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DUS Characterization of Germplasm Accessions in Foxtail Millet (*Setaria italica* (L.) Beauv.)

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A B S T R A C T

In the present study, 50 germplasm accessions of foxtail millet [*Setaria italica (L.) Beauv*.] were evaluated based on DUS descriptors for six morphological (qualitative) traits *viz.*, plant growth habit, plant pigmentation at auricle, inflorescence shape, inflorescence compactness, lobe compactness, seed colour and six quantitative characters *viz.*, flag leaf: blade length (cm), flag leaf: blade width (cm), peduncle length (cm), peduncle exertion, panicle length (cm) and plant height at maturity (cm). All the germplasm accessions were characterized into different groups based on each character. The results revealed significant variation among the germplasm accessions for all the characters studied implying that morphological characterization of the foxtail millet germplasm accessions had enormous genetic diversity that will assign them key diagnostic features facilitating selection process, enabling the plant breeders in proper documentation to protect them from any possible infringement.

Introduction

Foxtail millet (*Setaria italica* (L.) *Beauv.*), an annual autogamous diploid (2n = 18) small millet is a photosynthetically efficient C_4 monocot belonging to the family, *Poaceae*. Out of 80 k ha. grown in India, this crop is cultivated in an area of 51 k ha. in Andhra Pradesh with a productivity of 945 kg ha-1 compared to national terms of 900 kg ha-1 (Annual report, 2016-17). This millet grains offers an excellent source of quality proteins (leucine and methionine), β-carotene, minerals (Ca, Fe, K, Mg and Zn), antioxidants, dietary fibre, phytochemicals, vitamins (thiamine, riboflavin and niacin) and have low glycemic index, a requisite for healthy human diet (Murugan and Nirmalakumari, 2006). Besides, its small genome size of ~ 515 Mb (Li and Brutnell, 2011) provides ample scope for molecular and genetic research as a 'model crop' to understand deeper insights into plant biology. The 'Protection of Plant Varieties and

Farmers' Right Act, 2001 (PPV & FR Act, 2001) of India encourages public/private investment in research and development of new plant varieties by giving protection to the new plant genotypes against unauthorized multiplication of seeds or propagating materials for a specific period. In addition, the act insists on DUS characterization of extant, farmers and new varieties and recommends the registration of varieties for atleast any one specific novel character.

The new foxtail millet genotypes will be protected under the PPV & FR Act after confirming DUS testing through the comparison of new and existing varieties in similar environment for a set of morphological characters. Characterization of these diverse germplasm accessions for their morphological characteristics holds immense potential for their objective utilization in the breeding programme. Further they serve as an indispensable tool in selecting varieties or lines based on agronomical, morphological, genetic or physiological characters. Therefore, the present investigation was conducted to characterize the foxtail millet germplasm accessions for selected DUS characters, yield and yield attributing traits.

Materials and Methods

Plant materials and field trails

The experimental material for the present study comprised of 50 foxtail millet germplasm accessions chosen from 1038 accessions maintained at Regional Agricultural Research Station (RARS), Nandyal, Andhra Pradesh, India. These germplasm accessions were raised in a field trail of randomized complete block design (RCBD), replicated thrice with a plot size of 13 m × 15 m per each germplasm accession, with a spacing of 22.5 cm and 10 cm between rows and plants, respectively during *kharif*, season at RARS, Nandyal. Standard cultural and agronomic practices were adopted to raise a healthy crop. The experimental field was protected from bird damage during grain filling stage by installing bird scarers. Based on attainment of harvestable maturity, the foxtail millet germplasm accessions studied were harvested at varied intervals (Table 1).

Data recording and analysis

The observations based on DUS descriptors for six morphological (qualitative) traits (Table 2) *viz.,* plant growth habit, plant pigmentation at auricle, inflorescence shape, inflorescence compactness, lobe compactness, seed colour and six quantitative characters (Table 3) *viz.*, flag leaf: blade length (cm), flag leaf: blade width (cm), peduncle length (cm), peduncle exertion, panicle length (cm) and plant height at maturity (cm) were recorded for each germplasm accession on five randomly selected plants per replication.

