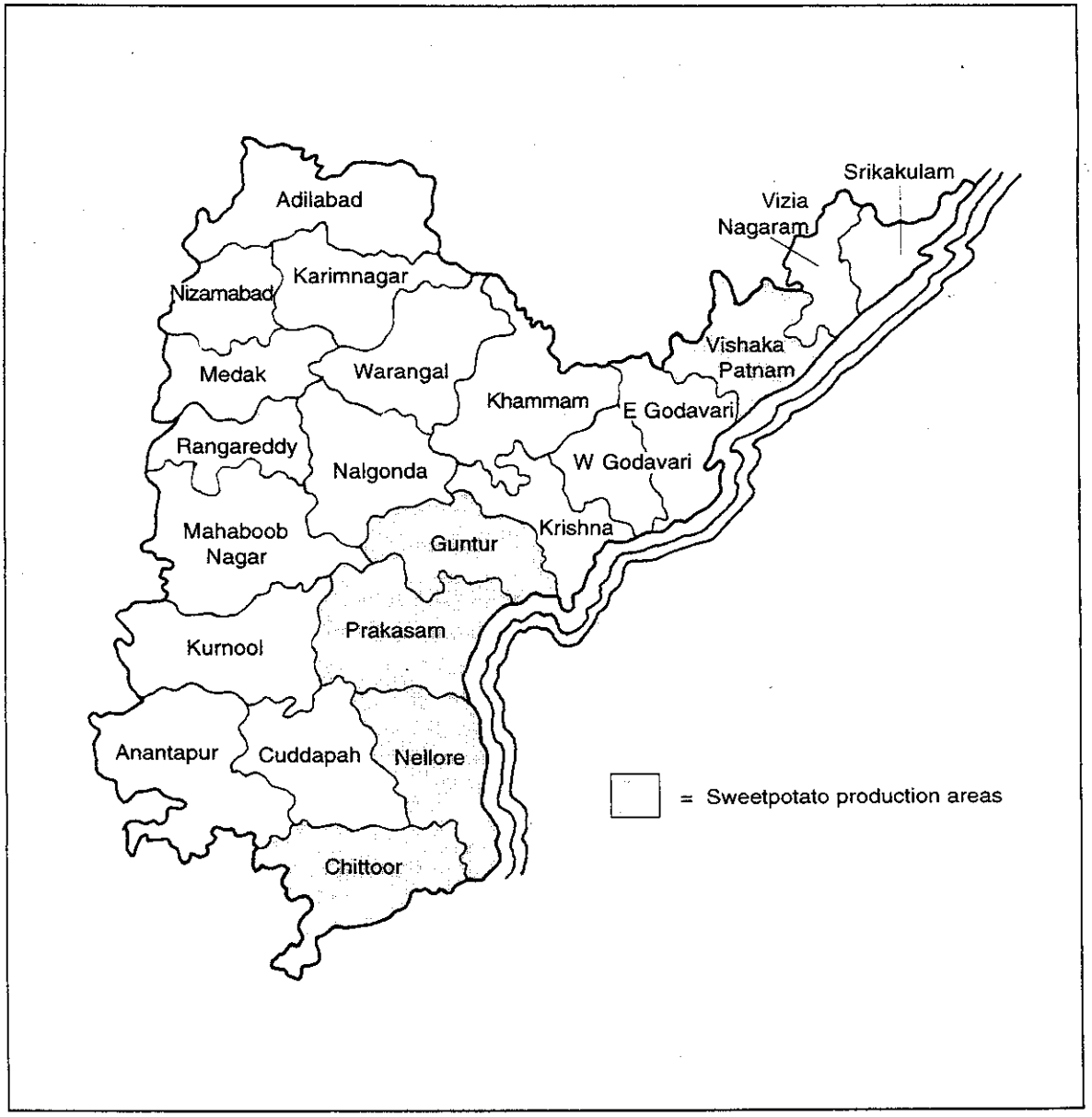

Figure 1. Main sweetpotato-producing areas of Andhra Pradesh.

Storage

In Andhra Pradesh, sweetpotato is consumed immediately after harvest without any intermediate storage; therefore, not much attention has been paid to curing and storing roots. Roots are left in the field and harvested daily or at 2-3-day intervals based on market demand. Rarely do farmers harvest the entire crop at once, except for certain occasions, such as the *Siva Ratri* festival. At this time because of great demand, farmers can secure high prices by sending sweetpotato to big wholesale and local markets.

If storing is unavoidable, roots are spread in a well-ventilated room or under shade with frequent inspections to eliminate any unhealthy roots. In no case are roots stored for more than a week after harvest. Farmers in Andhra Pradesh do not use roots as seed material for successive plantings; rather, small nurseries for vine cuttings are maintained to serve as seed for the next planting.

Since sweetpotato is not stored, storage problems from biochemical, fungal, and bacterial organisms are negligible. As the roots are kept in the field for 10-15 days after maturity, however, some pest and physiological problems occur.

Field and Storage Problems

Sweetpotato weevil

This is the most important sweetpotato pest. With disastrous results, this weevil enters roots in the field. Infection increases with each batch harvested. A delay in harvesting increases the chances of infection. Larvae completely spoil the roots by tunneling. Crevices made by weevils also promote dehydration and secondary invasion by saprophytes, making roots unsuitable for human consumption.

Dipping vines before planting and spraying at 15-day intervals during the crop growth stages with endosulfan or fenitrothion (0.05%) reduce weevil infestation in the field (Pillai and Magoon 1969). Fumigation with methyl bromide or sulfur kills weevils in different stages of development. Storing roots in heaps on floors and covering heaps with red earth prevent weevil entry and thus protect the roots.

Rodents

Rodents such as *Bandicota bengalensis* and *Mus biodunga* cause damage to roots in India. Yield losses are reported to range from 5 to 15%.

A combination of the following three methods is preferred for preventing rodent damage: trapping, poisoning, and environmental alteration. Zinc phosphide (a single dose) is widely used in root crops. Zinc phosphide (2%) mixed with suitable baits containing cereals, sugar, and oil is used. Chemical poisoning is usually followed by gassing (aluminum phosphide tablets) to get complete control. Weed control within the crop and around field edges will limit the number of rodents (Anonymous 1978; Barnett and Prakash 1975).

Physiological disorders

When roots are stored in ventilated rooms or under shade, the following physiological disorders and diseases are noticed in addition to the problems mentioned above.

Pithiness

Development of pithiness in the roots leads to weight loss. The overall cellular structure of the root changes during storage, which results in an increase in intercellular spaces. This makes the roots hard and spoils quality.

Sprouting

Sprouting is frequently noticed in sweetpotatoes kept beyond 20 days in the field or even in well-ventilated rooms at ambient temperatures. Sprouting enhances pithiness. Under field conditions, sprouting is generally controlled by harvesting within 20 days of maturity.

Diseases

Soft rot, surface rot, and dry rot are generally a problem in roots that have been stored in heaps.

Utilization

Though the concept of utilization of sweetpotato as food, feed, and in industries has been universally accepted, little attention had been paid to this in Andhra Pradesh, where use has been limited to fresh consumption. Very little sweetpotato is used as animal feed or for industrial purposes. Roots are consumed unprocessed after boiling, baking, or steaming. Sweetpotato is also served in curries and desserts. Vines, although a rich vitamin and protein source, are rarely used as greens.

Animal feed

Vines serve as a nutritious and palatable greenfeed for cattle. The feeding value of vines is close to that of alfalfa. Average vine yield in Andhra Pradesh is 20-30 t/ha when grown during June and July. In Andhra Pradesh, where sweetpotato is a crop cultivated by small and marginal farmers, vines are considered residues, and are immediately fed to cattle.

Industry

The exploitation of sweetpotato in industry for the manufacture of starch, liquid glucose, alcohol, and other by-products is almost nil in Andhra Pradesh. Maize (considered to be a cheaper raw material) is used for starch extraction. Sugarcane molasses is used for alcohol.

Marketing

Sweetpotato marketing in Andhra Pradesh begins in November and extends to May. There are two major marketing channels: one involves shipments to large wholesale markets in urban consumption centers, the other concerns sales to village markets in rural areas. The flows to the large wholesale markets are as follows:

Farmers → commission agents → wholesale dealers → retail dealers → consumers.

At the village level, one of the following two marketing channels is used:

Farmers → local collections in the field → consumers.
Farmers → local market direct sale by farmers themselves → consumers.

Unstable supplies

Of the sweetpotato produced on small holdings for household and local use, 70% of output is marketed in local village markets, or by hawkers in the village itself. Shipments to wholesale markets are only a small proportion of regional production (Table 2), which may be attributed to the following constraints:

- High transport costs, which small farmers cannot afford
- High perishability of roots
- Lack of storage facilities in markets
- Price disparity

These constraints contribute to large differences in prices for produce sold in villages and in big cities. As a result, sweetpotato becomes an inexpensive staple food in rural areas and an expensive commodity in cities (Table 3).
improvements merit consideration:

Table 2. Sweetpotato production, arrivals in wholesale markets of Hyderabad, 1979-89.

Year	Total production (t)[a]	Market arrivals (t)	%
1979	2,589	449	17
1980	3,042	362	12
1981	1,760	452	26
1982	1,453	320	22
1983	817	150	18
1984	1,009	200	20
1985	280	060	21
1986	1,500	278	18
1987	2,609	801	30
1988	1,944	567	29
1989	2,851	621	22

Source: *Statistics on marketing in eighties, 1980-81 to 1989-90*, Agricultural Marketing Committee, Hyderabad.
[a] Refers to the Telangana region only.

Table 3. Wholesale prices (Rs./quintal) of sweetpotato vs. other commodities in major markets in Andhra Pradesh, 1981-89.

Year	Wholesale price			
	Sweetpotato	Potato	Colocasia	Yam
1981	312	125	165	90
1982	210	178	163	95
1983	205	173	158	174
1984	235	115	171	144
1985	220	275	155	118
1986	230	239	223	115
1987	270	152	265	106
1988	475	300	200	137
1989	440	179	213	115

Source: *Statistics on marketing in eighties, 1980-81 to 1989-90*, Agricultural Marketing Committee, Hyderabad.

Future Prospects

If sweetpotato area and production are to increase, the following postharvest improvements merit consideration:

Storage facilities. Lack of storage facilities is one of the main limiting factors in sweetpotato production. The use of cold storage and proper ambient-temperature storage facilities in villages and markets can reduce postharvest losses, resulting in increased returns to farmers.

Transport facilities. Sweetpotatoes arriving at large, urban wholesale markets typically come from surrounding districts. Shipments from distant production centers rarely go to these markets because of high transport costs. The introduction of air-cooled cars in freight trains might increase marketing possibilities.

Reducing the price spread. Reducing the differential between prices obtained by farmers, wholesalers, and retailers is one important requirement for promoting root crops. One possible solution is to develop cooperative marketing societies. Such societies can help farmers by providing inputs, advisory services, remunerative prices for crops, and marketing arrangements.

Popularizing convenience foods. The use of convenience foods such as chips, wafers, and breakfast products can increase sweetpotato consumption, thereby increasing demand at the farm level. An initiative is needed to introduce and popularize such convenience foods, possibly by importing processing technologies from other countries.

Utilization as animal feed and in industry. Sweetpotato is currently used as a component in animal feed in parts of India. Such use might well be expanded through diffusion of improved varieties. Sweetpotato also has industrial processing potential in the manufacture of starch, glucose, and alcohol. Importing technologies from other countries would increase demand, resulting in an increase in area and production.

Financial assistance from governmental bodies would encourage sweetpotato utilization.

Changing the status of sweetpotato from a subsistence to a market-oriented crop requires a fresh approach aimed at getting this food back on people's tables. To meet this need, the following research and development areas require more support:

Production technology

- Develop superior varieties specifically for food, feed, and industrial purposes.
- Develop a certified seed production program to supply high-quality planting material; this would enhance yields up to 50%.
- Make efforts to include sweetpotato in different cropping systems. As a short duration crop, it can fit easily within various cropping systems.
- Develop an integrated pest management program, especially for weevil control.

Postharvest technology

- Improve storage facilities.
- Create an awareness in the public through different extension media of sweetpotato's nutritive values.
- Extend present utilization as a convenience food; sweetpotato should be available packaged and ready for cooking with minimum preparation.
- Develop needed innovations for feed utilization, such as low-cost drying, an efficient system for collecting produce in a form easily mixed with other feed ingredients, and storage facilities to reduce deterioration in quality.
- Improve quality for industrial purposes such as making starch, glucose, and alcohol, so that sweetpotato may be competitive with other starch-producing crops.
- Begin a vigorous research program to develop new processed products.

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Sweetpotato in Assam

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Abstract

In Assam, where climate and soils are quite suitable, sweetpotato has been grown for a long time by marginal farmers. Presently, area planted is 8,532 ha, with a production of 27,327 t. Sweetpotato has immense potential for extension and development. Though mostly used as a vegetable, sweetpotato is a supplementary food, with roots eaten either boiled or baked and sometimes used for preparing sweets. Postharvest storage has not been practiced on a large scale as the crop is cultivated by farmers for their own consumption. Excess production, if any, is sold in nearby markets by producers themselves. When demand requires storage, some farmers select good, undamaged roots and sun-dry them for about one week, then store them in small heaps or gunny bags. In some cases, roots are stored in alternating layers with sand in thatch houses for one month without much damage. Prospects for enhancing sweetpotato cultivation in Assam largely depend on the establishment of industries based on root crops as raw material. At this writing, there is no processing of sweetpotato in Assam. If small-scale industries were started in rural areas, however, cultivation could increase quickly and thereby generate employment opportunities.

Key words: Storage, perishability, utilization, extension, and research and development.

Introduction

Sweetpotato (*Ipomoea batatas*) is an important root crop in tropical and sub-tropical regions. The chief use of sweetpotato is for human consumption followed by the manufacture of starch and alcohol. Vines and leaves, dried or raw, are an excellent animal fodder, comparable in nutritive quality with legume grasses. Since sweetpotato is adapted to and cultivated in the sub-tropical regions of the world, it is suitable to the climate and soils of Assam. The favorable sub-tropical climate of Assam and its deep sandy or sandy loam soils are well suited for this crop. Sweetpotato is grown by low-income farmers on a home scale in both the plains and hill districts of the state.

Area and Production

There are no systematic and accurate estimates of sweetpotato production and area planted in the different districts of Assam. According to the Directorate of Economics and Statistics, Government of India, however, the total area of sweetpotato in Assam

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was about 8,532 ha (5.4%) of the 158,400 ha for the country in 1988-89, and production was about 27,327 t (2%) of the 1.3 million t country total. Yield is also low (3.2 t/ha) compared with the country average of more than 8 t/ha.

Sweetpotato area fluctuated between 8,200 and 10,500 ha between 1979 and 1989 and production was from 27,300 to 34,500 t. Yield remained more or less static, ranging from 3.2 to 3.3 t/ha (Table 1). Among the different districts of Assam, Dhubri alone accounts for 26% of area and 30% of production (Table 2 and Figure 1).

Table 1. Sweetpotato production, area, and yield in Assam, 1979-89.

Year	Production (000 t)	Area (000 ha)	Yield (t/ha)
1979-80	28.2	8.5	3.3
1980-81	33.2	10.0	3.3
1981-82	31.9	9.9	3.2
1982-83	31.5	9.5	3.3
1983-84	28.4	8.7	3.2
1984-85	34.5	10.5	3.3
1985-86	27.4	8.2	3.3
1986-87	28.6	9.0	3.2
1987-88	27.4	8.6	3.2
1988-89	27.3	8.5	3.2

Source: Directorate of Economics and Statistics, Department of Agriculture & Cooperation, Ministry of Agriculture, New Delhi (1989).

Table 2. Sweetpotato production, area, and yield in Assam, by district, 1988-89.

District	Production (t)	Area (ha)	Yield (t/ha)
Dhubri	8,307	2,230	3.7
Kokrajhar	2,365	550	4.3
Nagaon	2,186	686	3.2
Nalbari	1,947	590	3.3
Barpeta	1,840	800	2.3
Kamrup	1,812	840	2.2
Mongaldai	1,537	460	3.3
Dibrugarh	1,322	478	2.8
Golaghat	1,197	410	2.9
Sonitpur	816	272	3.0
Golgamat	822	274	3.0
Karbi Anglong	754	246	3.1
Lakhimpur	717	235	3.0
Cachar	624	140	4.5
Sibsagar	559	173	3.2
Karimganj	285	75	3.8
Jorhat	141	50	2.8
North Cachar Hills	113	23	4.9
Total	**27,327**	**8,532**	**3.2**

Source : Department of Agriculture & Cooperation, Ministry of Agriculture, New Delhi (1989).

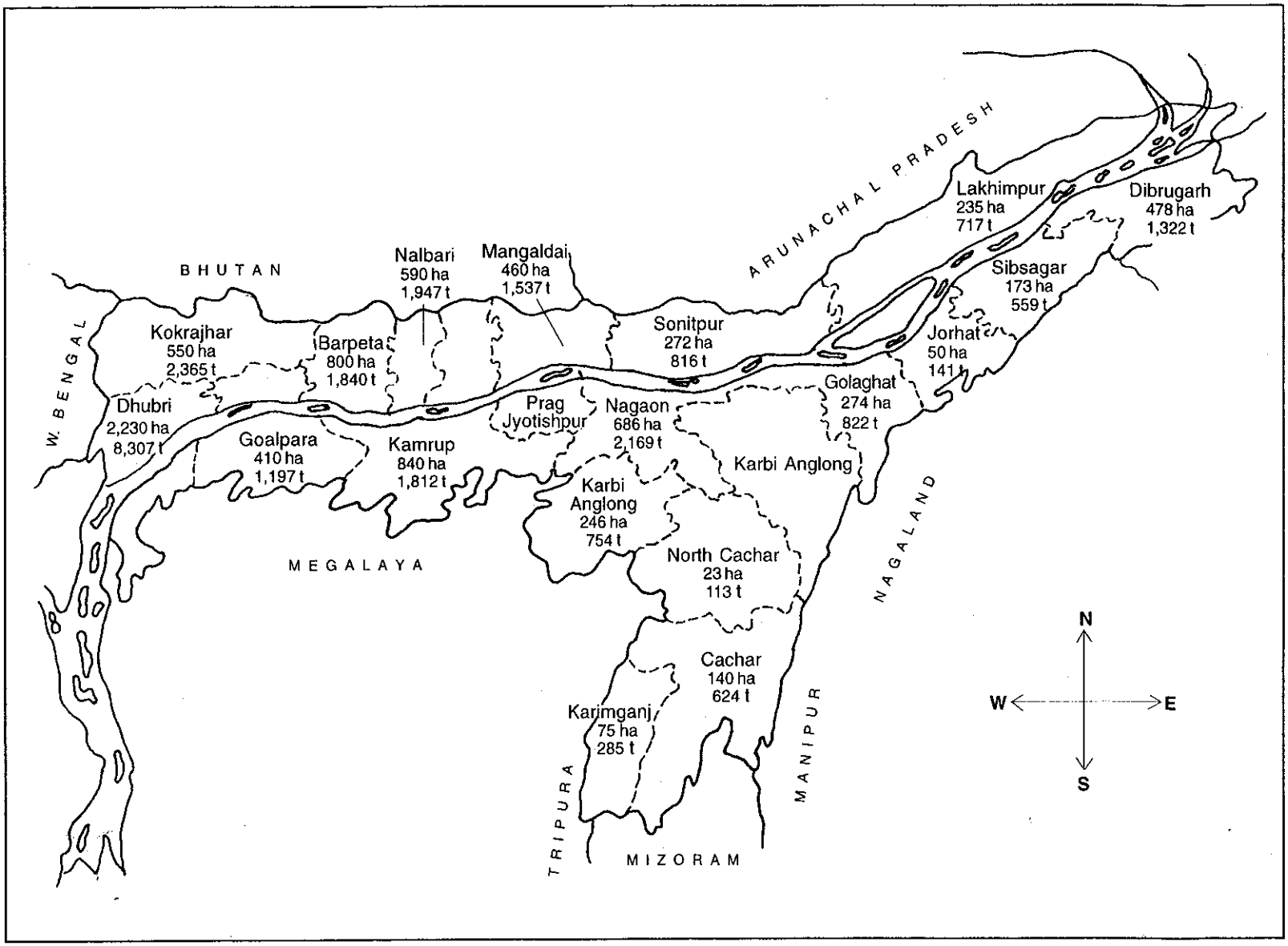

Figure 1. Sweetpotato area planted (ha) and production in Assam.

