CASSAVA BREEDING AND VARIETAL DISSEMINATION IN THE PHILIPPINES - MAJOR ACHIEVEMENTS DURING THE PAST 20 YEARS

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ASTRACT

During the past 20 years of close collaboration with CIAT in the cassava breeding program in the Philippines, much has been achieved, not only in terms of human capacity building but also in the acquisition of improved cassava germplasm. These materials were used in a multy-year selection scheme, which culminated in the release of several improved cassava varieties recommended for cultivation in the country, in order to support the need for food, feed and various industrial products.

Since 1982 a total of 40,809 cassava hybrid seeds were received from CIAT headquarters in Colombia and 11,280 hybrid seeds rom the Thai-CIAT cassava program. These were evaluated in all stages of selection under Philippine conditions. Three cassava varieties were released by the Center during the early years of establishment and 16 varieties were subsequently released by the National Seed Industry Council. From these released varieties, six are of local origin, eight are from CIAT materials and five from locally developed hybrids.

Progress in the selection of the materials received has been quite positive, meaning that a lot of the elite genetic materials introduced were selected for possible varietal release or as parental material for the breeding program. Considering the source of the two genetic populations we received, it was noted that hybrid seeds from Thailand performed very well in the Philippines; in fact, some of the elite materials have superior characteristics compared to the best Philippine varieties. About 0.15% of hybrid seeds received from CIAT/Colombia were eventually selected and maintained, while about 0.38% of seed received from the Thai-CIAT program were maintained for further trials and possible varietal release.

The dissemination of new cassava varieties has been intensified during recent years through the conducting of adaptation trials in various parts of the country in collaboration with farmers and individuals in the private sector. The involvement of the private sector in the industrial use of cassava for processing into various products has triggered widespread planting of the new cassava varieties. San Miguel Corporation has promoted the planting of cassava for production of animal feeds and for alcohol, to be used in the manufacture of gin, a popular alcoholic drink in the Philippines. In 1997, about 5,000 hectares were planted to cassava primarily using Lakan and Golden Yellow varieties. New clones, KU-50, Rayong 5 and PSB Cv-12 (SM972-20) are rapidly being multiplied to provide part of the planting materials required for San Miguel's cassava project expansion in Negros Occidental. In addition to this, starch factories continuously plant high yielding cassava (VC-5) for the starch industry. Starch factories now have an approximate combined area of 10,000 hectares of cassava planted to the recommended cassava varieties.

Future breeding work and selection will focus on the identification of superior varieties, not only with high yield but with high starch content, tolerance to existing pests and diseases, and other characters that will satisfy the requirements of the cassava-based industry.

INTRODUCTION

Cassava, (*Manihot esculenta* Crantz) has been cultivated in the Philippines even before World War I as a food source using the traditional varieties. Several early workers attempted to investigate the crop's potential in the production of starch, flour, animal feed

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and alcohol (Roxas and Mario, 1921; Sison, 1921). Realizing the multiple uses of cassava, the Philippine Congress passed the Republic Act 657, known as the Cassava Flour Law, in 1951 (Acena, 1953). This Act encouraged and promoted the production, processing and consumption of cassava flour as a measure to conserve dollars and reduce the importation of wheat. Since then, very little effort has been made to support the cassava industry and to fully implement the law.

Cassava varietal improvement in the Philippines started in the 1960s at the Institute of Plant Breeding (IPB) at Los Baños, Laguna (Bacusmo and Bader, 1992). However, activities consisted mainly of variety trials of a few local and introduced varieties (Mariscal, 1987). It was only when the Philippine Root Crop Research and Training Center (PhilRootcrops) was established in 1977 at Visayas State College of Agriculture, Baybay, Leyte, by virtue of Presidential Decree No. 1107, that a more organized and relatively well-supported cassava breeding program started. This resulted in the assemblage of various cassava germplasm collections, subsequent screening, and the identification and release of superior local varieties. The breeding program was further enhanced when PhilRootcrops established a strong linkage with CIAT's cassava program in 1982 through the leadership of Dr. Kazuo Kawano, CIAT's erstwhile cassava breeder, who initiated the CIAT Regional Cassava Program in Asia in 1983. CIAT provided the national program with improved cassava populations. This resulted in the release of several cassava varieties with parental origin from CIAT. More than that, CIAT has helped the center in strengthening the capability of its breeders to spearhead systematic evaluation and selection of the improved materials, and their subsequent utilization in breeding.