The range, mean and coefficient of variations for six quantitative characters were computed.

Results and Discussion

Qualitative descriptor

Characterization of the qualitative traits revealed a wide variation among the accession (Table 4). Each descriptor is categorized based on morphological descriptor and is presented as key for identification (Flow charts) (Fig. 3).

Plant growth habit

In the present study two kinds of Plant growth habit was noticed: Among 50 Italian millet germplasm accessions, Erect was dominant (41) over Decumbent (9). Similar results were reported by Reddy *et al.*, (2006), Reddy *et al.*, (2009) for erect type of growth habit (Fig. 1).

Plant pigmentation at auricle

Two types of plant pigmentation at auricle was occurred in Italian millet germplasm accessions and categorized as Pigmented types and Non-Pigmented.

The Non-pigmented types (42) were dominant over Pigmented types (8). Similar result was obtained by Banu *et al.,* (2015) for this trait

Inflorescence shape

In the present study, inflorescence shapes of genotypes were categorized into three groups *viz.*, oblong (27), cylindrical (14) and pyramidal (9). Similar classification was reported by Radha *et al.,* (2014) and Ahmed *et al.,* (2017) for this trait.

Inflorescence compactness

Based on this trait, the germplasm accessions were grouped into three types *i.e.*, loose (3), medium (44) and compact (3).

The results found were in conformity with the findings of Reddy *et al.,* (2006), Radha *et al.,* (2014).

Lobe compactness

Based on the lobe compactness, germplasm accessions were grouped into three classes loose (3), medium (44) and compact (3). Similar results were obtained by Radha *et al.,* (2014), Ahmed *et al.,* (2017).

Seed colour

Based on seed colour, the germplasm accessions were categorized as light yellow (34), yellow (13), white (1), orange (1) and red (1). Contrarily, Reddy *et al.,* (2006), Radha *et al.,* (2014) and Banu *et al.,* (2017) reported that yellow seeds were more dominant.

Quantitative descriptor

Range, mean and coefficient of variations for six quantitative characters were shown in Table 5 and Figure 2.

Flag leaf: Blade length (cm)

Majority (44) of the germplasm accessions exhibited medium while the remaining were long for the trait, flag leaf blade length.

This result is in accordance with the findings of Ahmed *et al.,* (2017) and Nehra *et al.,* (2017).

Flag leaf: Blade width (cm)

Medium blade width for flag leaf was observed in all the germplasm accessions. Similar finding was also reported by Ahmed *et al.,* (2017).

Peduncle length (cm)

All the germplasm accessions were characterized either medium (28) or long (22) for this trait.

This result is in consonance with the findings of Reddy *et al.,* (2006) and Amgai *et al.,* (2011).

Peduncle exertion

Among the germplasm accessions studied, the trait peduncle exertion was observed to be either long (47) or short (03). Similar result was reported by Amgai *et al.,* (2011) for this character.

Plant height at maturity (cm)

Most of the germplasm accessions were tall (44) accessions while few were medium (6). Similar result was obtained by Nehra *et al.,* (2016).

