Genetic resources of ginger (*Zingiber officinale* Rosc.) and its conservation in India

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Summary
Ginger (*Zingiber officinale* Rosc.) is believed to have originated in southeast Asia and now occurs only under cultivation. India is one of the world's leading ginger-producing countries. Ginger is also grown in almost all tropical countries (southern China, Taiwan, Philippines, Sierra Leone, Jamaica, Nigeria, Indonesia, Malaysia). Many landraces and improved cultivars of ginger which excel in yield and one or more quality traits are available in India. Considerable variability for yield and yield-contributing traits are found in India's ginger germplasm. Geographical spread accompanied by genetic differentiation and divergence into locally adapted populations might have been responsible for the variation encountered in this clonally propagated crop. A germplasm conservatory with 475 accessions of ginger and 988 accessions of related taxa is maintained at NRCS, Calicut.

Introduction
Ginger (*Zingiber officinale* Rosc.) is a rhizomatous herbaceous perennial, the underground rhizome of which is the source of an important spice. The ginger of commerce is the dried rhizome. Ginger is commonly used all over the world, especially in China where it forms an essential ingredient in most dishes. Ginger is used widely in the preparation of soft drinks and beverages such as gingerale, ginger beer, ginger tea, ginger wine, bitters, cordials and liquors, and in candies, pickles, sauces, preserves and bakery products. New products such as vitaminized effervescent ginger powders are now common. Ginger forms a major ingredient in the traditional medicine of India. Ginger oil is used in pharmaceutical preparations as a carminative, rubefacient and stimulant for alcoholic gastritis, dyspepsia, flatulent colic, etc. It is also prescribed as an adjunct to many tonics and stimulating remedies, and is used in veterinary medicine, in cases of indigestion in horses and cattle, in spasmodic colic of horses and to prevent the griping by purgatives. Related species, *Z. zerumbet* and *Z. casumunnar*, are employed as a hot remedy for coughs, asthma, worms and in skin diseases (Kirtikar and Basu 1984). Ginger also is used in certain toiletry articles.

The centre of origin of ginger is not clearly known, although it is believed to have originated in southeast Asia (Bailey 1949, Parry 1969). From there, ginger might have spread to south Asia which is now the predominant ginger-growing region.

Maximum variability for cultivated ginger exists in the northeastern region of India. Ginger was introduced into Europe in the 9th century AD (Lawrence 1984) and was brought to the Mediterranean region from India by traders during the 13th century. Purseglove *et al.* (1981) reported that ginger was known in Europe by the 1st century, in Germany and France during the 9th century and in England in the 10th century.

Zingiber is included in the tribe Hedychieae of Zingiberaceae, and in the series Zingibereae, which contains only one genus, *Zingiber* (Mabberley 1987). The genus *Zingiber* was divided into four sections by Baker (1880) and the cultivated ginger *Z. officinale* is included in Section II, Lampuzium. Baker (1880) described a total of 24 species of *Zingiber* from the Indo-Malayan region, while Gamble (1925) reported seven species from south India including *Z. officinale*.

Ginger was first described by Van Rheede in 1692 in his 'Hortus Indicus Malabaricus' the first printed document on the plants of the western coast (Malabar coast) of India. In 1807 Roscoe described *Z. officinale* from a plant in the botanical garden at Liverpool and referred to it as *Amomum zingiber* Wild (Sp.pl.1.P6). Linnaeus' *Amomum zingiber* is the basionym of the species. The genus *Amomum* of Linnaeus is a nomenclatural synonym of the conserved generic name *Zingiber* Boehm, so the correct name of ginger is *Zingiber officinale* Roscoe.

At present, ginger is cultivated in India, China, Taiwan, Philippines, Sierra Leone, Jamaica, Fiji and Nigeria on a commercial scale. India produces about 1 485 200 tonnes of ginger annually from an estimated area of 53 300 hectares. India's export of ginger during 1991-92 was 1 560 000 tonnes (Peter 1994). Ginger is grown in almost all the states; Kerala leads in area and production.

Many ginger cultivars, mainly identified by their locality of cultivation/collection, are prevalent in India. Many of these cultivars are confined to particular tracts only and are seldom known outside that area. These local races are facing the threat of extinction for many reasons, the most important being the rhizome rot caused by *Pythium* spp. and the bacterial wilt caused by *Pseudomonas*

solanacearum Smith (bv-4). These diseases make ginger cultivation difficult in many areas. The spread of a few high-yielding and exotic varieties is also posing a threat to many of the landraces.

In order to preserve the genetic resources of ginger in India, the National Research Centre for Spices (NRCS), Kozhikode, has been collecting ginger germplasm, both cultivated and wild, directly by undertaking expeditions to forests and different states in the country and indirectly through research/development/extension agencies of different places/states. Some exotic germplasm was also obtained either from abroad or from some secondary sources in the country.

