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Morphological Characterization of Sweet Potato (*Ipomoea batatas* (L.) Lam.) Genotypes

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ABSTRACT: Sweet potato (*Ipomoea batatas* (L.) Lam.) is one of the important tuber crops of tropical and sub-tropical regions of the world. Studies on morphological characterization of 51 sweet potato genotypes were carried out at Shalmala Vegetable Research Centre, Regional Horticultural Research and Extension Centre (RHREC), Dharwad (University of Horticultural Sciences, Bagalkot) during *rabi*, 2019-20 and 2020-21. Aim of study is to know the morphological variations in collected genotypes. The sweet potato genotypes showed wide morphological variability for plant type, inter-nodal length, leaf size, mature leaf shape, petiole length, tuber shape, tuber skin color and tuber flesh color. The observed morphological characters variations were used to discriminate genotypes into different groups. The morphological study helps for identifying superior genotypes for variety development.

Keywords: Sweet potato; Morphology; Genotypes.

INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam.) is one of the important tuber crops of tropical and sub-tropical regions of the world and forms the sixth important food crop after rice, wheat, potato, maize and cassava. It is native to South America and belongs to family *Convolvulaceae.* The family includes 55 genera and contains more than 1000 species (Watson and Dallwitz, 2000). It is popularly known as *'white potato'* or *'Irish potato'* in southern part of United States, while in India it is commonly called as *sakar kand.*

The total area of sweet potato in the world is about 77 lakh hectares with a production of 918 lakh tonnes. China is a leading producer in the world followed by Nigeria and Uganda, while, India ranks 9th position in production (Anon., 2019a). In India it is being cultivated in an area of 1.16 lakh hectares with a production of 11.86 lakh tonnes (Anon., 2019b). The major cultivating states in India are Orissa, West Bengal, Bihar, Uttar Pradesh, Madhya Pradesh, Maharashtra and Karnataka. Orissa being the leading state in area and production followed by West Bengal and Uttar Pradesh, while Andhra Pradesh recorded highest productivity. In Karnataka state sweet potato is grown in an area of about 2,730 hectare with production of 32,866 tonnes and productivity of 12.04 t/ha (Anon., 2019c).

Sweet potato (hexaploid: 2n=6x=90) is a perennial, dicot and vegetatively propagated tuber crop, but it is cultivated as an annual crop for tuber production. In nature sweet potato had wide range of variability in leaf shape, flowering habit, time of maturity, tuber yield, tuber skin color, flesh color, tuber shape and other morphological characters which can be exploited to determine the similarity and differences in morphological charecters of sweet potato genotypes. The knowledge of morphological characters is a basis for identification and development of desirable genotypes.

Sweet potato has great genetic polymorphism and high diversity in morphological traits (Andrade *et al.*, 2017; Su *et al*., 2016; Wadl *et al.*, 2018). Much of the genetic diversity of sweet potato is preserved at several germplasm collections throughout the world. Kim *et al*. (2018) described more than 20,000 *I. batatas* accessions in 10 collections from just nine countries, and Roca *et al*. (2007) reported more than 27,000 sweet potato accessions from 36 collections in 32 countries. This latter list was updated to include 35,478 sweet potato accessions held in ex situ gene banks globally (Food and Agriculture Organization, 2010). The most important sweet potato collection is with the International Potato Center (CIP), Lima, Peru with more than 5500 accessions of *I. batatas* listed (CIP, 2019). The U.S. Department of Agriculture,

Agricultural Research Service (USDA, ARS) also maintains an important sweet potato germplasm collection (762 accessions available) at the Plant Genetics Resources Conservation. The goal of this study was to characterize the sweet potato genotypes based on morphological traits.

MATERIALS AND METHODS

The current study was under taken in Shalmala Vegetable Research Centre, Regional Horticultural Research and Extension Centre (RHREC), Dharwad (University of Horticultural Sciences, Bagalkot) during *rabi*, 2019-20 and 2020-21. Totally 51 genotypes were collected from different sources and evaluated for morphological characters. Geographical site of experimental fields is located in the Northern Transitional Zone (Zone VIII) of Karnataka state situated at 15^0 26' North latitude, 75^0 07' East longitude with an altitude of 678 m above the mean sea level.

