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RESEARCH ARTICLE

GIS mapping of sorghum landraces collected from Tamil Nadu, India

M Elangovan[1*], K Ganesamurthy[2], K Sankarapandian[2] and P Kiran Babu[3]

1. Directorate of Sorghum Research (DSR), Rajendranagar, Hyderabad 500030, AP, India
2. Tamil Nadu Agricultural University (TNAU), Coimbatore 641003, TN, India
3. Indian Agricultural Research Institute (IARI), New Delhi, 110012, India

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Corresponding Author

M Elangovan

Abstract

Tamil Nadu state was explored for sorghum germplasm and 150 accessions were collected from 19 districts. The maximum number of accessions was collected from Coimbatore (21) followed by Karur (19) and Thoothukudi (15). Twenty five different landraces were collected including *irungu cholam, senjolam, vellai cholam, periya manjal cholam, manjal cholam, pei cholam, nattu cholam, senkaton cholam, karareddu cholam, thalaivirchchan cholam* and *makkatai cholam*. These landraces belong to five basic races and three intermediate races with the highest diversity (0.96–2.00) in Tiruvannamalai and Namakkal districts. The landraces richness map indicated that Theni, Dindigul and Southern Coimbatore districts had the highest diversity with a representation of 10-11 landraces. Present study was undertaken to investigate morphological grouping of the races and racial richness, diversity and distribution maps of sorghum collections of Tamil Nadu with the help of DIVA-GIS.

INTRODUCTION

Geographical Information System (GIS) has been successfully used to study the geographic distribution of cultivated crop species as well as pests infestation assessment of agricultural crops (Hijmans and Spooner, 2001; Ganeshaiah *et al.,* 2003). DIVA-GIS, is a GIS software designed to assist the plant genetic resources and biodiversity communities to map the range of distribution of crop species in which they are interested (Hijmans *et al.,* 2002). GIS has been successfully used by many in identifying areas of high diversity in Sorghum (Teshome *et al.,* 2007; wild Potatoes (Hijmans *et al.,* 2000); Mekbib, 2008); Maize (Ruiz Corral *et al.,* 2008); *Phaseolus* bean (Jones *et al.,* 1997); Soybean (Gai *et al.,* 2005); and Piper (Parthasarathy *et al.,* 2006).

Sorghum is of African origin (Kimber, 2000) and Africa has largest diversity of cultivated and related wild sorghum (Doggett, 1988; deWet, 1977). In the Indian sub-continent, there is evidence for early cereal cultivation at an archaeological site in Western parts of *Rojdi* (Saurashtra) which dating back to about 4500 before presents (Damania, 2002). So, India is considered to be the secondary center of origin of sorghum (Vavilov, 1992).

Landraces are defined as "variable plant populations adapted to local agro-climatic conditions which are named, selected and maintained by the traditional farmers to meet their social, economic, cultural and ecological needs" (Teshome *et al.,* 1999a). Landrace diversity at the field level is greater for farmers who apply more selection criteria to define their diverse needs and requirements (Teshome, 1996; Teshome *et al.,* 1999b). Both natural factors and farmers' selection criteria shape crop genetic diversity at the field and landscape levels (Teshome, 1996) with the sorghum farmers' varieties being variable in their levels of biological resistances to storage pests (Teshome 1996; Teshome *et al.,* 1999a). Folk and numerical taxonomies for the landraces are consistent with one another (Teshome

1996; Teshome *et al.,* 1997). Majority of traditional varieties in rainfed uplands tolerate moisture stress and possess strong root system under field conditions (Hanamaratti *et al*., 2008). Ganesamurthy *et al*., (2010) reported that genetic diversity is generally associated with geographical diversity but the former is not necessarily directly related with geographical distribution. The similar finding was also reported by Nadaf *et al.,* (1986) and Shanmugam and Rangasamy (1982).

