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Diversity Analysis in Tamarind Germplasm and Their Geo-Referencing Using DIVA-GIS

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Abstract

Tamarind (*Tamarindus indica*), an important leguminous tree was studied for its distribution pattern and diversity using DIVA-GIS software. The experimental material comprised of 47 tamarind germplasm, which were collected and maintained in the field gene bank at ICAR-NBPGR, Regional Station, Ranchi. The germplasm was evaluated for different quantitative traits *viz.* fruit length, fruit width, beak length, number of ridges per fruit, number of furrows per fruit, fruit weight, epicarp weight, number of seeds per fruit, number of fibres per fruit, number of fruits per tree and fruit yield per tree. It was observed that the tamarind germplasm exhibited wide range of varaiability for these characters. DIVA-GIS software was used for studying the spatial distribution and richness of these tamarind germplasm. Grid maps were generated for analyzing diversity among the germplasm for economically important characters *viz.* fruit length, fruit weight, number of seeds per fruit and number of fruits per tree. The high diversity for fruit length was observed in the collections made from Ranchi followed by East Singhbum districts of Jharkhand. The highest diversity index for fruit weight was recorded in the collections from central part of Ranchi followed by East Singhbum. The germplasm accessions collected from different parts of Ranchi had high diversity index for the characters *viz.* number of fruits per plant and number of seeds per fruit. This indicates that tamarind germplasm with high diversity in fruit length, fruit weight, number of fruits per tree and numbers of seeds per fruit can be collected from Ranchi and East Singhbum districts of Jharkhand. Thus, these areas should be considered for future exploration programmes to capture maximum diversity for these characters.

Key words: *Tamarind, exploration, diversity, DIVA-GIS, diversity index.*

Introduction

Tamarind (*Tamarindus indica* L.) is a tropical evergreen tree belonging to the family Fabaceae. It is a diploid species with somatic chromosome number 2n=26 (Purseglove, 1987). Tamarind is an important horticultural crop with multipurpose use. The fruits are the main acidulant used in preparation of foods in India and other Asian countries (Shankaracharya 1998). The tamarind fruit pulp is the richest natural source of tartaric acid (8–18%) and is used as flavoring agent in soups, jams, chutneys, sauces and juices (Isholoa *et al.* 1990). The leaves, bark and pulp have extensively been used in ethnobotany (Gupta *et al.*, 2014). It posses great medicinal application as a natural antioxidant. It also plays a significant role in the cosmetics, paints and varnishes industries (Santos *et al.*, 2012).

Tamarind is native to tropical and subtropical regions of Africa and South Asia (Doughari, 2006). The tamarind is facing the threat of genetic erosion, thus the valuable germplasm of tamarind has to be collected and conserved for utilization in improvement programmes. Due to its wide geographical distribution and adaptability to different agro climatic zones, large genetic diversity is observed in tamarind species. As tamarind is a cross pollination and seed propagated crop, it gives immense opportunity to locate elite trees having desirable horticultural traits (EL-Siddig *et al.*, 2006) and can be released as a variety. Thus the variation present between the trees within a population helps in the selection of promising tamarind germplasm suitable for that area.

The present study is an attempt to study the genetic diversity among the tamarind germplasm using DIVA-GIS software. DIVA-GIS is an open source geographic

information system (GIS) software used for mapping and analyzing data on biological diversity distribution to generate grid maps to identify the areas that have high, low, or complementary levels of species diversity. This software was specifically developed at CIP for analysing genebank data, available through national or international genebank documentation systems and SINGER. It supports the analysis of exploration, evaluation, gene bank and herbarium databases to elucidate genetic, ecological and geographic patterns of the distribution of crops and wild species (Gunjeet Kumar *et al.* 2013).The software was designed to assist the plant genetic resources curators and biodiversity managers to map the range of distribution in the species (Hijmans and Spooner, 2001).

Materials and methods

The experimental material comprised of tamarind germplasm maintained in the field gene bank at ICAR-National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Ranchi. These accessions were collected through exploration programmes from different agro-ecological regions by ICAR-NBPGR, RS, Ranchi. Among the tamarind germplasm maintained in the field gene bank at the station, 47 accessions which were in fruiting stage were used for the present study. The accessions were evaluated for different morphological traits *viz.* fruit length (cm), fruit width (cm), beak length (cm), number of ridges per fruit, number of furrows per fruit, fruit weight (g), epicarp weight (g), number of seeds per fruit, number of fibres per fruit, number of fruits per tree and fruit yield per tree (kg). The observations were recorded on 20 representative ripe fruits from each accession and the mean value were calculated and descriptive statistical analysis was performed. The geographical coordinates (latitude, longitude and altitude) of collection sites which were recorded using the Global Positioning System (Garmin GPS-12) during the time of exploration were used to study the spatial distribution and richness of tamarind germplasm using the DIVA-GIS software. The grid maps were generated for traits like fruit length, fruit weight, number of seeds per fruit and number of fruits per tree for identifying the areas with high diversity for these traits.