No concerted effort was made to increase area, production, or yield. The low yield in Assam is due to poor soils, inferior varieties, and pest damage. But with the implementation of the AICRP (All India Coordinated Research Program) on root crops (other than potato) at Assam Agricultural University, Jorhat, some research work has begun on sweetpotato. Present studies are confined to varietal improvement and improving recommended management practices.

Further development of sweetpotato cultivation in Assam largely depends on the establishment of industries based on root crops as raw material. At this writing, there is no processing of sweetpotato in Assam. If small-scale industries were started in rural areas, cultivation could increase quickly and this would generate employment opportunities.

Utilization

Consumption of sweetpotato in Assam is seasonal. The crop is not used as a regular part of the diet. As a supplementary food, roots are eaten either boiled or baked, and served as a part of vegetable dishes during the harvest season. Tender vines and leaves are used as a green vegetable. Sometimes sweetpotato replaces *panmeer* (*channa* flour) to prepare a kind of sweet. Although sweetpotato is a seasonal crop, there is a heavy demand for it during *Magh Bihu*, a festival of eating and rejoicing for Assamese people in mid-January. Sweetpotato is a required food on that occasion. Because of this demand, farmers adjust planting in such a way that the crop is harvested early in January.

Storage

Postharvest storage of sweetpotato in Assam is seldom practiced because the crop is cultivated by low-income farmers for home consumption. The little information available about such storage usually relates to basic methods traditionally used by farmers, who typically leave roots in the ground and harvest them when needed for immediate consumption. Aboveground storage is only required when sweetpotato use extends beyond the harvest period. Thus, some farmers select good and undamaged roots, sun-dry them for about one week, and store them in small heaps or in gunny bags. In some cases, roots are stored for up to one month without much damage in alternating layers with sand in thatch structures.

One of the major constraints to expanded use of sweetpotato is its perishability after harvest. Harvested roots cannot be stored under ambient conditions for long because of shrinkage, rotting, and pest infestation. The most destructive storage pest is sweetpotato weevil (*Cylas formicarius*). This weevil enters roots from the field and completely spoils them. The grub bores tunnels into roots in the field, as well as in storage. This damage results in odorous, rotten roots unfit for consumption.

Not much research has been done on storage methods in Assam; however, some preliminary observations have been made at Assam Agricultural University, Jorhat. In this work, various storage methods were tried, including curing roots and coating them with mud. The findings indicate that curing gives the best results. By keeping the harvested roots at 45-50°C at 85% RH for 3-4 days, harvest wounds healed and root quality was good, even during prolonged storage. In another experiment, roots were stored under ambient conditions to compare keeping quality. Roots injured during harvest suffered maximum damage. Biochemical changes that took place during storage of five varieties of sweetpotato were also studied. The analysis of random samples taken periodically showed that dry matter content decreased initially, but later steadily increased, probably because of dehydration. Starch showed a reduction and sugar content increased during storage.

Storage extends the period of availability of fresh vegetables by arresting metabolic breakdown and deterioration caused by fungi. Storage techniques such as refrigeration and controlled or modified atmosphere are expensive and involve a lot of energy use. Based on the principle of evaporative cooling, a low-cost and low-energy-input cool chamber has been developed at the Indian Agricultural Research Institute (IARI), New Delhi. The cool chamber can reduce temperatures by as much as 16-17°C during the peak summer months and maintain humidity above 90% throughout the year. These chambers are ideal for short-term sweetpotato storage.

Market

In Assam, sweetpotato is cultivated by farmers for their own consumption as a supplementary food. Any excess production is sold in nearby markets by farmers themselves. Thus, the role of middlemen in sweetpotato marketing is almost non-existent. Therefore, unlike the potato, sweetpotato is not an important commercial commodity. Harvested produce cannot be stored for long periods. Given this situation, large-scale cultivation of this crop will result in glut, low prices, and losses to farmers. This is one reason why middlemen shy away from large-scale marketing of sweetpotato.

Constraints to Use

Sweetpotato grows well in Assam with minimum inputs and the cost of cultivation is rather low. In Assam, this crop could be cultivated as a substitute for potato, because the sturdier sweetpotato can be grown with less care and can withstand unfavorable conditions better than potato. Sweetpotato research has been carried out by the Assam Agricultural University (AAU) under the auspices of the AICRP on root crops. AAU has identified several genotypes capable of giving higher yields with better quality. These have been distributed to a few select farmers.

Sweetpotato cultivation, however, has not yet caught the imagination of farmers in Assam. There are several reasons for the lack of interest in the crop in this region.

Food habits. People have not accepted sweetpotato as an important food item, partly because of the lack of knowledge about its food value and culinary preparation. If acceptable food preparations can be worked out, current eating habits may well change.

Lack of facilities for industrial use. Since roots are rich in starch, they are increasingly used as raw material for many industries and as animal feed. If small-scale industrial units for the production of starch, fuel alcohol, and fructose syrup are started in Assam, cultivation of this crop could quickly increase. The preparation of alcohol may attract the attention of tribal people for large-scale cultivation.

Non-availability of high-yielding planting material. Although sweetpotato is propagated by stem cuttings, cuttings ready for cultivation are not generally available through normal marketing channels. This is a practical problem faced by farmers and it should be corrected by encouraging the opening of nurseries to supply high-yielding planting material to prospective farmers. Private nurserymen, the NSC (National Seed Corporation), and Assam Seed Co-operation Ltd. should lead in this direction.

Inadequate extension efforts. Root crops, in general, do not receive proper support and encouragement from government agencies; efforts to extend the cultivation of sweetpotato should be taken up immediately. Sweetpotato should have a place on the agenda of extension agencies whose workers could be given special training. For example, a workshop on sweetpotato could be organized for imparting practical training to the extension staff of the state government.

Research Needs

Sweetpotato production has increased considerably, primarily because of the development of new production technologies, but its impact is low because of the huge losses that occur between harvesting and consumption. It is therefore essential to adopt an integrated, low-cost system from the preharvest stage until the produce reaches consumers. Various preharvest considerations such as selection of the right cultivar, appropriate planting time, timely irrigation and cultural practices, and the judicious application of fertilizers and pesticides can influence the storage life and processing quality of sweetpotato.

Processing sweetpotato into durable products during surplus production can go a long way toward reducing postharvest losses. Unfortunately, in India a negligible quantity of sweetpotato is processed. The Indian processing industry has not been able to accumulate a consumer base because production of these goods is expensive, requiring high expenditures on energy and high-cost techniques. Therefore, it is

necessary to develop low-cost techniques such as solar drying and pickling to make products affordable to the average consumer.

To meet the goal of higher sweetpotato production and use in Assam, a concerted varietal development program is needed to:

- Breed varieties having early maturity and weevil resistance.
- Identify varieties that yield substantial fodder and a reasonable number of roots.
- Make a concerted research effort on the use of sweetpotato foliage in animal feed formulations.
- Identify varieties with a competitive edge for use as human food, animal feed, and industrial raw material.

Sweetpotato in Bihar

V.S. Verma[1]

Abstract

Bihar, second among the Indian states in sweetpotato acreage, has witnessed a decrease in area and production in recent years. Farmers are choosing other crops because of storage problems and perishability of sweetpotato roots, and because its use has not been diversified. This has resulted in a gap between demand and supply. The present status and future prospects of sweetpotato in Bihar are discussed in this paper. Storage methods and problems, market demand, postharvest handling, and utilization are highlighted.

Key words: Staple, agroclimate, insect infestation, processing, utilization, nutrition.

Introduction

Sweetpotato (*Ipomoea batatas*) ranks third among the important root crops of South Asia. The crop can be grown extensively under a wide range of agroclimatic conditions in tropical and warm, temperate areas. It grows quickly, its roots bulk rapidly, and it produces high dry matter per unit of time and space. Sweetpotato is highly nutritious and is used as the raw material for making liquid glucose, starch, and alcohol in Japan, as well as other industrial products such as baby food, candies, sauces, snacks, crackers, and chips in the USA, noodles in Indonesia, kapek in China, and an ingredient in pastry- filling mixes in Sri Lanka (Moorthy 1990). It provides more calories than potato and has good quantities of vitamins and minerals (Villareal 1977).

In Bihar, roots of this high-energy crop are consumed within a few days after harvest, without storage and processing into other useful products. In spite of the crop's various uses, organized research on sweetpotato production has remained modest. For postharvest handling and use, practically no work has been done in Bihar, although as many as 43 sweetpotato recipes are available in India (Padmaja 1990).

Area, Production, and Yield

Orissa, Uttar Pradesh, and Bihar together account for 71% of the total acreage and 74% of the production of sweetpotato in India. Bihar is second in area and productivity, but third in production after Orissa and Uttar Pradesh. The most important districts for sweetpotato production in Bihar are Ranchi, Muzaffarpur, Gumla, Purnea, Samastipur, Sitamarhi, Vaishali, East Champaran, Madhopur, Saharsa, Begusarai, Madhubani,

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Mungher, Bhagalpur, Khagaria, and Bhojpur. Khagaria and Bhojpur have the highest productivity (20 t/ha), followed by Nalanda (16.6 t/ha) and Patna (11.6 t/ha). The rest of the districts have quite low yields, ranging from 4.8 to 9 t/ha. Compound growth rates for area, production, and productivity of sweetpotato in Bihar have been reported to be -2.97, -1.52, and +1.45, respectively. To step up sweetpotato acreage, it is imperative to increase production, supply quality vines, remove price disparity, popularize food and processed products, diversify industrial uses, reduce production costs, reduce perishability, lower transportation costs, and reduce storage losses.

Storage Methods

In Bihar, some sweetpotato storage problems are more severe for summer crops, compared with the rainy-season and winter crops. In the summer crop, bulking is poor and weevil attacks severe. Winter and rainy-season roots are stored at room temperature for 6-10 weeks. It has been reported that when cured roots are stored at 15.6°C at 90% RH, weight losses of 7-16% occurred after 5 weeks of storage (Picha 1986). A year-round supply of fresh roots is available in Bihar primarily due to three cropping seasons and varietal variability in maturity. This overcomes the problem of storage for longer periods at controlled temperature and humidity. No systematic work on storage methods and losses has been done so far.

When storing sweetpotato, farmers first sort infected roots from the lot and cure them for a week or so at a room temperature of 29°C ± 2°. Only a few farmers follow the tradition of preserving undamaged, infestation-free, cleaned, and cured roots in bamboo baskets, containers, or clamps (mounds) on the floor in sand in their houses for 6-8 weeks. Long-term storage methods, ground pits, ventilated mounds, shed storage, or ground storage without harvesting are not popular in Bihar. Ground storage of unharvested roots exposes them to weevil infestation, fibrous growth, and cracking.

Storage Problems

Sweetpotato as fresh storage roots is semi-perishable and faces various storage problems:

- Respiration losses leading to the breakdown of starch into sugars, which affects quality
- Weight loss
- Rottage from weevil infestations and pathogens
- Mechanical injury leading to enhanced wound respiration
- Polyphenol (furanoterpenes and coumarins)
- Sprouting
- Pithiness
- Internal cork formation
- Dehydration

- Discoloration
- Low-temperature injury in cold storage
- Storage diseases

Severe storage rots of sweetpotato roots in stores have often been reported. Soft rot (*Rhizopus* spp.) and blue mold rot (*Penicillium* spp.) have been isolated at Trihut College of Agriculture, Dholi, Muzaffarpur, Bihar, from roots stored under indigenous storage conditions. During varietal screening of certain sweetpotato genotypes against cercospora leaf blight disease, R.S. 43, C-63, C-67, C-73, C-75, C-81, C-82, and V-15 were found to be resistant to soft rot and circular spot diseases in the initial screening. Studies are needed to assess various storage methods for disease and root loss under long-term storage in permanent storage structures or under home conditions.

Utilization

Farmers do not generally store sweetpotato roots for long periods in Bihar. An estimated 80-90% of all sweetpotato roots produced are consumed fresh or as snacks after boiling, roasting (15-18%), or baking; 2-5% are consumed fresh in religious ceremonies. About 80-90% of vines are used as animal feed and 10-20% as planting material. Sweetpotato products such as sherbet, chips, cake, cookies, pie, *pakoras*, soufflé, crust, patties, stuffing, soup, biscuits, and bars are not commonly found in Bihar. However, some housewives occasionally make *gulab-jamun*, bread, and pudding. Sweetpotato is also candied with milk *khoa* and used in sweets prepared by some sweet makers. Sometimes it is used as *puja prasad* and eaten as part of a non-cereal diet during fasting. Orange-colored sweetpotato is used as salad. Vines are used as vegetables by a few Bengali families in Bihar.

Although at present sweetpotato is not being utilized for industrial products, it has a bright future, particularly for the manufacture of liquid glucose starch by the acid and enzyme hydrolysis method. The hydrolyzed product may be concentrated, following neutralization and filtration, to yield a syrup from which glucose crystals may be isolated after cooling. In addition, industry in Bihar could try the technique of alcohol fermentation using the *Endomycopses fibuligera*-glucoamylase enzyme preparation method as practiced in China (Saha and Ueda 1983).

Marketing

Most farmers in Bihar commercialize their own sweetpotato roots at nearby rural markets. To a certain extent however, agents are also involved in marketing sweetpotato roots or even a standing crop on a unit area basis. Agents collect roots at farm sites and carry them to nearby towns. The flow of sweetpotato roots from north Bihar to south Bihar, including Deoghar and Gaya districts and eastern Uttar Pradesh, has been observed occasionally. In some parts of Bihar, such as Bhagalpur, Banka, and

Gaya districts, certain farmers practice the barter system. In this system, 1 kg of sweetpotato is exchanged with one-half to 1 kg of paddy or maize.

Conclusions

To increase sweetpotato production, several areas need improvement, such as the availability of quality planting material, price stability, popularizing low-cost processed food products, and reducing storage losses. For better storage of sweetpotato roots, the following procedures are recommended:

- Temperature 15 ± 1°C with 87 ± 3% relative humidity is optimum for storage.
- Clean, healthy, undamaged roots free from pathogens and weevils store better. Roots well cured at 29 ± 2°C for a week store better.
- Checking stores at weekly intervals in order to remove infested roots improves keeping quality.
- Properly ventilated farm storage with an optimum temperature of not below 15°C should be used.
- Use of sprout inhibitors such as maleic hydrazide (sprayed two weeks before harvest) increases dormancy.
- Keeping the temperature regime at not less than 15°C avoids chilling injury, decay, water retention, internal breakdown, impaired culinary quality, and loss of genetic variability.

Support for research to exploit possible utilization of sweetpotato to make baby food, sauces, jam, and snacks at the home and village levels is likely to generate employment among the rural peoples of Bihar. Although industrial and semi-industrial processing is not being practiced presently in Bihar, it has a good future provided it is supported with research to standardize processing techniques for entrepreneurs.

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Sweetpotato in Gujarat

S.C.P. Sachan[1]

Abstract

Sweetpotato is a minor or secondary crop in Gujarat. It is grown in only 9 of 19 districts, on 1,700 ha with an annual production of 25,500 t. Fresh roots are boiled, baked, roasted, or fried and consumed directly. No processed products of any kind, either on a home or industrial scale, are produced. Roots are mainly used for home consumption, with surplus produce sold in the market. Not much headway has been made in sweetpotato research in the state. However, by screening a large number of varieties, two—Cross-4 (white) and Collection-7 (red)—were found promising and recommended to growers. Agricultural practices such as spacing, planting methods, and fertilizer application levels have also been researched. Future prospects for sweetpotato expansion in Gujarat are excellent, particularly by planting in September-October and again in November-December in southern Gujarat and July-August in northern and western Gujarat. Using this schedule, sweetpotato can be grown throughout the year in the state.

Key words: Production, food value, curing, storage.

Introduction

Sweetpotato (*Ipomoea batatas*) is an important root crop grown in every state of India except Jammu and Kashmir. Notwithstanding, the crop has not gained as much popularity as it deserves. In Gujarat, the status of sweetpotato is miserable and only stray cultivation is done by farmers on a small scale. Based on the crop's potential, future prospects for expansion of sweetpotato would seem to be high. But sweetpotato continues to be considered a minor or secondary crop and is therefore not being seriously promoted. Farmers in Gujarat grow sweetpotato only for home consumption and not as a commercial crop. Surplus produce is sold in the local market.

Economic Importance

Sweetpotato is a staple food in several tropical countries including India. It is known as the world's highest yielding crop, with a total food production per unit area greater than that of rice, and it has a higher food value than rice. Sweetpotato also requires fewer inputs. In the sub-tropical and tropical regions, it can be grown throughout the year. Sweetpotato production was ranked seventh in world crop statistics after wheat, rice, maize, potato, barley, and cassava (Shanmugavalu 1989). Because of its drought-

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tolerant attributes, sweetpotato can be grown readily on lands of low fertility where a considerable yield can be obtained due to the crop's high solar energy-fixing efficiency.

Food value

The nutritive value of sweetpotato is high. It is a good source of energy, supplying sugars and other carbohydrates, calcium, iron, and other minerals and vitamins, particularly vitamin A (Bose and Som 1986). The nutritive value of roots and leaves is shown below:

Roots
Rich in starch (16%)
Sugar (4%)
Appreciable in carbohydrates, protein, and fat
Cheapest energy source

Leaves
Protein 3.2% (fresh-weight basis) and 12.6% (dry-weight basis)
Rich in carotene and vitamin C
Good source of calcium, phosphorus, and iron

Area and Production

Although sweetpotato is not a commercially important crop in Gujarat, it is being grown in 9 of 19 districts on 1,700 ha of land, with an annual production of 25,500 t (DOA 1991). This is a small proportion of the state's total area planted in vegetables, 75,000 ha, and vegetable production of nearly 1.3 million t.

Sweetpotato is grown throughout the year by planting in September-October and again in November-December in south Gujarat, whereas in northwestern Gujarat it is planted in July-August. The highest acreage and production are in Mehsana District (500 ha), followed by Kheda and Valsad, each having 300 ha in sweetpotato (Table 1 and Figure 1). Average yield in Gujarat is 15 t/ha versus 8 t/ha in India as a whole.

Curing

After harvesting, the roots are cured to promote rapid healing of wounds inflicted during harvesting, and to increase the toughness of the root's skin. Curing is necessary to minimize infection by microorganisms during storage and to make the root more resistant to subsequent handling. Curing should begin immediately after harvesting. This is done by subjecting roots to high temperature and high relative humidity. A temperature range of 27-29.5°C and 85-90% RH applied for 4-7 days are common. Curing should be done in heated storage houses. Following curing, roots are stored at 13-16°C and 85-90% RH. In the tropics, where artificial curing may not be necessary,

roots should be allowed to cure for 4-5 days under ambient conditions before they are stored (Onweumi 1978).

Storage

Sweetpotato growers in Gujarat do not store their crop under the controlled conditions recommended above because no such facilities are available, and lower acreage and production do not allow creating such facilities. Some circumvent the need for storage by leaving the crop in the field and harvesting only as needed. The other storage method is to harvest the whole crop and store it indoors in heaps to be consumed at home or sold in the local market. In some places, roots are stored in underground pits covered with grass; however, this method is not followed in Gujarat, where some farmers store roots in baskets. Sprouting and spoilage are common with these methods and roots cannot keep satisfactorily for more than one or two months. No insect and microbial control measures are used before storage, so spoilage is quite high.

Utilization and Marketing

To maximize sweetpotato's economic value, all plants parts are used. Uses involve:

Fresh root. Throughout Gujarat, sweetpotato is consumed boiled, baked, roasted, or fried. Some fresh roots are fed directly to livestock. Roots are occasionally used as animal feed in Gujarat without following a hygienic procedure such as washing, shredding, treating with sulfur, and drying. Roots unfit for human consumption are usually fed to animals without shredding.

Vines and leaves. In some countries, leaves and tender shoots of sweetpotato are used as vegetable food. Leaves are usually eaten boiled or incorporated into soups and stews. They are also fed to livestock either fresh or in the form of silage. In Gujarat, however, leaves and shoots are used as green fodder for cattle and not for human consumption at all.

