Indian Journal of Agricultural Sciences **89** (10): 1744–7, October 2019/Short Communication

Morphological characterization of ginger (*Zingiber officinale*) using DUS descriptors

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Received: 24 September 2018; Accepted: 02 April 2019

Key words: DUS, Ginger, Growth habit, Rhizome characters

Ginger of commerce is the underground rhizome of *Zingiber officinale* Rosc., belonging to the family Zingiberaceae is originated from South-East Asia. It is one of the oldest and most important spices, being cultivated in Tropical Asia for over 3000 years (Purseglove *et al.* 1981). Herbaceous perennial grown as annual crop and plant is erect, has many fibrous roots, aerial shoots (pseudostem) with leaves and the underground stem (rhizome) (Ravindran *et al.* 2005). Several cultivars of ginger are grown in different ginger growing areas of India and they are generally named after the localities where they are grown. Breeding of ginger through selection and hybridization is seriously handicapped by lack of variability, absence of natural seed set and exclusive vegetative propagation. Sexual reproduction is not reported in ginger, however the geographical spread accompanied by genetic differentiation into locally adapted population augmented by mutation is the main factor responsible for diversity in this clonally propagated crop (Parthasarathy *et al.* 2011). The knowledge of the variability structuring could allow not only the description of genotypes but also development of a conservation strategy for future breeding purposes.

Characterization of the ginger genotypes based on certain morphological traits which are not altered by the environmental interactions will be of greater help for easy identification of the genotypes. Protection of Plant Varieties and Farmers Right of India has set certain qualitative and quantitative Distinctness, Uniformity and Stability (DUS) guidelines for grouping of ginger genotypes (PPV&FRA, 2007). In the present study, 27 ginger genotypes which includes released varieties, promising genotypes and local cultivars were studied to characterize the genotypes for different morphological and rhizome characters based on DUS guidelines.

Twenty seven ginger genotypes, viz. IISR Varada, IISR Mahima, IISR Rejatha, Suprabha, Suravi, Suruchi, Sourabh, Athira, Karthika, Aswathy, KAU Chandra, Mohini, Rio de Janeiro, Nadia, Maran, Himachal, Bhaise, Gorubathane, Mahim, Zaheerabad local, Arunachal Pradesh local, Acc. 247, Acc. 65, Acc. 578, Acc. 219, Acc. 833 and RG 3 were characterized for two consecutive years 2016–17 and 2017–18 at ICAR-Indian Institute of Spices Research, Experimental Farm, Peruvannamuzhi, Kozhikode, Kerala in a randomized block design. The standard package of practices was followed (Jayashree *et al.* 2015). Genotypes were evaluated for 10 DUS traits, viz. growth habit, plant height, number of tillers/clump, shoot diameter, number of leaves on main shoot, leaf length, leaf width, rhizome thickness, rhizome shape and dry recovery. Observations on different DUS characters (PPV&FRA, 2007) were recorded at 150 days after planting for vegetative characters and after harvest for rhizome characters from five randomly selected plants.

Morphological characters help in easy and quick identification of genotypes. Among the 10 DUS characters studied maximum variation was observed for growth habit, number of tillers, shoot diameter, rhizome thickness, rhizome shape and dry recovery. Plant height, number of leaves on main shoot, leaf length and leaf width were monomorphic, four characters such as growth habit, shoot diameter, rhizome thickness and dry recovery were dimorphic and two characters i.e. number of tillers per clump and rhizome shape were polymorphic. Grouping of genotypes as per the DUS guidelines is presented in Table 1 and Fig 1.

Plant characters: Growth habit of the 27 ginger genotypes was found to be dimorphic with 15 genotypes (55.55%) having erect growth habit and 12 genotypes (44.45%) exhibited semi erect growth habit. Plant height was a monomorphic character and all the genotypes were grouped under short (<100 cm) category. Number of tillers was found to be polymorphic character which were grouped as 18 genotypes (66.67%) with few (<10) tillers, eight genotypes (29.63%) with medium (10-15) tillers and only one (3.7%) genotype i.e. Mahim with many (>15) tillers.