The morphological characters like plant type, vine inter-nodal length, leaf size, mature leaf shape, petiole length, tuber shape, tuber colour and flesh colour were recorded based on descriptor of International Potato Center (CIP) (Huaman, 1991) (Table 1).

Table 1: Morphological description of sweet potato genotypes (Huaman, 1991).

Character	Description
Plant type	Erect (< 75 cm), Semi-erect (75-150 cm), Spreading (151-250) and Extremely spreading (> 250)
Vine inter-nodal Length	Very short (< 3 cm), Short (3-5 cm), Intermediate (6-9 cm), Long (10-12 cm) and Very long (> 12 cm)
Leaf size	Small (< 8 cm), Medium (8-15 cm), Large (16-25 cm) and Very large (> 25 cm)
Mature leaf shape	Slightly lobed**,** Very slightly lobed**,** Moderately lobed**,** Deep lobed**,** Very deep lobed**,** Triangular**,** Hastate and Cordate
Petiole length	Very short (< 10cm), Short (10-20 cm), Intermediate (20- 30 cm) and Very long (> 40 cm)
Tuber shape	Long irregular/Curved, Ovate, Elliptic, Oblong, Round elliptic, Long elliptic, Long oblong, Irregular, Longitudinal grooves, Obovate and Round
Tuber colour	Pink, Purple red, Cream, White, Dark purple, Brownish orange and Orange
Flesh colour	White, Cream, Pale yellow, Intermediate orange, Dark yellow, Dark orange and Strongly pigmented with anthocyanin

RESULTS AND DISCUSSIONS

The value of any germplasm collections is increased when that material has been evaluated, characterized, and properly documented for useable morphological traits (Araus and Cairns, 2014; Gruneberg *et al*., 2015; Jackson *et al*., 2020). It is important that genetic resources are well characterized and readily available for use in breeding programs for developing varieties with improved agronomic characters.

Morphological characters of sweet potato genotypes

The observed morphological characters of sweet potato genotypes like plant type, vine inter- nodal length, leaf size, mature leaf shape, petiole length, tuber shape, tuber colour and flesh colour were recorded and the information are presented in Table 2 and 3.

Plant type: Sweet potato genotypes showed wide variations in growth habit. Based on the vine length, genotypes were grouped into two type's semi-erect and spreading type. Out of 51 genotypes, 31 genotypes (58.82 %) belongs to semi-erect and remaining 20 genotypes (41.18) are spreading nature (Table 2). Similarly, Reddy *et al.* (2018) characterized the sweet potato cultivars based on plant type.

Vine inter-nodal length: Sweet potato genotypes exhibited diverse variations for vine inter- nodal length (Table 2). Among the evaluated 51 sweet potato genotypes, 2 genotypes are very short, 43 are short and 7 are intermediate in vine length. The present findings are in line with works of Daros *et al.* (2002); Veasey *et al*. (2007) for vine inter-nodal length of sweet potato genotypes showed great heterogeneity for the trait.

Leaf size: Sweet potato genotypes showed greater variations for leaf size. Based on the leaf length, genotypes are grouped into two groups *viz.*, short (12 genotypes) and medium (39 genotypes) size group (Table 2 and Plate 1). Similarly, Daros *et al*. (2002); Ritschel and Huaman (2002) classified the sweet potato accessions based on leaf size.

Mature leaf shape: Sweet potato genotypes exhibited wide variations for mature leaf shape. Based on the leaf shape of genotypes were grouped into 6 categories *viz.*, slightly lobed (5 genotypes), very slightly lobed (2 genotypes), moderately lobed (3 genotypes), deep lobed (6 genotypes), very deep lobed (25 genotypes), triangular (6 genotypes), hastate (3 genotypes) and cordate (1 genotypes) (Table 2 and Plate 1). Based on mature leaf shape Cavalcante (2008) observed greater frequency of lobed shape (45.5%), followed by triangular (27.3%), lanceolate (18.2%) and cordate (9.1%) shapes. Similarly, Daros *et al.* (2002); Ritschel and Huaman (2002) grouped the sweet potato accessions based on leaf shape.