There is no commercial application of roots in Gujarat for manufacturing starch, alcohol, or syrup, nor is sweetpotato used in any processed products.

Most of the state's sweetpotato production is consumed locally and surplus produce is sold in the local market. Produce from Mehsana, Kheda, and Valsad districts, however, where production is comparatively large, is marketed between districts. There is not much demand for sweetpotato in the market except at the time of the *Shivratri* festival.

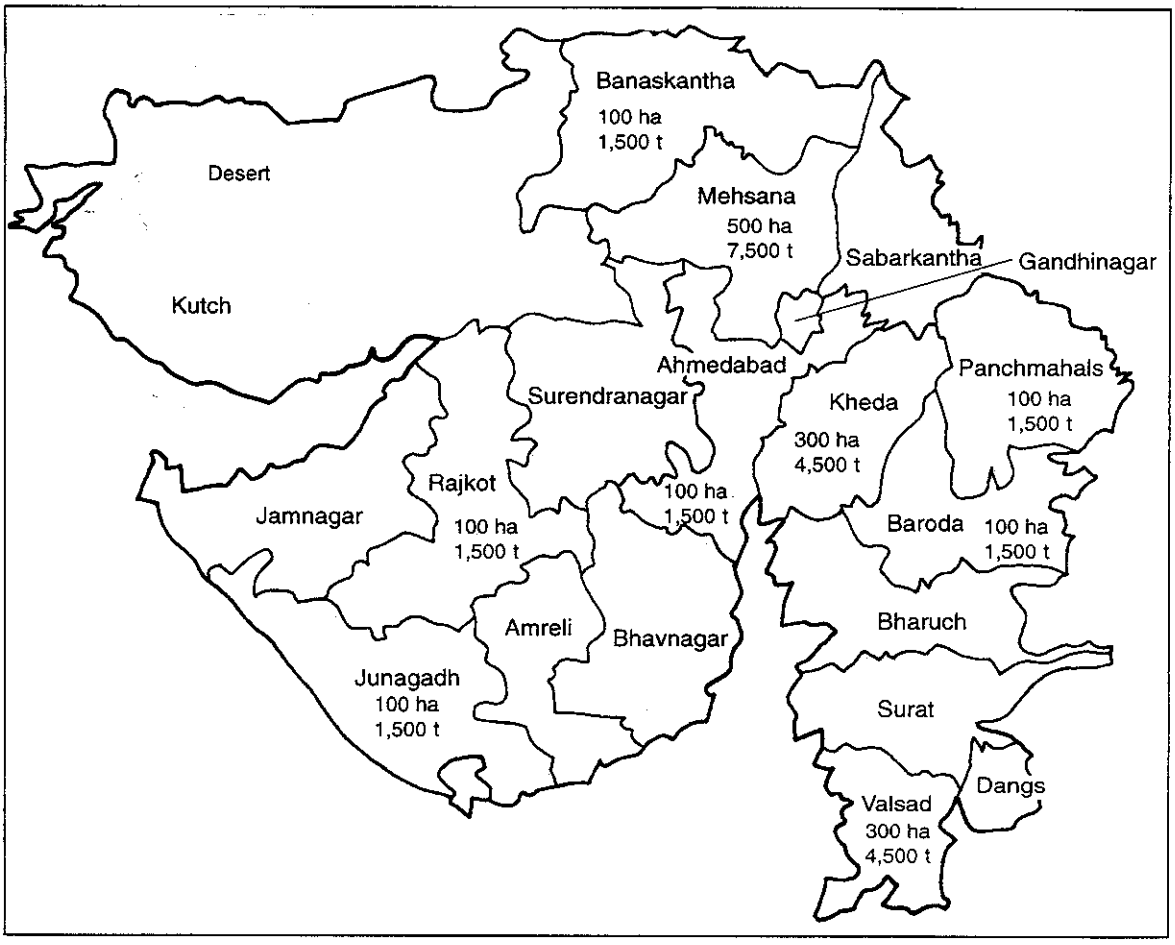

Figure 1. Sweetpotato production and area in Gujarat.

Research and Development

Little has been done in Gujarat on research and development in the areas of postharvest handling and utilization of sweetpotato. From 1973 to 1978, 21 sweetpotato varieties were evaluated under south Gujarat conditions. Of these, two —Cross-4 (white) and Collection-71 (red)—were the most promising and were recommended for commercial cultivation in the state. Some research work on planting methods, such as spacing and fertilizer levels, has been done. To standardize the improved agronomic techniques, some research work is in progress at Waghai Centre, Gujarat Agricultural University. This center is also likely to have an Indian Centre for Agricultural Research (ICAR) project on root vegetable crops in its 8th Five Year Plan.

Future prospects

The status of sweetpotato in Gujarat is not very sound, but future prospects are very good because the crop gives high yields in a relatively short time and requires little care. Its aggressive growth habits create little or no need for weed control and it can yield more carbohydrate per ha than many other crops. Also, sweetpotato can be grown throughout the year in Gujarat.

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Sweetpotato in Haryana

S.C. Khurana, B.S. Dhankhar, and S.S. Yadav[1]

Abstract

Area under sweetpotato in Haryana state has fluctuated over the last decade. In 1981-82, sweetpotato production area was 1,461 ha; by 1987-88, it fell to 720 ha. Average yields have been much higher than the national average; however, they fell from 23 t/ha in 1982-83 to 10.3 t/ha in 1987-88. This decline is due to growers shifting to shorter-duration varieties to capture higher prices earlier in the year.

Key words: Postharvest, utilization, marketing, processing.

Introduction

Sweetpotato (*Ipomoea batatas*) can play a significant role in meeting the needs of India's fast-growing population. In Haryana, it has been a neglected crop and no systematic research work has been done on sweetpotato breeding, cultivation, or postharvest handling. Trends in yield and area of sweetpotato in the state and its demand, utilization, and future prospects are discussed here.

Area and Yield

The most suitable period for growing sweetpotato in Haryana is from July to November, with only one crop per year. Table 1 presents figures on the area of sweetpotato grown in the districts of Haryana State from 1987 to 1988. Sonipat and Karnal districts contribute more than 70% of the area. In these two districts, most of the sweetpotato area is located along the banks of the Yamuna River. The sweetpotato-growing area in the state fluctuated from 1978-79 to 1987-88. The highest area of sweetpotato was 1,461 ha during 1981-82; this decreased to 720 ha during 1987-88. Area under sweetpotato in Haryana is low compared with other states in India. For example, during 1987-88, sweetpotato was grown on 58,700 ha in Orissa, 30,400 ha in Bihar, and 29,700 ha in Uttar Pradesh. But average yields in Haryana were higher than average yields in India from 1982-83 to 1987-88 (Table 2), except during 1986-87, when yield was the same as the national average. Haryana ranked first in yield from 1982-83 to 1984-85 and fourth during 1987-88. This indicates that environmental conditions of the state are suitable, even favorable, for sweetpotato cultivation. In spite of these conditions, yield per unit area fell from 23 t/ha in 1982-83 to 10 t/ha during 1987-88 (Table 2). The main reason for this reduction is the shift by farmers (in the major sweetpotato-growing areas, Karnal and Sonipat districts) to short-duration (70 d) local varieties such as Kali-Satha

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Table 1. Area (ha) planted in sweetpotato in different districts of Haryana, 1978-88.

District	Year									
	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88
Hisar	131	92	9	88	47	71	71	25	31	36
Sirsa	3	1	1	1	71	10	2	15	8	8
Bhiwani	30	25	16	19	17	n.a.	4	2	n.a.	n.a.
Gurgaon	86	99	69	56	36	72	51	188	11	2
Faridabad	n.a.	50	89	135	112	138	105	113	118	10
Jind	71	55	11	19	27	21	21	19	38	6
Mahen-dargarh	30	11	16	27	5	40	6	12	12	1
Ambala	101	43	43	96	32	13	9	11	4	11
Karnal	194	274	249	372	248	280	226	237	323	420
Kurukshetra	28	26	18	54	18	19	15	29	32	6
Rohtak	14	17	13	4	3	n.a.	4	3	n.a.	n.a.
Sonipat	303	465	570	590	540	486	326	386	287	220
Total	**991**	**1,158**	**1,185**	**1,461**	**1,156**	**1,150**	**840**	**1,040**	**864**	**720**

Source: Statistical abstracts of Haryana.
n.a. = not available.

instead of long-duration varieties. In these districts, farmers plant sweetpotato the last week of June or the beginning of July and harvest after about 90 days to sell produce at a higher price in September. A new variety is needed for this area that is capable of bulking even under the high temperatures and long days of July-August.

Current Utilization Patterns and Future Prospects

Market demand

Since Haryana state shares a border with Delhi, there is a strong demand for sweetpotato. Most sweetpotatoes produced in Haryana are sold by farmers either in the nearby local markets—where some is consumed locally and some taken to Delhi by traders—or farmers themselves sometimes transport roots to the Delhi market. In other cases, traders purchase sweetpotato directly from farmers' fields for transport to other parts of the country. Sweetpotato is normally disposed of within 2-3 days of harvesting. In some cases, however, when farmers are busy in other important agricultural operations, they store the produce in farm sheds either in gunny bags or in heaps for 15-20 days before marketing. Only good roots are stored, and during this short period losses are low because the temperature at this time of year is around 20°C. Sweetpotato is harvested from September to November depending upon the variety and purpose for

Table 2. Average sweetpotato yields (t/ha) in Haryana versus other states in India, 1982-88.

State	Year					
	82-83	83-84	84-85	85-86	86-87	87-88
Haryana	22.3	23.1	21.4	17.7	8.5	10.3
Gujarat	17.9	14.9	14.9	14.7	14.7	14.5
Maharashtra	14.0	13.4	14.8	14.3	13.8	14.5
Tamil Nadu	10.0	9.8	10.0	21.6	19.6	21.7
Bihar	6.7	7.1	10.0	8.1	10.1	10.0
Orissa	7.5	6.7	7.6	7.6	8.0	6.1
Uttar Pradesh	8.6	8.7	9.0	9.0	9.2	8.8
All India	5.9	7.2	8.1	7.9	8.4	7.7

Source: Agricultural situation in India.

which it is being grown. Because on most farms sweetpotato is followed by wheat, harvesting is completed by the end of November.

Consumption patterns

Most sweetpotatoes are consumed within 10-15 days of purchase. They are stored for a further 15-20 days in just a few cases. People usually eat roasted or boiled sweetpotato roots. In some cases, curry is also prepared from sweetpotato. Roots with high sugar content are preferred. Sometimes boiled roots are dipped in a sugar solution before eating to make them sweeter. Roots unfit for human consumption are fed to animals. At present, sweetpotato is neither processed in the state nor are any processed products available in the market. Sweetpotato flour, which can be used after mixing with wheat flour for making *chapatis*, bread, and biscuits, has a great potential in villages as well as in cities. However, flour from existing varieties that have a high sugar content cannot be mixed with wheat flour to make *chapatis* or bread; therefore, we need to develop non-sweet varieties for this particular purpose. Food products such as chips, flakes, jams, jelly, and candy also have a potential, but this is restricted to towns and cities. We also need to develop specific varieties for this purpose.

Labor availability is a major problem of the region; therefore, farmers prefer crops that need less labor during the growing season. For this purpose, sweetpotato is most suited to the *kharif* season. Since sweetpotato is fast growing, one weeding 20-30 days after planting is enough. Even this weeding can be avoided if a herbicide like Stomb (pendimethalin) is sprayed at a rate of 1.25-1.75 kg a.i./ha 6-10 days before planting.

Sweetpotato in cropping systems

Sweetpotato fits nicely in the cropping system of the region. Where soils are light, sweetpotato is preferred over maize and other *kharif* crops because it needs fewer labor

days. Sweetpotato could be preferred in clay loam soils where not enough water is available to grow paddy.

Research and Development

At Haryana Agricultural University, Hisar, we started collecting sweetpotato varieties in 1990-91 and need to continue to strengthen this program. Germplasm needs to be evaluated for its suitability for bulking for early and late crops; resisting biotic and abiotic stresses; making sweetpotato flour; consuming boiled, baked, or roasted; and making other processed products such as chips, flakes, *gulab jamun*, jam, and jelly.

Following germplasm evaluation, a proper breeding program needs to be carried out to evaluate varieties according to specific regional needs. Management practices for improved cultivation need to be standardized for the region. At present, there are no recommendations for bulk storage of sweetpotato. To provide a remunerative price to farmers, a storage system needs to be developed where produce from at least 0.5-1.0 ha can be stored for 45-60 days without much loss.

Sweetpotato in Kerala

V. Muraleedharan Nair[1]

Abstract

In Kerala, sweetpotato is commercially important in the districts of Palakkad, Malappuram, and Kasaragod, which account for 85% of the state's production. Almost 95% of the produce is sold to wholesale agents who dictate the price at the time of harvest. Sweetpotato flour and *pappads* prepared by Kasaragod farmers are the only known processed foods. Development of proper processing and storage techniques could improve the present status of sweetpotato in Kerala.

Key words: Postharvest, storage, consumption.

Area and Production

Area planted in sweetpotato in Kerala declined gradually from 1979 to 1989 (Table 1). In 1979-80, the crop occupied 5,000 ha, whereas in 1988-89 it covered 3,200 ha, a reduction of nearly 36% (Nair et al. 1989; Pal and Ramanathan 1989).

Sweetpotato production also showed a declining trend over the years. In 1979-80, total production was estimated to be 32,000 t, whereas in 1988-89 it was just over 26,500 t. The fall in production (18%), however, was not as steep as that of the area under cultivation.

Sweetpotato yields were below the national average prior to 1984-85. Since then, however, productivity has picked up, slightly passed the national average (8.1 t/ha), and maintained that marginal difference at 8.4 t/ha (Nair et al. 1989; Pal and Ramanathan 1989).

Table 1. Sweetpotato production, area, and yield in Kerala, 1979-89.

Year	Production (000 t)	Area (000 ha)	Yield (t/ha)
1979-80	32	5.0	6.4
1980-81	33	5.0	6.5
1981-82	35	5.3	6.5
1982-83	33	5.0	6.6
1983-84	34	5.1	6.6
1984-85	39	4.6	8.4
1985-86	41	4.8	8.4
1986-87	33	3.9	8.4
1987-88	28	3.4	8.3
1988-89	27	3.2	8.4

Source: Farm guide, Farm Information Bureau, Kerala.

[1] Kerala Agricultural University, Trichur, Kerala, India.

Of the fourteen districts in the state, Palakkad (central zone) and Malappuram and Kasaragod (north zone) alone account for almost 85% of the area and production under sweetpotato (Figure 1). Among these three districts, Palakkad accounts for 40%, Malappuram 30%, and Kasaragod 15%.

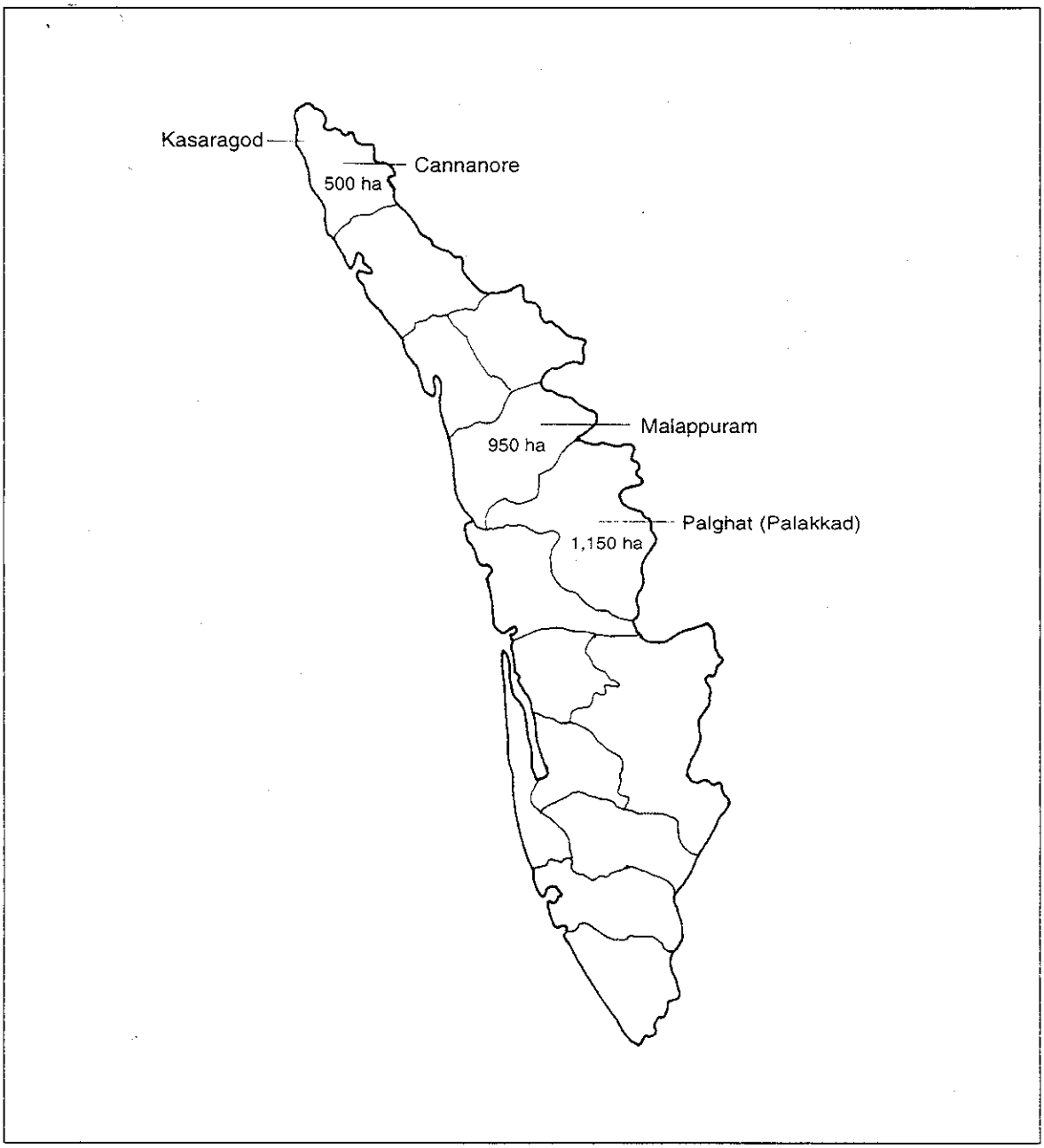

Figure 1. Main sweetpotato production areas in Kerala.

Storage

Farmers in Malappuram and Kasaragod are reported to store very small quantities of roots. In Malappuram, farmers heap roots in ventilated rooms for 15-30 days. A few farmers store roots with a portion of the basal vine that has been carefully harvested. A weight loss of 5-10% is reported as a result of dehydration during this storage period.

Quality deteriorates in storage because of sprouting and attacks by pests and pathogens. The most important storage pest is sweetpotato weevil. Harvested roots may contain the weevil at all life stages, allowing damage to continue during storage. Adult weevils are also attracted to exposed sweetpotato roots in storage. Grubs bore into the roots, make tunnels, and feed on the internal tissue, leading to root dehydration and shrinkage (Palaniswami et al. 1990). Weevil-infested roots are unfit for consumption because they taste bitter.

Rodents cause considerable losses and damage to stored roots. Whereas smaller roots are carried away by rats straight to their burrows, larger roots are slowly eaten and rendered unfit for consumption (Pillai and Rajamma 1984).

The best way to avoid or reduce damage in storage is to store healthy roots free from insects and mechanical injury. Such roots, when heaped and covered with dry soil or wood ash, last for about two months. Keeping roots in earthen pots sealed with fine net or cloth prevents the entry of pests and prolongs the storage period for up to three months (Rajamma 1984).

Thomas (1965) compared roots stored in ash, dry sand, and dry sawdust. Although he did not observe any difference in storage life using the different media, all were superior to storage in the open.

Utilization

Nearly all sweetpotato is used for human consumption in Kerala. Roots are eaten boiled. Thin roots are often sliced and half-fried in oil and consumed as a side dish. Non-marketable roots and wastes are sometimes fed to cattle, composted, or heaped along with vines to serve as a thick mulch for banana plants or coconut trees.