Results and Discussion

The collection sites of the tamarind accessions used in the study were mapped using DIVA-GIS and is presented as Figure 1. It was observed the tamarind germplasm accessions used for the present study were collected from different locations in Ranchi, Deoghar, Dumka and East Singhbum districts of Jharkhand.

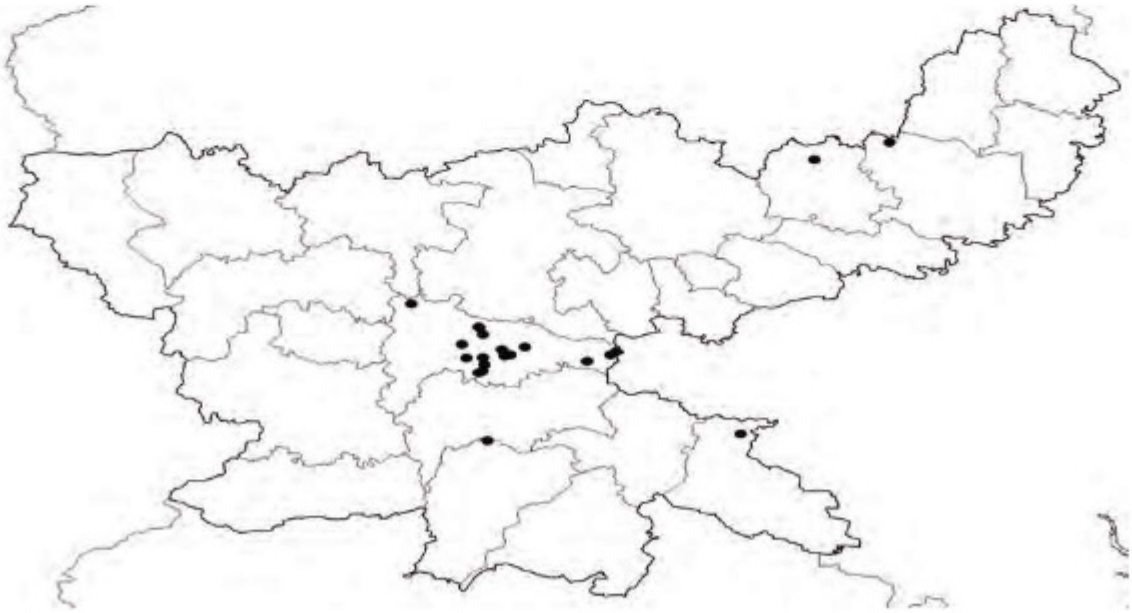

Figure 1. DIVA-GIS mapping of collection sites of tamarind germplasm from Jharkhand.

The 47 tamarind accessions were evaluated for different traits *viz.* fruit length, fruit width, beak length, number of ridges per fruit, number of furrows per fruit, fruit weight, epicarp weight, number of seeds per fruit, number of fibres per fruit, number of fruits per tree and fruit yield per tree. The descriptive statistical analysis was done to study the variability among the tamarind germplasm for these characters and presented in Table 1 . It was observed that the germplasm exhibited wide range of varaiability for these traits. The fruit length in tamarind accession ranged from 7.25 cm (IC 209899) to 20.11 cm (IC 339915) with a mean fruit length of 13.48 cm. The fruit width ranged from 5.26 cm (IC 339916) to 8.04 cm (IC 339918), with a mean fruit width of 6.71cm.The beak length varied from 0.05 cm in (IC 209889, IC 594328) to 0.15 cm (IC 209888) with a beak length of 0.10 cm. The number of ridges in the fruits ranged from 1.60 (IC 209897) to 3.45 (IC 209900) with a mean of 2.58. The number of furrows ranged from 0.75 (IC 339924) to 2.45 (IC 209900) with a mean of 1.61. The fruit weight ranged from 7.5 g (IC 209899) to 27.79 g (IC339918), with a mean fruit weight of 16.64 g. The epicarp weight of the fruits ranged from 5.43 g (IC 209899) to 21.02 g (IC 339918), with a mean of 12.28 g. The number of seeds per fruit ranged from 2 (IC 209899) to 11.05 (IC 339922), with an mean of 8.05 seeds per fruit. The number of fibers in the fruit ranged from 3.00 (IC 594321, IC 594326) to 4.85 (IC 594322), with a mean of 3.71. The number of fruits per tree ranged from 63 (IC 594316) to 5700 (IC 209882), with a mean of 1419.53 fruits per tree. The fruit yield per tree ranged from 0.62 kg (IC 594316) to 57.55 kg (IC 209892), with a mean fruit yield of 14.15 kg.

