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Evaluation of Sweet Potato Germplasm Accessions for High Tuber Yield and Carotene Content

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Abstract

The experiment on the evaluation of sweet potato accessions was carried out in Randomized Block Design (RBD) with 73 accessions at Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University Coimbatore. The accessions were evaluated (3 seasons) for its growth parameters *viz.,* vein length, flowering habit, tuber length, tuber girth, number of tubers, yield and carotene content. The evaluation was done to screen the accessions/varieties with objectives based on the preference of the farming communit of Tamil Nadu with short duration, medium sized tubers, maximum number of tubers and high tuber yield. The results of the experiments revealed that, the vine length ranged from 92.57 cm (Ib 17) to 317.24 cm (Ib 4); tuber length ranged from 9.61 cm (Ib 9) to 24.74 cm (Ib 63) and tuber girth ranged from 2.43 cm (Ib 41) to 8.43cm (Ib 36). The sweet potato accessions such as Ib 14, Ib 27, Ib 44, Ib 55, Ib 57, Ib 63, Ib 66 and Ib71 showed non-flowering habit. The maximum (5.27) and minimum number of tubers (1.42) was recorded in Ib 19 and Ib 52 respectively. Mean single tuber weight ranged from 54 g (Ib 39) to 142 g (Ib 22). Among the accessions evaluated, CO 5 was excelled with high tuber yield (315.31 kg plant^{-1}) and carotene content (20.02 µg/g). However, Ib 72 (white flesh type) has exhibited equally good tuber yield of 315.02 kg/plant

Key words: Sweet potato, Genetic resource, Collection, Conservation, Evaluation

Introduction

Sweet potato, *Ipomoea batatas* (L.) Lam., is a tropical perennial but cultivated as an annual; grown in more than 100 countries. It ranks on the world's seventh most important food crop. More than 133 million tons are produced globally per year. Asia is the world's largest sweet potato producing region, with 125 million tons/year; China with 117 million tons/year accounts for 88% of world production. African farmers produce only about 7 million tons of sweet potato annually (Collins, 1998; CIP, 2007). In Tamil Nadu the sweet potato is cultivated in an area of 938 hectares with a production and productivity of 17640 tonnes and 17.74 tonnes/ha respectively (Tamil Nadu Horticulture and Plantation Crops Statistics, 2016).

Sweet potato, is an important food crop widely cultivated in the world. It has wide genetic diversity for most desirable traits, which could be exploited by breeders (Adebisi *et al*., 2001; Afuape et al., 2011; Chaudhary and Singh, 1982; Veasey et al., 2008). Sweet potato is cultivated primarily for the enlarged edible storage roots which provide high amounts of starch and in some countries tender leaves are consumed as vegetable. Mature vines are also fed to livestock, especially dairy cows and pork fattening

Morphological characterization has been used for various purposes including identification of duplicates, studies of genetic diversity patterns and correlation with characteristics of agronomic importance (CIAT, 1993).

Sweet potato cultivars are generally distinguished on the basis of morphological traits and have a wide variability of botanical characteristics. Morphological and agronomic characters coupled with reaction to pests, diseases and other stresses have been used to characterize sweet potato. Phenotypic characterization in sweet potato is done by assessing variations in the vine, leaf, flower and storage root characteristics (Huaman, 1991) and it has been traditionally used for identification of sweet potato cultivars. Morphological characterization is an important first step in the assessment of sweet potato diversity.

Collection and characterization of plant material has the basic step in crop improvement and diversity has long been seen as vital for rational management and use of crops. Sweet potato is a cross-pollination species, allowing exchange of favorable alleles between varieties through hybridization. The genetic relationship reflects the difference of genetic background between accessions, thus selection of genetically distant accessions as parents in breeding is possible to generate elite hybrids and varieties. Thus, evaluation of genetic relationships among diverse cultivars and landraces is critical for successful and efficient exploitation of the available genetic diversity in the germplasm.