In Kasaragod district, most farmers convert raw roots into powder and *pappads* and store them for 5-6 months without deterioration in quality.

Market demand

Sweetpotato is grown mainly as a commercial crop in the three districts surveyed. In Palakkad, nearly the entire crop is sold to wholesale agents at the farm site. These agents sell roots in nearby towns and market roots to adjoining towns such as Coimbatore, Pollachi, and Erode in Tamil Nadu district. In Malappuram and Kasaragod districts, only about 5% of the total production is consumed by the farm family. The rest is marketed in nearby towns through wholesale agents.

Sweetpotato vines are used as green manure in the three major production centers (Palakkad, Kasaragod, and Malappuram). A portion of the vine is used as fodder.

It has been reported that almost 95% of the roots from the three main production centers are sold to traders. Therefore, farmers are at the mercy of the traders who decide the price at the time of harvest. Farmers are compelled to dispose of the crop immediately after it attains maturity to avoid weevil damage.

Lack of facilities for safe and extended storage of fresh roots limits farmers' abilities to get more attractive prices. The development of cheap and effective techniques for both small- and large-scale storage may enable farmers to fetch higher returns.

Although sweetpotato vines are said to be an excellent source of fodder for cattle, survey results indicate a limited use of vines as fodder. Because Kerala experiences fodder shortages, vine preservation is likely to enhance income from sweetpotato cultivation.

Processing

Sweetpotato flour and *pappads* are made by certain farmers in Kasaragod. Roots are first washed and then, after scraping the peel, are boiled in water till properly cooked. The water is drained and the roots are allowed to cool. A paste is prepared by crushing the cooked roots with the palm of the hand. The paste is then spread on bamboo mats in the open and allowed to dry. The dried powder is stored for future use. This sweetpotato flour is used to make *rava, puttu,* or other traditional preparations. To prepare *pappads,* cooked roots are pounded in a mortar. Small balls of the paste are pressed flat with a wooden roller and sun-dried. The *pappads* are usually stored in biscuit containers and consumed after frying in oil.

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Sweetpotato in Madhya Pradesh

K.C. Dubey[1] and M.S. Bhale

Abstract

This paper reviews the state of varietal improvement and agronomic practices for sweetpotato cultivation in Jagdalpur, Chhindwara, Mandsaur, and other areas of Madhya Pradesh. The occurrence of important diseases and pests of sweetpotato is highlighted. Processing and utilization are also briefly discussed.

Key words: Varietal improvement, protein, carotene, reducing sugar.

Introduction

In Madhya Pradesh, sweetpotato is cultivated on 9,488 ha, with an annual production of 61,300 t (Amarchand et al. 1986). Considering the importance of the crop in India and in Madhya Pradesh, several studies have been done at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, and at the Zonal Agricultural Research Station, Chhindwara. Some significant research findings are reported here.

Varietal Improvement

Through seven years of breeding and evaluation work, selections made led to the development of variety Jawahar Sakarkand 145 (Amarchand et al. 1986). This sweet and firm cultivar was found to be acceptable in Chhindwara, Jabalpur, and Mandsaur when tested for more than three years. The variety outyielded Pusalal, the local check, at both Jabalpur and Chhindwara.

Agronomic Practices

On the basis of various studies and observations made on sweetpotato in Madhya Pradesh, it has been concluded that for *rabi* (the post-rainy season), cuttings can be planted from the second week of September to the second week of October, and for rainfed crops from the first week of June to the last week of July. Planting the terminal portion of vine cuttings (18 cm long) at a spacing of 45 cm x 30 cm yielded the best results. At the time of field preparation, 1,500 kg of farmyard manure was incorporated into the soil, supplemented with 60 kg/ha N, 60 kg/ha P, and 40 kg/ha K in addition to organic manure. A basal dressing of 60 kg/ha P_2O_5 and 40 kg/ha K_2O incorporated before planting with a first top dressing with 20 kg N 30 days after planting and the remaining 40 kg after 65 days of planting has been observed to be the most effective.

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Two weedings are sufficient: one at 20 days after planting, and the second at 65 days after planting. For the *rabi* crop, one irrigation every 10-12 days is essential.

Treating vines with fungicides has resulted in comparatively less disease and better sprouting, resulting in higher yields.

Sweetpotato Diseases

Diseases of sweetpotato vary considerably in their distribution and importance. Some diseases affect sweetpotato primarily in the field, whereas others affect the crop in storage, handling, and marketing. Sweetpotato diseases can be broadly classified into three groups: field diseases, field and storage diseases, and storage diseases. The most damaging diseases are vine rot, stem rot, and charcoal rot (Table 1).

Other diseases of minor importance in sweetpotato are leaf spot (*Cercospora bataticola*) and leaf spot (*Alternaria alternata*). Common storage diseases are dry rot (*Fusarium oxysporum*), charcoal rot (*Macrophomina phaseolina*), soft rot (*Rhizopus stolonifer*), and *Penicillium* spp. and *Aspergillus* spp. molds.

A common insect pest in Madhya Pradesh is root and shoot-boring weevil (*Cylas formicarius*). The sweetpotato weevil is the most destructive and widespread pest of sweetpotato. The weevil attacks the crop in the field as well as stored roots. In the field, adults feed on the tender buds, leaves, vines, and roots. Damage to vines is characterized by black patches and damage to roots by small holes on the surface. Table 2 shows the distribution of weevil in Jabalpur and Chhindwara.

Processing, Storage, and Utilization

Variety Jawahar Sakarkand 145 developed by J.N. Agricultural University, Jabalpur, Madhya Pradesh, contains 21% total sugar, 3.65% reducing sugar, 4.69% protein, and 16 ppm carotene.

In Madhya Pradesh, sweetpotato roots are usually consumed after boiling. In some cases, chips are also prepared. Since sweetpotato is known as a poor man's crop, no systematic studies on processing, storage, and utilization have been carried out; partly because, in general, roots are not stored but are eaten or sold right after harvesting. Sweetpotato flour is prepared and consumed on special occasions of *puja*, or fasting. Contamination or fungal spoilage, however, is a big problem.

Table 1. Economically important sweetpotato diseases in Madhya Pradesh.

Disease	Symptoms and causal organism
Vine rot	The disease appears on young seedlings around 25-35 days after sowing; typical white cottony mycelium and sclerotial bodies in and around the infection court have been recorded (Amarchand and Bhale 1985). The disease is caused by *Sclerotium rolfsii* Sacc. In badly infected roots, the disease-causing fungal agent is transmitted to storage, where this disease causes more damage when environmental conditions favor its growth. In one experiment, steam-sterilized soil was put into earthen pots and the top 1.5 cm of soil was inoculated with about 750 sclerotia of *S. rolfsii*. The sclerotia had been harvested from 20-day-old cultures grown on maize meal media. Vines were planted in the pots and observations on vine rot revealed that, of 12 varieties, none showed the desired resistance: Pusasafed, Pusalal, JIB 110, 116, 146, 177, 152, and 189 were susceptible; JIB 114 and 105 were highly susceptible. JIB 45, however, was quite promising.
Stem rot	The first symptom of this disease (caused by *Fusarium oxysporum*) is a general yellowing of the youngest leaves, with discoloration of vascular bundles. Infected plants wilt, collapse, and ultimately die. An infected root may show the black-ring symptom under severe infection conditions. The disease has been recorded under both field and storage conditions. In storage, dry rot symptoms are common. Losses of up to 18% have been recorded.
Charcoal rot	Infected vines show blackening of the vine and root before they wilt, and die. The disease, caused by *Macrophomina phaseolina* and *Rhizoctonia bataticola*, appears after about 150 days. It can be identified by black fruiting bodies on the infected portion of the vine and root. The disease has been recorded under both field and storage conditions. Losses of up to 12% have been recorded under field conditions.

Table 2. Weevil infestation (%) in fields under different agroclimatic conditions in Madhya Pradesh.[1]

Variety	Location		Weevil damage
	Jabalpur	Chhindwara	(mean)
Jawahar Sakarkand 145[2]	10.0	4.2	12.5
Pusalal	25.9	25.5	24.7
B16	26.0	25.0	25.5
JIB 177	-	15.8	15.6
JIB 152	13.0	13.3	13.2

[1] Average of three years, 1975-78.
[2] Average of three years, 1979-81.
Source: Amarchand et al. 1986.

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Sweetpotato in Orissa

R.C. Ray, P.S. Bhat, P.P. Kumar, and M. Nedunzhiya[1]

Abstract

Orissa is the largest producer of sweetpotato in India, accounting for 33% of annual production. In Orissa, farmers generally consume fresh roots within a few days after harvest. Only when there is surplus produce do they either sell it in the market or store it in their houses for 1-4 months. Production area and productivity of sweetpotato have been declining in Orissa in recent years. This trend is influenced by several factors, of which the most important are lack of proper storage, the perishable nature of sweetpotato, supply and demand constraints, and utilization technologies.

Key words: Postharvest, sweetpotato use, *kharif*, *rabi*, insect damage, storage methods.

Introduction

Orissa grows more sweetpotato than any other state in India, accounting for 33% of total annual national production (Anonymous 1989). The crop is grown either as a kitchen garden or field crop in almost every district, with major concentrations in the drought-prone tribal districts of Kalahandi, Koraput, Keonjhar, and Bolangir (Figure 1). Two sweetpotato crops are grown in Orissa per year, in *kharif* (June-October) and *rabi* (October-February). More sweetpotato is produced in *kharif* than in *rabi*.

Postharvest Handling

Harvesting, curing, and grading

Harvesting is done manually by uprooting the whole plant, digging using a spade, or harrowing. Harvesting usually takes place over a period of time depending on farmers' own needs or prices in the market. In some places, farmers cut vines, then allow roots to remain in the ground for one week to facilitate the sweetening process in them. Roots are then carefully dug up and partially sun-dried for one week, with a waterproof cover during the night. This is the usual curing process. Curing hardens the skin and hastens the healing of surface wounds. After curing, farmers grade and sort roots into small, medium, large, and cut and bruised types. Medium and large roots are either sent to the market for sale or kept in storage.

[1] Regional Centre of Central Root Crops Research Institute (ICAR), Dumuduma Housing Board, Bhubaneshwar - 751019, Orissa, India.

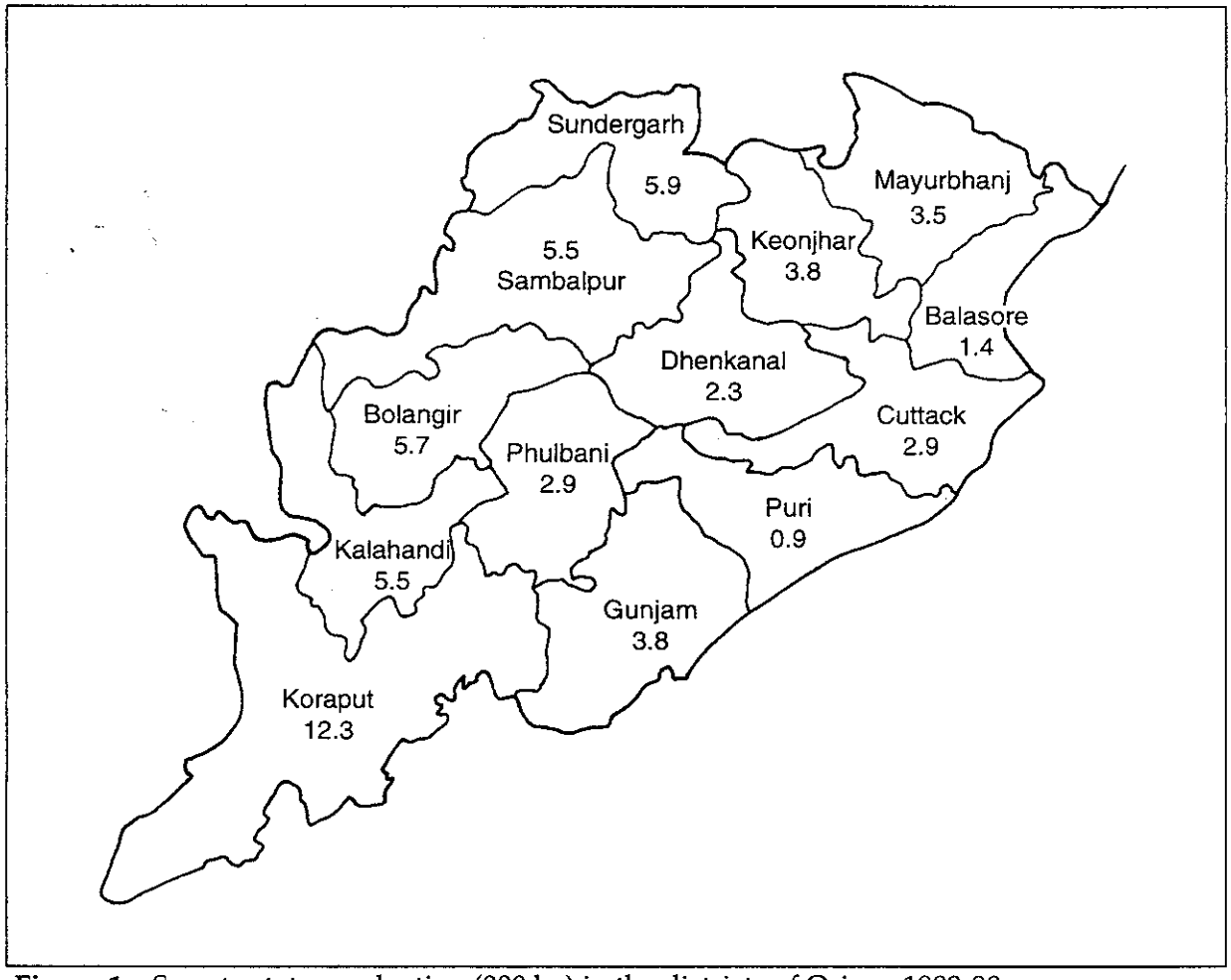

Figure 1. Sweetpotato production (000 ha) in the districts of Orissa, 1989-90.

In some parts of Orissa, farmers clean the roots, wash them in water, and dip them in hot water for 1-2 minutes to increase their storability.

Storage methods

The following storage methods are common in Orissa. Roots can be stored safely for 1-4 months using these methods.

Pits. In districts such as Keonjhar, Koraput, and Kalahandi, sweetpotato is commonly stored in pits. Farmers dig pits in an open area or in the corner of the house. Graded roots are piled in these pits, covered with paddy straw, and plastered with mud. Farmers often smear the inner surface of the pits with mud and cow dung slurry.

Sand beds. Farmers make sand beds 8-10 cm deep and store roots inside the beds. This practice is widely followed in the coastal districts of Cuttack, Puri, and Balasore where sand is easily available from river beds.

Earthen pots. Large earthen pots, locally called *ghuma,* are used to store roots in small quantities. The pots are filled two-thirds full with graded roots; these are covered with paddy straw and mud plaster.

Heaps. The most common storage method in Orissa is heaping roots on a plain surface or in the corner of the house and covering the heap with a thin layer of paddy straw or dried grass. To withdraw a few roots at a time, a small hole is made in the heap or the mud plaster of the earthen pot is removed. After withdrawal, the hole or pot opening is again covered with paddy straw.

Problems in Postharvest Handling

Studies at CTCRI's regional center at Bhubaneswar have shown that the weight loss of roots during curing and subsequent storage for 60 days was about 20-27% of the initial fresh weight. It is theorized that this weight loss can be minimized by placing the roots in sand, soil, or sawdust media (R.C. Ray, unpublished results).

Diseases

Like any other tropical vegetable crop, sweetpotato is subject to many postharvest and storage diseases (Misra 1989). Results of some preliminary studies on postharvest diseases of sweetpotato are described below.

Soft rot. This disease mostly occurs when humidity is high (80% or more) and the temperature is above 35°C. Sometimes the entire root rots within 3-4 days. The causal agents are *Rhizopus stolonifer* and *R. oryzae.* Figure 2 shows symptoms of soft rot in sweetpotato caused by *R. oryzae.*

Java black rot. This is by far the most common disease in stored sweetpotato in the tropics, particularly in Bangladesh (Jenkins 1981). The causal agent is *Botryodiplodia theobromae* Pat. Infected tissues at first are yellowish brown and fairly firm; they later darken to black. After 4-5 weeks, the affected roots become mummified (Figure 3) and the skin is pimpled with minute black bodies (pycnidia).

Fusarium rot. Surface rot caused by either *Fusarium pallidoroseum* or *F. oxysporum* is typical, with the rot progressing from either or both ends of the root. Initially, margins of the lesions are brown to black. As the decay progresses, the lesions shrink and shrivel and small cavities containing white mycelium develop within the lesions.

Insect damage

Sweetpotato weevil (*Cylas formicarius*) is the most damaging sweetpotato pest in the field as well as in storage. Pillai and Prasad (1983), in their survey of pests and diseases of root crops in Orissa, reported that damage to crops and to roots during storage is 40-60% in Ganjam, Koraput, Bolangir, and Sambalpur districts. Weevil incidence varied from 7 to 55% in these districts when the crop was grown from July/August to November/December. In addition to time of planting, the rate of weevil infestation is associated with type of nursery practice, time of harvest, and cropping patterns.

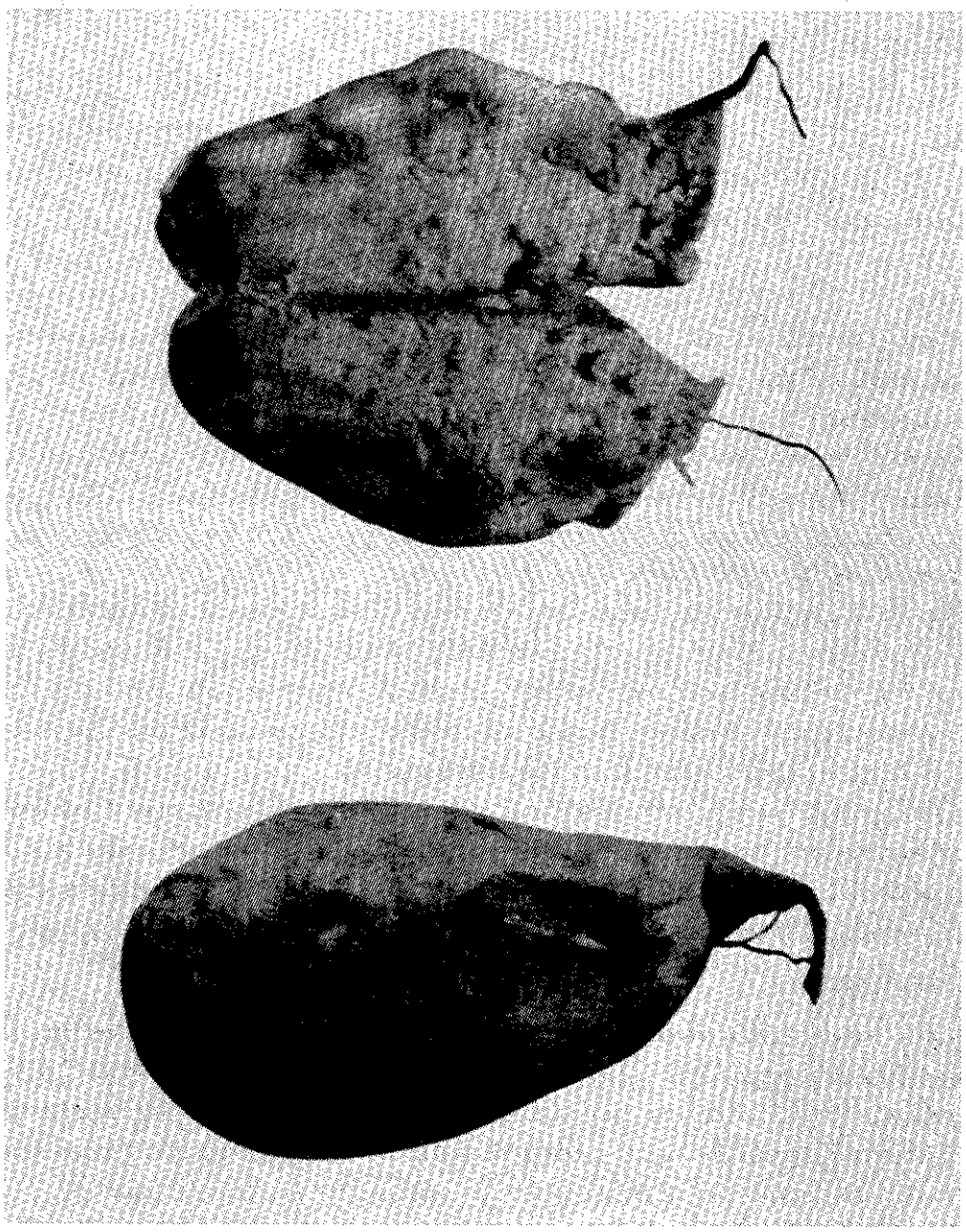

Figure 2. Soft rot in sweetpotato caused by *Rhizopus oryzae*.

