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*Short Communication*

# Multivariate analysis of ginger (*Zingiber officinale* Rosc.) germplasm of North Eastern India

**A. Kumar, C. Kapoor*, H. Rahman[1], R. Karuppaiyan[2], S. Rai and R. Denzogpa**

ICAR-Research Complex for NEH Region, Sikkim Centre, Tadong Gangtok 737 102; [1]National Institute of Veterinary Epidemiology and Disease Informatics, Hebbal Main Road, Bengaluru; [2]Sugarcane Breeding Institute, Regional Centre, Karnal 132 001

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**Abstract**

**Eighty two ginger (*Zigiber officinale* Roc.) accessions collected from North-Eastern region of India were subjected to study genetic diversity considering 12 quantitative and 7 qualitative characters using multivariate analysis. Considerable variation was recorded among ginger accessions for all the morphological traits studied. Yield showed significant but not of high degree correlation with eight characters studied. Most of the qualitative characters were found to be non-significantly correlated among themselves and with quantitative characters. Principal component analysis based on different characteristics grouped the germplasm into eight clusters. Seven cultivars found to yield consistently well under organic conditions. Considerable variation was observed among the clones related to internal colour of rhizome and pungency.**

**Key words:** Genetic diversity, ginger, germplasm, multivariate analysis

Ginger is an important commercial crop belonging to family *Zingiberaceae* grown for its aromatic rhizomes which are used both as spice and medicine. The North Eastern states have a sizeable share in ginger production in India as around 40% of ginger comes from Assam, Meghalaya, Mizoram, Sikkim and Arunachal Pradesh (www.spicesindia.com). Realizing the potential of ginger crop in the region, studying diversity in ginger germplasm is most important for documentation of ginger clones of different regions and classifying them according to the quantitative and qualitative characters for utilization in crop improvement through clonal selection. A considerable genetic diversity in ginger has been reported (Sanjeev et al. 2011) from the north-eastern states in India. The present study reports the patterns of germplasm variation for different morphological characteristics using multivariate statistical methods.

Eighty two ginger clones were collected from all the north-eastern states (Table 1). The collected rhizomes were planted in field during April, 2009 and 2010 in RBD replicated thrice at research farm of ICAR Research Complex for NEH Region, Sikkim centre situated at an altitude of 1320 m amsl. Data were recorded on twelve quantitative and seven qualitative characters namely, plant height (cm) at the end of the growing phase (PH), shoot height (cm) at the end of the growing phase (SH), shoot diameter (cm) at the end of the growing phase (SD), leaf length (cm) at full expansion of leaves achieved (LL), leaf width (cm) at full expansion of leaves achieved (LW), number of leaves on main shoot at full expansion of leaves achieved (NL), rhizome length (cm) at the time of harvest (RL), rhizome width (cm) at the time of harvest (RW), internode length (cm) at the end of the growing phase (IL), primary rhizome length (cm) at the time of harvest (PRL), primary rhizome diameter (cm) at the time of harvest (PRD), rhizome yield (q)/ hectare at the time of harvest (Y), leaf color (LC) [1. Light green (LG), 2. Dark green (DG)], Shoot Intensity of green color (SIGC) [1. Light green (LG), 2. Dark green (DG)], Rhizome shape (RS) [1. Straight (ST), 2. Curved (C), 3. Zigzag (Z)], Scale color (SC) [1. Light brown (LB),

*Corresponding author's e-mail: chandannaarm@gmail.com
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**Table 1.** A list of ginger germplasm and source of collections from north-east India

| S.No. | State | Germplasm lines |
|---|---|---|
| 1 | Arunachal Pradesh | ARG-1, ARG-2, ARG-3, ARG-4, ARG-5, ARG-6 and ARG-7 |
| 2 | Assam | ASG-1, ASG-2, ASG-3, ASG-4, ASG-5, ASG-6, ASG-7, ASG-10, ASG-11, ASG-12, ASG-13, ASG-15, ASG-17, ASG-18, ASG-19, ASG-20, ASG-21, ASG-22, ASG-23, ASG-24 and Nadia |
| 3 | Manipur | MNG-1, MNG-3, MNG-4, MNG-5, MNG-6, MNG-11, MNG-15, MNG-17, MNG-20, MNG-21, MNG-23, MNG-27 and MNG-29 |
| 4 | Meghalaya | MLG-1, MLG-2, MLG-3, MLG-4, MLG-5, MLG-6 and MLG-7 |
| 5 | Mizoram | MZG-1, MZG-2, MZG-3, MZG-4, MZG-5, MZG-6 and MZG-7 |
| 6 | Nagaland | NLG-1, NLG-2, NLG-3, NLG-4, NLG-5, NLG-6 and NLG-7 |
| 7 | Sikkim | SKMG-1, SKMG-2, SKMG-3, SKMG-4, SKMG-5, SKMG-6, SKMG-7, SKMG-8, SKMG-9, SKMG-10, SKMG-11, SKMG-14 and SKMG-15, |
| 8 | Tripura | TRG-1, TRG-2, TRG-3, TRG-4, TRG-5, TRG-6 and TRG-7 |