Table.1 Details of 50 foxtail millet germplasm accessions utilized for study

S. No	Germplasm accession	Parentage
1	SiA 3085	Selection from SiA 2644 from farmers field
2	SiA 3156	Pureline selection from SiA 2871
3	SiA 3221	SiA 3075 x ISC 379
4	SiA 3322	Selection from ISC 1161
5	SiA 3327	Selection from ISC 1076
6	SiA 3328	Selection from ISC 748
7	SiA 3333	Selection from ISC 909
8	SiA 3335	Selection from ISC 745
9	SiA 3340	Selection from ISC 362
10	SiA 3346	Selection from ISC 160
11	SiA 3347	Selection from ISC 1162
12	SiA 3354	Selection from ISC 18
13	SiA 3355	Selection from ISC 869
14	SiA 3363	Selection from ISC 1134
15	SiA 3364	Selection from ISC 267
16	SiA 3367	Selection from ISC 1118
17	SiA 3369	Selection from ISC 1177
18	SiA 3375	Selection from ISC 838
19	SiA 3376	Selection from ISC 796
20	SiA 3377	Selection from ISC 254
21	SiA 3378	Selection from ISC 525
22	SiA 3381	Selection from ISC 398
23	SiA 3382	Selection from ISC 403
24	SiA 3383	Selection from ISC 200
25	SiA 3384	Selection from ISC 480
26	SiA 3386	Selection from ISC 907
27	SiA 3389	Selection from ISC 507
28	SiA 3390	Selection from ISC 828
29	SiA 3392	Selection from ISC 717
30	SiA 3393	Selection from ISC 375
31	SiA 3394	Selection from ISC 792
32	SiA 3395	Selection from ISC 931
33	SiA 3396	Selection from ISC 846
34	SiA 3397	Selection from ISC 917
35	SiA 3398	Selection from ISC 179
36	SiA 3399	Selection from ISC 237
37	SiA 3400	Selection from ISC 388
38	SiA 3401	Selection from ISC 735
39	SiA 3403	Selection from ISC 842
40	SiA 3404	Selection from ISC 195
41	SiA 3405	Selection from ISC 364
42	SiA 3407	Selection from ISC 96
43	SiA 3447	Selection from ISC 1704
44	SiA 3381	Selection from ISC 936
45	Srilakshmi	Pureline selection from local
46	Suryanandi	Pureline selection from SiA 1244
47	Prasad	Selection from Dronachalam village
48	Narasimharaya	SiA 805 x SiA242
49	Krishnadevaraya	SiA 326 x SiA242
50	ISC 347	ICRISAT gene bank

Table.2 Characteristics of six morphological traits

S.No	Character	Status	Stage of Observation
1	Plant growth habit	Erect	Flowering
		Decumbent	
2	Plant: Pigmentation at auricle	Absent	Flowering
		Present	
3	Inflorescence: Shape	Oblong	Flowering
		Pyramidal	
		Cylindrical	
4	Inflorescence Compactness	Loose	Dough
		Medium	
		Compact	
5	Lobe compactness	Loose	Maturity
		Medium	
		Compact	
6	Seed: Colour	Orange	Maturity
		Red	
		Yellow	
		Light Yellow	
		Straw	

Table.3 Characteristics of six quantitative characters

S.No	Character	Status	Note	Stage of Observation
1	Flag leaf: Blade length (cm)	Short (<20)	1	Flowering
		Medium (20-35)	9	
		Long (<35)		
2	Flag leaf: Blade width (cm)	Narrow (<1.5)	1	Flowering
		Medium (1.5-3.0)		
		Long (>3.0)	9	
3	Peduncle length (cm)	Short (<20)	1	Flowering
		Medium(20.0-30.0)		
		Long (30.0-40)	3	
		Very long (>40)	5	
4	Peduncle exertion	Short (<20)	3	Dough
		Medium(20.0-30.0)		
		Long (30.0-40)	5	
		Very long (>40)	7	
4	Plant height at maturity	Short (<80)	3	Maturity
		Medium (80-120)	5	
		Compact (> 120)	7	
6	Panicle length	Short (<10)	-	Maturity
		Medium(10.0-15.0)		
		Long (>15)		

Table.4 Morphological characterization in 50 foxtail millet germplasm accessions

S.No.	Name of the descriptor	Descriptor state	No. of accesssions	Frequency (%)
1	Plant growth habit	Erect	41	82
		Decumbent	9	18
2	Plant pigmentation at auricle	Pigmented	8	16
		Non Pigmeneted	42	84
3	Inflorescence shape	Oblong	27	54
		Pyramidal	9	18
		Cylindrical	14	28
4	Inflorescence compactness	Loose	3	6
		Medium	44	88
		Compact	3	6
5	Lobe compactness	Loose	3	18
		Medium	44	72
		Compact	3	10
6	Seed colour	Yellow	13	26
		White	1	2
		Orange	1	2
		Red	1	2
		Light Yellow	34	68
		Yellow	13	26

Table.5 Quantitative variations for six descriptors of foxtail millet germplasm accessions