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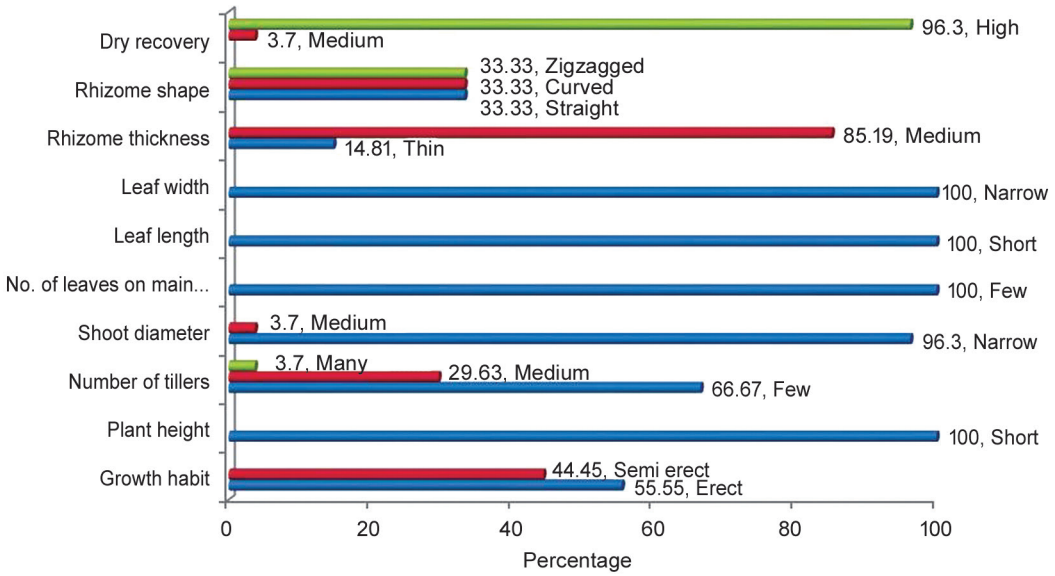

Fig 1 Grouping of ginger genotypes as per the DUS guidelines (PPV&FRA, 2007)

Sasikumar *et al.* (1992) also reported good variability for number of tillers among the 100 ginger genotypes evaluated. Twenty six genotypes (96.3%) exhibited narrow (<3 cm) shoot diameter and one genotype (3.7%) Aswathy exhibited medium (3-5 cm) shoot diameter. Similar reports were reported by Aswathy (2013) in the characterization of ginger somaclones where the plants were erect or semi erect and majority of the somaclones were short.

Leaf characters: Leaf characters under study as per the DUS guidelines were number of leaves on main shoot, leaf length and leaf width. All the three characters were found to be monomorphic. Twenty seven genotypes exhibited few (<25) number of leaves on main shoot. In case of leaf length and leaf width, all the genotypes were grouped into one category *i.e.* short (<25 cm) and narrow (<2.5 cm) leaf length and width respectively. Results are in accordance with Aswathy (2013) where the leaves of ginger somaclones were fewer,

Table 1 Grouping of ginger genotypes as per the DUS guidelines (PPV&FRA, 2007)