2. Dark brown (DB), 3. Dark brown with purple tinge (PT), Dark brown with Rosseting (R)], Internal color of rhizome(ICR) [1. Bluish yellow (BY), 2. Lemon yellow (LY), 3. Cream Yellow (CY), 4. Yellow (Y), 5. Bluish yellow with blue ring (BY, BR), 6. Light yellow with blue ring(LY, BR), 7. Yellow with blue ring (Y,BR), 8. Cream yellow with purplish tinge (CY, PT), 9. Cream yellow with yellowish ring (CY, YR) and 10. Yellow with yellowish ring (Y, YR) and Yellow with blue ring (Y, BR), External color of rhizome (EC) [1. Light brown (LB), 2. Dark brown (DB)] and Pungency (P) [1-3. Low, 4-5. Medium and 6-9. High].

The data were subjected to analyses to perform Pearson correlation coefficient, clustering of genotypes in to similarity groups using average linkage method and principal component analysis (PCA) and to determine the patterns of morphological variation. Data processing was performed using statistical software SAS 9.3 (Anon 2012). Combined analysis of variance revealed significant variation for all the twelve quantitative characters studied and considerable variation in qualitative characters. Greater plant height and shoot height were recorded in ASG-21(74.90 cm) and ASG-3 (71.05 cm), respectively. Ginger accessions from Assam had the highest mean plant height (58.56 cm) while shortest was recorded in the accession from Mizoram (44.41 cm). Leaf length varied from 26.30 cm in SKMG-1 to 15.70 cm in MZG-3. Highest mean rhizome length was recorded in the accessions (17.56cm) from Arunachal, while lowest among the collections from Mizoram (12.62cm). Wide differences were observed in case of yield, ranging from lowest of 5.0q/ha in MNG-4 to highest in SKMG-3 (590q/ha). Genotypes, namely, ARG-1, ARG-3, ASG-3, ASG-7, SKMG-2, SKMG-3 and SKMG-9 gave

**Table 2.** Correlation analysis of 12 quantitative characters in ginger germplasm

| Trait | PH | SH | LL | LW | NL | SD | RL | RW | IL | PRL | PRD | Y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PH | 1.00 | **0.94** | **0.63** | **0.37** | **0.67** | **0.44** | **0.22** | 0.11 | 0.13 | 0.10 | **0.18** | **0.29** |
| SH | | 1.00 | **0.61** | **0.35** | **0.69** | **0.41** | **0.18** | 0.06 | 0.11 | 0.06 | 0.13 | **0.28** |
| LL | | | 1.00 | **0.57** | **0.51** | **0.49** | **0.26** | **0.38** | 0.12 | **0.20** | **0.29** | 0.15 |
| LW | | | | 1.00 | **0.27** | **0.35** | **0.31** | **0.28** | 0.09 | **0.21** | **0.33** | **0.28** |
| NL | | | | | 1.00 | **0.44** | **0.19** | 0.14 | 0.06 | 0.10 | 0.17 | **0.25** |
| SD | | | | | | 1.00 | 0.27 | 0.33 | 0.14 | **0.20** | **0.31** | **0.19** |
| RL | | | | | | | 1.00 | **0.48** | **0.42** | **0.73** | **0.53** | **0.47** |
| RW | | | | | | | | 1.00 | 0.12 | **0.51** | **0.45** | **0.41** |
| IL | | | | | | | | | 1.00 | **0.41** | **0.27** | 0.13 |
| PRL | | | | | | | | | | 1.00 | **0.55** | **0.40** |
| PRD | | | | | | | | | | | 1.00 | 0.41 |
| Y | | | | | | | | | | | | 1.00 |

*Bold figure means significant at 5% level of significance

considerably high rhizome yield as compared to other accessions.