Genetic diversity analysis determines close, or diverse, relationships between genotypic and phenotypic traits (Karuri et al., 2010). In addition to morphological characters, quality characters are preferred for nutritive value and market demand (Nicolle et al., 2004; J. Singh et al., 2002; Tsegaye et al., 2007). The objective of this work was to characterize the phenotypical diversity of sweet potato collected from different agro-climatic zones in Tamilnadu.

Materials and Methods

Study area

The study was conducted in the Department of Vegetable Crops, Horticultural college and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India (longitude: 77°E and latitude: 11°N and elevation 426 M). The soil texture varies from clay loam to sandy clay. This region has tropical climatic conditions which receives both South West and North East monsoon and the annualrainfall ranges from 650-700 mm. The average annual temperature ranges from 25°C-38°C.

Table 1. Sweet potato accessions with respective place of collection and habitat

S.N.	Accession	Block	Habitat	S.N.	Accession	Block	Habitat
1.	Ib 1	Thenkasi	Cultivated	22.	Ib 22	Erode	Cultivated
2.	Ib 2	Coimbatore	Cultivated	23.	Ib 23	Perundurai	Cultivated
3.	Ib 3	Coimbatore	Cultivated	24.	Ib 24	Uthankarai	Cultivated
4.	Ib 4	Coimbatore	Variety	25.	Ib 25	Harur	Cultivated
5.	Ib 5	Coimbatore	Variety	26.	Ib 26	Krishnagiri	Cultivated
6.	Ib 6	Rasipuram	Landrace	27.	Ib 27	Periyanaikanpalayam	Cultivated
7.	Ib 7	Rasipuram	Landrace	28.	Ib 28	Mettupalayam	Cultivated
8.	Ib 8	Pudupalayam	Cultivated	29.	Ib 29	Karamadai	Cultivated
9.	Ib 9	Namakkal	Cultivated	30.	Ib 30	Anaimalai	Cultivated
10.	Ib 10	Kallikudi	Landrace	31.	Ib 31	Thondamuthur	Cultivated
11.	Ib 11	Thenkasi	Landrace	32.	Ib 32	Kovilpatti	Cultivated
12.	Ib 12	Thirunelveli	Cultivated	33.	Ib 33	Elayirampannai	Cultivated
13.	Ib 13	Thondamuthur	Cultivated	34.	Ib 34	Kovilpatti	Cultivated
14.	Ib 14	Valapadi	Cultivated	35.	Ib 35	Thoothukudi	Cultivated
15.	Ib 15	Singipuram	Cultivated	36.	Ib 36	Pasuvanthanai	Cultivated
16.	Ib 16	Seelanaikanpatti	Cultivated	37.	Ib 37	Kovilpatti	Cultivated
17.	Ib 17	Seelanaikanpatti	Cultivated	38.	Ib 1	Pollachi	Cultivated
18.	Ib 18	Salem	Cultivated	39.	Ib 1	Sankarankovil	Cultivated
19.	Ib 19	Mangalapuram	Cultivated	40.	Ib 1	Kurivikulam	Cultivated
20.	Ib 20	Mangalapuram	Landrace	41.	Ib 1	Thenkasi	Cultivated
21.	Ib 21	Kodumudi	Cultivated	42.	Ib 1	Vilathikulam	Cultivated

43.	Ib 1	Kadayam	Cultivated	59.	Ib 1	Thirunelveli	Cultivated
44.	Ib 1	Nanguneri	Cultivated	60.	Ib 1	Dharmapuri	Cultivated
45.	Ib 1	Vilupuram	Cultivated	61.	Ib 1	Harur	Cultivated
46.	Ib 1	Tindivanam	Cultivated	62.	Ib 1	Krishnagiri	Cultivated
47.	Ib 1	Ettayapruam	Cultivated	63.	Ib 1	Kovilpatti	Cultivated
48.	Ib 1	Vanur	Cultivated	64.	Ib 1	Thoothukudi	Cultivated
49.	Ib 1	Thirukoilur	Cultivated	65.	Ib 1	Mettupalayam	Cultivated
50.	Ib 1	Ulundurpetai	Cultivated	66.	Ib 1	Thondamuthur	Cultivated
51.	Ib 1	Kallakurichi	Cultivated	67.	Ib 1	Thoothukudi	Cultivated
52.	Ib 1	Sankarapuram	Cultivated	68.	Ib 1	Perundurai	Cultivated
53.	Ib 1	Karimangalam	Cultivated	69.	Ib 1	Valapadi	Cultivated
54.	Ib 1	Thiruvannamalai	Cultivated	70.	Ib 1	Rasipuram	Cultivated
55.	Ib 1	Nallampalli	Cultivated	71.	Ib 1	Coimbatore	Variety
56.	Ib 1	Palakodu	Cultivated	72.	Ib 1	Kanyakurmari	Cultivated
57.	Ib 1	Pappireddipatty	Cultivated	73.	Ib 1	Coimbatore	Variety
58.	Ib 1	Vilupuram	Cultivated				

