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Evaluation of genetic diversity and chemical profile of ginger cultivars in north-western Himalayas

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ABSTRACT

Eighteen ginger cultivars from Northwest Himalayan region, showing significant differences in rhizome size, texture and pungency, were selected and characterized both by chemical and genetic analyses. The genetic analysis was undertaken utilizing molecular markers (ISSR and SSR) while chemical characterization was done through HPLC of four chemical markers (gingerol homologues and shogaol). The data revealed moderate to high diversity in the collection, clustering them broadly into two groups. Both ISSR and SSR techniques were efficient in distinguishing all the 18 ginger cultivars, however, SSR markers were observed to be better in displaying average polymorphism (77.8%) than ISSR (66.7%). Based on statistical analysis, one ISSR and two SSR primers could be identified which effectively distinguished closely related ginger cultivars. Chemical profiling and subsequent multivariate analysis distinguished five lines which were distinct from rest of the collection. The study has contributed in understanding the genetic and chemical diversity of the region, characterization of lines for commercial exploitation and ginger gene pool conservation.

1. Introduction

Zingiber officinale Roscoe. (Ginger) is an important horticultural crop valued for its aromatic and pungent rhizome all over the world. The rhizome is used as spice, food additive and herbal medicine since ancient times (Ravindran and Nirmal, 2005). It has carminative and stimulant effects on gastrointestinal tract, suppresses the central nervous system and inhibits prostaglandins formation. In traditional system of medicine, ginger rhizome is used as digestive aid and in rheumatism (Govindarajan, 1982) and also in ginger bread, biscuit, cakes, curries, pickles, flavoring beer and wines (Lawrence, 1984). Essential oil and oleoresins are the important quality parameter of ginger rhizome. Chemically, solvent extract of rhizome (oleoresin) is rich in gingerol homologues and shogaol whereas hydro-distilled essential oil constituents imparts different aroma and flavors to ginger, ranging from lemon-like to Camphor-type (Gupta et al., 2011).

Due to its wide distribution and broad range adaptability, ginger is grown in many subtropical and tropical regions of the world (Kress et al., 2002), main producers being India and China (Spice board, India). In India, the crop is grown in diverse agro-climate, varying from humid tropical condition of Kerala to cold sub-tropical and temperate Himalayas (Ravindran and

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Nirmal, 2005). Ginger produce from Kerala is of premium quality and contributes majorly to its export (Spice board, India). The herb from north eastern Himalayan region has unique flavor and pungency which has contributed to its recognition in the world market (Rahman et al., 2009). However, the north western Himalayan ginger has not been subjected to detailed molecular and chemical evaluation. Here, local farmers grow the crop based on their requirement which is well adapted in the prevailing climatic conditions. Most of these landraces survive on farms and are either locally named based on trait, or location of cultivation. They are the result of selection operated by farmers based on their judgment, over centuries. Since these cultivars are grown in marginal areas and pose a strong threat of erosion or extinction, they need to be conserved. As such, detailed information about the spatial organization of genetic variability of ginger, adapted for the climate and specific use, is essential for the conservation, utilization and improvement of the plant resource. Documented reports from other regions extend limited information of genetic diversity (Prem et al., 2008; Kavitha et al., 2010; Kizhakkayil and Sasikumar, 2010) of this widely grown vegetative crop. Studies done by Jatoi et al. (2006, 2008) using rice primer, however was successful in displaying very high inter- and intra-species polymorphism (71–99.5%) in Zingiberaceae.

