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Diversity in bulb traits in onion germplasm collected from Chhattisgarh and Maharashtra

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ABSTRACT

Onion germplasm was collected from Chhattisgarh (Bastar Plateau) and Maharashtra (central eastern Vidarbha region) in Peninsular India during May 2009 in collaboration with Directorate of Onion and Garlic Research, Pune and Indira Gandhi Agricultural University, Jagdalpur to assess the diversity in bulb traits for their potential utilization in onion improvement. Ninety-two samples (bulbs-91; seeds-1) were collected from 25 villages and 15 mandals. Wide range of variation was observed for bulb shape, colour and size, number of hearts and total soluble solids. Majority of the accessions possessed globe (32%), thick flat (24%) and ovate (23%) shapes. Major colours obtained were dark red (56%), light red (27.4%) and white (13.2%). Bulb weight showed maximum diversity, followed by neck thickness, equatorial diameter and polar diameter. Highest TSS of 14.5% was recorded in IC573752 (dark red, thick flat, Lohandiguda, Bastar). The thinnest neck (0.18 cm) was found in IC573779 (dark red, ovate) from Bastar, Chhattisgarh. Twenty-five accessions were observed with single centres including IC573729 (light red, ovate, Bastar), IC573743, IC573769 (dark red, globe, Bastar), IC573780 (light red, flat globe, Bastar), IC573794 (white, ovate, Gadchiroli) and IC573810 (white, thick flat, Chandrapur). Largest bulbs were observed in IC573822 (105 g) and IC573820 (97 g) both light red and thick flat, from Yavatmal and IC573774 (94.5 g, light red, globe) and IC573781 (93.5 g, dark red, flat globe) from Bastar. These accessions hold potential for utilization in breeding programmes for further genetic improvement of onion. Specific diversity rich areas identified can be developed into onion villages for on-farm *in-situ* conservation.

Key words: Onion, bulb trait diversity, Chhattisgarh, Maharashtra.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most extensively grown commercial vegetable-cum-spice crops in India with intrinsic export value. The National Bureau of Plant Genetic Resources, New Delhi through explorations intensively collected and conserved well over 700 onion accessions from major traditional areas of cultivation in the country (Pandey *et al*., 10). In addition, about 800 onion germplasm are also maintained at the Directorate of Onion and Garlic Research, Pune, which is responsible as a National Active Germplasm Site (NAGs) for maintenance of onion germplasm, its breeding and improvement. This paper discusses the diversity and potential of collections from parts of Chhattisgarh and Maharashtra especially with regard to bulb characters of significance, *viz.*, bulb size, shape, colour, neck thickness, TSS and presence of single centre.

MATERIALS AND METHODS

In an effort to supplement the existing collections with diversity from hitherto unexplored areas, and to assess their potential utilization in onion improvement an exploration was undertaken in Chhattisgarh (Bastar Plateau) and Maharashtra (central eastern Vidarbha region) in Peninsular India during May 2009 in collaboration with Directorate of Onion and Garlic Research and Indira Gandhi Agricultural University, Raipur. Technical information given by the Departments of Agriculture and Horticulture, Chhattisgarh and Maharashtra, analysis of earlier surveys undertaken in the region and inputs given by the farmers formed the basis to target the diversity rich pockets for collection and to finalize survey route. Farm stores, threshing yards, kitchen gardens/ farmer's fields and local markets were chosen for selective sampling as suggested by Huaman *et al*. (3). All 'morphotypes' in field, market or threshing yard were identified and 15-25 bulbs of each were collected, and this process was repeated at each sampling site. Care was taken to sample only landraces based on farmer's information. Passport data for each sampled accession and the geographical coordinates of its sampling location were recorded, the latter using the Garmin GPS-12 system. Data were also recorded on two qualitative traits - bulb shape and colour

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and six quantitative traits - polar diameter (mm), equatorial diameter (mm), neck thickness (mm), bulb weight (g), TSS (%) and number of centres. The data on quantitative traits were analyzed using descriptive statistics. Relationships among traits were assessed using Pearson's coefficient of correlation and regression analysis. The multivariate techniques of ordination using non-metric multidimensional scaling (MDS) was used to note the presence of any possible grouping in the sampled accessions into distinct genetic classes. Ordination was based on a proximity matrix estimated from four quantitative traits (polar diameter, equatorial diameter, neck thickness, bulb weight) and two qualitative traits (bulb shape and bulb color) using Gower's measure of similarity (Gower, 2). Euclidean distance for the four quantitative traits and simple matching coefficient for the two qualitative traits were used to derive the Gower's measure of similarity. Data analyses were performed using GenStat 12 software.