Petiole length: Based on the petiole length of leaves sweet potato genotypes were grouped into 3 categories *viz.*, very short (2 genotypes), short (43 genotypes) and intermediate (6 genotypes) (Table 2 and Plate 1). Similar findings were observed by Jackson *et al* (2020) for petiole length in sweet potato genotypes and they reported 13.3 % genotypes were short and 20.7 % were long petiole length.

Table 2: Plant morphological characters of sweet potato genotypes.

Characters	Genotypes	No. of genotypes
Plant type		
Spreading	BSP-1, BSP-4, BSP-6, BSP-10, BSP-15, BSP-17, BSP-22, BSP-23, BSP-25, BSP-29, BSP-37, BSP-42, BSP-43, BSP-44, BSP-45, BSP-47, BSP-48, ST-14, NBS-1, NBS-4, CIP-1	21
Semi erect	BSP-8, BSP-18, BSP-19, BSP-20, BSP-21, BSP-24, BSP-26. BSP-27, BSP-28, BSP-30, BSP-31, BSP-32, BSP-33, BSP-34, BSP-35, BSP-36, BSP-38, BSP-39, BSP-40, BSP-41, BSP-46, BSP-49, BSP-50, BSP-51, BSP-52, Khanapur local, NBS-2, NBS-3, CIP-2, Sree Bhadra	30
Vine internodal length		
Very short	BSP-38, BSP-40	2
Short	BSP-1, BSP-6, BSP-8, BSP-10, BSP-15, BSP-19, BSP-20, BSP-21, BSP-22, BSP-24, BSP-25, BSP-26, BSP-27, BSP-28, BSP-29, BSP-30, BSP-31, BSP-32, BSP-34. BSP-35, BSP-36, BSP-37, BSP-39, BSP-41, BSP-42, BSP-43, BSP-44, BSP-45, BSP-46, BSP-47, BSP-49, BSP-50, BSP-51, BSP-52, ST-14, Khanapur local, NBS-1, NBS-2, NBS-3, NBS-4, CIP-1, CIP-2	43
Intermediate	BSP-4, BSP-17, BSP-18, BSP-23, BSP-33, BSP-48, Sree Bhadra	7
Leaf size		
Medium	BSP-1, BSP-4, BSP-6, BSP-8, BSP-10, BSP-15, BSP-17, BSP-18, BSP-19, BSP-20, BSP-22, BSP-23, BSP-24, BSP-25, BSP-26, BSP-27, BSP-28, BSP-29, BSP-30, BSP-31, BSP-32, BSP-34. BSP-35, BSP-36, BSP-37, BSP-38, BSP-39, BSP-40, BSP-41, BSP-42, BSP-44, BSP-46, BSP-47, BSP-49, BSP-50, BSP-51, BSP-52, ST-14, Sree Bhadra	39
Short	BSP-21, BSP-33, BSP-43, BSP-45, BSP-48, Khanapur local, NBS-1, NBS-2, NBS-3, NBS-4, CIP-1, CIP-2	12
Mature leaf shape		
Slightly lobed	NBS-2, NBS-3, NBS-4, CIP-2, Sree Bhadra	5
Very slightly lobed	BSP-23, ST-14,	2
Moderately lobed	BSP-6, BSP-44, BSP-52	3
Deep lobed	BSP-10, BSP-25, BSP-30, BSP-37, BSP-41, BSP-47	6
Very dee p lobed	BSP-1, BSP-8, BSP-18, BSP-19, BSP-20, BSP-21, BSP-24, BSP-26, BSP-27, BSP-28, BSP-29, BSP-31, BSP-32, BSP-34, BSP-38, BSP-39, BSP-40, BSP-45, BSP-46, BSP-49, BSP-50, BSP-51, Khanapur local, NBS-1, CIP-1	25
Triangular	BSP-4, BSP-17, BSP-36, BSP-42, BSP-43, BSP-48	6
Hastate	BSP-15, BSP-22, BSP-35	3
Cordate	BSP-33	1
Petiole length		
Very short	BSP-19, Khanapur local	2
Short	BSP-1, BSP-6, BSP-10, BSP-15, BSP-17, BSP-20, BSP-21, BSP-22, BSP-23, BSP-24, BSP-25, BSP-26, BSP-28, BSP-29, BSP-30, BSP-31, BSP-32, BSP-33, BSP-34, BSP-35, BSP-36, BSP-37, BSP-38, BSP-39, BSP-40, BSP-41, BSP-42, BSP-43, BSP-45, BSP-46, BSP-47, BSP-48, BSP-49, BSP-50, BSP-51, BSP-52, ST-14, NBS-1, NBS-2, NBS-3, NBS-4, CIP-1, Sree Bhadra	43
Intermediate	BSP-4, BSP-8, BSP-18, BSP-27. BSP-44, CIP-2	6