Characteristic	Status	Note	No. of genotypes	Genotypes
Growth habit	Erect	1	15	Suravi, Suruchi, Aswathy, KAU Chandra, Nadia, Maran, Gorubathane, Mahim, Zaheerabad local, Andhra Pradesh local, Acc. 247, Acc. 65, Acc. 578, Acc. 219, RG 3
	Semi erect	3	12	IISR Varada, IISR Mahima, IISR Rejatha, Suprabha, Athira, Karthika, Sourabh, Mohini, Rio de Janeiro, Himachal, Bhaise, Acc. 833
	Spreading	5	0	Nil
Plant height	Short (<100)	3	27	IISR Varada, IISR Mahima, IISR Rejatha, Suprabha, Suravi, Suruchi, Athira, Karthika, Aswathy, Sourabh, Mohini, KAU Chandra, Rio de Janeiro, Nadi, Maran, Himachal, Bhaise, Gorubathane, Mahim, Zaheerabad local, Arunachal Pradesh local, Acc. 247, Acc. 65, Acc. 578, Acc. 219, Acc. 833, RG 3
	Medium (100-120)	5	0	Nil
	Tall (>120)	7	0	Nil
Number of tillers	Few (<10)	3	18	IISR Varada, IISR Mahima, IISR Rejatha, Athira, Karthika, Mohini, KAU Chandra, Nadia, Maran, Himachal, Bhaise, Gorubathane, Zaheerabad local, Acc. 247, Acc. 65, Acc. 578, Acc. 219, Acc. 833
	Medium (10-15)	5	8	Suprabha, Suravi, Suruchi, Aswathy, Sourabh, Rio de Janeiro, Arunachal Pradesh local, RG 3
	Many (>15)	7	1	Mahim
Shoot diameter	Narrow (<3)	3	26	IISR Varada, IISR Mahima, IISR Rejatha, Suprabha, Suravi, Suruchi, Athira, Karthika, Sourabh, Mohini, KAU Chandra, Rio de Janeiro, Nadia, Maran, Himachal, Bhaise, Gorubathane, Mahim, Zaheerabad local, Arunachal Pradesh local, Acc. 247, Acc. 65, Acc. 578, Acc. 219, Acc. 833, RG 3
	Medium (3-5)	5	1	Aswathy
	Broad (>5)	7	0	Nil

Contd.

Table 1 (*Continued*)

Characteristic	Status	Note	No. of genotypes	Genotypes
Number of leaves on main shoot	Few (<25)	3	27	IISR Varada, IISR Mahima, IISR Rejatha, Suprabha, Suravi, Suruchi, Athira, Karthika, Sourabh, Mohini, KAU Chandra, Rio de Janeiro, Nadia, Maran, Himachal, Bhaise, Gorubathane, Mahim, Zaheerabad local, Arunachal Pradesh local, Acc. 247, Acc. 65, Acc. 578, Acc. 219, Acc. 833, RG 3
	Medium (25-35)	5	0	Nil
	Many (>35)	7	0	Nil
Leaf length	Short (<25)	3	27	IISR Varada, IISR Mahima, IISR Rejatha, Suprabha, Suravi, Suruchi, Athira, Karthika, Sourabh, Mohini, KAU Chandra, Rio de Janeiro, Nadia, Maran, Himachal, Bhaise, Gorubathane, Mahim, Zaheerabad local, Arunachal Pradesh local, Acc. 247, Acc. 65, Acc. 578, Acc. 219, Acc. 833, RG 3
	Medium (25-30)	5	0	Nil
	Long (>30)	7	0	Nil
Leaf width	Narrow (<2.5)	3	27	IISR Varada, IISR Mahima, IISR Rejatha, Suprabha, Suravi, Suruchi, Athira, Karthika, Sourabh, Mohini, KAU Chandra, Rio de Janeiro, Nadia, Maran, Himachal, Bhaise, Gorubathane, Mahim, Zaheerabad local, Arunachal Pradesh local, Acc. 247, Acc. 65, Acc. 578, Acc. 219, Acc. 833, RG 3
	Medium (2.5-3.5)	5	0	Nil
	Broad (>3.5)	7	0	Nil
Rhizome thickness	Thin (<2)	3	4	Karthika, Rio de Janeiro, Mahim, Arunachal Pradesh local
	Medium (2-3)	5	23	IISR Varada, IISR Mahima, IISR Rejatha, Suprabha, Suravi, Suruchi, Athira, Sourabh, Mohini, KAU Chandra, Nadia, Maran, Himachal, Bhaise, Gorubathane, Mahim, Zaheerabad local, Acc. 247, Acc. 65, Acc. 578, Acc. 219, Acc. 833, RG 3
	Bold (>3)	7	0	Nil
Rhizome shape	Straight	1	9	IISR Mahima, Aswathy, KAU Chandra, Maran, Arunachal Pradesh local, Acc. 247, Acc. 219, Acc. 833, RG 3
	Curved	3	9	Suravi, Suruchi, Karthika, Sourabh, Mohini, Rio de Janeiro, Nadia, Himachal, Gorubathane
	Zigzagged	5	9	IISR Varada, IISR Rejatha, Suprabha, Athira, Bhaise, Mahim, Zaheerabad local, Acc. 65, Acc. 578
Dry recovery	Low (<16)	3	0	Nil
	Medium (16-18)	5	1	Rio de Janeiro
	High (>18)	7	26	IISR Varada, IISR Rejatha, IISR Mahima, Suprabha, Suravi, Suruchi, Athira, Karthika, Aswathy, Sourabh, Mohini, KAU Chandra, Nadia, Maran, Himachal, Bhaise, Gorubathane, Mahim, Zaheerabad local, Arunachal Pradesh local, Acc. 247, Acc. 65, Acc. 578, Acc. 219, Acc. 833, RG 3

