Morphological Characterization of *Allium* spp. Using Multivariate Analysis

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Thirty-five accessions of *Allium* species were characterized for foliage colour, density of leaves, foliage attitude, cross-section of leaf, degree of leaf waxiness, storage organ, bulb skin colour, shape of mature dry bulbs, ability to flower, seed coat colour, leaf length, leaf girth, number of leaves/plant and plant height. High level of variability was observed for bulb colour and shape of mature dry bulbs as they were distributed into maximum of six classes and least variability was observed for ability to flower. The significant differences were observed for all the measureable characters. In principal component analysis, first five components explained 74.53% of the total variation, where first component explained 22.92% and second accounted for 16.66% of total variation. In, PC-1 storage organ has highest positive contribution and shape of mature dry bulbs in PC-2. The different *Allium* species show extensive overlapping in PCA plot draw based on the morphological characters.

Key Words: *Allium*, Eigen value, PCA, species

Introduction

Allium is a large genus which is widely distributed in the Central Asia, North America and Indian Himalayan regions (Stearn, 1992; Negi and Pant, 1992). Several *Allium* species are grown by local tribes in wild or semi-domesticated forms in India. These species are utilized as vegetables, condiments and medicinal plants to fulfill their daily needs (Negi, 2006; Pandey *et al*., 2008).

About 40 *Allium* species are available in wild or semi-domesticated form in Himalayan region but not much attention was paid on their collection and characterization. To realize the full potential of available germplasm, explorations were made in Himalayan region and a number of *Allium* species was collected (Negi, 2006). Prior to utilization, the detailed knowledge of genetic, cytogenetic and agro-morphological characteristics of wild species is a pre-requisite. Among them, morphological characterization of germplasm is very useful for botanist, breeder and geneticist to assess genetic erosion, germplasm exploration, conservation and utilization strategies. In order to optimize better utilization of *Allium* germplasm this work was planned with objective of characterizing *Allium* germplasm based on morphological characters to identify major components of variation and grouping of various *Allium* species based on them. The goal was to identify the differences among the accessions and major variables which leads to the identification of possible groups and relationships among accessions.

Materials and Methods

Thirty-five accessions of different *Allium* species (Negi, 2006) were grown on the beds of 3' x 3' size during 2010-11 and 2011-12 in Randomized Block Design at Bhowali, Nainital, India (Table 1). The data were recorded following IBPGR descriptors (IBPGR, 2001) for foliage colour, density of leaves, foliage attitude, cross-section of leaf, degree of leaf waxiness, storage organ, bulb skin colour, shape of mature dry bulbs, ability to flower, seed coat colour, leaf length, leaf girth, number of leaves/plant and plant height. The data was analyzed to calculate mean and range values to estimate degree of variability for quantitative descriptors. Distribution analysis was performed to identify various classes to measure the extent of variability in qualitative descriptors. Principal component analysis (PCA) was performed to identify major variables by aggregation of variables. First and second principal component axes scores were plotted to aid visualization grouping pattern of *Allium* germplasm using SAS software package (NC, USA, 2008).

Results

Distribution Analysis

The distribution analysis for qualitative characters showed maximum number of classes for bulb skin colour and shape of mature dry bulbs (6) followed by cross-section of leaf (4) and storage organ (4). All accessions fall in one class for ability to flower, two for seed coat colour and three for foliage colour, density of leaves, foliage

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Table 1. *Allium* species used for morphological characterization

S. No.	Species	S. No.	Species
1.	*A. fistulosum*-EC321643	19.	*A. albidium*-EC328484
2.	*A. schoenoprasum*- EC328499	20.	*A. fistulosum*-NIC23426
3.	*A. altaicum* EC-328485	21.	*A. auriculatum*-IC353529
4.	*A. scorodoprasum*- EC328450	22.	*A. auriculatum*-IC353531
5.	*A. ledebouranum*-EC328491	23.	*A. carolinianum*-IC353527
6.	*A. oreoprasum*-EC328494	24.	*A. ascalonicum*-IC353531
7.	*A. oschaninii*-EC328495	25.	*A. proliferum*-NIRP/SSM 2799
8.	*A. tuberosum*-IC353524	26.	*A. proliferum*-NIRP/SSM 2801
9.	*A. pskemence*-EC328497	27.	*A. roylei*-IC353540
10.	*A. cernuum*-IC353525	28.	*A. hookeri*-HN 2800
11.	*A. scorodoprasum*-EC328501	29.	*A. griffithianum*-NIC94272
12.	*A. fistulosum*-NIC20231	30.	*A. angulosum*-EC328486
13.	*A. ramosum*-EC328498	31.	*A. carolinianum*-IC326228
14.	*A. obliqum*-EC328493	32.	*A. cernuum*-IC142272
15.	*A. ameloprasum*-IC353526	33.	*A. clarkei*-IC383446
16.	*A. fistulosum*-IC353541	34.	*A. chinense*-NAF 89/61
17.	*A. consanguineum*-IC212783	35.	*A. cepa*
18.	*A. senescens*- EC328503		