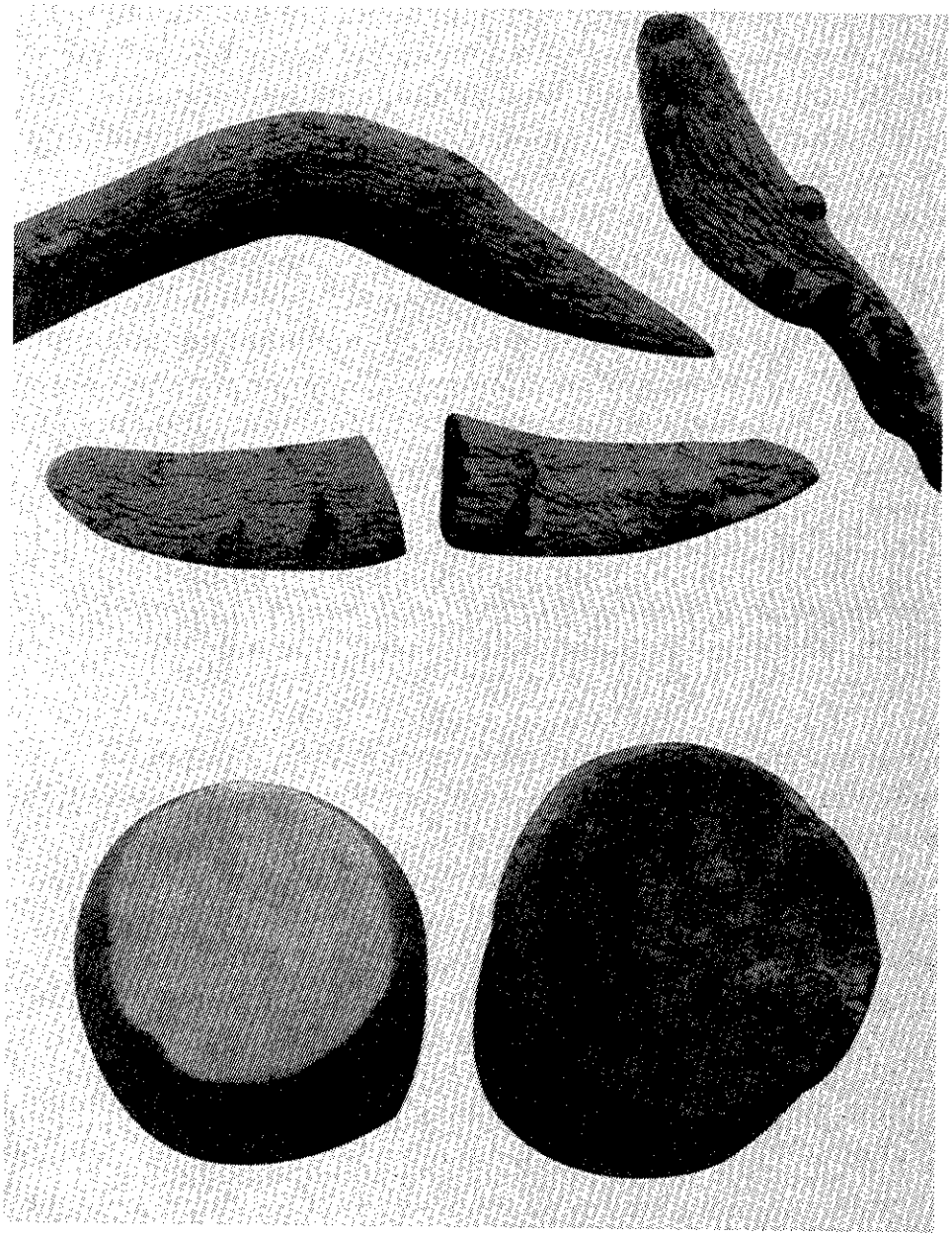

Figure 3. Java black rot in sweetpotato caused by *Botryodiplodia theobromae.*

Utilization

In Orissa, people consume sweetpotato root fresh or as processed chips. Vines are used for cattle feed.

Fresh consumption

Roots are mostly eaten after boiling, steaming, or baking. The common practice is to boil the root, to be peeled just before eating. A popular alternative is to roast the root unpeeled in a slow fire. Kumar (1990) reported that farmers of Koraput district often roast roots in a special way. They put good-sized roots in an earthen pot and thoroughly cover the mouth of the pot with paddy straw. The pot is then turned upside down and embers are placed around the pot surface. After 3-4 hours of roasting, roots are ready for consumption. These roots are peeled, cut, and served as a vegetable. A delicious dish is prepared by cooking peeled root with raw mango and *jaggery* (crudely refined sugar). Sweetpotato and yams are invariably used in daily *prasadam* in the famous Jafannath Temple of Puri. Boiled and peeled roots are crushed into pulp and mixed with wheat flour, and the dough is made into desirable shapes and then fried in vegetable ghee. The fried pulp is candied with syrup or milk and syrup to make *gulab jamon*, *rasavali*, and many other local desserts. Leaves are also fried with bengal gram flour to make *pakoda*.

Chips

Occasionally, chips are prepared from sweetpotato roots, in the same way as potato chips, and sun-dried. Dried chips are fried in oil and eaten as snacks.

Cattle feed

Green vines serve as a nutritive and palatable green feed for cattle. Vine yield is reported to average 8-10 t/ha (Kumar 1990). When green vines are in surplus, they are sun-dried and dried leaves are stored for cattle feed.

A 3-year experiment (1986-88) at the experimental farm of the Regional Centre CTCRI-Bhubaneswar showed that a vine yield of up to 17.6 t/ha could be obtained safely without affecting root yield from a standing crop of sweetpotato (Roy Chowdhury and Ravi 1990). Preferably, vine harvesting could be done at 60 days after planting.

Conclusions

There is now a trend for the surplus sweetpotato production in Orissa to be diverted for use in industry to develop some value-added products. At the home level, surplus produce could easily be used to manufacture good-quality jam, jelly, and sweets and to

manufacture starch for commercial use. The crop has great prospects in the food processing and pharmaceutical industries.

Acknowledgments

The authors are thankful to the Director, CTCRI, Trivandrum, for permission to participate in this workshop and to the Scientist in Charge, Regional Centre, CTCRI-Bhubaneswar, for discussion and encouragement.

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Sweetpotato in Tamil Nadu

I. Irulappan[1]

Abstract

Trends in sweetpotato production area and yield in Tamil Nadu from 1975 to 1988 are reviewed in this paper. Area and production have declined, whereas yields have remained stable and unaffected. Important areas of sweetpotato cultivation are indicated. Detailed accounts of crop improvement, crop management, varietal release, utilization, and recipes developed from sweetpotato at the Department of Horticulture, Tamil Nadu Agricultural University, are also presented.

Key words: Weather parameters, ethrel, utilization, recipes.

Introduction

Sweetpotato (*Ipomoea batatas*) ranks third after cassava and potato among the root and tuber crops in Tamil Nadu, where sweetpotato was cultivated on 1,958 ha, with total production of 42,530 t and an average productivity of 21.7 t/ha during the 1987-88 crop season (Table 1).

The major sweetpotato growing districts in Tamil Nadu include Thiruchirapalli, South Arcot, V.O. Chidambaranar, Salem, Anna, Nellai-Kattabomman, Chengai-MGR, Madurai, and Dharmapuri (Figure 1).

Sweetpotato area planted is declining in Tamil Nadu (Table 2), although production has not fallen steeply. This is because productivity per hectare has increased through growing high-yielding varieties and adopting improved agro-techniques.

Crop Improvement

Sweetpotato is essentially a warm-weather crop. It performs best under abundant sunshine and relatively high light intensity. The growing season for sweetpotato in Tamil Nadu is from September to February. The climate also favors growth. Rainfall, number of rainy days, maximum and minimum temperature, and relative humidity were averaged over 5 years; means of these measurements are given in Table 3.

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Table 1. Sweetpotato production, area, and yield in Tamil Nadu, 1987-88.

District	Production (t)	Area (ha)	Yield (t/ha)
Thiruchirapalli	13,271	611	21.7
South Arcot	6,885	317	21.7
V.O. Chidambaranar	5,148	237	21.7
Salem	2,932	135	21.7
Anna	2,802	129	21.7
Nellai-Kattabomman	2,737	126	21.7
Chengai-MGR	2,498	115	21.7
Thiruvannamalai	2,346	108	21.7
Sambuvarayan			
Madurai	1,890	87	21.7
Dharmapuri	1,586	73	21.7
Nilgiris	304	14	21.7
Periyar	109	5	21.8
Kamarajar	22	1	22.0
Ambecar	--	--	--
Coimbatore	--	--	--
Kanyakumari	--	--	--
Pasumpon, Thevar	--	--	--
Pudukottai	--	--	--
Ramanathapuram	--	--	--
Thanjavur	--	--	--
Total	**42,530**	**1,958**	**21.7**

-- = no production.

Table 2. Sweetpotato production in Tamil Nadu, 1975-88.

Factor	Year					
	1975	1976	1985	1986	1987-88	Reduction compared with 1975 (%)
Production (t)	72,450	66,620	43,548	59,220	42,530	41.3
Area (ha)	7,735	5,030	4,424	2,986	1,958	74.4
Yield (t/ha)	9.3	13.2	9.8	19.8	21.7	

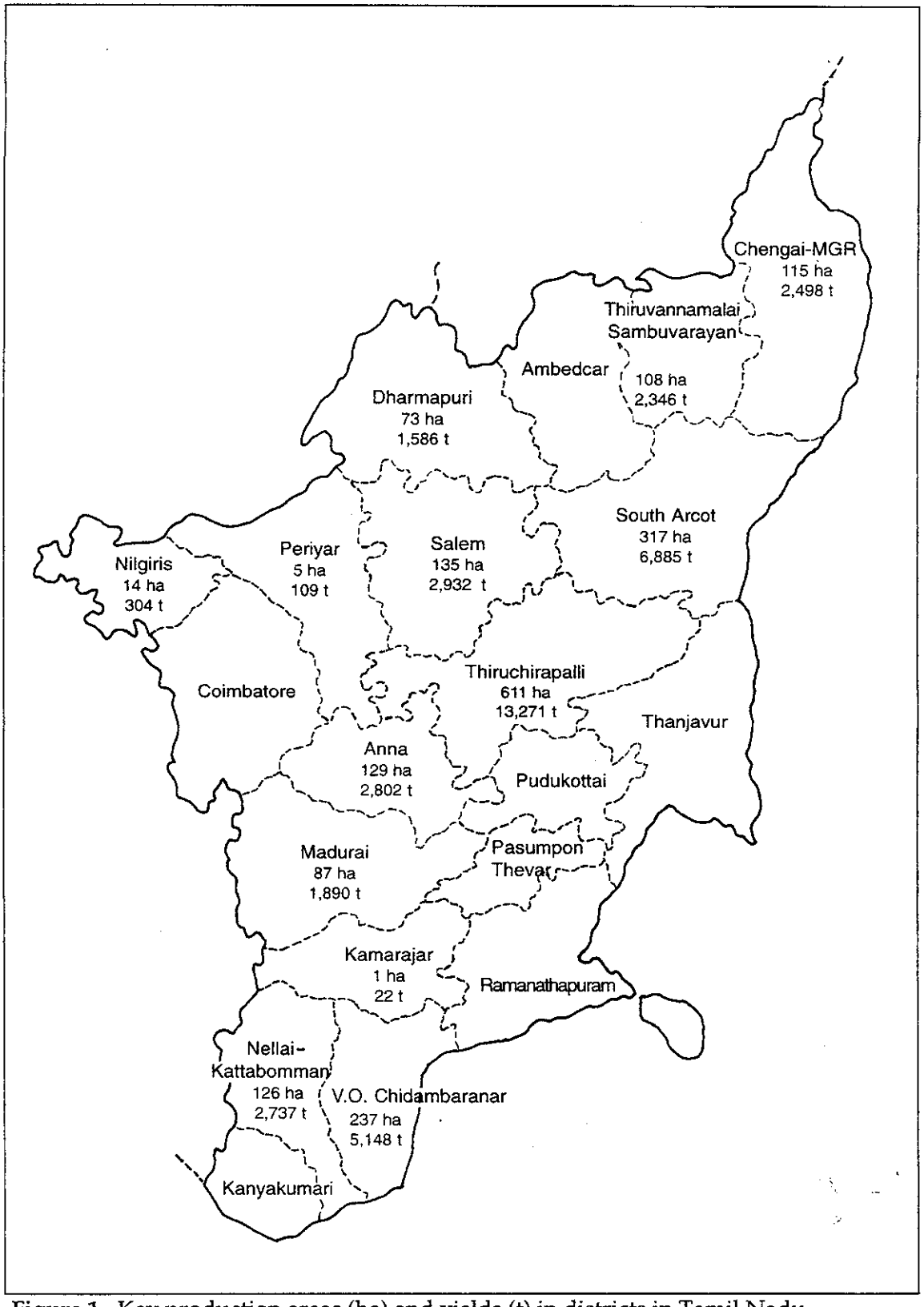


Figure 1. Key production areas (ha) and yields (t) in districts in Tamil Nadu.

Table 3. Prevailing weather during the sweetpotato cropping season (5-year mean).

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Humidity (%)
			Max	Min	
Sept	62.3	4.4	32.6	31.9	82
Oct	153.0	8.8	31.2	22.0	88
Nov	82.7	4.6	29.5	20.8	87
Dec	36.1	2.8	29.4	19.9	86
Jan	5.5	0.4	30.0	18.0	86
Feb	2.3	0.2	30.6	18.2	77
Annual total	**341.9**	**21.2**	-	-	-

Three improved sweetpotato varieties have been released: Co.1 and Co.2 are clonal selections; Co.3 is a selection from a population of open-pollinated seedlings. Crop duration of these released varieties ranged from 110 days for Co.3 to 135 days for Co.1. Root yield ranged from 28 t/ha for Co.1 to 42 t/ha for Co.3. The starch content of roots was 19% in Co.1, 29% in Co.2, and 31 % in Co.3. Variety Co.3 is carotene-rich, with a carotene content of 13.3 mg/100 g. Ascorbic acid content of the roots ranges from 17.15 mg/100 g in Co.2 to 21.58 mg/100 g in Co.3.

Crop Management

Several research projects were carried out to standardize sweetpotato management practices. Some of the salient findings are described below briefly. In a study on the use of vine cuttings as planting material, results indicate the superiority of planting terminal vine cuttings (15 cm length) to get high root yields (Table 4). Planting terminal vine cuttings increased root yield by 24% over median vine cuttings, and 40% over the slips from roots.

A planting-season study found that either the second half of September or the first half of October is the best time to plant to obtain maximum root yields, because of the short-day and long-night conditions in the postplanting period. Plantings done during this season increased root yield by 19% over plantings in other months.

Table 4. Effect of type of vine cutting on sweetpotato root yield, 1968-70.

Type of cutting	Yield (kg/plot)			
	Year 1	Year 2	Year 3	Mean
Terminal	23	26	40	29.9
Median	19	22	31	24.0
Slips from roots	17	19	27	21.3

Table 5. Effect of ethrel on sweetpotato.

Ethrel concentration (ppm)	Foliage weight (kg/plot)	Root weight (kg/plot)	Yield (kg/ha)	Percent over control
Control	9.2	1.4	11.98	-
50	5.8	1.5	12.62	+5.4
100	4.5	2.0	16.39	+36.8
200	4.6	2.2	18.01	+58.6
250	4.0	2.5	20.78	+73.4

In a fertilizer experiment, researchers found that the optimal fertilizer dose for maximizing sweetpotato yield is 40:80:120 kg/ha of NPK. Split applications of nitrogen —2/3 as basal soil application and 1/3 as foliar spray (2% urea)—one month after planting increased root yield by 17%. Five sprays of ethrel at 250 ppm, starting from 15 days after planting and continuing at 15-day intervals, increased root yield by 73% over the control (Table 5).

Utilization

In Tamil Nadu, sweetpotato is primarily a human food, with almost the entire crop eaten fresh after boiling at meals or as snacks.

Flour

Sweetpotato flour made according to the flow chart (Figure 2) can be used as a partial substitute for wheat flour. Sweetpotato that has been processed into flour could be used in ready-to-use food mixes and for preparations such as *murukku*.

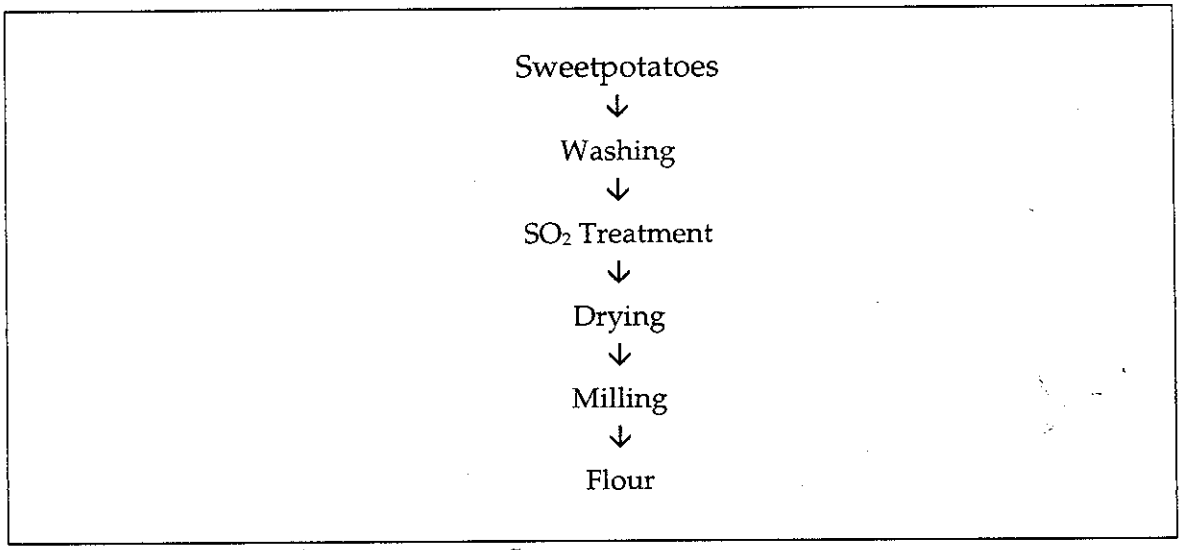


Figure 2. Flow chart for sweetpotato flour.

Starch

An attempt was made to explore the possibilities of utilizing sweetpotato as a raw material for the production of industrial starch. This untapped resource can be commercialized to produce sweetpotato starch. On the basis of a pilot-plant study, a material balance for the production of 5 t/day of starch was made (Appendix 1, Table 1-1 and Figure 1-1).

The production cost for starch has been worked out to be about R 3,800/t. Sweetpotato starch is cheaper to produce and the quality is comparable with that of other standard starches. It is estimated that 86% starch can be extracted (Appendix 1, Table 1-2).

Foods

The Food Science and Nutrition Unit of the Horticultural College and Research Institute, Coimbatore, has developed several recipes for the use of sweetpotato roots: mixes for typical foods (Appendix 2); vermicelli noodles (Appendix 3); and a ready-to-serve (RTS) beverage (Appendix 4) prepared with sweetpotato juice in combination with pineapple juice. In taste tests of the nine recipes listed in Appendix 2, they were found to be highly acceptable for all the quality characteristics, i.e., color, flavor, texture, and taste.

Sweetpotato can be used in many other ways. It is highly acceptable in the processing of candy and jam made with sweetpotato and fruit juice. Sweetpotato starch can also be utilized successfully for candy and confectionery processing; sweetpotato flour mixed with 30% legume flour can be used to process protein-rich noodles.