For the last 20 years of cassava research, a modest increase of the national average yield of cassava from 6.0 t/ha in 1977 to 9.0 t/ha in 1997 was attained. This yield, however, is one of the lowest in Southeast Asia. The modest yield increase is attributed to gradual adoption of high-yielding cassava varieties and improved cultural practices (Rootcrops National RDE Agenda, 1999).

With globalization, governments around the world are increasingly dismantling tariff barriers and eliminating protective subsidies in preparation of the full implementation of the General Agreement on Tariffs and Trade (GATT). For ASEAN member countries such as the Philippines, trade liberalization is even more accelerated as signatories of the Asean Free Trade Area's (AFTA) move to reduce tariffs ahead of other regions. This provides new opportunities and poses new challenges to producers, traders and consumers. In this context, the potential of cassava shall be exploited mainly in terms of domestic utilization for food, feed and industrial products. Walters (1983), Lynam (1986) and Singh (1986) emphasized that cassava will play a major role in satisfying the domestic needs of the country, and that any future increase in output by the cassava producing countries in Asia should be aimed primarily at their domestic markets, such as for animal feed and starch production (food processing, textiles, paper and board, sweeteners and ethanol). True to the projections of the economists, recently in the Philippines a tremendous demand for cassava was observed for production of animal feed, starch and alcohol. With the present unstable production of sugar in the Philippines, La Tondena Distillers Incorporated, which consumes 60% of the molasses in the Philippines, has turned to cassava as an

alternative raw material. The existing demand for cassava, therefore, needs backstopping in terms of superior varieties from the varietal improvement program.

This paper, therefore, highlights the research accomplishments of cassava breeding in the Philippines over the last 20 years (1979-1999).

CASSAVA BREEDING OBJECTIVES

The breeding objectives for cassava in the Philippines for the last 20 years aim to satisfy the needs of farmers who grow cassava in diverse agro-climatic conditions, as well as those of the processors who utilize the storage roots in a variety of ways. The breeding objectives are as follows:

1. High yield
2. High dry matter and starch content
3. Early harvestability
4. Resistance to pests and diseases
5. Tolerance to environmental stresses
6. Good plant type (root formation, root shape and branching habit).

The level of hydrogen cyanide (HCN) in cassava, although not correlated with yield, is also considered during selection. Low HCN varieties are identified and selected for farmers who use cassava as a staple food. High HCN varieties, on the other hand, are preferred by starch millers because they tend to produce higher yields and have higher starch content, while also discouraging thefts. Those varieties having low HCN and high dry matter and starch contents are considered dual-purpose varieties (for table use and processing).

MAJOR ACHIEVEMENTS (1979-1999)

Germplasm Collection

The nucleus of a successful breeding program is the availability of a wide-based germplasm collection. As such, PhilRootcrops has maintained and upgraded its genetic stocks of cassava since its establishment. After more than twenty years of existence, the center has a field genebank of 354 cassava accessions. These include local and introduced foreign germplasm, together with elite materials selected from the advanced trials of both introduced and local hybrids. There are 107 elite cassava materials that possess desirable characters important for breeding. Of these materials, 53 come from CIAT/Colombia, 43 from the Thai-CIAT program, and 12 from locally developed hybrids (**Table 1**).

Breeding and Selection Strategies

1. F_1 field selection

Hybrids that are developed in the project, including those introduced from CIAT, are subjected to individual plant selection at the F_1 stage. Entries are planted at 2 m between rows and 1 m between hills. Harvest is at ten months after planting and selection criteria are limited to harvest index, plant type, and general appearance of the crop.

Table 1. Germplasm collections maintained at PhilRootcrops,ViSCA, Baybay, Leyte (Jan, 2000).

Source	No. of Accessions
Local	86
Foreign	131
Tissue culture (CIAT)	30
Elite clones	107
-CIAT/ Colombia	(52)
-Thai-CIAT program CIAT	(43)
-PhilRootcrops	(12)
Total collection	**354**

2. Observational trial

Selections from F_1 field-testing are entered into this stage of evaluation. Normally, five to seven stakes are prepared and planted for each selected clone in a 1 x 1 m planting pattern without replication. One row of a check variety is planted after every ten rows. Selection criteria include yield per plant, harvest index, dry matter content, and reaction to pests.