Descriptors	Mean	Range	CV (%)
Flag leaf: Blade length (cm)	32.19	25.60-37.80	9.97
Flag leaf: Blade width (cm)	1.86	1.29-2.14	7.42
Peduncle length (cm)	29.80	23.10-37.73	7.38
Peduncle exertion	15.19	9.77-23.00	16.32
Plant height at maturity (cm)	131.87	101.73-153.33	6.31
Panicle length (cm)	18.07	10.55-22.10	12.34

Fig.1 Qualitative characters

1. Plant growth habit

Erect

Decumbent

2. Plant pigmentation at auricle

Pigmented

Non- pigmented

3. Inflorescence shape

Cylindrical

Oblong

Pyramidal

4. Inflorescence compactness

Loose **Medium** **Compact**

5. Lobe compactness

Loose **Medium** **Compact**

6. Seed colour

Fig.2 Quantitative characters

1. **Flag leaf: Blade length (cm)**

2. **Flag leaf: Blade width (cm)**

3. **Peduncle length (cm)**

4. **Peduncle exertion**

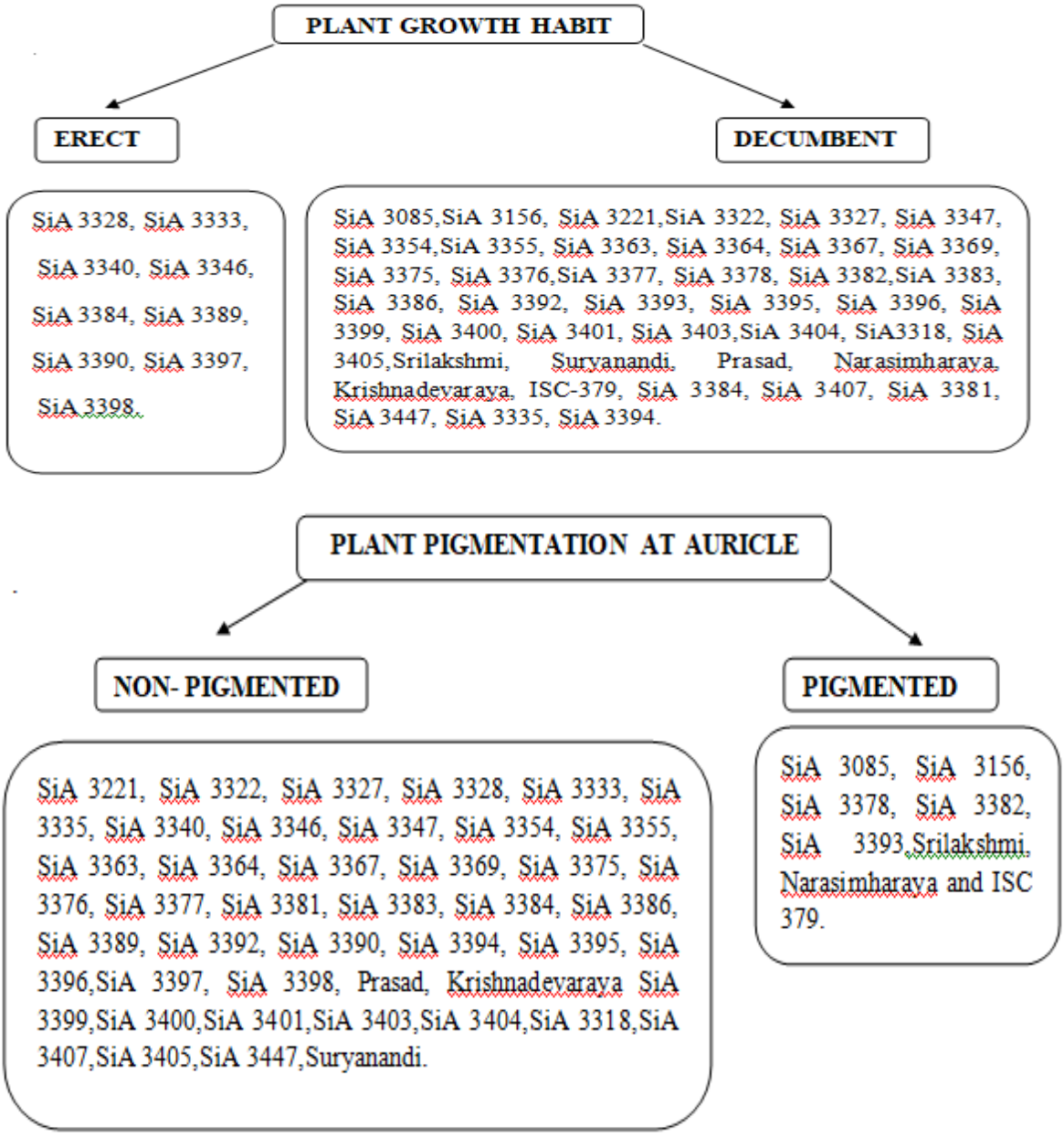
5. **Panicle length** (cm)