The protein content of sweetpotato flour is low (Table 6). Therefore, trials were conducted to enhance the protein content by adding legume flour of green gram, black gram, and defatted soy flour at the 10, 20, and 30% levels. Results showed that the protein content of the flour can be improved by adding 20% incorporation of legume flour (Table 7.)

Table 6. Nutritive value of sweetpotato flour (100 g).

Moisture (%)	Ash minerals)	Calories (kcal)	Protein (g)	Calcium (mg)	Iron (mg)	Reducing sugar (g)	Total sugar (g)
9.5	2.05	366	2.4	96.78	2.93	2.8	3.1

Table 7. Nutritive value of legume-incorporated (20% level) sweetpotato vermicelli (100 g).

Mix type	Calories (kcal)	Protein (g)	Calcium (mg)	Iron (mg)	Phosphorus (mg)
Basic mix	234	6.10	34.5	1.46	85.5
- with green gram flour	184	7.89	31.9	1.50	122.8
- with black gram flour	184	7.79	47.7	1.40	118.3
- with defatted soy flour	196	14.19	64.9	2.76	42.0

Secondary and waste products from sweetpotato

Sweetpotato roots were tested as a substrate for alcohol production (Table 8). Direct fermentation of the root extract with *Saccharomyces cerevisiae* yielded 44-56 g^{-1} 1^{-1} in 48 hours of incubation. Four samples were tested for immobilizing yeast and performance in alcohol production. Immobilized yeast improved yield from 52 to 83^{-1} 1^{-1} and of the four supports tested —earthen beads, pectin, agar, and packing materials—earthen beads recorded a higher alcohol yield.

Scarification of sweetpotato with commercial amylases and *Bacillus* sp. was attempted. A conversion rate of 80% starch to sugar was recorded with amyloglucosidase (CFTRI) enzyme (Figure 3). This provides the additional possibility of producing alcohol and pectin-rich residue for cattle feed.

Table 8. Sweetpotato clones identified for high ethanol content by screening germplasm.

Clone	Ethanol (mg/100 g)
OP 102	34.3
OP 104	34.2
OP 123	34.0
Co.2	32.6
Co.3	32.6
OP 23	31.2
OP 109	30.8
OP 121	30.6

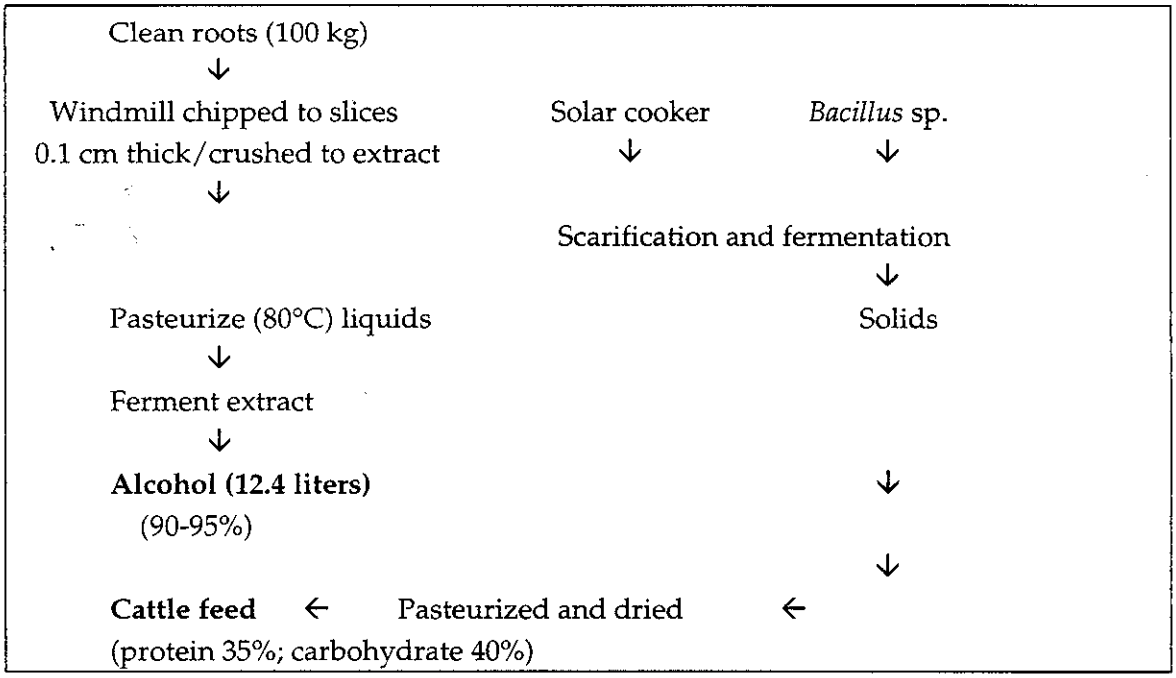


Figure 3. Flow chart for alcohol production.

Future Research

The following list mentions high-priority research activities that should be undertaken to promote and improve sweetpotato in Tamil Nadu.

- Develop highly productive varieties with more available protein and beta-carotene.
- Breed for varietal resistance to sweetpotato weevil.
- Develop management practices designed to narrow yield gaps and optimize farmers' returns.
- Develop varieties having more nutritious roots and vines that are more acceptable to consumers.
- Develop shade-tolerant varieties.
- Develop varieties to fit into different cropping systems, including rice fallows.
- Develop varieties for industrial purposes (starch, alcohol, cattle feed).
- Develop and promote new recipes.
- Promote the use of sweetpotato in processed livestock feed.

Appendix 1. Starch Production

Table 1-1. Material balance extract using 250 kg of ground sweetpotato.

	Weight (kg)	Starch content in sweetpotato (%)	Percentage recovery
Starch content	53.5	21.0	100.0
Starch obtained (anhydrous)	38.5	15.4	73.3
Starch obtained from waste water	7.7	2.7	12.9
Starch left in pulp	7.2	2.9	13.8

Table 1-2. Materials required to produce sweetpotato starch.

Materials required	Quantity
Sweetpotato (t)	27.6
Water for washing (t)	90.5
Lime water for grinding (0.04N) (t)	77.5
Fresh water for slurry making (for 7,000 kg of 40% moisture content starch) (t)	7.4
Sodium hypochlorite solution (6%) for bleaching (kg)	525

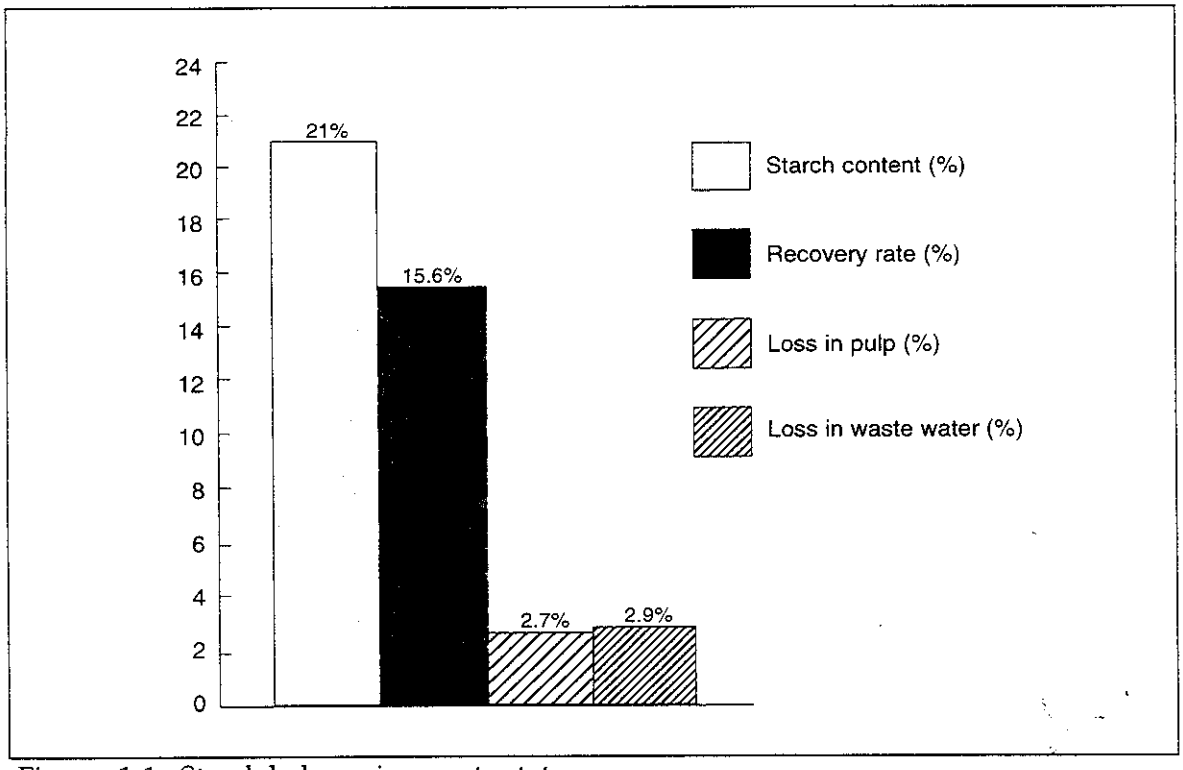


Figure 1-1. Starch balance in sweetpotato.

Appendix 2. Recipes

Food	Ingredient	Amount	Preparation method
Chappati mix	Sweetpotato flour	200 g	1. Make dough with water.
	Refined wheat flour	100 g	2. Knead well and set aside for 10
	Salt	to taste	minutes.
	Water	150 ml	3. Divide into lime-sized balls.
			4. Roll out into flat, round chappatis.
			5. Shallow-fry and serve hot.

Food	Ingredient	Amount	Preparation method
Murukku mix	Sweetpotato flour	500 g	1. Add cold water and mix the flour
	Bengal gram/	100 g	well into a thick and soft paste.
	polished blackgram		2. Press through the murukku flour
	Vanaspati/margarine	100 g	mold and deep fry in oil till it
	Salt	10 g	becomes golden brown in color.
	Red chili powder	5 g	
	Cumin and	10 g	
	asafoetida powder		

Food	Ingredient	Amount	Preparation method
Omapodi mix	Sweetpotato flour	500 g	1. Make a thick paste with enough
	Omam powder	3 g	water.
	Asafoetida powder	15 g	2. Press through mold and deep-fry in
	Salt	15 g or to	oil till golden brown.
		taste	

Food	Ingredient	Amount	Preparation method
Pakoda mix	Sweetpotato flour	75 g	1. Mix all the ingredients.
	Bengal gram flour	75 g	2. Add enough water to make into a
	Garlic powder	5 g	thick paste and take a small portion
	Asafoetida powder	2 g	to fill into the ribbon pakoda mold.
	Chili powder	3 g	3. Heat oil in a pan and press the
	Salt	to taste	ribbon pakoda into the pan; cook
	Hydrogenated fat	30 g	until it becomes golden yellow and
			serve.

These products can be stored around 15 days in an airtight container.

Food	Ingredient	Amount	Preparation method
Halva mix	Sweetpotato flour	200 g	1. Add 3/4 cup of the mix and dissolve.
	Powdered sugar	400 g	2. Cook for 5 minutes with constant stirring over a low flame.
	Cardamom powder	2 g	3. Add 4 tablespoons of ghee hydrogenated fat/refined vegetable oil, and continue to cook till all the water evaporates and ghee oozes out.
	Desired food coloring	100 mg	4. Transfer the cooked mass to a greased pan.
			5. Allow to cool.
			6. Cut into desirable sizes. Garnish with cashews and raisins.

Food	Ingredient	Amount	Preparation method
Idiappam (steamed for breakfast)	Sweetpotato flour	200 g	1. Add water to flour and make a thick dough.
	Oil	2 tsp	2. Steam for 7 minutes.
	Mustard	1/4 tsp	3. Press through idiappam mold and collect in a plate.
	Polished black gram dhal	1 tsp	4. Season with oil, mustard, polished black gram dhal, chopped cashew nuts, onion, green chilies, and salt.
	Chopped cashew nuts	1 tsp	
	Chopped onion	2 tsp	
	Chopped green chilies	1 tsp	
	Salt	to taste	
	Lime juice	1 tsp	

Food	Ingredient	Amount	Preparation method
Poli	Cooked and mashed sweetpotato	1 cup	1. Mix sweetpotato, mash with sugar and cardamom.
			2. Shape into lime-sized balls (a).
	Powdered jaggery or sugar	1/4 cup	3. Knead maida into a thick dough with water and divide into small balls (b).
	Powdered cardamom	1 pinch	4. Roll each of the maida dough balls (b) into flat circular sheets of desired size and place the sweetpotato balls (a) at the center.
	Oil/hydrogenated fat	25 g	
	Maida (refined wheat flour)	1/2 cup	5. Enclose the balls (a) with maida layer and place on a greased banana leaf.
	Water	30-50 ml	6. Grease fingers and flatten as 1 cm thick chappati (like pie crust).
			7. Fry on both sides until golden brown.
			8. Serve hot.

Food	Ingredient	Amount	Preparation method
Laddu	Sweetpotato flour	2 cups	1. Roast the sweetpotato flour for 2 minutes.
	Powdered sugar	1 cup	2. Add powdered sugar and mix well.
	Ghee (melted butter)	1/4 cup	3. Roast the cashew nuts and raisins slightly in a little ghee and add to the mix.
	Broken cashew nuts	1/4 cup	4. Heat the remaining ghee and add to the mix.
	Raisins	1/8 cup	5. Mix well and make small balls.

Food	Ingredient	Amount	Preparation method
Pakoda	Sweetpotato flour	120 g	1. Chop onion, green chilies, and curry leaves. Add salt and mix well.
	Bengal gram flour	70 g	2. Mix sweetpotato and Bengal gram flour; add melted hydrogenated vegetable oil.
	Salt	to taste	
	Onion	50 g	3. Add all the ingredients and mix to a thick paste, adding a little water.
	Green chilies	5 g	
	Broken cashew nuts	20 g	4. Heat the oil; sprinkle pakodas of various sizes into the hot oil and deep-fry until golden brown.
	Curry leaves	a few	
	Hydrogenated vegetable oil	2 tsp	5. Drain on paper and serve hot.
	Oil for frying		

Appendix 3. Vermicelli

Flow chart for vermicelli

Sweetpotato

Wheat flour mix (79%) + moisture level (20%) + salt (1%)

Flour mix	Pulse flour (green gram flour/ black gram flour/defatted soy flour)
↓	
59%	10%
49%	20%
39%	30%

↓

Mixing (moisture level 30%)

↓

Addition of salt (10%) and water

↓

Steaming (physical conditions required)

- Mean drying time = 18 h
- Temperature = 35.5°C
- Moisture = 11.5%

↓

Extrusion

↓

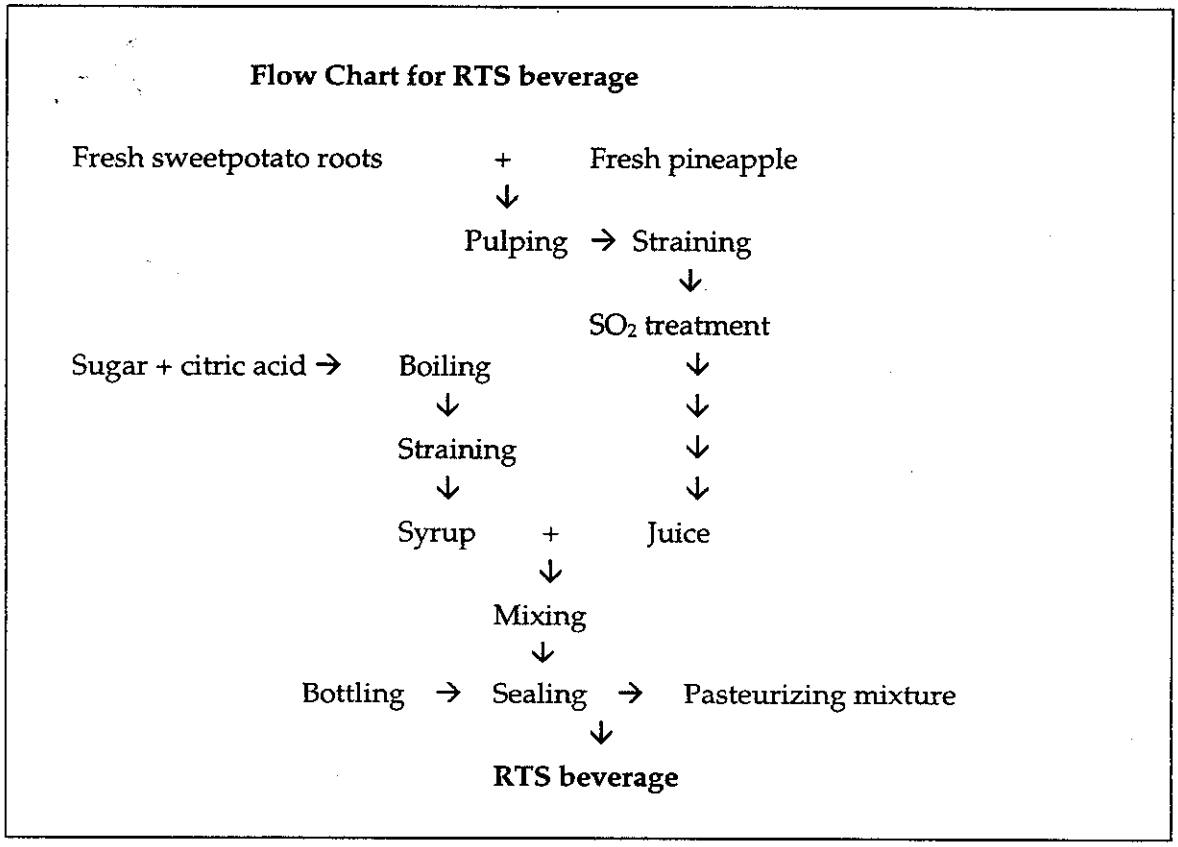
Drying

↓

Vermicelli

Vermicelli could also be prepared using 50% sweetpotato flour and 50% refined wheat flour (*maida*).

Appendix 4. RTS Beverage



Sweetpotato in West Bengal

H. Sen[1]

Abstract

In West Bengal, sweetpotato is grown in all six agroclimatic zones, but is mostly planted in the new and old alluvial zone, red and laterite zone, and coastal saline zone. Although sweetpotato is grown almost all year, its cultivation is mostly restricted to the *rabi* season, because the favorable climate leads to higher yields. Red-skinned sweetpotato roots are generally preferred, and they are eaten after boiling or baking. Upper- and middle-class consumers use sweetpotato to prepare *chapatis* and sweets. Almost the entire root harvest is utilized for human consumption in lieu of industrial use. Vines are used as fodder for dairy cattle. Normally, growers market roots straight from the field; therefore, no proper storage method has been developed. Harvesting bruised, overmature, and weevil-damaged roots is a main storage constraint. Experiments have shown that healthy roots can be stored for up to 90 days under local earth, dry sand, or sawdust without much weight loss or rotting. Weevil attacks can be avoided by harvesting roots in March. Infestation can also be checked considerably by spraying monocrotophos (0.05%) at three-week intervals. Cultivation of short-duration, early-bulking types using proper management practices also helps to reduce weevil damage.

Key words: *Rabi* and *kharif* seasons, laterite-alluvial soils, saline zone, *terai* zone, postharvest, utilization.

Introduction

Sweetpotato is being grown in all six agroclimate zones of West Bengal, though it is not widely cultivated. Planting times vary in different zones, but better, weevil-free roots are obtained during the *rabi* season. Because roots are consumed within a few days of harvest, there is no perceived need for storage. Therefore, proper storage methods have not been developed in West Bengal. Overmature and off-season roots infested with weevil can be avoided by adjusting planting dates. Sweetpotato roots are mostly eaten either as a vegetable or directly after boiling or baking. A steady market is available within the state year-round. At times roots are sold at a higher price, particularly in the off-season. Selection of varieties to meet particular zonal needs, development of management technologies to better assure weevil-free roots, and development of a low-cost storage technology would help increase area planted and production. The national

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production. The national and state governments must come forward to support sweetpotato, whose success depends not only on research results but also on an effective extension program.