As expected, rhizome yield showed significant correlation with rhizome length, rhizome width, primary rhizome length, plant height, shoot height and leaf width (Table 2). Significant positive correlation with length of primary finger, plant height, number of primary fingers and diameter of primary finger has been reported earlier (Ravishanker et al. 2014). The traits *viz*., plant height, leaves/tiller and tiller thickness directly influences the rhizome yield (Jatoi and Watanabe 2013). Realizing the handicaps in ginger breeding, selection of traits such as rhizome length, width and primary rhizome dimensions can be useful for identifying high yielding clones from ginger germplasm. Apart from these characters, plant height, shoot height and leaf width had positive associations with rhizome yield. The first three principal component analysis explained around 70% of the variability in the ginger germplasm. Variables with higher scores on PC1 were plant height, leaf length and shoot height, while in PC2 primary rhizome length while in PC3 inter-nodal length and rhizome width were the major contributors. Plant height, shoot height, rhizome length, rhizome width and inter-nodal length were the major contributors to the variation recorded in the germplasm. The cumulative variance contributed by the first three PCs exhibited great influence on the phenotype of the ginger accessions and could effectively be used for selection among them. Momina et al. (2011) reported first six principal components explaining 77% of the total variation in ginger germplasm. The first principal component was the average effects of the trait, such as leaf length, leaf area, plant height, rhizome width, dry rhizome yield and days to maturity. The first three principal components used for cluster analysis divided 82 ginger clones in to nine clusters. Wide range was recorded in mean values among different traits *viz*., plant height (42.60-68.32 cm), shoot length (30.04-60.19 cm), leaf length (18.43-24.38 cm), leaf width (2.08-2.71 cm), number of leaves (11.67-21.43 cm), shoot diameter (2.14-3.50 cm), rhizome length (10.19-21.72 cm), rhizome width (3.26-7.89 cm), inter-nodal length (0.97-1.79 cm), primary rhizome length (6.90-12.40 cm), primary rhizome diameter (1.85-4.15 cm) and rhizome yield (6.0-814 q/ha). Maximum accessions grouped in cluster III (18) followed by cluster V (16), cluster II (12), cluster 1 (11), cluster IX (6), cluster IV, VI and VIII having 5 clones each and cluster VII (4) (Fig. 1). The ginger accessions form Northeastern India clustered irrespective of their geographical origin. So far this is the first study on genetic diversity of ginger germplasm of north-east India using morphological traits. More studies on germplasm exploration and germplasm characterization using molecular markers are needed to have in depth analysis of the population structure of these highly potential and economic genetic resources.

**Eigenvalues**

| Number | Eigenvalue | Percent | 20 40 60 80 | Cum Percent | ChiSquare | DF | Prob>ChiSq |
|---|---|---|---|---|---|---|---|
| 1 | 5.5835 | 46.530 | | 46.530 | 645.890 | 77.000 | <.0001* |
| 2 | 1.7361 | 14.468 | | 60.997 | 304.920 | 65.000 | <.0001* |
| 3 | 1.0558 | 8.799 | | 69.796 | 214.916 | 54.000 | <.0001* |
| 4 | 0.8122 | 6.769 | | 76.564 | 171.252 | 44.000 | <.0001* |
| 5 | 0.6396 | 5.330 | | 81.894 | 139.986 | 35.000 | <.0001* |
| 6 | 0.4917 | 4.097 | | 85.992 | 117.877 | 27.000 | <.0001* |
| 7 | 0.4369 | 3.641 | | 89.633 | 105.362 | 20.000 | <.0001* |
| 8 | 0.4027 | 3.356 | | 92.989 | 93.293 | 14.000 | <.0001* |
| 9 | 0.3451 | 2.876 | | 95.864 | 77.869 | 9.000 | <.0001* |
| 10 | 0.2479 | 2.066 | | 97.930 | 59.598 | 5.000 | <.0001* |
| 11 | 0.2059 | 1.716 | | 99.646 | 45.916 | 2.000 | <.0001* |
| 12 | 0.0425 | 0.354 | | 100.000 | 0.000 | 0.000 | . |

**Fig. 1. Eigen value of correlation matrix**

## References


Anonymous. 2012. SAS 9.3, Copyright © 2012, SAS Institute Inc., Cary, NC, USA.

Jatoi S. A. and Watanabe K. N. 2013. Diversity analysis and relationships among ginger landraces. Pak. J. Bot., **45**: 1203-1214.

Momina A., Alamerew S., Michael G. and Tesfaye A. 2011. Variability of ginger accessions (*Zingiber officinale* Rosc.) accessions for morphological and some quality traits in Ethiopia. International J. Agri. Res., **6**: 444-457.

Ravishanker, Kumar S., Chatterjee A., Baranwal D. K. and Solankey S. S. 2014. Genetic variability for yield and quality traits in ginger (*Zingiber officinale* Rosc.). The Bioscan, **8**: 1383-1386.

Sanjeev S., Roy A. R., Langrai B., Pattanayak A. and Deka B. C. 2011. Genetic diversity analysis in the traditional and improved ginger (*Zingiber officinale* Rosc.) clones cultivated in North-East India. Scientia Horticulturae, **128**: 182-188.