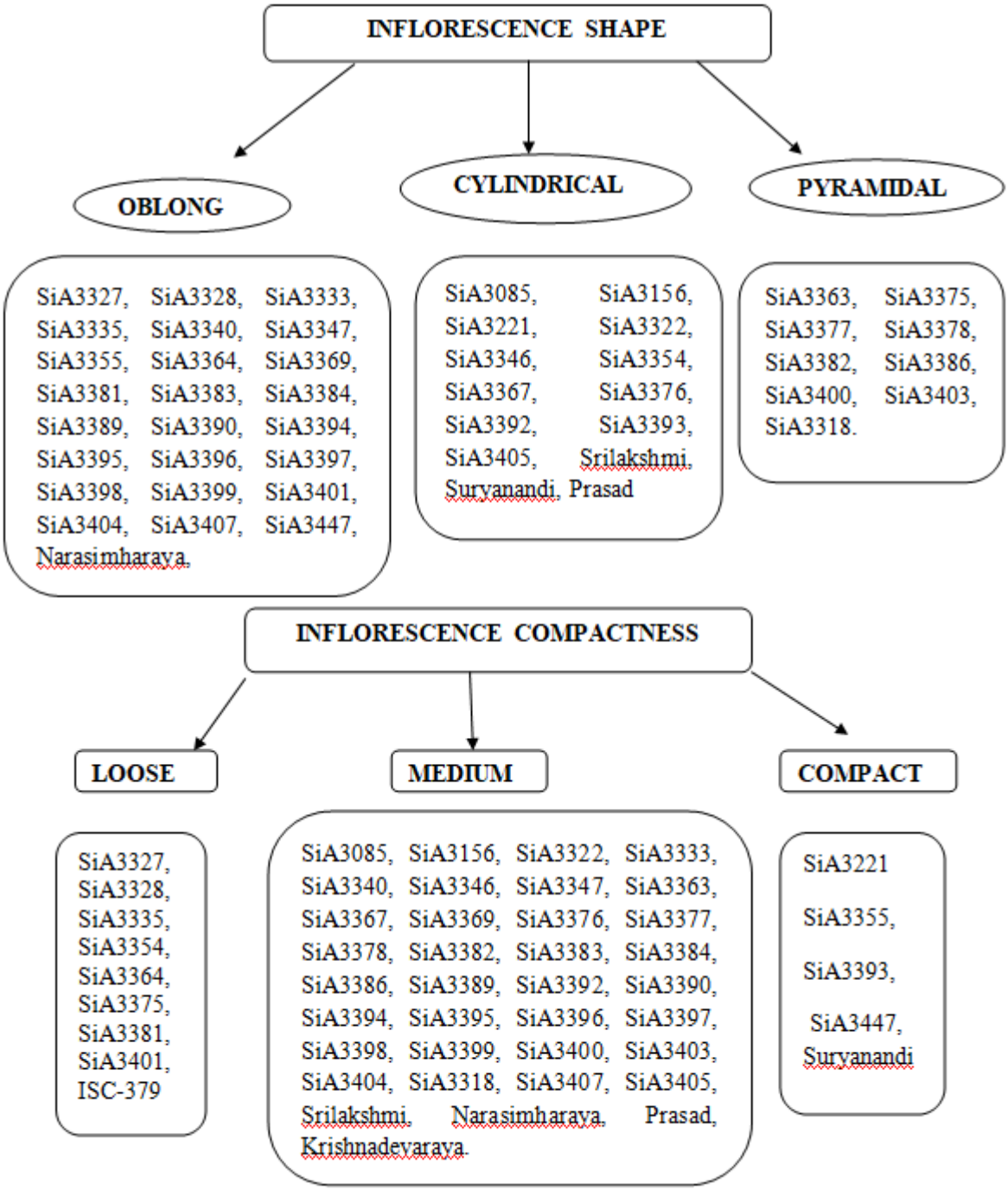
6. **Plant height at Maturity (cm)**