Production

Sweetpotato is grown in all six agroclimatic zones of West Bengal: the new alluvial, old alluvial, red and laterite, coastal saline, *terai*, and hill zones. But because of socioeconomic, cultural, and agricultural constraints, the total area under sweetpotato is about 8,000 ha (Table 1) and total production is estimated at around 50,000 t, with an average yield of 6 t/ha.

Sweetpotato is grown in almost all the districts of the state (Figure 1). Although the crop can be grown year-round, cultivation is concentrated in the *rabi* season (October/November to February/March), mainly because of higher yields in *rabi* than in *kharif*. Also, cropping patterns allow for greater sweetpotato cultivation in rainfed areas during the *rabi* versus the *kharif* season. Sweetpotato is grown as a rainfed crop in the alluvial zones (old and new), and as a *rabi* crop in the uplands (where other important crops are not grown successfully), following the harvest of upland paddy or jute. Sweetpotato's productivity makes it a very profitable crop in the *rabi* season.

In the coastal and saline zones of 24 Parganas (south) and the Midnapore districts, sweetpotato is normally planted following the harvest of lowland paddy (January) and harvested in the summer months. This results in poor yield. Because of a favorable effect of temperature and humidity on pests, roots suffer from severe sweetpotato weevil infestations, making them unfit for human consumption. Similarly, in the red and laterite and hill zones, cultivation is restricted to a rainy season (planted in July or August) in which moisture is depleted quickly in the *rabi* season after the cessation of the rainy season toward the end of October. Mostly red-skinned local cultivars of late-bulking types are grown as rainfed crops on the river banks or in poor soils using a minimum of inputs, which results in poor yields (6-7 t/ha). Productivity can be increased by selecting suitable early-bulking cultivars, adjusting planting dates, and adopting proper cultural and management practices. Early-bulking cultivars can easily be put into different cropping sequences to increase area planted and yields.

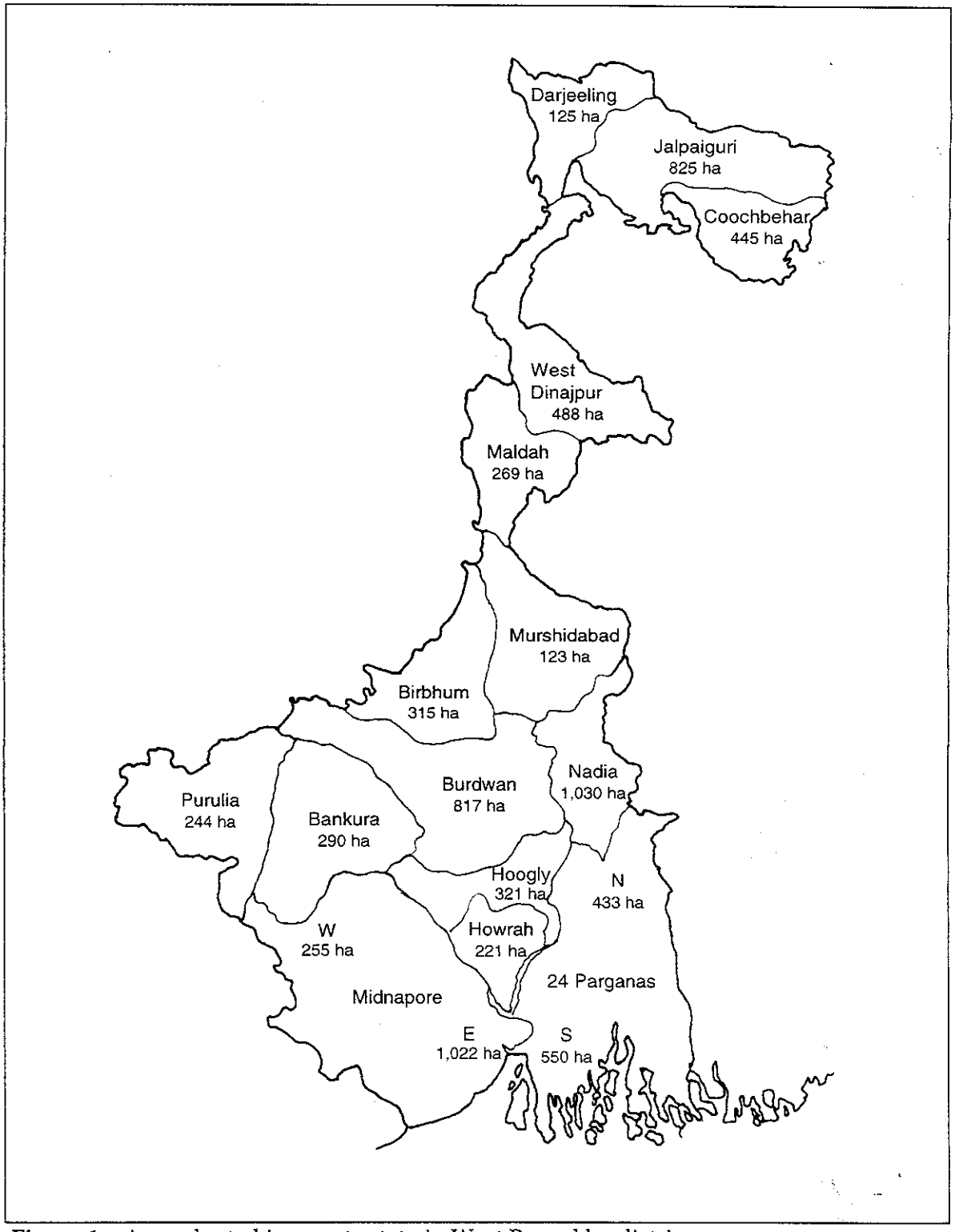

Figure 1. Area planted in sweetpotato in West Bengal by district.

Table 1. Sweetpotato area planted (ha) in West Bengal, by district and growing season.

District	Growing season			Total
	Rabi	*Bhadoi*	*Kharif*	
Bankura	150	130	10	290
Birbhum	165	50	100	315
Burdwan	315	250	252	817
Coochbihar	325	10	110	445
Darjeeling	110	--	15	125
Hoogly	164	48	109	321
Howrah	94	50	277	221
Jalpaiguri	485	250	90	825
Midnapore (E)	1022	--	--	1,022
Midnapore (W)	135	--	120	255
Maldah	90	179	--	269
Murshidabad	50	73	--	123
Nadia	675	--	335	1,030
Purulia	94	150	--	244
West Dinajpur	278	--	210	488
24 Parganas (N)	70	137	226	433
24 Parganas (S)	290	50	210	550

-- = no area planted.

Storage

Sweetpotato roots are usually consumed within a few days after harvest. Farmers prefer to market roots straight from the field. Therefore, there is no perceived need for proper storage and none has been developed, even though experimental evidence indicates that weight loss is severe when roots are stored exposed. The same roots are capable of maintaining 50-60% fresh weight for up to 90 days when stored under earth or sawdust (Mukhopadhyay et al. 1991a).

Harvesting damaged roots, overmature roots, and weevil-damaged roots are the three major constraints of storage. Overmature and off-season roots are normally infested with weevil and 50-60% of the harvest is lost to this pest. Sweetpotato weevil can be successfully avoided, however, if the growing season is between October and February (Mukhopadhyay et al. 1991b), during the cooler months. Also, roots must be harvested at the proper stage of maturity. Because sweetpotato is grown mostly under rainfed conditions, roots are normally formed deeper under the soil and are more prone to damage during harvest. Cultivation of short-duration, early-bulking types (90-105 days) may preempt most weevil infestation (Sen et al. 1990). Spraying with fenthion or monocrotophos (0.05%) a month after planting and at intervals of three weeks is also effective (Sen and Roychoudhury 1988).

Utilization and Demand

In West Bengal, sweetpotato roots are mainly used for human consumption either as a vegetable or eaten after boiling or baking. Tribal peoples in the red and laterite zone prefer sweetpotato because it is higher in energy than the millets they are used to. Upper- and middle-class consumers also use sweetpotato to prepare sweets. Boiled roots are sometimes mixed with wheat flour to prepare *chapatis* or purée. There is thus a steady market for sweetpotato year-round.

Sweetpotato vines considered to be a highly nutritious fodder for dairy cows. As the entire sweetpotato harvest is utilized for fresh consumption, no attempt has been made to explore the possibility of industrial use. But there is some scope for increasing production to meet the need if a starch industry is developed.

In West Bengal, red-skinned sweetpotato roots are preferred; to meet this preference, traders sometimes artificially color white-skinned roots for the market. The price of sweetpotato in the market varies from R 0.20/kg to as high as R 0.10/kg depending on demand. Higher prices prevail during festival months and in the off-season. Obviously, development of appropriate storage methods would not only fetch more money for growers but also provide an incentive to increase sweetpotato acreage.

Possibilities

Red and laterite zone

Cultivation of paddy sometimes suffers in the uplands because of erratic rainfall, resulting in poor yields. The highlands can be successfully used to grow sweetpotato as a *kharif* crop after harvesting maize in August. A satisfactory root yield can be expected in December when using residual soil moisture. Sweetpotato is a much more risk-tolerant and remunerative crop than paddy, having a cost-benefit ratio of 1:4. Because sweetpotato is responsive to potassium, there is a great possibility to increase root yield through judicial applications of potassium, particularly in this zone's acidic soils.

New and old alluvial zone

Irrigated uplands are mostly occupied by highly remunerative vegetables after harvesting jute or upland paddy, but unirrigated uplands can easily incorporate sweetpotato as a *rabi* crop. A satisfactory root yield (15-20 t/ha) could be expected within 120 days with early-bulking cultivars. Sweetpotato could prove to be an important crop in this zone. River banks and islands could be planted with sweetpotato in late November after water levels recede. A good harvest could be expected from this rainfed crop, which could be cultivated without special care and management.

Coastal and saline zone

Lands in this zone remain occupied till the end of December by *kharif* rice of the long-duration, tall indica variety. Virtually all fields are uncultivated from January to June, when sweetpotato would be an ideal and beneficial crop.

Discussion

If given more emphasis, the following initiatives would improve the harvest of weevil-free roots, and bring a better market price for locally stored roots:

- Select appropriate varieties for different agroclimatic zones with respect to soil condition, growing period available, and season.
- Develop appropriate management technologies (a package of practices), particularly cultural practices directed at different zones and for harvesting weevil-free roots.
- Develop a low-cost storage technology so farmers can fetch a better price for their produce.
- Develop a low-cost technology for processing roots to reduce bulk and increase the price, and then train farmers in this technology.

Most important, the government must come forward and support sweetpotato. Once policymakers comprehend its economic potential and understand its benefits as a second crop in existing cropping systems, this can be demonstrated to farmers by extension specialists. Sweetpotato's use for animal feed or in agro-processing industries would be realized once production reached sufficient proportions.

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Sweetpotato Storage

Sweetpotato Storage Pests and Their Control in India

K.S. Pillai[1]

Abstract

Pests such as *Cylas formicarius, Araeocerus fasciculatus, Alphitobius laevigatus,* and *Gonocephalum* spp. can do considerable damage to stored sweetpotato. Storage trials revealed that storing uninfested roots in earthen pots and in dry sand was highly effective in controlling storage pests. For periods of up to 2 1/2 months, damage was either nil or negligible using these methods.

Key words: Arthropods, infestation, pit storage, processing.

Introduction

Sweetpotato (*Ipomoea batatas*) is the second most important root crop cultivated in tropical, sub-tropical, and certain warm, temperate regions of the world. It is important as a food crop in many developing countries and is also used in the feed and processing industries. Global sweetpotato production is 124 million t (CIP 1996). In India, sweetpotato is cultivated on approximately 140,000 ha, with a production of 1.15 million t (CIP 1996). Sweetpotato yields in India average only 8 t/ha, considerably lower than the world average (13 t/ha) and lower than yields in China (15 t/ha). One of the main reasons for such low productivity is pest infestation. In India, nearly 80 species of arthropods infest sweetpotato in the field and in storage (Pillai and Palaniswami 1984). Talekar (1987) has listed 287 species of arthropods infesting sweetpotato globally. The majority of these pests attack the crop in the preharvest stage and cause significant yield reduction, whereas many destroy the produce in postharvest storage. In India, the most important of these are the sweetpotato weevil (*Cylas formicarius*), coffee bean weevil (*Araeocerus fasciculatus*), black fungus beetle (*Alphithobius laevigatus*), and ground beetle (*Gonocephalum* spp.). The first three species riddle the roots completely and cause decay, whereas the ground beetle feeds on the periderm by making irregular galleries. The coffee bean weevil and the black fungus beetle are polyphagous storage pests that cause widespread damage to stored root and tuber crops in the tropics. In India, sweetpotato roots are used for human consumption both as a subsidiary (staple) food or as a vegetable. Rarely is sweetpotato used in the processed food industry. Hence, the importance of postharvest storage for future use cannot be ignored.

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Storage

When large-scale cultivation is practiced immediately after harvest, roots are packed in gunny bags and transported in trucks to distant markets. In this situation, the question of storage does not arise. Marginal farmers and the tribal people who cultivate sweetpotato often adopt different storage methods to preserve roots for longer periods. Leaving the crop in the field and piecemeal harvesting are practiced in some places. One major disadvantage of this practice is pest infestation. Infestation by the sweetpotato weevil intensifies when the crop remains in the field for longer periods.

In fact, the best method to minimize weevil damage is early harvest. Where there is no weevil problem, delayed harvest and ground storage can be practiced. But ground storage has the disadvantage of quality deterioration, such as depletion of starch, fibrous development, and crack formation on the root surface. Hence, this method is not generally recommended.

While conducting a survey in Northeastern India, Pillai and Prasad (1983) observed a storage method adopted by the tribal people in Orissa, reported to be effective for up to six months. The interiors of huts in this area are cool and dark, with no excessive heat. Immediately after harvest, farmers piled roots in heaps and covered them with a layer of straw. Heaps were then plastered with a mixture of clay soil and cow dung. Roots stored in this manner remained fresh for as long as six months (Pillai and Prasad 1983). But when this method was tried at CTCRI, it was not found to be as effective as claimed. Roots remained fresh for up to 45 days, but then rotting began. After two months, microbial rotting and insect damage became severe. Cracks in the mud plastering allowed insects, especially black fungus beetles, to enter. This method has been found to be effective only as a short-term storage device.

For long-term sweetpotato storage, many countries commonly use the pit method. In Barbados, roots are stored for up to four months in subterranean or semi-subterranean pits covered with dried leaves and sand. Roofing is also provided. However, storage life is generally extended to one or two months only because of rotting and sprouting (Kay 1973). Onwueme (1978) reported a trench storage method used in the Philippines. Roots were stored in trenches 50 cm deep, covered with sand, and sheltered with a roof. But using this method resulted in 30% of the roots decayed and 45% sprouted. At CTCRI, the pit method was tried. Pits 50 cm deep were dug. Roots stored in these pits were then covered with dried banana leaves and soil; roofing was also provided. Roots remained fresh for up to one month. After 45 days, severe rotting occurred. Whatever method is used, long-term storage of sweetpotato roots is unsuccessful because of excessive weight loss, dry matter depletion, rotting, and insect damage.

Uninfested and insect-free roots can be successfully stored for short periods. In Nigeria and Papua New Guinea, roots are stored in well-ventilated storehouses on

raised platforms, in heaps on floors, in baskets, or in roof spaces. A fire is often lit to provide additional heat and the roots become slightly smoked. In certain areas, ash is also used to cover roots. Using these methods, roots can be successfully stored for up to four weeks (Olurunda 1979).

Hahn and Anota (1982) reported the effect of lower temperature for controlling sweetpotato weevil in stores. At a storage temperature of 20°C, weevil mortality surpassed 89%. They further reported the efficacy of immersing roots in hot water for weevil control. All larvae and adult weevils died within ten minutes after immersing the roots in water at 52° or 62°C. When studying the effect of soil depth in underground storage for weevil control, they found that weevil mortality in roots stored in sand depends on soil depth: at 5 cm below the soil surface, 90% mortality occurred within 5 days (Hahn and Anota 1982).

At CTCRI, different storage methods were tested to control storage pests. Uninfested and uninjured roots were stored in earthen pots, fine sand, laterite soil, wood ash, and sawdust. These were compared with exposed storage as the control; observations were recorded at 50 and 75 days after storage. At day 50, there was no damage in the different treatments; while 100% damage was observed in the control, because of pest infestation, rotting, and drying. At day 75, damage was nil in earthen pots and negligible (2%) in fine sand, while in other treatments damage was 16-20%. In light of this finding, a large quantity of roots were stored in a wooden box in thick layers of fine sand. First, a thick layer of sand (10 cm) was laid down and roots were arranged over it, followed by alternating layers of sand and roots, ending with a thick layer of sand on top. Stored roots were observed at 2 1/2 and 4 1/2 months for weight loss and damage. After 2 1/2 months (75 days), weight loss was 22% and damage from rotting was 7%. At 4 1/2 months, weight loss increased to 49% and damage from rotting to around 20%. Though there was no pest infestation, the weight loss and root rotting were significant. Therefore, it was concluded that sweetpotato roots could be effectively stored for only up to 75 days. Beyond this time, storage of roots was uneconomical (Pillai and Rajamma 1991).

Reports from other countries corroborate this view. For short-term storage, earthen pots, wood ash, and fine sand are the best media, if roots selected for storage are free from pests and injury.

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Sweetpotato Storage Diseases and Their Control: Results of a Survey

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Abstract

Sweetpotato is subject to many diseases while in storage, in transit, and in the market. In India, as many as fifteen fungal pathogens have been implicated in root rot. Soft rot (*Rhizopus stolonifer*), charcoal rot (*Macrophomina phaseolina*), circular rot (*Sclerotium rolfsii*), surface rot (*Fusarium oxysporum*), and Java black rot (*Diplodia rooticola*) are important and destructive. The present status of postharvest diseases of sweetpotato roots in India is discussed and a future line of work suggested.

Key words: Pathogens, physiological, pathological, ubiquitous, injury, bacterial damage, microbial damage, fungicide, ultraviolet irradiation.

Introduction

Sweetpotato is subject to many diseases caused by fungi, bacteria, viruses, and mycoplasma-like organisms at different stages of its production, storage, transit, and marketing. More than 40 pathogens in different parts of the world have been reported to attack sweetpotato both in the field and in storage (Halsted 1890; Steinbauer and Kushman 1971; Clark and Moyer 1988). In India, however, only 25 pathogens have been reported. Some attack in the field or in storage, whereas others attack both in the field and in storage (Thankappan 1989).

Postharvest or storage diseases probably account for the greatest losses in sweetpotato production. This is particularly true in temperate regions where the crop is grown only once a year and where roots are stored for a long period. Booth (1978) estimated that the global loss from postharvest diseases is about 25%. In tropical countries, two or three sweetpotato crops are grown in a year; therefore, much of the produce is consumed soon after the harvest and little is stored. In India, the extent of loss caused by postharvest diseases of sweetpotato has not been estimated but preliminary observations indicate that these diseases can cause substantial loss. A perusal of the literature reveals that in India more than 15 species of fungi are involved in spoiling sweetpotato roots and products after harvest, in storage, in transit, and in the market (Table 1).

Postharvest losses may be caused by physical, physiological, or pathological factors or the combined effect of all three. Attack by fungi may be the most serious. Physical and physiological factors predispose stored roots to attack by pathogens. The majority of sweetpotato storage diseases begin in fields and carry over to stores. Others are

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Table 1. Common postharvest diseases of sweetpotato reported in India.

Disease	Pathogen	Reference
Storage diseases		
Soft rot	*Rhizopus stolonifer*	Sinha and Prasad 1986
Charcoal rot	*Macrophomina phaseolina* *Rhizoctonia bataticola* *Sclerotium bataticola*	
Wet/circular rot	*Sclerotium rolfsii*	AICPTC 1980-85
Surface rot	*Fusarium oxysporum*	
Java black rot	*Diplodia rooticola*	
Scurfy lesion	*Pellionella indica*	Subramoniam and Rao 1975
Black mold rot	*Mucor* sp.	
Blue mold rot	*Penicillium* sp.	
Market diseases	*Rhizoctonia solani* *Penicillium digitatum* *Myrothecium roridum* *Arthenium phaeospermum* *Stemphylium botryosum* *(Pleospora herbarum)*	Ravichandran and Sullia 1983
Flour spoilage	*Aspergillus* sp.	Vasudeva 1946; Gattani 1951

caused by fungi that infect roots through wounds caused during harvest, transport, and handling.