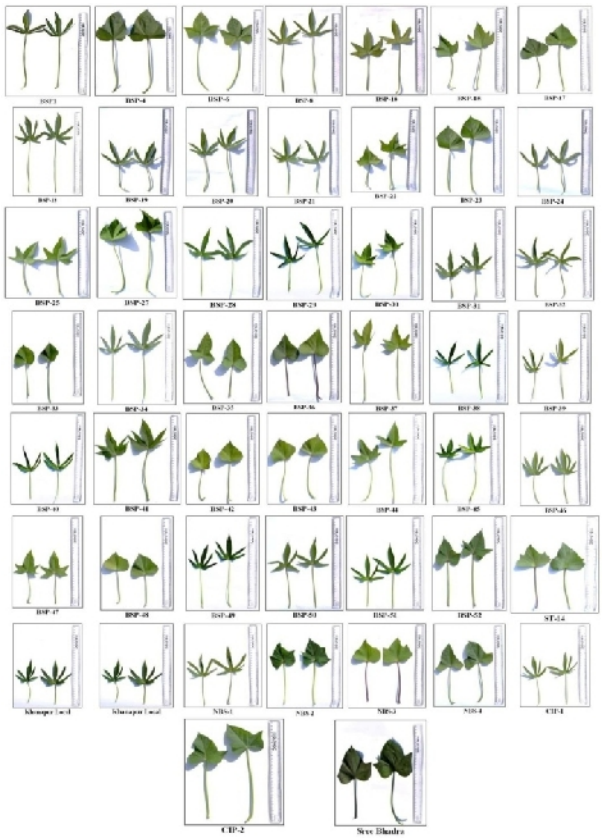

Plate 1: Leaf morphology of 51 sweet potato genotypes.

Tuber shape: The sweet potato genotypes showed greater variability for tuber shape and they are grouped into eleven classes based on their physical appearances of tuber. The 51 sweet potato genotypes were categorized into long irregular/curved (13 genotypes;), ovate (3 genotypes), elliptic (9 genotype), oblong (3 genotypes), round elliptic (4 genotypes), long elliptic (6 genotypes), long oblong (4 genotypes), irregular (3 genotypes), longitudinal grooves (1 genotype), long irregular (1 genotype), obovate (2 genotypes) and round (1 genotype) (Table 3 and Plate 2). Ritschel and Huaman (2002) also studied 324 sweet potato accessions for tuber shape and classified into eight classes, with a predominance of long elliptic (42.5%), irregular (21.1%) and none of the accessions belongs to oval shape.

Tuber colour. Sweet potato genotypes showed diverse variations for tuber skin colour. Based on the predominant color of the tuber skin of the genotypes are characterized into 7 categories *viz.*, purple red (15 genotypes), along with the colorings; cream (12 genotypes); white (12 genotypes); pink (5 genotypes); dark purple (5 genotypes); brownish orange (1 genotype) and orange (1 genotype) (Table 3 and Plate 2). Similarly, based on the tuber skin colour Daros *et al.* (2002) reported the pink color as predominant (50%) tuber skin colour in sweet potato genotypes. While, Veasey *et al.* (2007); Ritschel and Huaman (2002) observed the predominant colour as cream and white, respectively.

Flesh colour: Sweet potato genotypes showed significant variations for flesh colour. Based on flesh colour genotypes were grouped into 7 categories *viz.*, white (20 genotypes), cream (17 genotypes), pale yellow (8 genotypes), intermediate orange (2 genotypes), dark yellow (1 genotype), dark orange (1 genotype) and strongly pigmented with anthocyanin (2 genotypes) (Table 3 and Plate 3). Among the genotypes studied for the flesh colour in the present study showed predominance of white colour. While, Ritschel and Huaman (2002); Veasey *et al.* (2007) observed predominance of cream colour in germplasm assessed genotypes.