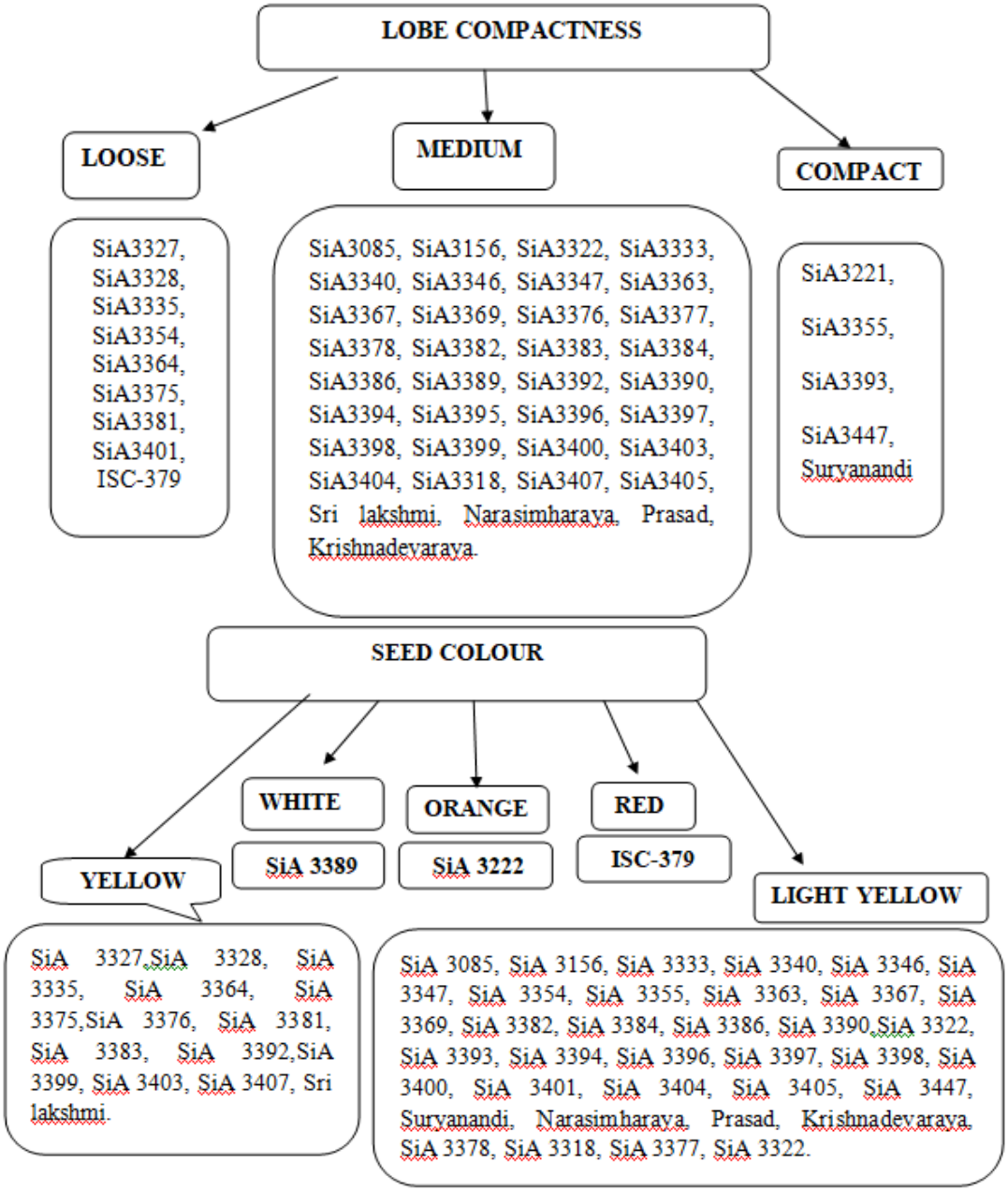
Medium (80-120 cm)