Materials and Methods

NRCS has collected 361 accessions of ginger germplasm comprising landraces, improved cultivars, mutants, polyploids, wild species and exotic material from different places within and outside the country. These collections are being maintained at the research farm of the NRCS at Peruvannamuzhi. A status chart of the ginger germplasm is given in Table 1. All material (barring the wild species) was evaluated or is being evaluated in replicated trials in cement pots (45 x 45 cm), for the purpose of characterization and maintenance. The characterization of about 100 ginger germplasm accessions was made on the basis of data collected on various morphological, yield and quality parameters.

The morphological characters studied include plant height, leaf number, tiller number, leaf length, leaf width, days to maturity, dry recovery and rhizome yield. Among these characters plant height and tiller number are known to have a high correlation with yield (Ratnambal *et al.* 1982).

Quality in ginger is determined by the taste (pungency), flavour and aroma. The pungent taste is due to the presence of gingerol and shogaol. Gingerol is a mixture of different homologues of 1-(4-hydroxy3-methoxyphenyl)5-hydroxyalkane 3-ones. During storage, gingerol can become converted into compounds such as shogaol, zingerone, (6)-paradol and vanillylamide. The aroma and flavour are contributed by volatile oil, which contains over 60 components, the most important being alpha and beta-zingiberene, beta-sesquihellandrene, ar-curcumene, farnesene and sesquiterpene alcohols. Ar-curcumene is a secondary product formed from zingiberene and beta-phellandrene (Sankarikutty *et al.* 1982). The ratio of zingiberene + beta-sesquiphellandrene to ar-curcumene is indicative of the age of the oil (Salzer 1977, Govindarajan 1982).

The taste and flavour components are together extracted as oleoresin. This is done by cold extraction with acetone (Govindarajan 1982). Gingerol and shogaol contents are determined from ginger oleoresin by the method of Ananthakrishnan and Govindarajan (1974) using vanillin as standard.

Results and Discussion

The accessions are classified according to the source of collection and category (Table 1). Ginger germplasm available at other centres in India is listed in Table 2. The wild species are collected mainly from the Western Ghat forests bordering Kerala State whereas the landraces are collected through specific expeditions conducted for the purpose. The polyploid cultivars, produced by colchicine treatment, are obtained from the Department of Botany, University of Kerala, Kariavattom. Induced polyploidy was tried with the aim of breaking the sterility barrier and also for testing the usefulness of polyploidy in crop improvement.

Table 1. Materials and accessions of ginger (*Zingiber officinale*) and related taxa maintained at the National Repository of Ginger Germplasm at NRCS

Types of materials/species	No. of accessions
Cultivars	
Landraces - Exotic	10
Landraces - Indigenous	391
Improved cultivars	54
Mutants	18
Tetraploids	2
Related taxa	
Costus	1
Zingiber spp.	42
Amomum spp.	3
Alpinia spp.	2
Kaempferia spp.	3
Hedychium spp.	2
Curcuma spp. (including accessions of *C. longa*, turmeric)	682
Elettaria cardamomum (cardamom)	253

Considerable variability was observed for most of the yield and quality traits (Table 3). Tiller number per plant had the highest variability followed by rhizome yield per plant. Among the quality traits, shogaol content recorded the highest variability, followed by crude fibre and oleoresin. Moderate variability was observed for all other traits studied. None of the cultivars possessed resistance to the causal organism of leaf spot disease, *Phyllostica zingiberi*.

Yield superiority of accessions Rio-de-Janeiro, Thingpui, Nadia, Karakkal, Maran, Suprabha and Suruchi was reported by several workers (Muralidharan and Sakunthala 1974, Nybe *et al.* 1982, Sreekumar *et al.* 1982, Mohanty *et al.* 1990, Sasikumar *et al.* 1994). High dry recovery of cultivars like Zahirabad, Jorhat local, Maran, Kuruppampadi local, Ernad Chernad, Thingpui, China and Assam was established by many workers (Mohanty *et al.* 1990, Zachariah *et al.* 1993, Sasikumar *et al.* 1994). Cultivars like Zahirabad, Kuruppampadi local, Mizo, PGS-16, Nadia, Poona and Jamaica are low in fibre content

whereas Waynad Kunnamangalam, Ambalavayalan, Ernad Chernad, Santhingpui, Rio-de-Janeiro, PGS-59, Himachal Pradesh and China are rich in oleoresin content (Sreekumar *et al.* 1982, Zachariah *et al.* 1993). However, quality traits in ginger such as dry recovery, oleoresin and fibre content are observed to vary with the soil type, cultural conditions and climates. Mohanty *et al.* (1990) reported cvs. Maran, Anamika, HP, Burdwan 1 and Poona as less susceptible to soft rot and Maran less susceptible to *Phyllostica* leaf spot disease. In an evaluation of 33 accessions of ginger, including 4 exotic types, none was found tolerant to rhizome rot disease (Sharma *et al.* 1979).