Table 1: Descriptive statistical analysis for different characters in tamarind germplasm

No.	Attributes	Range	Mean	SE	SD	CV
1	Fruit length (cm)	7.25 -20.11	13.48	0.33	2.26	16.73
2	Fruit width (cm)	5.26 - 8.04	6.71	0.08	0.57	8.56
3	Beak length (cm)	0.05-0.15	0.10	0	0.01	14.06
4	No. of ridges per fruit	1.60-3.45	2.58	0.06	0.40	15.57
5	No. of furrows per fruit	0.75-2.45	1.61	0/05	0.36	22.20
6	Fruit weight (g)	7.5 - 27.79	16.64	0.58	3.94	23.70
7	Epicarp weight (g)	5.43- 21.02	12.28	0.44	3.04	24.75
8	No. of seeds per fruit	2.00 - 11.05	8.05	0.21	1.47	18.25
9	No. of fibres per fruit	3.00-4.85	3.71	0.07	0.48	12.82
10	No. of fruits per tree	63.00- 5700	1419.53	208.80	1431.48	100.84
11	Fruit yield per tree (kg)	0.62 - 57.55	14.15	2.04	13.96	98.66

The grid maps were generated using DIVA GIS software to study the genetic diversity in tamarind germplasm for different characters. The grid maps for fruit length, fruit weight, number of seeds per fruit and number of fruits per tree were prepared and presented in Fig 2 & 3.

The colours of the grids are indicative of the extent of diversity in tamarind germplasm. The high Shannon diversity index (18-21) for fruit length in tamarind was observed in the collections made from Ranchi, followed by East Singhbum. The highest diversity index (24-28) for fruit weight was recorded in the collections from central part of Ranchi followed by different areas in Ranchi and East Singhbum. The high diversity index (4500-5700) for number of fruits per tree was observed in the tamarind collections made from Ranchi. The highest diversity index (10-12) for number of seeds per fruit was observed in the germplasm collections from different blocks of Ranchi district. Thus it can be concluded that tamarind germplasm with high diversity in fruit length, fruit weight, number of fruits per tree and number of seeds per fruit can be collected from Ranchi and East Singhbum districts in Jharkhand.

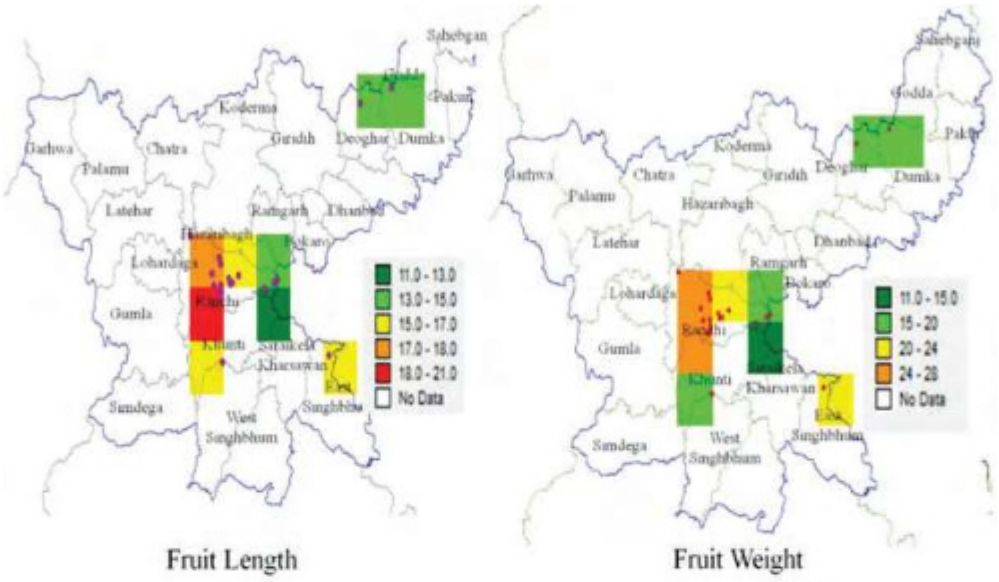

Fig. 2. Grid maps showing diversity of fruit length and fruit weight in tamarind germplasm collected from Jharkhand, India