Tall (>120 cm)

Fig.3 Morphological key for identification of 50 Italian millet germplasm accessions




INFLORESCENCE SHAPE
OBLONG
CYLINDRICAL
PYRAMIDAL
SiA3327, SiA3328, SiA3333, SiA3335, SiA3340, SiA3347, SiA3355, SiA3364, SiA3369, SiA3381, SiA3383, SiA3384, SiA3389, SiA3390, SiA3394, SiA3395, SiA3396, SiA3397, SiA3398, SiA3399, SiA3401, SiA3404, SiA3407, SiA3447, Narasimharava.
SiA3085, SiA3156, SiA3221, SiA3322, SiA3346, SiA3354, SiA3367, SiA3376, SiA3392, SiA3393, SiA3405, Srilakshmi, Suryanandi, Prasad
SiA3363, SiA3375, SiA3377, SiA3378, SiA3382, SiA3386, SiA3400, SiA3403, SiA3318.
INFLORESCENCE COMPACTNESS
LOOSE
MEDIUM
COMPACT
SiA3327, SiA3328, SiA3335, SiA3354, SiA3364, SiA3375, SiA3381, SiA3401, ISC-379
SiA3085, SiA3156, SiA3322, SiA3333, SiA3340, SiA3346, SiA3347, SiA3363, SiA3367, SiA3369, SiA3376, SiA3377, SiA3378, SiA3382, SiA3383, SiA3384, SiA3386, SiA3389, SiA3392, SiA3390, SiA3394, SiA3395, SiA3396, SiA3397, SiA3398, SiA3399, SiA3400, SiA3403, SiA3404, SiA3318, SiA3407, SiA3405, Srilakshmi, Narasimharava, Prasad, Krishnadevaraya.
SiA3221
SiA3355,
SiA3393,
SiA3447, Suryanandi



Panicle length (cm)

For the trait, panicle length, majority of the germplasm accessions reported long (46) while only few (4) were medium. Similar results were noted by Nirmala kumari *et al.*, (2010) and Nehra *et al.*, (2016) for this trait.

In conclusion, morphological characterization of 50 foxtail millet germplasm accessions for six qualitative traits revealed existence of ample polymorphism for the characters. It was observed that for plant growth habit, erect was dominant over decumbent; for plant pigmentation at auricle, non-pigmentation was dominant over pigmentation; for inflorescence shape, oblong was dominant over cylindrical and pyramidal; for inflorescence compactness, medium was dominant over compact and loose; for lobe compactness, presence was dominant over

absence; for seed colour; yellow was dominant over light yellow, orange, red and white. Data analysis for six quantitative traits inferred medium for flag leaf blade length, flag leaf blade width, peduncle length; long for peduncle exertion and panicle length; tall for plant height. Based on the findings, it can be concluded that morphological DUS descriptors can be effectively used for identification, documentation and grouping of varieties along with their use in registration and unambiguous identification in the field. The morphological descriptors are of immense help to the plant breeders for selecting desirable genotypes easily through visual assessment and further the highly contrasting germplasm accessions for a particular trait can be utilized to develop mapping populations in order to map QTLs. Although DUS testing has been done precisely to provide diversity assessment at morphological level but there remains a further scope to validate the findings through diversity analysis at molecular level as molecular markers based genetic diversity analyses helps for more effective assessment of genetic relationship among the genotypes.

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