attitude and degree of leaf waxiness. In bulb colour, dark brown was predominant with 29.00% share and 37.00% of total accessions fall in broad elliptic bulb shape. The green foliage colour was observed in 42.00, medium density of leaves in 63.00, erect leaf habit in 71.00, flat cross-section in 46.00, medium degree of leaf waxiness in 71.00, bulb (single) as a storage organ in 54.00 and black seed coat colour in 80.00% of total accessions.

Variability

The leaf length ranged from 16.50 cm (*A. senescens,* EC328503) to 50.00 cm (*A. schoenoprasum,* EC328499) with mean of 31.79 cm, while, plant height varied from 19.00 cm (*A. senescens,* EC328503) to 56.93cm (*A. ledebouranum,* EC328491) with average of 38.94 cm. The leaf girth among different accession of *Allium* species varied between 0.27 cm (*A. roylei,* IC353540) to 2.20 cm (*A. carolinianum,* IC353527) with mean of 0.86 cm and number of leaves/plant from 3.80 (*A. fistulosum,* EC321643) to 10.00 (*Allium tuberosum,* EC353524) with average of 6.52 (data not given).

Principal Component Analysis

The first five components were identified as major based upon their eigen values and explained 74.53% of the total variation. The first component has 22.92% share in the total variation, where, storage organ (0.47229), seed coat colour (0.34583), number of leaves/plant (0.32225) and density of leaves (0.27640) contributed positively. While, plant height (-0.35551), leaf length (-0.34863), degree of leaf waxiness (-0.25985) and foliage colour (-0.25769) have negative effects. The second PC accounted for 16.66% of the total variation have positive contribution from foliage colour (0.37942), density of leaves (0.35470), cross-section of leaf (0.46021), bulb skin colour (32.824), shape of mature dry bulbs (0.48114) and number of leaves/plant (0.32161), while none of

Table 2. Contribution of each character towards principal components for various characters

Eigen Vectors	Prin1	Prin2	Prin3	Prin4	Prin5
Foliage colour	-0.25769	0.37942	-0.25744	0.18933	-0.16067
Density of leaves	0.27640	0.35470	0.31162	0.10971	-0.32072
Foliage attitude	-0.17924	0.01264	0.01285	0.67016	0.26520
Cross-section of leaf	0.11127	0.46021	-0.05836	-0.02237	0.33948
Degree of leaf waxiness	-0.25985	0.02794	-0.30364	0.07814	0.08503
Storage organ	0.47229	-0.17203	-0.02297	-0.05724	0.23898
Bulb skin colour	0.12957	0.32824	-0.09926	-0.15444	0.48774
Shape of mature dry bulbs	-0.06618	0.48114	-0.05419	-0.22129	0.16842
Ability to flower	-0.00000	0.00000	-0.00000	-0.00000	0.00000
Seed coat colour	0.34583	-0.20472	0.21541	0.11867	0.42194
Leaf length (cm)	-0.34863	0.03017	0.44897	-0.31748	0.13881
Leaf girth (cm)	-0.17139	0.03501	0.36096	0.48507	0.17542
Number of leaves/plant	0.32255	0.32161	0.34629	0.14120	-0.33193
Plant height (cm)	-0.35551	-0.03430	0.47890	-0.22403	0.12998
Eigen value	2.9803	2.1658	2.0937	1.2547	1.1948
% Variation explained	22.92	16.66	16.10	9.65	9.19
% Cumulative variance	22.92	39.58	55.69	65.34	74.53