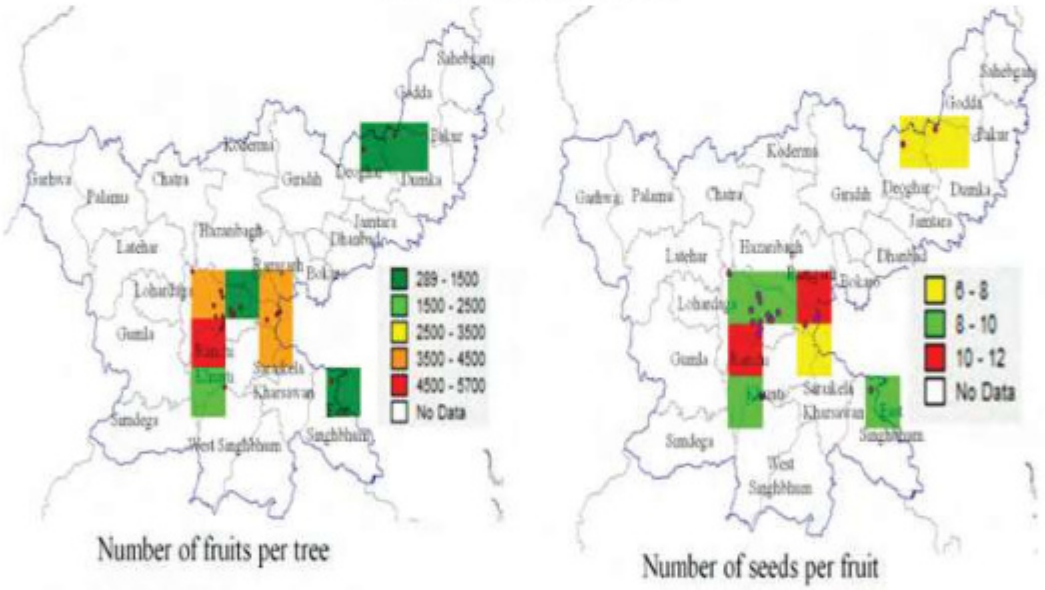

Fig. 3. Grid maps showing diversity of number of fruits per plant and number of seeds per fruit in tamarind germplasm collected from Jharkhand, India

GIS mapping is widely used in assessing the agro biodiversity (Varaprasad *et al*., 2008) and in identifying the areas of high diversity in Phaseolus bean (Jones *et al*. 1997), forest vegetation (Ganeshaiah *et al*. 1998), Murali *et al*.1998, Udaya Lakshmi *et al*. 1998), wild potatoes (Hijmans and David, 2001), piper (Parthasarathy *et al*., 2006), medicinal plants (Varaprasad *et al*., 2007), horsegram (Sunil *et al*., 2008), linseed (Sivaraj *et al*., 2009), Jatropha curcas (Sunil *et al*., 2009; Shabani-mofrad *et al*., 2011), blackgram (Babu Abraham *et al*., 2010), Canavalia fatty acids (Sivaraj *et al*., 2010) etc.

Conclusion

GIS mapping is effectively used for documentation, diversity analysis, identifying gaps in collection, assessment of loss of diversity, developing new strategies for conservation, and sustainable utilization, particularly in the wake of recent international developments related to food and nutritional security (Gunjeeet Kumar). The present study was done to understand the variability among the tamarind germplasm maintained in the field gene bank at ICAR-NBPGR, RS, Ranchi using DIVA-GIS software. The fourty seven tamarind germplasm used for the present study was collected through exploration by ICAR-NBPGR, Regional station, Ranchi from 23 different sites in different blocks of Ranchi, Deoghar, Dumka and East Singhbum districts of Jharkhand. These genotypes were evaluated for eleven quantitative characters and grid maps was generated for fruit length, fruit weight, number of seeds per fruit and number of fruits per tree using DIVA GIS software. The grid map analysis revealed the the highest diversity index for fruit length was observed in the collections made from different blocks of Ranchi followed by East Singhbum. The highest diversity index for fruit weight was recorded in the collections from central parts of Ranchi followed by different areas in Ranchi and East Singhbum. The germplasm accessions collected from Ranchi district recorded high diversity index for number of fruits per plant and number of seeds per fruit. This indicates that Ranchi and East Singhbum districts in Jharkhnad are the potential areas for collection of tamarind germplasm to capture the maximum diversity for these characters. Thus these areas has to be considered in future exploration programmes for exploiting the genetic diversity of tamarind germplasm in Jharkhand.

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