3. Preliminary yield trial

Entries selected from the observational trial, as well as local and exotic accessions, enter this phase of screening. Test entries are planted in four to five rows per plot without replication, following the same planting pattern as in the observational trial. Selection is based on yield per plot, dry matter content, harvest index, HCN content, and general appearance of the crop.

4. General yield trial

Selections from the preliminary yield trial are entered into this trial. Test clones are planted in four to five rows per plot, replicated three to four times. Planting distance is 1.0 x 0.75 m. Harvesting is at ten months after planting. Important economic characters are closely monitored at this stage, and yield per hectare is computed.

5. Advanced yield trial

This is the last stage of evaluation before clones are included in the regional trials of the National Root Crop Cooperative Testing Program. A plot measuring 5 x 6 m is used for each entry and replicated three to four times. A minimum of three different testing sites is required for each entry before it is included in the next cycle of evaluation. Harvesting is at ten months after planting, and parameters considered are yield per hectare, dry matter content, HCN content, plant architecture, and general reaction to pests.

6. Regional yield trial

The number of entries at this stage of evaluation is determined by the Technical Working Group for Root Crops. Agencies involved in variety development submit lists of entries to the group for inclusion in this trial. Potential entries should have passed the

advanced yield trial evaluation. A minimum of six locations throughout the country is required per set of entries, and testing is over two cropping seasons. Normally, twelve entries are allowed per cropping, replicated four times. Results of this trial provide the basis for recommendation for varietal release to the National Seed Industry Council (NSIC).

Varietal Release

During the early years of cassava breeding in the Philippines, six local varieties were released for cultivation (**Table 2**). Three of these varieties were released by the Philippine Root Crops Research and Training Center, ViSCA, Baybay, Leyte in March, 1980. These were PR-C 13 (Kadabao), PR-C 24 (Golden Yellow) and PR-C 62 (Colombia). All three varieties are high-yielding and widely grown by farmers for food. The three other varieties were released by the University of the Philippines at Los Baños, College, Laguna, the most famous of which is UPL Ca 2 (Lakan) that is widely grown for food, feed and starch.

Table 2. Recommended cassava varieties selected from local accessions in the Philippines.

Variety	Maturity (months)	Fresh root yield (t/ha)	Root dry matter (%)	Starch content (%)	Uses
1. PR-C 13 (Kadabao)	10-12	42.0	34.3	20.3	Food/feed
2. PR-C 24 (Golden Yellow)	8-10	43.0	39.3	21.5	Food/feed
3. PR-C 62 (Colombia)	10-12	46.0	33.0	19.8	Food/feed
4. UPL Ca 1 (Datu)	9-10	35.0	33.8	22.4	Starch
5. UPL Ca 2 (Lakan)	10-12	40.0	35.0	20.4	Food/feed/starch
6. UPL Ca 4 (Vassourinha)	8-10	30.0	33.8	21.4	Food/feed

Source: *PhilRootcrops, 2000.*

Close collaboration with CIAT in the introduction of improved hybrid populations has resulted in the release of eight cassava varieties of CIAT origin (**Table 3**). These varieties have yields ranging from 24 to 40 t/ha with dry matter contents ranging from 32 to 34%. The major use of these varieties is for starch processing. VC-5 (MCol 1684) is widely used by starch millers in Mindanao. The other varieties have yet to find their niche in the countryside.

Table 3. Recommended cassava varieties selected from CIAT clones and hybrid seed.

Variety name	Maturity (months)	Fresh root yield (t/ha)	Root dry matter (%)	Starch content (%)	Uses
1. VC-1 (CM323-52)	9-10	40.8	33.8	22.4	starch/flour
2. VC-2 (CMC 40)	8-10	40.2	33.0	20.3	food/flour
3. VC-3 (CM3590-1)	10-12	30.0	33.5	20.9	starch/flour
4. VC-4 (CM4014-3)	8-10	30.2	33.8	21.4	starch/flour
5. VC-5 (MCol 1684)	8-10	35.7	34.0	26.5	starch
6. PSB Cv-11 (CM3419-2A)	10-12	25.0	32.1	22.4	starch/flour
7. PSB Cv-12 (SM972-20)	10-12	24.1	33.9	21.5	food/flour
8. PSB Cv-15 (CM3422-1)	10-12	24.0	34.2	21.9	starch/flour