Pl Note: Fig 1 and Table 2 refered

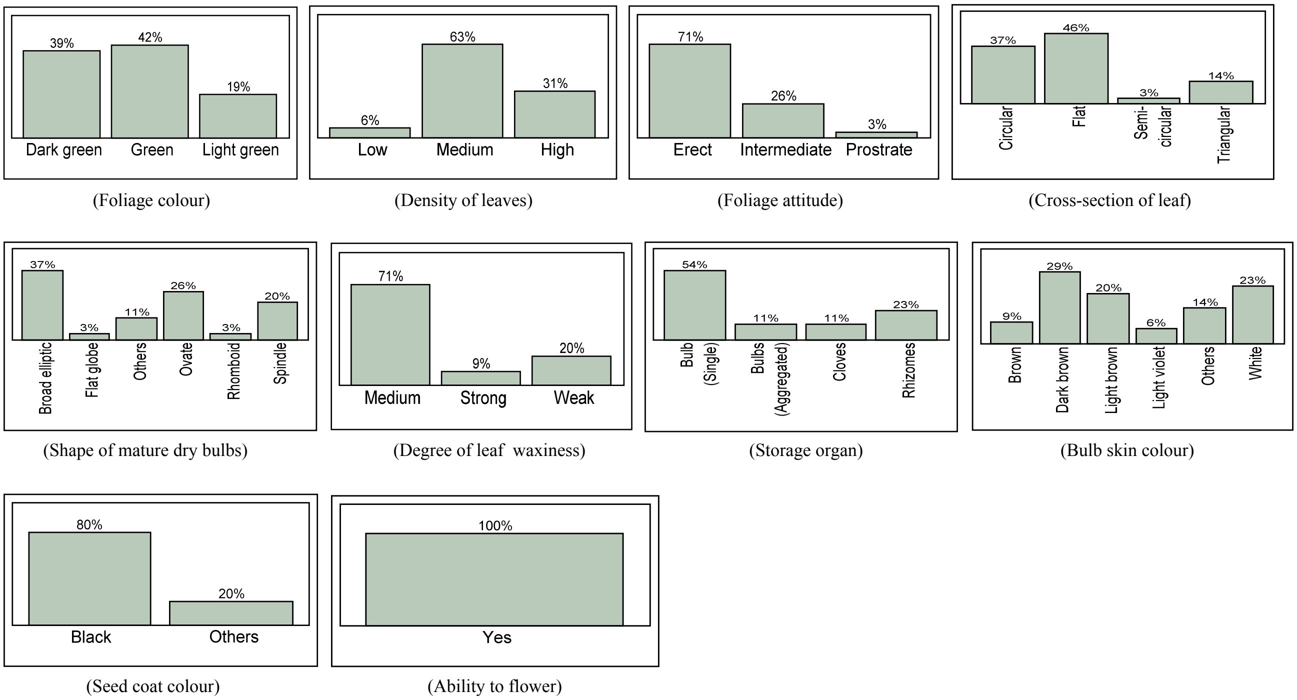

Fig. 1. Distribution analysis for different morphological characters in various *Allium* species

the characters gave significant negative effect. In PC 3, density of leaves (0.31162), leaf length (0.44897), leaf girth (0.36096), number of leaves/plant (0.34629) and plant height (0.47980) contribute positively with 16.10% of total variation. Whereas, PC 4 has foliage attitude (0.67016) and leaf girth (0.48507), while, PC 5 includes foliage attitude (0.26520), cross-section of leaf (0.33948), bulb skin colour (0.48774) and seed coat colour (0.42194) with 9.65 and 9.19% share of total variation, respectively.

Principal Component Analysis shows extensive overlapping of accessions of different *Allium* species in PCA plot (Fig. 2). The exotic accession *A. fistulosum*, EC 321643 (1) was quite different from *A. fistulosum*, IC 353541 (16) and *A. fistulosum*, NIC 23426 (20). Both accessions of *A. auriculatum* (21, 22) and *A. proliferum* (25,26) group together but differences existed within accessions. The genetic variability was also observed between *A. cernuum*, IC 353525 (10) and *A. cernuum*, IC 142272 (32). Four accessions *viz. A. fistulosum*, EC 321643 (1) *A. schoenoprasum*, EC 328499 (2) *A. scorodoprasum*, EC 328450 (4) and *A. chinense*, NAF 89/61 (34) are quite different from other *Allium* germplasm as they group apart in PCA plot (Fig. 2).