RESULTS AND DISCUSSION

Diversity of onion germplasm consisting of 92 samples were collected - 58 from 16 villages of Chhattisgarh and 34 from nine villages of Maharashtra. All samples were collected as bulbs except for one collection as seed. The collections were made between latitudinal and longitudinal ranges of 17º 9' N and 21º 2' N and 77º 1' E and 82º 1' E respectively. Altitude ranged from 210 to 592 m. Table 1 shows the distribution of the accessions according to their bulb shape and color. Majority of the accessions possessed

Table 1. Distribution of sampled accessions in different bulb shape and colour classes.

Trait (#Acc, %)	Accession (s)
Bulb Shape	
Flat (7, 7.7)	IC573734, IC573777, IC573809, IC573788, IC573797, IC573790, IC573764
Flat globe (11, 12.1)	IC573739, IC573771, IC573773, IC573774, IC573783, IC573796, IC573827, IC573760, IC573780, IC573824, IC573807
Globe (29, 31.9)	IC573732, IC573733, IC573735, IC573738, IC573740, IC573743, IC573742, IC573747, IC573748, IC573749, IC573750, IC573753, IC573754, IC573755, IC573766, IC573767, IC573769, IC573815, IC573823, IC573828, IC573798, IC573782, IC573786, IC573799, IC573800, IC573801, IC573802, IC573811, IC573813
Ovate (21, 23.1)	IC573745, IC573758, IC573759, IC573768, IC573770, IC573775, IC573776, IC573778, IC573779, IC573781, IC573806, IC573729, IC573751, IC573756, IC573757, IC573761, IC573762, IC573772, IC573821, IC573794, IC573817
Thick flat (22, 24.2)	IC573730, IC573731, IC573737, IC573744, IC573746, IC573752, IC573765, IC573814, IC573829, IC573741, IC573763, IC573784, IC573787, IC573793, IC573818, IC573820, IC573822, IC573826, IC573789, IC573810, IC573816, IC573825
Round (1, 1.1)	IC 573791
Bulb colour	
Dark red (51, 56.0)	IC573734, IC573777, IC573809, IC573764, IC573739, IC573771, IC573773, IC573774, IC573783, IC573796, IC573827, IC573732, IC573733, IC573735, IC573738, IC573740, IC573743, IC573747, IC573748, IC573749, IC573750, IC573753, IC573754, IC573755, IC573767, IC573769, IC573815, IC573823, IC573828, IC573742, IC573745, IC573758, IC573759, IC573768, IC573770, IC573775, IC573776, IC573778, IC573779, IC573781, IC573806, IC573730, IC573731, IC573737, IC573744, IC573746, IC573752, IC573765, IC573814, IC573829, IC573825
Light red (26, 28.6)	IC573788, IC573797, IC573760, IC573780, IC573824, IC573782, IC573786, IC573766, IC573729, IC573751, IC573756, IC573757, IC573761, IC573762, IC573772, IC573821, IC573741, IC573763, IC573784, IC573787, IC573793, IC573798, IC573818, IC573820, IC573822, IC573826
Milky White (1, 1.1)	IC573790
Red (1, 1.1)	IC573791
White (12, 13.2)	IC573807, IC573799, IC573800, IC573801, IC573802, IC573811, IC573813, IC573794, IC573817, IC573789, IC573810, IC573816

globe, thick flat and ovate shapes; round and flat shapes were less represented. Dark red, light red and white onions were most predominant accounting for 56, 28 and 13% of the collections. In keeping with the regional preferences, all collections (63%) from the Bastar plateau were dark/ light red types, whereas those from the Vidarbha region included both dark/ light red types (23%) and white/ milky white (13%) types. A wide range of variation was also observed for the six quantitative traits with significant correlations (Tables 2 & 3). Bulbs from the Bastar plateau showed a wider range for bulb weight and TSS as compared to those from the Vidarbha region. In general, average bulb weight, showed maximum variation (14 to 105 g) followed by neck thickness, equatorial diameter, and polar diameter.