Source: *PhilRootcrops, 2000.*

Aside from evaluation of the introduced materials from CIAT, hybridization work was carried out utilizing elite materials from CIAT and local germplasm. At present there are five locally developed hybrids that were released by the National Seed Industry Council as new cassava varieties (**Table 4**). Among these hybrid varieties, PSB Cv-14 was found to be high-yielding with a high dry matter content that is suitable for starch extraction. It has an average yield of 29 t/ha with a dry matter content of 34.8%.

The 20 years of breeding and selection of cassava in the Philippines have produced a total of 19 cassava varieties, which can be broken down as follows: six local varieties, eight CIAT varieties and five locally developed varieties.

Table 4. Recommended cassava varieties selected from locally developed hybrids in the Philippines.

Variety name	Maturity (months)	Fresh root yield (t/ha)	Root dry matter (%)	Starch content (%)	Uses
1. PSB Cv-13 (CMP62-15)	10-12	26.4	33.0	22.8	starch/flour
2. PSB Cv-14 (CMP21-15)	10-12	29.3	34.8	20.3	starch/flour
3. PSB Cv-16 (CMP32-10)	10-12	33.6	33.4	20.8	starch/flour
4. UPL Ca 3 (G50-3)	10-12	45.0	33.5	20.9	starch/flour
5. UPL Ca 5 (G29 r-3)	8-10	25.0	33.6	22.5	starch/flour

Source: *PhilRootcrops, 2000.*

Advances in Selection

Since 1982, a total of 40,199 hybrid seeds from CIAT/Colombia have been introduced to PhilRootcrops, comprising 736 crosses (**Table 5**). These materials were subjected to the different stages of selection until the advanced yield trial. From these populations only 0.13% was retained and placed in the genebank as elite materials for further breeding and possible varietal release. Moreover, two varieties have been released

from these populations introduced from CIAT/Colombia, namely: VC-3 (CM3590-1) and VC-4 (CM4014-3).

Table 5. Hybrid seeds from CIAT/Colombia supplied to PhilRootcrops, ViSCA, Baybay, Leyte, Philippines from 1982 to 1998.

Date	Number of seeds	Number of crosses
1. June, 1982	2,200	43
2. November, 1982	5,550	100
3. January, 1985	2,800	56
4. October, 1985	3,000	60
5. January, 1987	2,100	42
6. February, 1988	2,350	41
7. October, 1988	2,000	40
8. February, 1989	2,386	48
9. January, 1991	4,079	89
10. January, 1992	2,794	44
11. June, 1993	2,361	35
12. July, 1994	2,038	35
13. March, 1995	2,043	35
14. January, 1996	2,230	31
15. February, 1997	2,268	37
Total	**40,199**	**736**

Source: *PhilRootcrops, 2000.*

In addition, the Thai-CIAT cassava program has provided PhilRootcrops with a total of 11,190 hybrid seeds since 1990, comprising 189 crosses (**Table 6**). Similarly, these materials were subjected to various stages of selection. It was observed that these populations performed better than the CIAT/Colombia populations. In fact, the program has selected elite clones from about 0.38% of the total populations evaluated. Generally, they have high yield and high dry matter content with good plant architecture. It is expected that in the next few years several of the elite clones from the Thai-CIAT cassava program will be released as new varieties in the Philippines.

Progress in selection among improved populations has been very encouraging. Results from the advanced yield trial of Thai-CIAT materials (**Table 7**) show that performance of the elite clones surpassed the check cultivars, which are all newly released varieties. The elite clones have yields ranging from 32 to 56 t/ha and with dry matter contents ranging from 33 to 35%; the check cultivars have yields ranging from 29 to 48 t/ha and with dry matter contents ranging from 30 to 32%. There was an improvement of 106% in terms of dry matter content and 116% in yield over the best check variety.

Table 6. Hybrid seeds from the Thai-CIAT program supplied to PhilRootcrops, ViSCA, Baybay, Leyte Philippines from 1990 to 1998.