Planting materials

A collection of 73 sweet potato accessions collected from different agro-climatic zones in Tamil Nadu were utilized for this study. The collection strategy consisted of visiting the different agro-climatic regions at random in the main conventional cultivation areas and collected one or more tubers or vines from each sweet potato variety/landraces they were cultivating (Table 1). Thus, a total of 73 plants or accessions were evaluated, including four commercial varieties. These accessions were planted in the field under *ex situ* conditions in Coimbatore, Tamil Nadu, India. In this study, vine cuttings of 15-20 cm are planted 10 cm deep in the ridges farmed 60 cm apart with a spacing of 20 cm between plants at the onset of the planting season. Prior to establishing the plants in the field, they were multiplied in pots in the nursery, where part of the assessment was undertaken. In the main field the accessions were planted in Randomized Block Design with two replications.

Sweet potato reproduction

Sweet potato *Ipomoea batatas* (L.) (Lam.), and its wild relatives, are members the family Convolvulaceae. The genus includes 600-700 species of which sweet potato is the only one cultivated. *Ipomoea batatas* is an open pollinated, mostly self-incompatible species; pollination is carried by insect vectors. Sweet potato seems to be an hexaploid ($2n = 6x = 90$), whose basic chromosome number is $n = 15$. Cross-ability barriers have been identified including scarce natural flowering, saprophytic incompatibility and partial sterility. Sweet potato's high heterocygosis is maintained through vegetative propagation using stem cuttings or vines.

Observations recorded

Ten morphological vegetative aerial descriptors, nine phenological and floral descriptors, and five storage root traits were recorded.

The aerial vegetative morphological descriptors were evaluated in the open field, 90 days after sprouting, when sufficient vegetative growth was available. Sweet potato phenology was evaluated in the field recording the date of flowering initiation and flowering period with weekly visits to the field plots. Seven floral descriptors (Huaman, 1991) were also evaluated (Table 2), with three flowers examined per plant. Root assessments (three storage roots per plant) were carried out during harvest.

Data analysis

The collected data were entered into excel spread sheets. The data were analyzed using Statistical Package for Social Sciences (SPSS, 2007) and the percentage respondents were calculated and presented in the results.

Results and Discussion

The sweet potato accessions, also called local varieties, grown by traditional farmers of the Tamilnadu and few released varieties evaluated exhibited high morphological variability (Table 3). A wide range in flowering initiation

Table 2. Descriptors used to assess the phenology, floral and storage root traits in sweet potato accessions