Research and Development

Research on sweetpotato postharvest diseases has been meager in India. Few research centers and workers are engaged in postharvest pathology studies. The amount of information available on the subject is therefore very limited. Only 20 research papers or reports have been published in India on postharvest diseases of sweetpotato. Many of these deal with reports of one or another organism involved in the spoilage of roots in stores from certain geographical areas. In-depth studies on pathological aspects have not been done, such as information on the distribution, intensity, and extent of damage; predisposing factors; and methods of control. This is probably because in India the damage done by the pathogen on stored sweetpotato was not believed to be that great because roots were not stored for long periods. Major postharvest diseases of sweetpotato and results of this research are summarized below.

Storage Diseases

Soft rot

Among the eight diseases that attack sweetpotato roots, soft rot is the most important, widespread, and studied (Thankappan 1989). Though the soft rot or rhizopus rot of sweetpotato has been known to occur in temperate regions since 1921 (Harter et al. 1921), it was only recently recorded in India (Sinha and Prasad 1986). This is the most serious and destructive disease among the storage diseases of sweetpotato. This disease causes about 10% of losses at the farm level.

Infected roots quickly turn soft and moist at one end or at both ends, become stringy, and emit a characteristic fermented smell. Thick tufts of superficial mycelium and black fruiting structures appear on the surface of affected roots. Studies on patterns of infection and incidence have shown that infection is worse during the harvest than at earlier stages of plant development.

Pathogens

Rhizopus stolonifer (Ehr. ex Fr.) Lind., a synonym of *R. nigricans* Ehr., has been identified as the causal organism. The pathogen is ubiquitous and is therefore constantly present in the air, crop debris, containers, and storehouses. It is a wound parasite requiring fresh wounds or injuries on roots for infection and rot to occur. Along with this pathogen, other bread mold species, such as *Mucor*, have often been observed as associate causal organisms.

Other minor root rots

Studies conducted at the Rajendra Agricultural University, Dholi, Bihar, between 1979 and 1985 on storage diseases of sweetpotato have revealed that other pathogens, besides *R. stolonifer*, the soft rot pathogen, cause postharvest spoilage (AICPTC 1980-85; Thankappan 1990).

Among the pathogens associated with rots (Table 1), *M. phaseolina* (vascular ring disease or charcoal rot), *S. rolfsii* (circular rot), *F. oxysporum* (surface rot), and *D. tubericola* (Java black rot) are important and destructive. But the extent of damage or loss caused by these pathogens has not been estimated. These pathogens infect plants in the field. Infected roots brought to stores cause severe rots when conditions favor the pathogen.

A 1975 report by Subramoniam and Rao indicates that sweetpotato roots are subject to a disease known as scurfy lesion (caused by *Pellionella indica*), but no current details are available.

Market Diseases

Besides the field and storage diseases described above, sweetpotato is subject to attack and spoilage by several pathogens while in transit and marketing. Ravichandran and Sullia (1983) reported that at least five fungi —*Rhizoctonia solani* Kühn, *Penicillium digitatum* Sau., *Myrothecium roridum* Tode, *Arthenium phaeospermum* Corda and Elis, and *Stemphylium botryosum* Waltr. (*Pleospora herbarum*)— are responsible for root spoilage in transit and in the market.

Sweetpotato product spoilage

Sweetpotato flour, which can be stored for longer periods than fresh roots, has also been reported to be spoiled by certain fungal organisms. A species of *Aspergillus* was found to be the most common organism responsible for sweetpotato flour spoilage (Vasudeva 1946; Gattani 1951).

Bacterial diseases

Bacterial pathogens such as *Erwinia chrysanthemi, E. carotovora* subsp. *carotovora, Pseudomonas solanacearum,* and an actinomycete, *Streptomyces,* have been reported elsewhere as responsible for both field and storage diseases (Clark and Moyer 1988). So far, these organisms have not been found on sweetpotato either in the field or in stores, even though they have been observed in India.

Virus diseases

Many virus diseases are known to affect sweetpotato in the field (Clark and Moyer 1989). Among them, sweetpotato feathery mottle virus (SPFMV) is found in almost all places where the crop is cultivated. Many strains of SPFMV have been identified. Strains known as russet crack and internal cork also affect the roots. The russet crack strain causes necrotic lesions that girdle the fleshy and fibrous roots. The internal cork strain causes necrotic lesions inside the roots; these lesions increase with prolonged storage.

Virus and virus-like diseases in sweetpotato have also been reported recently from India (Mahto and Sinha 1978; Thankappan and Nair 1990; Kumar et al. 1991). Though russet crack and internal cork symptoms have not been found during the screening of several sweetpotato germplasm accessions exhibiting virus symptoms at CTCRI (AICPTC 1989, 1990), the role of virus diseases in the spoilage of sweetpotato roots in storage is worth investigation.

Storage diseases not reported in India

Several fungal pathogens causing storage rots on sweetpotato elsewhere have not been reported to occur in India (Table 2). The most important among these are *Ceratocystis fimbriata* (black rot), *Monilochaetes infuscans* (scurf), *Diaporthe batatatis* (dry rot), *Botrytis cinerea* (grey mold rot); and *Trichoderma koningii* (punky rot). Most of the listed

Table 2. Common postharvest diseases of sweetpotato not reported in India.

Disease	Pathogen
Black rot	*Ceratostomella fimbriata*
Scurf	*Monilochaetes infuscans*
Root rot	*Fusarium solani*
Dry rot	*Diaporthe batatatis*
Alternaria rot	*Alternaria* sp.
Grey mold rot	*Botrytis cinerea*
Punky rot	*Trichoderma koningii*
Rootlet rot	*Streptomyces ipomoea*
Foot rot	*Plenodomus destruens*
Bacterial soft rot	*Erwinia chrysanthemi*
	E. carotovora
	Pseudomonas solanacearum
Virus diseases	Russet crack strain of SPFMV
	Internal cork strain of SPFMV

pathogens are already prevalent on other crops in India, but are either not found or not reported on sweetpotato in India.

Control of Storage Diseases

Since damages caused by postharvest diseases have not been properly estimated, no systematic work has been undertaken in India to study and evaluate appropriate control measures for the diseases mentioned above, except for soft rot. The following are the control measures generally recommended:

- Properly select roots for storage, thus avoiding injured/wounded and immature roots. Disinfect containers and storerooms to help reduce disease incidence in stores.
- Properly cure roots before storage to help reduce disease incidence in stores. Curing of sweetpotato roots before storage at 29°C and 85-90% RH for ten days (Mukerjee and Prasad 1972) or at 45-50°C and 85% RH for three days (Balagopal and Padmaja 1984) prevented microbial damage and helped prolong their storage period. The farm practice (in the main sweetpotato production areas) of sun-drying roots before storage (Nanda 1984) is probably directed towards prolonging their storage life. Because most of the causal pathogens of storage diseases are wound parasites and require wounds to cause infection, curing roots helps to heal wounds and thereby prevent or reduce disease incidence.

- Use resistant varieties. Studies conducted at Rajendra Agricultural University, Dholi, Bihar, for more than five years have shown varying degrees of susceptibility to storage rots among roots of different sweetpotato lines. Screening trials involving 50 sweetpotato lines have helped identify 10 lines resistant to rhizopus rot, 17 to sclerotium rot, 20 to diplodia rot, and 12 to fusarium rot.
- Use protective fungicides. Sweetpotato roots meant for seed/propagation purposes can be treated with any protective fungicide before storage to avoid losses from storage diseases.

Future Research

Storage and postharvest diseases of sweetpotato have not been adequately studied in India. Losses from such diseases may be far greater than what is now believed. No systematic survey has been conducted to properly estimate the number of diseases that attack sweetpotato in stores, the organisms involved, losses in both quantity and quality, conditions favorable to disease development, and measures to prevent losses. Therefore, we suggest that researchers involved in sweetpotato improvement do the following work:

- Survey the major sweetpotato-growing areas such as Orissa, Bihar, and Uttar Pradesh for storage methods, length of storage, disease incidence, organisms involved, extent of damage, and measures adopted by farmers to prevent losses.
- Study varietal reaction to different storage diseases.
- Study the feasibility and effect on storage diseases of irradiating roots with ultraviolet rays. Recent studies in the USA have shown that sweetpotato irradiated with ultraviolet rays had significantly less mold attack than the control, and the roots irradiated had a higher starch content (Stevens et al. 1990).
- Study and evaluate certain protective fungicides as root/seed dips and their effect on storage diseases.
- Breed varieties resistant to storage diseases. Varieties highly resistant to black rot (*Ceratostomella fimbriata*) have been successfully developed by mutation breeding using gamma rays in China (Lu et al. 1988).

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Comparing Low-Cost Sweetpotato Storage Methods in India

Suhas K. Mehra and T.R. Dayal[1]

Abstract

We compared different factors governing sweetpotato storage using four different methods. We described procedures for storing sweetpotato in ground pits, sand, a rustic store in heaps, and gunny bags. We recorded the extent of physiological weight loss and other processing parameters, such as peeling and paring, and the influence of variations in temperature on varieties in different storage systems. Of the four storage systems, we found sand storage to be best, resulting in minimum weight loss and less peeling and paring time over a two-month storage period.

Key words: Storage processing, peeling and paring, weight loss, variety.

Introduction

Wide adaptability and high nutritive value make sweetpotato one of the most widely grown root crops in India. Recently, area planted and production have declined (Nayar and Rajendran 1989). Jairath and Pal (1989) reported that demand was one of the most important constraints to sweetpotato production in India, followed by marketing and storage. Limited demand results in weak sales and unremunerative prices for farmers. The problem of seasonal oversupply at harvest could be avoided by developing suitable storage practices, which could be used by producers to store part of their produce and sell it when prices are higher. Sweetpotato is a perishable commodity and storing it in a good condition for human consumption is a major problem in the tropics (Data et al. 1989). A comparative study of sweetpotato storage methods in India is presented here.

Study Procedure

We purchased sweetpotato roots of red- and white-skinned varieties from a wholesale vegetable market in December, 1990. We hand-sorted roots from both genotypes into marketable and cull size.

We evaluated four storage practices prevalent in sweetpotato-growing areas using marketable-sized roots from two genotypes. The experiment was conducted in a random block design with three replications. In each replication, 30 kg of marketable-grade sweetpotato were stored for sixty days.

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Pit

Pits 3 x 3 x 4 ft were dug in a raised-ground area. The walls and bottoms of these pits were first plastered with cow dung and, after the plaster dried, paddy straw was placed against them. Sweetpotato roots were placed in the pits. The pit openings were covered with tree leaves and twigs, paddy straw, and a layer of mud. Two coatings of cow dung plaster were applied to restrict the entry of rainwater.

Sand

The Council of Scientific and Industrial Research (1959) reported that sweetpotato roots could be stored in sand. More recently, Dayal et al. (1990) reported successful storage of sweetpotato roots in sand. They found that the foremost factor influencing this storage practice was the dryness of the sand.

Fresh sand was brought from a river bed and thoroughly dried for 3 days. We selected a store site free of moisture for the experiment. On the floor of this site, we spread four inches of dry graded sand, and then spread sweetpotato roots and a one-inch-thick layer of sand over the initial layer. The four-inch top layer was to prohibit the entry of rodents and insects.

Rustic

A 20-t-capacity rustic potato store was designed by the International Potato Center (Region VI), IARI, New Delhi, India, at SOTEC, Barielly. These stores have one-foot-thick walls and a thatch roof. The principle of passive evaporative cooling is used by spreading water on the floor. Sweetpotato roots of both genotypes were stored as small heaps on the false floor of these stores. Because of low temperatures during December-February when the experiment was conducted, evaporative cooling was not necessary.

Bags

Jute bags were filled with sweetpotato and openings tightly sealed. We kept these bags on a raised wooden platform. We took temperatures three times a day during the storage period and took monthly data on physiological weight loss for both genotypes. Stored sweetpotatoes were processed first at the end of 30 days' storage and then at 60 days to observe variations in two processing attributes: paring time (time taken to remove dark skin and diseased portions after peeling the roots for 5 min) and recovery rate (percentage dehydrated material recovered in processing).

Research Results

After two months of storage, peeling roots of both varieties stored in the rustic store was difficult. Increasing the peeling duration to ten minutes proved futile. Therefore, we conducted the analysis for adjusted paring time and recovery rate without considering the roots stored in the rustic store.

Physiological weight loss

Average physiological weight loss during the first month was 21% and 43% in the second, a significant difference. But the genotypic effect was not significant. Lower physiological weight loss was observed for the roots stored in sand. After one month of storage, no significant difference was observed between roots stored in pits and bags. But after two months, storage in bags was found to be significantly better. Storage in rustic stores as small heaps was the least effective method. The genotype-store type interactions were not significant for roots stored for one month, but were significant for those stored for two months (Table 1).

Paring time

Average paring time for processing stored roots was 11 min for roots stored one month and 6 min for those stored two months. Paring time was significantly lower for the white-skinned genotypes, but the significance level decreased with storage duration. This implies that with the passage of time both genotypes tend toward a similar physiological condition. The lowest paring time was observed for roots stored in sand. After one month of storage, the differences between paring time for roots stored in bags

Table 1. Average physiological weight loss (kg) observed for various treatments.

Source	After 1 month	After 2 months
Genotype		
- White	21	42
- Red	21	45
Significance level	ns	ns
Store type		
- Pit	17 B	39 C
- Sand	9 C	19 B
- Bag	17 B	49 B
- Rustic	41 A	66 A
Significance	(0.00)	(0.00)
LSD (at p=0.05)	4.39	5.24
Genotype x store type		
- White x pit	16 B	49 C
- White x sand	10 C	16 F
- White x bag	18 B	41 D
- White x rustic	41 A	63 AB
- Red x pit	19 B	29 E
- Red x sand	9 C	23 EF
- Red x bag	16 B	58 B
- Red x rustic	41 A	69 B
Significance level	ns (0.25)	(0.00)
LSD (at p=0.05)	4.39	7.42

Figures in parentheses indicate significance level.

and pits were not significant. After two months' storage, however, a significantly higher paring time was observed for roots stored in bags than for those in pits. The highest paring time was recorded for roots from the rustic store (Table 2).

Recovery rate

The average recovery rate for the first month was 27% and for the second month, 25%. The genotype effect was not significant. Except for roots stored in the rustic store, no significant differences were observed for recovery in processing the roots stored in pits, sand, or bags. Genotype-store type interaction was significant for the roots stored for two months. A higher recovery rate was observed for the interaction of red-skinned sweetpotato by store type compared with white-skinned by store type (Table 3).

Table 2. Average paring time (min.) for various treatments.

Source	After 1 month	After 2 months
Genotype		
- White	11	6
- Red	12	7
Significance level	(0.01)	(0.03)
Store type		
- Pit	10 B	6 B
- Sand	6 C	5 C
- Bag	9 B	A
- Rustic	21 A	--
Significance	(0.00)	(0.00)
LSD (at p=0.05)	1.43	1.17
Genotype x store type		
- White x pit	9 C	6 B
- White x sand	6 D	4 C
- White x bag	9 C	7 B
- White x rustic	20 B	--
- Red x pit	11 C	6 BC
- Red x sand	6 D	5 BC
- Red x bag	9 C	10 A
- Red x rustic	22 A	--
Significance level	ns (0.24)	(0.03)
LSD (at p=0.05)	2.02	1.66

Figures in parentheses indicate significance level.

Table 3. Average recovery rate (%) observed for various treatments.

	After 1 month	After 2 months
Genotype		
- White	25	25
- Red	26	26
Significance level	ns (0.14)	ns (0.06)
Store type		
- Pit	28 A	26 A
- Sand	26 A	25 A
- Bag	27 A	25 A
- Rustic	22 B	--
Significance	(0.00)	ns (0.18)
LSD (at p=0.05)	1.54	1.48
Genotype x store type		
- White x pit	26 BC	25 ABC
- White x sand	25 C	24 C
- White x bag	27 ABC	25 ABC
- White x rustic	23 D	--
- Red x pit	29 A	26 AB
- Red x sand	27 ABC	27 A
- Red x bag	28 AB	24 BC
- Red x rustic	20 D	-
Significance level	(0.03)	ns (0.11)
	2.18	2.09

Figures in parentheses indicate significance level.

Temperature variation

Average daily temperatures were computed and used for the analysis. The highest temperatures were recorded in pit storage. The mean temperatures over the entire storage duration were at room temperature for bag storage (17.6°C), sand (14.5°C), pit (28.3°C), and rustic (16.6°C). These were significantly different (p = 0.05; LSD = 0.55).

Kushman and Deonier (1975) reported optimum storage conditions as 15°C and 85-90% relative humidity. McCombs and Pope (1958) reported that the dry matter of sweetpotato generally decreased during storage and that it was usually higher at 18.5°C than at lower temperatures. In a study on the influence of storage temperature on sweetpotato cultivars Porto-Rico, Allgold, and Goldrush, Kushman and Deonier (1975) found that roots of all three varieties kept very well at 15.5°C and nearly as well at 21°C, but not at 10°C.

The lowest physiological weight loss was observed for sand storage and the average temperature in this store was approximately 15°C. Even though the difference between average sand storage and rustic store or room temperature (bag storage) was less than 3°C, the difference in physiological weight loss was significant. On the other hand, the average temperature in the pit was 28°C and in the rustic store 16.6°C, but the

physiological weight loss in the rustic store was significantly higher. This implies that temperature might not be the sole factor influencing sweetpotato storage.

Sweetpotato stored in sand was the least exposed to ventilation. In bag storage, there was some ventilation, but in the rustic stores roots were fully exposed to ventilation. Physiological weight loss was the least in sand storage and the most in the rustic store. This study thus indicates that degree of ventilation is directly related to physiological weight loss. Sweetpotatoes stored in pits were also exposed to the least ventilation, but because of weevil infestation, faster sprouting, and other storage diseases, their physiological weight loss was significantly higher than that of the sand store. This might be due to the faster life cycle of weevil at 30-32°C compared with 22-24°C (Pillai 1988).

Conclusions

The differences in physiological weight loss between varieties of sweetpotato were not significant. Roots stored in sand were in the best physiological condition. The highest physiological weight loss and paring time and the lowest recovery rate were observed for the roots stored in the rustic store. Therefore, efforts should be made to avoid storing sweetpotato roots in small heaps exposed to ventilation in a rustic store; however, as a temporary arrangement, they could be stored in bags. Improvements in pit storage to minimize weevil infestation need to be explored.

Reduction in paring time resulted from an increase in storage duration because roots stored for one month had smaller and shallower parts to pare. Therefore, finer cuts and less material were removed in one-month stored roots compared with two-month stored roots. The material loss was also reflected as a lower recovery rate for the two-month stored roots (Table 3).

Genotype effect on physiological weight loss and recovery rate was not significant. But a significantly lower paring time was observed for white-skinned roots. Therefore, choice of genotype should be based on the economics of processing.

Roots stored in sand showed the lowest physiological weight loss and shortest paring time. Ignoring the rustic store, the store-type influence on recovery rate was not significant. Computing the recovery rate as a percentage of dehydrated material recovered from the initial weight of the roots stored, the recovery rate for pit storage was 18%, sand 22%, and bag 17%. Therefore, storage of roots in sand implies an increase of at least 4% in overall recovery rate, with the added advantage that paring time is also reduced.

A significant increase in weight loss over the duration of storage indicates that further improvement in the sand storage method is required.

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Appendix

About the Workshop

A regional workshop on postharvest handling, storage, and utilization of sweetpotato was held 9-13 September 1991 at the Central Tuber Crops Research Institute, Trivandrum , India, in collaboration with the International Potato Center (CIP), New Delhi. Researchers from Bangladesh, India, Nepal, and Sri Lanka participated in this meeting. The main workshop objectives were to:

- Review existing practices in postharvest handling, storage, marketing, processing, and utilization of sweetpotato in South Asia.
- Document research results to date and make suggestions for future work.
- Make recommendations for improved technologies on storage, handling, and utilization of sweetpotato.
- Publish a proceedings.

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