Cytological studies reported so far by different workers indicate the uniform somatic chromosome number of 2n = 22 in the genus (Raghavan and Venkatasubban 1943, Sharma and Bhattacharyya 1959, Sato 1960, Ramachandran 1969, Omanakumari and Mathew 1985). The evidence shows that *Zingiber* is a monobasic genus with x = 11; and probably has arisen from a protokaryotype of four chromosomes (Sato 1960). Intraspecific karyotype variability was reported by Ratnambal (1979), who also indicated an asymmetric karyotype for the genus. Cultivated ginger does not set seed. The cause of the sterility is not clearly understood.

Quality analysis - based on ginger oleoresin, gingerol and shogaol - revealed the genetic variability for these characters in the germplasm (Table 3). It may be noted here that the standard specifications recommend a minimum of 18% gingerol for good quality oleoresin of ginger. During long storage, gingerol undergoes conversion to shogaol and the pungency also decreases in the order gingerol→shogaol→zingerone. On the basis of oleoresin, gingerol and shogaol contents, the cultivars were classified into three quality categories: low, medium and high (Zachariah *et al.* 1993).

The geographical spread of crops to new places is one of the dominant processes in the history of agriculture, indeed in the history of humankind. In many cases the major production centres are far from the areas of origin of the crop concerned (Simmonds 1979). This seems to be not true of ginger ~~as well~~. The Indo-Malayan region is very rich in Zingiberaceous flora (Holttum 1950) and is a major centre of genetic diversity. Considering the present distribution of genetic variability it is only logical to assume that the Indo-Malayan region is probably the major centre of genetic diversity for ginger. The maximum variability is now encountered in the northeastern region of India. It may be inferred that geographical spread accompanied by genetic differentiation into locally adapted populations caused by mutations could be the main factor responsible for variations encountered in cultivated ginger. The early movement of the settlers across the length and breadth of Kerala State, where maximum ginger cultivation is found, and the story of shifting cultivation ('jhum') in northeastern India are well-documented sociological events. The farmers invariably carried small samples of the common crops they grew in their original place along with them and domesticated the same in their new habitat, in most cases virgin forest lands. Conscious selection by man for different needs such as high fresh ginger yield, good dry recovery and less fibre content over years has augmented the speed of differentiation in this crop. This would have ultimately resulted in the landraces of today.

Table 2. Ginger germplasm maintenance at other centres in India

Location	No. of accessions
High Altitude Research Station, Pottangi, Orissa	140
Dept. of Vegetable Crops. Y.S. Parmer Univ. of Forestry & Horticulture, Solan, H.P	152
NBPGR Regional Station, Trichur	149

Table 3. Mean, range and coefficient of variation (CV) for yield, yield attributes and quality traits in ginger germplasm

Character	Mean	Range	CV (%)
Plant height	59.20	23.13 - 88.60	19.00
Leaf number/plant	37.14	17.00 - 52.00	18.17
Tiller number/plant	16.81	2.75 - 35.50	45.92
Leaf length	23.79	17.01 - 36.50	10.90
Leaf width	2.65	1.95 - 3.75	10.82
Days to maturity	225.92	214.00 - 235.50	13.53
Dry recovery	21.70	14.00 - 28.50	14.30
Rhizome yield/plant	363.12	55.00 - 770.00	39.33
Crude fibre	4.31	2.10 - 7.00	23.34
Oleoresin	6.12	3.20 - 9.50	21.70
Gingerol	19.95	14.00 - 27.00	15.16
Shogaol	4.12	2.70 - 7.50	24.35

Problems in conservation

The major constraints in the conservation of germplasm - and also for its cultivation - are the two soil-borne diseases, namely the rhizome rot caused by *Pythium* spp. (*P. aphanidermatum*, *P. myriotylum* and *P. vexens*) and the bacterial wilt caused by *Pseudomonas solanacearum* (bv.4). These diseases are extremely difficult to control or prevent under field conditions. Once they make their appearance in a field, they spread rapidly and the entire crop will be killed in no time. So at NRCS the ginger germplasm is maintained in specially made cement tubs.

Screening of ginger germplasm for locating tolerance or resistance did not yield any result. Production of somaclones and their screening under *in vitro* and nursery situations are in progress at NRCS.

At NRCS an *in vitro* genebank has started functioning recently. Here we aim at conserving the germplasm of ginger under *in vitro* conditions for medium-term storage. We have also initiated work on cryopreservation for long-term conservation of germplasm. All the existing

germplasm will be deposited in the *in vitro* genebank by the end of 1995.

Crop improvement work in ginger has been very slow owing to the totally sterile nature of the plant. Only three improved clonally selected lines have been available until now. At NRCS efforts are in full swing for developing high-yielding, disease-resistant and high-quality lines.

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