These traits, both qualitative and quantitative, are important in describing the accessions and establishing taxon/ accession identity and form the basis for assigning economic value to a genotype. Bulb shape and colour are important criteria in consumer preference. Red onions with high pungency are preferred in India and other areas in the tropics and sub-tropics while yellow-skinned sweet onions have high demand in the European market. White onions with lower pungency and higher TSS are preferred by the dehydration industry. Red types have a high nutritional value, possessing high anthocyanides and flavonoids and consequently a high antioxidant and anti-cancerous activity. Red onions are also better storers than either white or yellow types. Generally, globe shaped or spherical/ ovate shapes are favoured over the flat shaped onions as they facilitate trimming of necks and roots with little loss of bulb flesh. Total soluble solids give a measure of sweetness of the genotype, and those with a high value possibly enhance keeping quality (El-Aweel, 1). Onions with a high TSS are also highly pungent and these two qualities are important attributes for processing and storage. Red varieties released for commercial growing have a range of TSS from 11 to 14%. In the present study, the highest TSS of 14.5% was recorded in IC573752 (dark red, thick flat, Lohandiguda, Bastar), which was on par with released variety Punjab Selection. Neck thickness is important in the bulb curing process and preventing disease entry into the bulb during storage (Singh, 12). In the present study, neck thickness showed a positive and significant correlation with average bulb weight (Table 3). Neck thickness is reported to have high estimates of heritability along with a negative-direct effect on yield indicating that thin neck trait was associated with improvement in bulb yield (Mohanty, 8). The thinnest neck (0.18 cm) was

Table 2. Summary statistics for bulb traits.

Trait	Region									
	Bastar Plateau (n = 57)					Central Eastern Vidarbha (n = 34)				
	Min.	Max.	Mean	SD	CV%	Min.	Max.	Mean	SD	CV%
Polar diameter (mm)	30.8	51.8	39.6	5.0	12.6	28.7	50.2	39.7	5.2	13.0
Equatorial diameter (mm)	32.0	61.3	45.3	8.2	18.1	25.8	63.7	47.4	6.9	14.6
Neck thickness (mm)	1.8	8.4	3.6	0.9	24.6	2.8	5.2	3.7	0.5	14.8
Av. bulb weight (g)	16.2	94.5	47.5	21.1	44.3	13.9	105.0	51.0	19.7	38.6
TSS (%)	8.0	14.5	10.2	1.3	12.5	7.8	12.5	10.5	1.1	10.6
No. of centres	1.0	4.0	1.6	0.7	40.6	1.0	3.0	1.8	0.6	30.3

Table 3. Correlations among bulb traits.

Trait	Polar diameter (mm)	Equatorial diameter (mm)	Neck thickness (mm)	Av. bulb weight (g)	Total soluble solids (%)
Equatorial diameter (mm)	0.772**				
Neck thickness (mm)	0.487**	0.422**			
Av. bulb weight (g)	0.806**	0.942**	0.367*		
Total soluble solids (%)	-0.181	-0.136	-0.041	-0.144	
No. of centres	0.225	0.456**	0.086	0.392**	-0.145

* P < 0.05, ** P < 0.01

found in IC573779 (dark red, ovate) from Bastar, Chhattisgarh. Single centres with large concentric rings assume importance particularly when bulb types are meant for fresh consumption or processed as onion rings. Single centredness, a desirable character in onion improvement (Khar *et al*., 6), is also a trait that is associated with bulb firmness (Larsen *et al*., 7) and better storability. Twenty-five accessions were observed with single centres (Chhattisgarh – 18 and Maharashtra – 7) some of which include IC573729 (light red, ovate, Bastar), IC573743, IC573769 (dark red, globe, Bastar), IC573780 (light red, flat globe, Bastar), IC573794 (white, ovate, Gadchiroli) and IC573810 (white, thick flat, Chandrapur). These cultivars hold promise for possible utilization in breeding programmes. However, continuous selection is necessary to maintain single-centredness in bulbs, since, in the absence of selection cultivars tend to 'drift' away from this ideal.