Tamil Nadu is located $08^0$05'N and $13^0$34'N latitudes and $76^0$14'E and $80^0$21'E longitudes with an area of 1,30,058 sq km and elevation varies from 150m to more than 3000m. Collection and characterization of sorghum germplasm is an important activity for identifying potential germplasm for utilization in the varietal improvement programme. Deb *et al.,* (2004) documented the levels of adaptation of improved sorghum cultivars in this region. Hence in order to rescue the landrace diversity from un-surveyed and surveyed areas, sorghum explorations were undertaken during 2002 - 2010 in Tamil Nadu and a total of 150 accessions collected and characterized (Elangovan *et al.,* 2012, 2009, 2006, 2005; Ganeshamurthy *et al.,* 2010; Elangovan, 2006).

Materials and Methods

Directorate of Sorghum Research (DSR), Hyderabad has organized exploration to collect the sorghum landraces from Tamil Nadu during 2002 – 2010. Nineteen districts were explored for sorghum germplasm and 150 accessions collected. The explorations were jointly undertaken with the All-India Coordinated Sorghum Improvement Project (AICSIP), Tamil Nadu Agricultural University (TNAU), Coimbatore and Agricultural Regional Station, Kovilpatti. The germplasm collection programmes were planned to cover the unexplored areas and areas explored in the past to collect representative diversity of the region. The altitude, longitude and latitude of the collection site were recorded with the help of Garmin 12XL Global Positioning System (GPS). The data were plotted using DIVA-GIS software to study the distribution, diversity and richness of sorghum landraces (Hijmans *et al.,* 2005).

The present study was undertaken to investigate morphological grouping of the races and racial richness, diversity and distribution maps of sorghum collections with the help of DIVA-GIS. The spatial data was used to prepare map and describe the geographic distribution of sorghum races in Tamil Nadu. This study will provide baseline data for further gap-analysis on exploration, collection, conservation and use of germplasm of landraces and wild crop relatives as well as for studies on the factors that explain the geographic distribution of sorghum landraces.

Results and Discussion

Nineteen districts were explored for the sorghum germplasm and 150 accessions collected. The maximum number of accession was collected from Coimbatore (21) followed by Karur (19) and Thoothukudi (15), Perambalur (13), Dindigul (11), Erode (10), Trichy (9), Vellore (8), Cuddalore (7), Virudhunagar (6), Tirunelveli and Theni (5), Madurai, Namakkal, Ramanathapuram and Selam (4), Tiruvannamalai and Krishnagiri (2) and Dharapuri (1) (Figure.1). In the state, majority of the landraces belongs to *irungu cholam, senjolam, vellai cholam, periya manjal cholam, manjal cholam, pei cholam, nattu cholam, senkaton cholam, kararedду cholam, thalaivirchchan cholam* and *makkatai cholam*. In these collections, some of the sorghum landraces are named with the village name as prefix to the landrace viz., *Kovilpatti cholam* and *Tenkasi vellai.* Sorghum landraces are also named based on the grain colour viz., *vellai cholam (white), manjal cholam (yellow), senjolam (red), karuncholam (black glume).* In some areas, landraces are also named based on the shape of the ear head viz., *matthappu cholam* (ear head shape like flower-pot cracker fireworks) (Figure 2). Sixteen accessions collected with the popular landrace name *vellai cholam*, followed by *irungu cholam* (14), *sencholam* (14), *nattu cholam* and *periya manjal cholam* (6), *manjal cholam* (4), *sivappu irungu, vella cholam, karuppu irungu* (3), *tenkasi vellai, kararedду cholam, karuncholam, makkatai cholam, vailkattu cholam* and *vailkattu cholam* (2) were represented by fewer accessions.

The sorghum landraces diversity map (Figure 2), revealed two hot spot areas with very high landrace diversity (1.294-2.000) one consisting of Coimbatore, Dindigul, Theni and Erode districts and the other including parts of Namakkal and Tiruchirapalli. Districts of Erode, Thoothukudi and southern Tiruchirapalli showed a high (0.971 - 1.294) range whereas, Dharmapuri and Vellore had a medium diversity range of (0.324 to 0.647). Southern Coimbatore and central Tiruvannamalai districts showed the lowest landraces diversity of (0.324).