Descriptors	Observed Classes Morphological traits
1) Vine length	Total length from the base to tip and expressed in cm.
2) Vine pigmentation	1-Green; 2-Green with few purple spots; 3-Green with many purple spots; 4-Mostly purple; 5-Totally purple.
3) Vine tip pubescence	1-Absent; 2-Sparse; 3-Moderate; 4-Heavy.
4) Leaf lobes type	1-No lateral lobes (entire); 2-Very slight (teeth); 3-Slight; 4-Moderate; 5-Deep.
5) Shape of central leaf lobe	1-Triangular; 2-Semi-circular; 3-Semi-elliptic; 4-Elliptic.
6) Abaxial leaf vein pigmentation	1-Green; 2-Purple spot in the base of main rib; 3-Main rib partially purple; 4-All veins
7) Mature leaf colour	1-Green; 2-Green with purple edge; 3-Green with purple veins on upper surface.
8) Immature leaf colour	1-Green; 2-Green with purple edge; 3-Green with purple veins on upper surface; 4- Slightly purple; 5-Mostly purple; 6-Purple both surfaces; 7-Dark purple both surfaces.
9) Petiole pigmentation	1-Green; 2-Green with purple near leaf; 3-Green with purple at both ends; 4-Green with purple spots throughout petiole; 5-Green with purple stripes; 6-Mostly purple; 7- Totally purple.
10) Leaf lobes number	1;3;5;7.
Floral traits	
1) Flowering initiation date	Marked when at least one opened flower was observed per plant, in weekly visits to the field
2) Flowering period	In weekly visits to the field, all flowering plots were marked.
3) Flower colour	1-White limb with purple center; 2-White limb with pale purple center; 3-Pale purple limb with purple center; 4-Purple limb and center; 5- Pale purple limb and pale purple center.
4) Shape of limb	1-Semi-stellate; 2-Pentagonal; 3-Rounded.
5) Sepal colour	1-Green; 2-Green with purple spots; 3-Totally pigmented - pale purple; 4-Totally pigmented - dark purple.
6) Colour of stigma	1-White; 2-Pale purple.
7) Colour of style	1-White; 2-White with purple at the top; 3 - Purple.
8) Colour of filament	1-White with purple at the base; 2- Purple.
9) Stigma exertion	1-Inserted (shorter than the longest anther); 2- Same height as highest anther; 3-Slightly exerted; 4-Exerted (longer than longest anther).
Storage root traits	
1) Storage root cortex thickness	1-Very thin (< 1mm).
2) Storage root skin colour	1-White; 2-Cream; 3-Yellow; 4-Orange; 5-Pink; 6-Purple; 7-Dark purple.
3) Predominant storage root flesh colour	1-White; 2-Cream; 3-Yellow; 4-Pale orange; 5-Purple.
4) Secondary storage root flesh colour	1-Absent; 2-White; 3-Cream; 4-Yellow; 5-Brown orange; 6-Pink; 7-Purple.
5) Distribution of secondary flesh colour	1-Absent; 2-Broad ring in cortex; 3- Scattered spots in flesh; 4- Narrow ring in cortex; 5-Ring and other areas in flesh; 6-In longitudinal sections.

Huaman (1991).

periods was observed for the 73accessions. Flowering initiation started in July and went on until September. Some differences were observed in the flowering of landraces and fifteen landraces did not flower, representing 20.5% of the total accessions. Rajendran & Amma (1996), evaluated 764 sweet potato accessions in Trivandrum, India, also observed the absence of flowering in 13.9% of them. In Indonesia, Mok & Schmiediche (1999) reported that 40% of the accessions collected did not flower. Absence of seed production was observed in 37.3% of the accessions examined by Rajendran & Amma (1996).

Table 3. Phenological traits observed in the sweet potato accessions.

Sl. No.	Traits	Range
1.	Vine Length (cm)	92.57 (Ib 17) - 317.24 (Ib 4)
2.	Tuber Length (cm)	9.61 (Ib 9) - 24.74 (Ib 63)
3.	Tuber Girth (cm)	2.43 (Ib 41) – 8.43 (Ib 36)
4.	Number of tubers	1.42 (Ib 52) – 5.27 (Ib 19)
5.	Mean tuber weight (g)	54 (Ib 39) - 342 (Ib 22)
6.	Per plant yield (g)	75.36 (Ib 38) – 915.41 (Ib 73)

The considerable variability was observed in this study in the phenology of the accessions was enough to classify the landraces in early, intermediate and late varieties, which can be explored in plant breeding programs due to the correlation of this trait and the storage root harvest periods. The predominant colors of the sweet potato flowers were pale purple upon the limb and purple in the center (74%) and no white limb with purple in the center was observed among the collection evaluated.