A strong positive association was found between bulb weight and equatorial diameter ($r = 0.94$, $P < 0.001$) and polar diameter ($r = 0.81$, $P < 0.001$) (Table 3). The latter two also exhibit a positive relationship ($r = 0.77$, $P < 0.001$). The strong positive relationship of bulb weight with equatorial diameter and polar diameter suggests that bulb weight (Y) could be predicted from using equatorial (X1) and polar diameter (X2) as explanatory variables. A regression modeling of this relationship resulted in the prediction equation $Y = -78.90 + 2.081\ X1 + 0.801\ X2$ ($R^2 = 90\%$, RMSE = 6.50, $P < 0.001$). This finding is in agreement with earlier observations by Kamala *et al*. (4), and Trivedi *et al.* (13), who also reported high correlation of bulb weight with equatorial and polar diameter. As higher yields are associated with large bulbs with a diameter greater than 45 mm (Khar *et al*., 6), an assessment of equatorial and/or polar diameter in germplasm accessions could give a good estimate of the bulb weight and in turn the yield potential for selection of promising accessions for yield improvement. In the present syudy, accessions IC573822 (105 g) and IC573820 (91 g) both light red and thick flat, from Yavatmal had the largest bulbs with IC573774 (94.5 g, light red, globe) and IC573781 (93.5 g, dark red, flat globe) from Bastar, Chhattisgarh, following a close second. Some promising accessions for equatorial diameter include IC573735 (Bastar) and IC573822 (Yavatmal). However, these potentially useful collections need to be evaluated in different seasons and regions to establish their stability (Khar *et al*., 5; Prasad *et al*., 11).

The relationship of bulb weight with altitude is given in Fig. 1. The solid line provides an idea of how, on average, bulb weight is likely to vary as

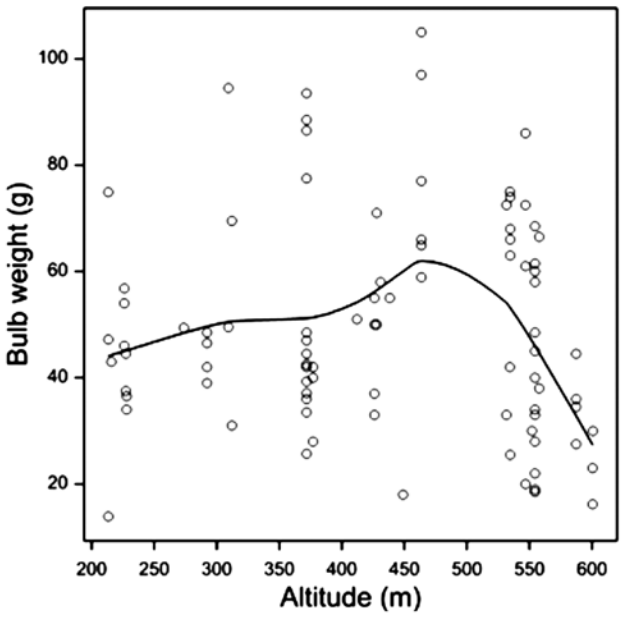

Fig. 1. Relationship of onion bulb weight with altitude.

altitude increases. While the four districts surveyed in Maharashtra do not raise onions traditionally as a commercial crop there appears to be potential for onion cultivation especially in Nanded, Chandrapur and Yavatmal from where collections with high bulb weight were sampled. This information may help in more objectively targeting future explorations for higher bulb weight at locations between these altitudes. MDS-based ordination analysis (Fig. 2) showed the 91 accessions loosely fall into three clusters, one cluster formed by the single accession IC573735 collected from Bastar, which while it had an equatorial diameter of >6 cm also had a neck thickness of 0.84 cm. The grouping of accessions in other two clusters did not reflect either separation based on the geographic region from which the collections were made, or any of the traits. These two clusters do not appear to be so well separated, suggesting presence of a nearly continuous variation among the genotypes for the traits. Similar results were reported by Mohanty (9) and Khar *et al*. (5). This is however, in contrast to the pattern obtained in an earlier study (Kamala *et al*., 4) where the collections from northern Telangana, Andhra Pradesh, a commercially growing onion region, were clearly differentiated based on bulb shape and colour. It is possible that in this tribal dominated region, since the bulbs are used mainly for their own consumption/ local market the selection pressures in operation are based on organoleptic, culinary and/or medicinal aspects, whereas in the earlier study they were driven by specific market requirements.