From the sorghum landraces richness map (Figure 3), it was found that highly landrace rich districts in sorghum landraces are Theni, Dindigul and Southern Coimbatore with 10-11 landraces; Thoothukudi, Ramanathapuram and Virudunagar consisting 8-9 landraces; Namakkal, Tiruchirapalli, Erode, Tirunelveli and Northern Coimbatore

districts representing 5-7 landraces; Dharmapuri, Krishnagiri and Vellore districts having 3-4 landraces; and Tiruvannamalai and Western Coimbatore districts consisting least 1-2 landraces richness.

The genus Sorghum has been classified into 48 taxa (Snowden 1936). De Wet (1978) simplified the classification on the basis of ploidy levels and interfertility relationships, and amalgamated all the cultivated races and their inter-fertile diploid wild and weedy forms into a single species, *Sorghum bicolor* (2n = 20). Cultivated sorghum, along with its diploid wild subspecies *S. bicolor* ssp. *verticilliflorum* (Steud.), diploid weedy form (*S. bicolor* ssp. *drummondii* Steud.) and two tetraploid rhizomatous perennial species, *S. halepense* (Linn.) Pers. and *S. propinquum* (Kunth.) Hitche., constitute the section Eusorghum. All these taxa constitute the primary gene pool of Sorghum. The remaining species of Sorghum that come under the sections *Parasorghum*, *Chaetosorghum*, *Stiposorghum*, and *Heterosorghum* form the tertiary gene pool. The cultivated races under *S. bicolor* ssp. bicolor have been classified into five basic races *viz., bicolor, guinea, caudatum, kafir* and *durra*, these basic races are further classified into ten intermediate races durra *caudatum*, *durra guinea, durra kafir, durra bicolor, caudatum guinea, caudatum kafir, caudatum bicolor, guinea kafir, guinea bicolor,* and *kafir bicolor* (Harlan and de Wet 1972).

There were five major races and two intermediate races collected from the state. Out of 150 accessions, 60 accessions were with *bicolor* race followed by 42 with *durra* race. Majority of the collections belongs to *bicolor* race which is the most primitive race and exclusively present in fodder sorghum. The second largest race *durra* is the advanced race and exclusively present in grain sorghum. The existence of both primitive and advanced races and other three major races in the state has proved the civilization in agriculture in the state since so many years. The race *durra* was selected from early *bicolor* that had moved into India some 3,000 years ago. From the sorghum races diversity map (Figure 4), it was found that Tiruchirapalli, Namakkal, Karur, Selam, Dharmapuri, and Perambalur districts have the highest sorghum races diversity. The sorghum races diversity map (Figure 4) showed very high races diversity (0.96 –2.00) in Tiruvannamalai and Namakkal districts; Karur, Dindigul, Ramanathapuram, Erode, Dharmapuri, Perambalur, north and southern Tiruchirapalli and northern Thoothukudi showed medium (0.48-0.72) ranging; Tiruvannamalai, Tirunelveli and northern Thoothukudi showed low ranging racial diversity (0.24-0.48) and western Combatore and southern Thookudi showed low racial diversity (0-0.24).

The results of races richness map (Figure 5) revealed that, Namakkal and northern Tiruvannamalai districts showed high diversifying area with 6 races richness followed by Virudunagar, Erode, Dharmapuri, Perambalur, Karur, Ramanathapuram and eastern Thoothukudi showed medium races richness (3-4), Tiruvannamalai, Theni southern Coimbatore and western Thoothukudi representing low richness with 2 races and western Coimbatore showed very low richness with single race.

Using GIS, we can establish plant genetic resources GIS network with the information on GIS mapping of all the plant genetic resources in the country for further utilization and management of plant genetic resources networks. This also helps to locate the wild species available spots and leads to *in situ* conservation. The genetic erosion of the landraces, crop replacement and change in the pattern of cultivation due to other crops also can be monitored. Regional specific genotypes, soil types and rainfall and temperature pattern also can be monitored for alternate crops.