Table 3: Tuber morphological characters of sweet potato genotypes.

Sr. No.	Tuber Shape	Genotypes	No. of Genotypes
1.	Long irregular/Curved	BSP-1, BSP-26, BSP-31, BSP-32, BSP-34, BSP-39, BSP-40, BSP-42, BSP-45, BSP-46, BSP-47, BSP-50, Khanapur Local,	13
2.	Ovate	BSP-4, BSP-21, Shree Bhadra,	3
3.	Elliptic	BSP-8, BSP-17, BSP-20, BSP-38, BSP-41, BSP-43, BSP-48, BSP-49, NBS-1	9
4.	Oblong	BSP-6, BSP-10, BSP-37	3
5.	Round elliptic	BSP-15, BSP-44, ST-14. NBS-2	4
6.	Long elliptic	BSP-18, BSP-24, BSP-28, BSP-35, BSP-51, NBS-4	6
7.	Long oblong	BSP-19, BSP-22, BSP-29, BSP-30	4
8.	Irregular	BSP-23, NBS-3, CIP-1	3
9.	Longitudinal grooves	BSP-25	1
10.	Long irregular	BSP-27	1
11.	Obovate	BSP-33, BSP-36	2
12.	Round	BSP-52,CIP-2	2
Sr. No.	**Tuber Colour**	**Genotypes**	**No. of Genotypes**
1.	Pink	BSP-1, BSP-8, BSP-32, BSP-34, BSP-40	5
. 2.	Purple Red	BSP-4, BSP-6. BSP-15, BSP-18, BSP-38, BSP-39, BSP-41, BSP-50, Khanapur Local, NBS-1, NBS- 2,NBS-4, CIP-1, CIP-2, Shree Bhadra	15
3.	Cream	BSP-10, BSP-17, BSP-28, BSP-29, BSP-30, BSP-31, BSP-33, BSP-37, BSP-44, BSP-48, BSP-49, BSP-51	12
4.	White	BSP-19, BSP-20, BSP-21, BSP-24, BSP-25, BSP-26, BSP-27, BSP-42, BSP-43, BSP-45, BSP-46, BSP-47,	12
5.	Dark Purple	BSP-22, BSP-23, BSP-35, BSP-36, BSP-52	5
6.	Brownish Orange	ST-14	1
7.	Orange	NBS-3	1
Sr. No.	**Flesh Colour**	**Genotypes**	**No. of Genotypes**
1.	White	BSP-1, BSP-6, BSP-8, BSP-20, BSP-22, BSP-25, BSP-27, BSP-30, BSP-33, BSP-35, BSP-36, BSP-37, BSP-41, BSP-42, BSP-43, BSP-44, BSP-46, BSP-48, CIP-2, Shree Bhadra	20
2.	Cream	BSP-4, BSP-15, BSP-17, BSP-19, BSP-21, BSP-26, BSP-28, BSP-29, BSP-31, BSP-34, BSP-39, BSP-40, BSP-45, BSP-47, Khanapur Local, NBS-1, CIP-1,	17
3.	Pale Yellow	BSP-10, BSP-18, BSP-24, BSP-32, BSP-38, BSP-49, BSP-51, BSP-52	8
4.	Intermediate Orange	BSP-23, NBS-3	2
5.	Dark Yellow	BSP-50	1
6.	Dark Orange	ST-14	1
7.	Strongly pigmented with anthocyanin	NBS-2, NBS-4	2

Plate 2: Tuber morphology of 51 sweet potato genotypes.

CONCLUSION

Significant morphological variation were observed among the 51 sweet potato genotypes studied. Majority of genotypes having semi erect plant (30 genotypes), short inter-nodal length (43 genotypes), medium size leaf (39 genotypes), very deep lobed leaf (29 genotypes) and short petiole length (43 genotypes). Similarly tuber shape, tuber skin colour and flesh colour showed greater variability. The study reveals that the morphological characters used in this study would effectively discriminate the different genotypes. The evaluation of morphological characters of distinct genotypes helps for identifying superior genotypes for crop improvement.

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Conflict of Interest. None.

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