The predominant sepal color was green and the shape of limb rounded. Only 7% of the flowers presented pentagonal limb shapes. The colors of the stigma were predominantly white (93%). The position of the stigma in relation to the anthers of sweet potato, four types of occurrences were observed: stigma shorter than longest anther, stigma of the same height than highest anther, stigma slightly exerted and exerted (longer than longest anther). This variation in the position of the stigma indicates the occurrence of heterostyly in sweet potato, which probably reinforces the self incompatibility system observed for this crop (Martin, 1968). Seed yield was not evaluated consistently in the present study, but seed production was observed to be more intense in some varieties. Harvested seed germinated promptly after scarification with sandpaper, indicating the presence of mechanical dormancy (Martin Jr., 1946) due to the seed coat of sweet potato seeds.

The aerial vegetative descriptors with most variability, represented by the highest number of phenotypic classes with a significant percentage of individuals in each class, were the vine tip pubescence, the leaf lobes type, the leaf lobes number and the shape of central leaf lobe (Fig.1). Predominantly vine tip pubescence absent (32.88%); leaves with very slight lobes (36.99%); the central lobe of triangular shape (53.42%); and leaves with five lobes (39.73%). The mature leaf color was mostly green (53.42%) and the immature leaf color was mainly green with purple edges (42.47%) (Fig. 2).

As for the storage roots, most of the varieties presented a cream storage root skin color (46.58%) followed by pink (21.92%), white (10.96%) and purple colors (5.48%). The predominant storage root flesh colour is cream(57.53%) (Fig. 3). Ritschel *et al*., (1998) reported

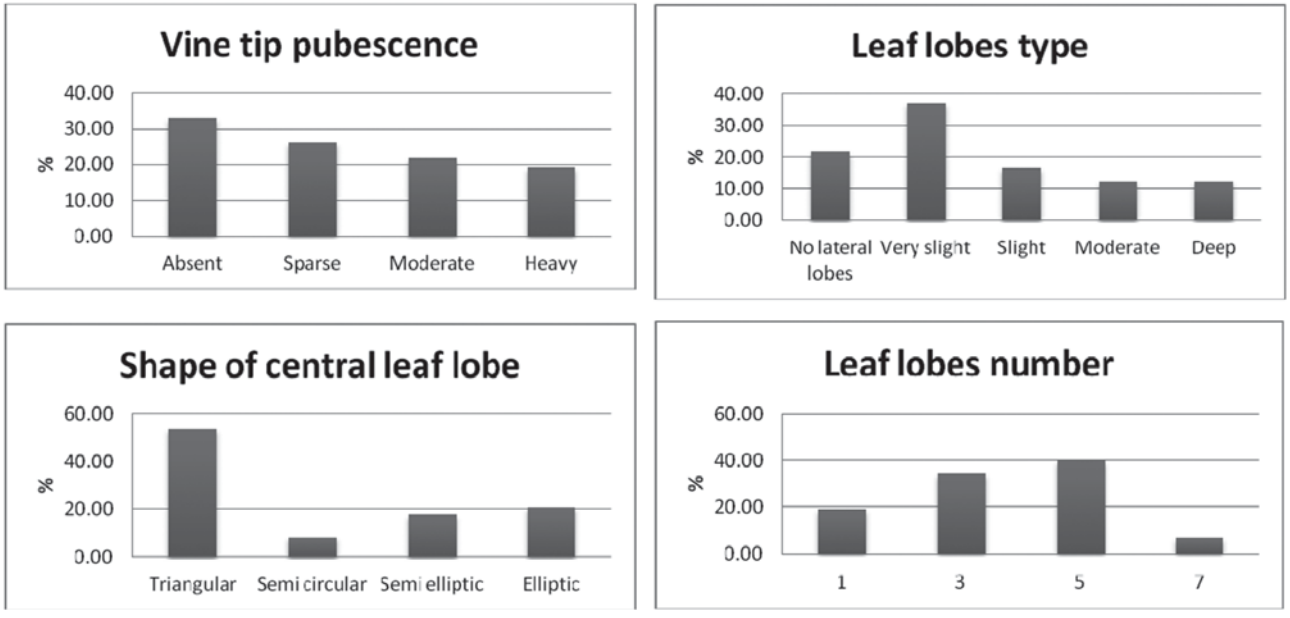


Fig.1. Morphological vegetative aerial descriptors (vine tip pubescence, leaf lobe types, shape of central leaf lobe and leaf lobe number) evaluated in 73 landraces of sweet potato