Date	Number of seeds	Number of crosses
1. April, 1990	1,550	21
2. June, 1993	1,050	29
3. July, 1994	1,250	26
4. May, 1995	1,190	17
5. April, 1996	1,350	19
6. July, 1996	1,450	19
7. April, 1997	1,100	20
8. July, 1998	2,250	38
Total	**11,190**	**189**

Source: *PhilRootcrops, 2000.*

Table 7. Yield parameters[1)] of ten cassava hybrids from the Thai-CIAT program evaluated with local checks in an Advanced Yield Trial at the PhilRootcrops Center, ViSCA, Baybay, Leyte, Philippines in 1999/2000.

Entry	Fresh root yield (t/ha)	Root dry matter (%)	Harvest index	HCN score[2)]
1. CMR37-16-8	56.2	34.6	0.70	6.0
2. CMR37-50-26	47.4	33.8	0.59	5.0
3. CMR37-24-1	55.2	33.8	0.63	5.0
4. CMR38-109-24	24.2	34.8	0.41	5.0
5. CMR38-136-15	36.0	33.9	0.54	3.0
6. OMR38-10-8	36.8	34.0	0.63	6.0
7. OMR38-64-3	40.4	33.6	0.60	3.0
8. OMR38-64-4A	41.4	33.3	0.59	7.0
9. OMR38-65-13	32.3	35.8	0.45	6.0
10. OMR38-65-5	39.8	34.2	0.52	6.0
11. Lakan (Check)	39.0	32.0	0.54	4.0
12. VC-5 (Check)	30.6	29.4	0.47	8.0
13. PSB Cv-13 (Check)	34.6	31.7	0.44	4.0
14. PSB Cv-14 (Check)	48.3	30.1	0.60	5.0
15. PSB Cv-16 (Check)	28.7	31.1	0.43	4.0
Mean across hybrids	**41.0**	**34.2**	**0.57**	**5.0**

[1)]Data averaged over four replications

[2)]Picrate test rating of 1 to 9: 1= very low, 9=very high

Source: *PhilRootcrops, 2000.*

On the other hand, results from the advanced yield trial of elite clones from CIAT/Colombia also show that yields are considerably higher compared to check varieties. Yields of the elite clones ranged from 29 to 47 t/ha and with dry matter contents ranging from 30 to 35%; the check cultivars had yields ranging from 30 to 45 t/ha and with dry matter contents of 29-32 %. It is expected that some of these materials will also be released as new varieties for the food, feed and starch industries.

There are a lot of elite materials right now that are next in line for regional trials, which is the final stage of testing prior to varietal release. These materials are envisioned to cater to the needs of the feed and industrial sectors.

Variety Dissemination

The available recommended cassava varieties have not been fully utilized at present. Reasons for this include: lack of information on the varieties, low availability of planting material and low demand for the product. Through the years, farmers tend to plant cassava varieties which are familiar to them, even though these are of low productivity. It was only in the 1990s that demand for cassava started to pick up due to utilization of the crop for feed as well as starch and its derivatives. Nowadays, the demand for planting material of high-yielding cassava varieties continues to rise. This is the outcome of the involvement of the private business sector in the widespread commercial production of cassava. The San Miguel Corporation, through its La Tondena Distillery, plans to utilize cassava alcohol for the liquor industry. Initially they need 2,000 ha for the distillery plant in Negros Occidental. Furthermore, the starch millers have at least 10,000 ha of cassava. The Starch Millers' Association in the Philippines also include cassava growers cultivating about 50,000 ha. At present, these areas are planted with Golden Yellow, Lakan, VC-5, Datu and other available cassava varieties.

To help disseminate improved varieties of cassava to the farmers, several activities were undertaken: on-farm trials of recommended varieties, adaptation trials of recommended varieties, and establishment of model farms in strategic places where cassava is grown.

Results from an on-farm trial of recommended cassava varieties such as VC-1, VC-2, VC-3 and Lakan have drawn a positive response among farmers in southern Leyte. Farmers readily plant these varieties to supply the feedmill and piggery of a multipurpose cooperative to which they are affiliated.

One-hectare model farms were established in Mindanao where the bulk of cassava is grown. These model farms showcase the recommended varieties plus the necessary cultural management practices. They also serve as a source of planting material for subsequent planting. One model farm in Bukidnon, Mindanao has produced an average yield of 40 t/ha.