Discussion

Genetic variability was observed within and between various accessions of different *Allium* species. High level of variability was observed for bulb skin colour and shape of mature dry bulbs, whereas, differences were moderate for other traits, except ability to flower in different *Allium* species. These results were consistent with previous findings (Negi and Pant, 1992; Negi 2006; Verma *et al.*, 2008). It indicates that all qualitative characters are also crucial for the characterization of various alliums. The wide differences for all the quantitative characters were recorded in present investigation which was also supported by earlier observations (Verma *et al.*, 2008). In, PCA first five major components explained 74.53% of total variability, where storage organ and shape of mature dry bulbs were the major contributors in PC-1 and PC-2. Nearly similar results were reported in garlic where first four components explained about 80.00% of total variation and bulb related characters contributed significantly towards the total variability (Panthee *et al.*, 2006). The multiple accessions of *Allium* species show genetic variability within species and grouped together which indicates that selection can be followed for the improvement of other alliums used by local tribes in

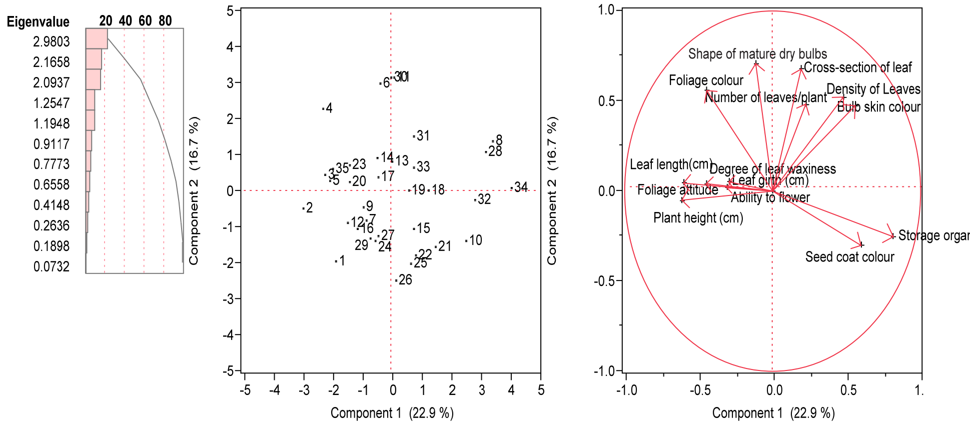

Fig. 2. Principal component analysis for different morphological characters in various *Allium* species (numbers indicate *Allium* species as mentioned in table in serial order)

India. The exotic bunching onion accessions are quite different from indigenous which was also detected at molecular level (Khosa, 2012).The overlapping of accessions based on morphological characters indicates that there is urgent need to use molecular markers to establish phylogenetic relationships.

From present investigation it was concluded that *Allium* species show complex morphological variability which must be conserved. At present *A. roylei is* regarded as endangered species in the red data list of IUCN even in its native habitat (Walter and Gillet, 1997). In coming years some more species might come under endangered list due to global warming, increase in habitat area and extensive use by local tribes. So, there is urgent need for the management of different *Allium* species in India. It seems necessary the accomplishment of new collections of botanical material of the wild species seeking the enlargement of the conserved variability as well as definition of preservation strategies to avoid losses of genetic variability. In nutshell, collaborative and multidisciplinary strategies for efficient management and utilization of *Allium* germplasm should be followed.

References

IBPGR (2001) Descriptors for *Allium* species. www.ipgri.cgiar.org.

Khosa JS (2012) Study on genetic divergence using morphological and simple sequence repeats markers in bulb onion (*Allium cepa* L.). MSc Thesis submitted to Punjab Agricultural University, Ludhiana.

Negi KS (2006) *Allium* species in Himalayas and their uses with special reference to Uttaranchal. *Ethnobot.* **18:** 53-66.

Negi KS and KC Pant (1992) Less-known wild species of *Allium* L. from mountain region of India. *Econ. Bot.* **46:** 112-114.

Pandey A, R Pandey, KS Negi and J Radhamani (2008) Realizing value of genetic resources of *Allium* in India. *Genet. Resour. Crop Evol.* **55:** 985-994.

Panthee DR, RB Kc, HN Regmi, PP Subedi, S Bhattarai and J Dhakal (2006). Diversity analysis of garlic (*Allium sativum* L.) germplasm available in Nepal based on morphological characters. *Genet. Resour. Crop Evol.* **53:** 205-212.

SAS Institute (2008) SAS user's guide: statistics. Version 9.1.3.ed. Cary.

Stearn WT (1992) How many species of *Allium* are known? *Kew Mag.* **9:** 180-182.

Verma VD, K Pradheep, A Khar, KS Negi, JC Rana (2008) Collection and characterization of *Allium* species from Himachal Pradesh. *Indian J. Plant. Genet. Resour.* **21:** 225-228.

Walters KS and HJ Gillet (1998) *1997 IUCN Red List of Threatened Plants*, Compiled by the World Conservation Monitoring Center.