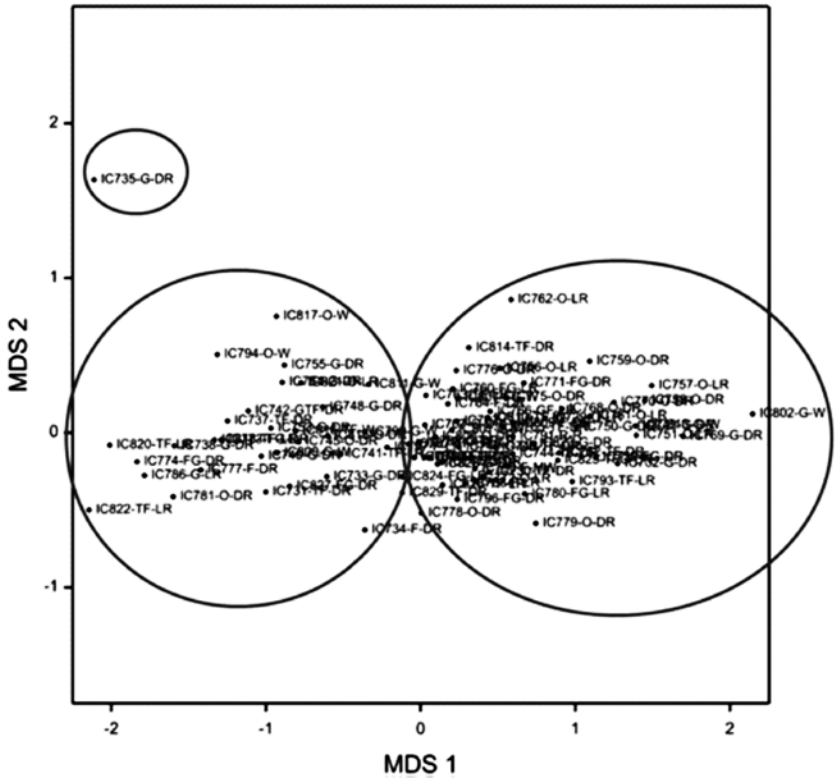

Fig. 2. Multi-dimensional scaling plot of 91 onion accessions from Chhattisgarh and Maharashtra.

Wide range of variation was observed for bulb characters of significance, *viz.,* bulb size, shape, colour, neck thickness, TSS and number of centres among the 91 collections of onion from parts of Chhattisgarh (Bastar plateau) and Maharashtra (central eastern Vidarbha region) in Peninsular India. They are valuable sources of genetic variation and several accessions have been identified for specific traits such as IC573735 (Bastar) and IC573822 (Yavatmal) for equatorial diameter, IC573752 (Bastar) for high TSS, IC573822 (Yavatmal) for bulb weight and IC573779 for the thinnest neck, that have potential to be included in breeding/ improvement programmes. Based on the diversity of the bulb traits and the passport information, Bastar (Lohandiguda, Narainpur, Bakawand) and Dantewada (Barsur and Gidam) districts of Chhattisgarh were highly diverse for equatorial/ polar diameter and neck thickness, while Gadchiroli, in the Vidarbha region of Maharashtra showed the maximum diversity for bulb shape and colour. These areas harbouring rich diversity for bulb traits may be further surveyed and may be developed into onion villages for on-farm *in-situ* conservation. In addition, keeping in view the multifarious uses of the crop and its commercial potential, such areas of diversity need to be harnessed to meet the dual objective of germplasm conservation and its commercial exploitation.

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