Fig. 1 Sorghum landraces spatial distribution in Tamil Nadu

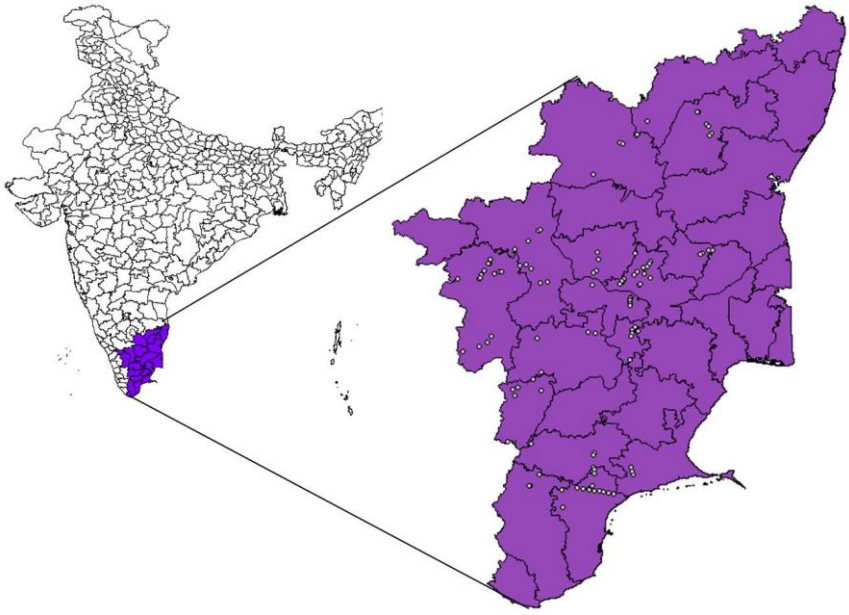


Fig. 2 Sorghum landraces diversity in Tamil Nadu

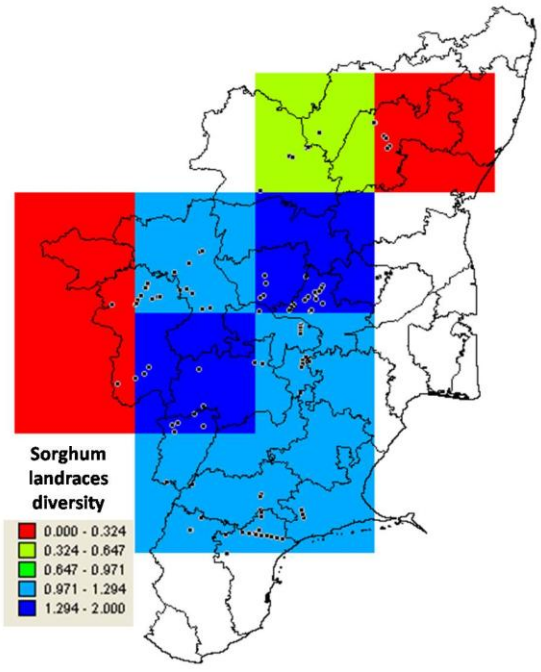


Fig. 3 Sorghum landraces richness in Tamil Nadu

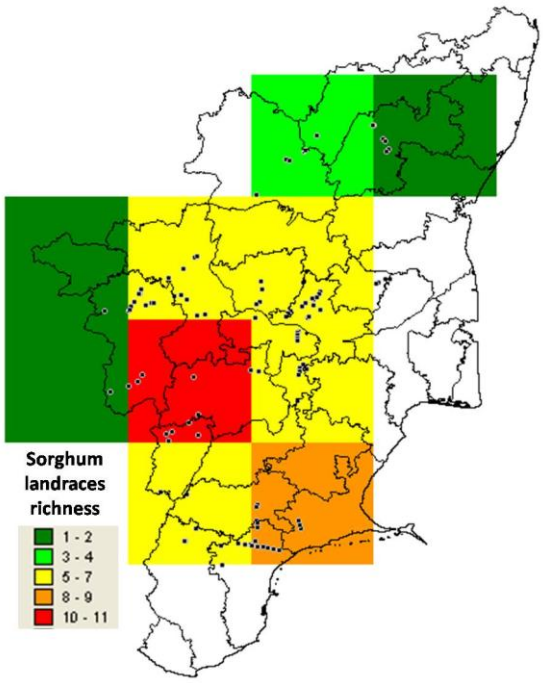
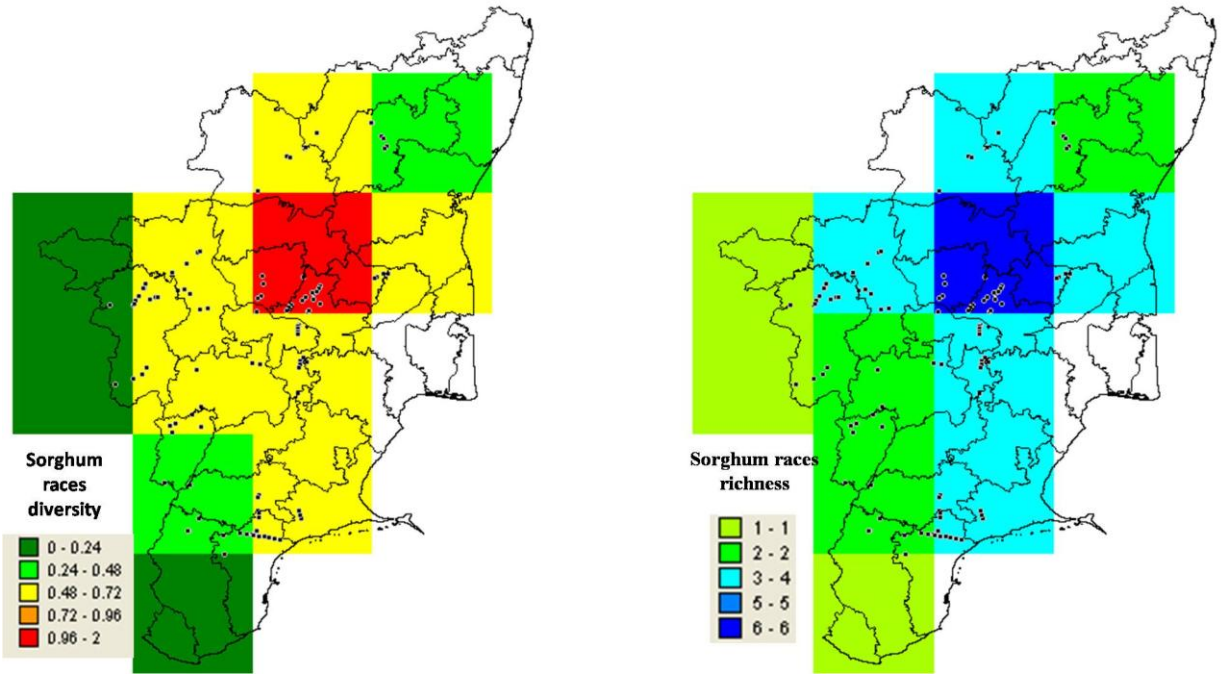


Fig. 4 Sorghum races diversity in Tamil Nadu Fig. 5 Sorghum races richness in Tamil Nadu



Conclusion

The present study is further useful to identify collection priority areas, explored and unexplored areas. Traditionally cultivated local landrace identification of their distribution at the micro level will help in identifying the location specific solutions through the effective use of remote sensing based resource information combined with other socio-economic data using GIS. This is being done by survey of resources at different scales using traditional and remote sensing techniques. The collated information like slope, topography, set of resource maps; generation of action plan maps gives site specific recommendations for development and management of agriculture, genetic resources collection and conservation. State-wise sorghum genetic resources collection and distribution; collection-gaps, priority areas and wild species existence mapping has helped in expanding and intensification of agricultural activities and also in identifying the land capability classes and crop suitability indices. Re-visiting the collection areas revealed that the loss of local landraces existence due to replacement of commercial crops. Based on available literature some of the area already surveyed and past study records of the sorghum germplasm, it was felt that the unexplored areas in the region must be surveyed vigorously, which can provide very valuable germplasm material and explored areas must be re-visited to check the genetic erosion of the local landraces. The local landraces which are yet to be known fully to the users must be conserved for their future utilization. GIS mapping help to relate the present germplasm exploration data points with the oldest agricultural civilization areas for further investigation.

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