The adaptation trial of recommended cassava varieties is another activity that screens varieties that will truly fit a specific growing environment. This serves as an avenue whereby a farmer can select the best variety in the locality. Results from the adaptation trial of recommended cassava varieties conducted in Ilijan, Bago City, Negros Occidental, show that of the nine varieties tested, three were found to be the best for the area (**Table 8**). These were PSB Cv-12 (SM972-20), PSB Cv-14 (CMP21-15) and Rayong 5 from Thailand. As far as dry matter content is concerned, KU-50 and Rayong 5 had the highest dry matter of 45.2 and 44.6%, respectively. The alcohol industry needs varieties, that are

high in dry matter content. Thus, it appears that these varieties, together with PSB Cv-12 and PSB Cv-14, are suitable for alcohol production as well as starch.

As a result of the campaign for utilization of new improved varieties, in 1997 about 5,000 ha of land were planted to Lakan and Golden Yellow to support the San Miguel Corporation's demand for cassava for production of animal feed and alcohol. VC-5 was planted to more than 3,000 ha in Lanao for starch. Gradually, adoption of other varieties have started to pick up, resulting in rapid multiplication of identified superior varieties, such as KU-50, Rayong 5 and PSB CV-12, in order to satisfy the requirements of planting material for expanding the cassava project of San Miguel Corporation in Negros Island.

Table 8. Yield parameters[1)] of eight cassava hybrids from CIAT/Colombia evaluated with local checks in an Advanced Yield Trial at the PhilRootcrops Center, ViSCA, Baybay, Leyte, Philippines in 1999/2000.

Entry	Fresh root yield (t/ha)	Root dry matter (%)	Harvest index	HCN score[2)]
1. SM 2085-9	45.0	32.2	0.58	5.0
2. SM 2100-15	43.0	32.9	0.64	5.0
3. SM 2102-23	40.8	34.5	0.53	8.0
4. SM 2116-16	47.2	30.5	0.64	5.0
5. SM 2160-27	36.3	31.4	0.52	5.0
6. SM 2160-43	38.7	31.8	0.55	3.0
7. SM 2065-2	38.4	35.0	0.50	5.0
8. SM 2080-9	28.9	31.8	0.44	3.0
9. Lakan (Check)	31.4	31.8	0.48	4.0
10.VC-5 (Check)	30.1	28.8	0.46	6.0
11.PSB Cv-12 (Check)	38.5	32.0	0.49	2.0
12.PSB Cv-14 (Check)	44.8	29.8	0.56	8.0
Mean across hybrids	39.8	32.5	0.55	5.0

[1)]Data averaged over four replications
[2)]Picrate rating scale of 1 to 9: 1 = very low, 9 = very high
Source: *PhilRootcrops, 2000.*

FUTURE DIRECTION

With the passing by Congress of the 1997 Agriculture and Fishery Modernization Act (AFMA), root crops research and development in the Philippines will play a role in food security, poverty alleviation, productivity improvement, global competitiveness and environmental protection and sustainability.

Considering the versatility of cassava in production and use, the PhilRootcrops Center will have to double its efforts in monitoring the performance of cassava varieties planted in various areas, and aggressively promote the adoption of new improved varieties through adaptation trials and on-farm trials. Furthermore, the center will strengthen its hybridization work utilizing elite materials from CIAT together with local varieties.

Emphasized in the selection will be the identification of superior varieties with high yield, high starch content and low HCN content that will suit the various needs for the food, feed and starch industries, which are the National Root Crops Research and Development Agenda.

Table 9. Performance of nine cassava varieties tested in an adaptability trial at Ilijan, Bago City, Negros Occidental in 1999.

Variety name	Fresh root yield (t/ha)	Dry matter content (%)
1. PSB Cv-11 (CM3419-2A)	18.27	38.7
2. PSB Cv-12 (SM972-20)	34.30	35.8
3. PSB Cv-13 (CMP62-15)	21.73	32.4
4. PSB Cv-14 (CMP21-15)	44.32	37.8
5. PSB Cv-15 (CM3422-1)	19.40	31.4
6. KU-50 (Kasetsart 50)	13.63	45.2
7. Rayong 5	23.13	44.6
8. Lakan	24.00	39.4
9. Golden Yellow	15.90	37.1

Source: *La Tondena, Inc.-PhilRootcrops, 2000.*

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