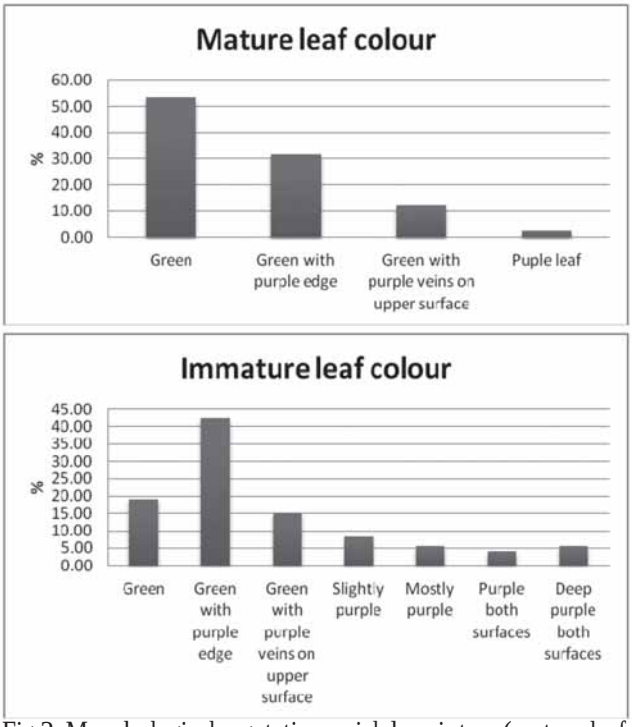


Fig.2. Morphological vegetative aerial descriptors (mature leaf color, immature leaf color)

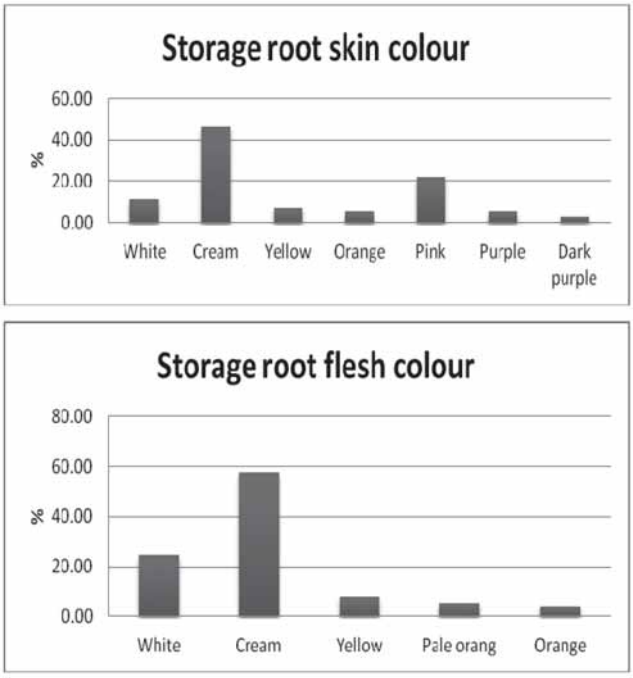


Fig.3. Storage root morphological descriptors (skin color, predominant flesh color)

that most of the accessions maintained by the Empresa de Pesquisa Agricola de Santa Catarina (EPAGRI), Brazil, showed red for the external skin (30%), followed by pink (27%) and white (26%), while cream color for this trait occurred in only 14% of the accessions. On the other hand, the storage root skin color was observed to be pink in 50% of the 14 sweet potato accessions of the State University of North Fluminense by Daros et al. (2002).