Diversity characterization is a prerequisite for exploiting available genetic resources for plant improvement. Traditionally, genetic diversity assessment was restricted to morphological observations and progeny evaluation, but they had limitation of being plastic and environmentally-sensitive. During the past two decades, molecular markers have been successfully used, overcoming these limitations. In recent years molecular marker techniques have demonstrated their potential and wide range of applications in identifying genetic purity of germplasm stocks (Joshi et al., 2000), understanding genome organization, frequency and level of diversity in large and complex genomes (Blair et al., 1999), identifying genetic relationships (Tsumura et al., 1996), chromosome mapping (Giura and Saulescu, 1996), trait tagging and inheritance (Kelly et al., 2003) and molecular breeding (Gupta and Varshney, 2000). Literature survey revealed lack of information on the morphological, chemical and molecular characterization of ginger from North western Himalayan region. Systematic chemical and genetic diversity assessment studies on ginger population growing in North-west Himalayan region, will help in understanding diversity of the region, identifying lines for commercial exploitation and conservation of gene pool for breeding purposes.

The present study was carried out to assess molecular and chemical diversity in ginger rhizome collected from the North western Himalayan region and its comparison with collections from diverse areas.

2. Materials and method

2.1. Plant material

Fresh rhizomes of ginger (*Zingiber officinale Roscoe*) were collected from different parts of India (Table 1). Fourteen of these samples were from three North western Himalayan region-Jammu and Kashmir (32°43′N, 74°54′E), Himachal Pradesh (31°53′N, 76°88′E) and Uttar Pradesh (26°30′N, 80°58′E), and two each from coastal regions of Gujarat (22°27′N, 70°07′E) and Kerala (11°15′N, 75°49′E). Out of the18 samples investigated, 16 were collected directly from cultivation field of the farmers of

Table 1
Collection and chemical content profile (μg) of 18 ginger rhizomes (in triplicate with RSD) investigated in the study.

S. no.	State	Germplasm code	6G[a] (%RSD[h])	8G[b] (%RSD)	Shog[c] (%RSD)	10G[d] (%RSD)
1	J&K[e]	IMGJK 281	4.81 0.34	0.97 1.11	0.45 0.78	2.80 0.38
2	J&K	IMGJK 284	5.02 0.23	1.42 1.07	0.59 0.63	3.46 0.83
3	J&K	IMGJK 285	4.50 0.63	0.87 1.51	0.99 0.23	2.03 0.58
4	J&K	IMGJK 286	10.5 0.12	1.77 0.77	0.31 1.01	6.46 0.22
5	J&K	IMGJK 287	6.87 0.46	1.07 0.37	0.68 0.58	3.46 0.31
6	J&K	IMGJK 288	3.58 1.13	0.63 0.52	0.56 1.07	2.19 0.32
7	J&K	IMGJK 291	7.96 1.02	1.54 0.72	0.31 0.48	5.05 0.51
8	Gujarat	IMGGJ 289	4.02 0.57	0.78 0.89	0.68 0.29	2.17 0.43
9	Gujarat	IMGGJ 290	8.45 0.66	1.32 1.21	0.44 0.54	3.98 0.76
10	HP[f]	IMGHP 292	1.13 0.78	0.22 1.05	0.40 0.48	0.54 1.04
11	HP	IMGHP 293	1.88 1.03	0.35 1.42	0.60 0.97	0.99 1.21
12	HP	IMGHP 294	3.75 1.32	0.90 1.09	0.97 0.37	2.57 1.13
13	HP	IMGHP 297	4.41 1.02	0.78 0.42	0.69 0.28	2.36 0.49
14	HP	IMGHP 299	5.42 0.78	3.87 1.11	1.40 0.63	1.52 0.52
15	HP	IMGHP 300	2.19 0.35	1.27 0.76	0.88 0.55	0.72 0.63
16	Kerala	IMGKL 310	2.32 0.61	1.77 0.49	0.55 0.39	0.64 0.87
17	Kerala	IMGHP 313	4.69 0.33	1.95 0.89	1.38 0.43	1.44 0.73
18	UP[g]	IMGUP317	2.02 0.69	1.53 0.72	0.99 0.67	0.56 1.31

[a] 6 gingerol.
[b] 8 gingerol.
[c] 10 gingerol.
[d] Shogaol.
[e] Jammu and Kashmir.
[f] Himachal Pradesh.
[g] Uttar Pradesh.
[h] Relative standard deviation.