short and narrow.

Rhizome characters: Rhizome being the economic part in ginger plays an important role in differentiating the genotypes into different categories and which ultimately influence the yield. Rhizome thickness exhibits positive correlation with rhizome yield. Ravishanker *et al.* (2013) also reported similar findings where rhizome yield had significant positive correlation with rhizome thickness. Rhizome thickness was dimorphic character and among the 27 genotypes, four genotypes exhibited <2 cm (thin) rhizome thickness where the rhizomes were slender and 23 genotypes exhibited 2–3 cm (medium) rhizome thickness. Jatoi and Watanabe (2013) also reported high variance for rhizome weight and rhizome thickness among the 19 ginger accessions studied. Rhizome shape was found to be polymorphic character and there was equal distribution of genotypes *i.e.* nine genotypes (33.33%) in each category (straight, curved and zigzagged).

Yield per plant on dry weight basis is dependent on the dry recovery (%). Higher the dry recovery more will be the yield. Among the 27 genotypes, none of the genotype was with low dry recovery (%), one genotype (3.7%) Rio de Janeiro recorded medium (16–18%) dry recovery and other 26 genotypes (96.3%) exhibited high (>18%) dry recovery. Nybe *et al.* (1980) stated that, the variation in drying percentage might be attributed to the difference in size of the rhizome, moisture and fibre content of the cultivars.

Results observed in case of rhizome characters in the present study were in accordance with the results obtained by Aswathy (2013), where all the three types of rhizome shapes were observed and rhizomes were of medium size in ginger somaclones.

Ginger genotypes were grouped as per the DUS guidelines by using quantitative and qualitative traits. From this grouping of genotypes it can be concluded that the difference in the morphological characters among the genotypes was narrow and most of the genotypes were grouped together in each category. Grouping of genotypes with respect to the rhizome characters gives an insight in to the availability of variation among the genotypes and use of the genotypes with good rhizome characters for further selection and crop improvement programmes as well as protection of plant varieties.

SUMMARY

Ginger (*Zingiber officinale* Rosc.) is an important spice crop cultivated for its fresh and dried rhizomes. Ginger never sets seed and sexual recombination has never been reported. Cultivars have evolved by unconscious selection and are generally known by the name of the region. Moreover, it is propagated vegetatively and hence, differentiation of genotypes morphologically is difficult. Twenty-seven ginger genotypes were characterized morphologically using DUS guidelines for eight quantitative and two qualitative characters. Among the characters, four characters were monomorphic, four were dimorphic and two were found to be polymorphic. Grouping of genotypes showed narrow variability for most of the morphological characters whereas, rhizome characters exhibited remarkable variability.

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