Cream as the predominant storage root flesh color was also observed for 70% of the accessions by Ritschel et al. (1998) and for 50% of the accessions evaluated by Daros et al. (2002). Evaluating 14 sweet potato accessions, Daros et al. (2002) observed high morphological variability, concluding that the most informative descriptors were the vine tip pubescence, the abaxial leaf vein pigmentation and the shape of the roots. Oliveira *et al*. (2000) also observed high genetic divergence between 51 clones of sweet potato accession. Such descriptors can be utilized in in- heritance studies as morphological markers.

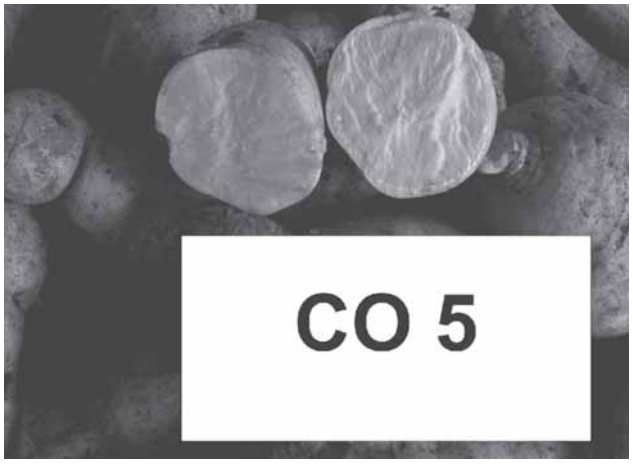
As a result of systematic screening of germplasm and accessions received through All India Coordinated Research Project on Tuber Crops, the orange flesh sweet potato CO 5 was released as state variety in Tamilnadu. The yield performance of CO 5 and CO 3 are given in Table 4. The variety CO 5 have high beta carotene content and thus are used as health and functional food (Table 5). Moreover, sensitization of orange fleshed sweet potato as source of vitamin A has created a demand for

Table 4. Performance of orange-fleshed sweet potato variety CO5 in Multi Location Trial, Advance Regional Trial and on farm trials.

Particulars	No. of trials	Total tuber yield (t/ha)		Marketable tuber yield (t/ha)	
		CO 5	CO 3	CO 5	CO 3
HC & RI, Coimbatore	6	25.40	18.64	23.25	16.43
MLT	10	30.29	20.98	28.97	19.91
ART/OFT	51	30.09	22.66	29.14	23.14
Mean	—	28.59	20.76	27.12	21.52
Per cent increase	—	37.71		26.02	

Table 5. Special features of CO 5 sweet potato

β-carotene(mg/g)	:	20.02 mg/g
Tuber dry matter	:	18.27%
Harvest index	:	44.31%
Lowest cooking time	:	11min
Flavour acceptance	:	Good
Total tuber yield	:	28.59 t/ha
Marketable tuber yield	:	27.12 t/ha
Yield increase over CO 3	:	37.71%
Weevil percentage	:	6.94%



these varieties, hence generating market. Moreover, this also shows that farmers were receptive to improved and released varieties compared to local landraces.

Conclusion

Overall, the sweet potato has high levels of genetic diversity. However, the presence of unique alleles in populations from various agro-ecological zones of Tamilnadu's as well as the regional diversity patterns, indicates the value of collecting and characterizing the germplasm in more depth. This ûnding is of particular signiûcance for genetic diversity conservation because farmers are likely to gradually shift from their poor performing cultivars to improved ones and receptive to adoption of improved orange fleshed sweet potato (OFSP) varieties. Thus, there is a need to promote breeding and production of OFSP varieties which are rich in beta carotene.

Intensified research is required towards generating resistance varieties to drought, weevil, and virus which were the major constraints to sweet potato production found in this study. Local cultivars and landraces serve as source of genetic variability and could be used as gene donors in varietal improvement program. Therefore, the collection and germplasm conservation of sweet potato are very important in order to maintain the full range of genetic variability within the species. Lastly, appropriate technology and seed multiplication and distribution method is required to ensure availability of clean and enough planting materials at onset of rains.

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