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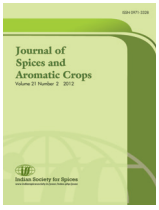

Diversity analysis of sesame germplasm using DIVA-GIS

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Abstract

Sesame (*Sesamum indicum* L.) was studied for its distribution and diversity in India using DIVA-GIS. Grid maps were generated for diversity analysis of the eight quantitative traits *viz*., plant height, inter-node length, leaves per plant, number of flowers per plant, number of capsules per plant, number of seeds per capsule, seed weight and seed yield. The results indicated that diverse accessions for all these traits can be sourced from Maharashtra, Gujarat and Madhya Pradesh (partly covering Chattisgarh) states and these states are diversity rich pockets for sesame germplasm in India.

Keywords: DIVA-GIS, germplasm, India, mapping, *Sesamum indicum*

Introduction

Sesame (*Sesamum indicum* L.) family Pedaliaceae, is an important source of edible oil and is widely used as one of the ingredients in food products especially in bakery foods and animal feed. Sesame germplasm has tremendous variability. Efficient and systematic exploitation of this diversity is the key to any crop improvement program. This, however, requires as a first step, the assessment of genetic diversity and population structure of the species under consideration. DIVA-GIS, a Geographic Information System (GIS) is designed to map the range of distribution of species in which one is interested (Hijmans *et al*. 2000). GIS has been successfully used in identifying areas of rich diversity in various parts of the world. DIVA-GIS is a software tool for the analysis of diversity and it enables us to understand and comprehend the distribution of diversity on the geographical scale and also helps in identifying gaps in collection.

Materials and methods

The experiment was carried out during late *Kharif* 2008–09. The experimental materials were sown in simple Randomised Block Design with 60 × 10 cm spacing in three replications at College Farm, College of Agriculture, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad. Recommended

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agronomic practices and prophylactic measures were adopted.

Assessment of diversity in sesame germplasm and geographical distribution using DIVA-GIS

Characterization data recorded on the sixty accessions of sesame such as plant height, internode length, leaves plant^{-1}, number of flowers plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, seed yield and seed weight was subjected to DIVA-GIS analysis. To know the spatial distribution and assessment of variability DIVA-GIS version 7.1.6, was used. Geographical coordinates of the collection sites from various parts of India were also obtained using Garmin 12 Global Positioning System (GPS). India shape file was used for plotting the georeferenced points using the layer menu on the software. Point- to- grid option using 'simple' method on the "Analysis Menu" and the output variables "Diversity and Statistics" were selected for getting the output files. Under diversity, Shannon diversity index was picked and for the statistics, coefficient of variation was selected. Grid maps on the diversity, and coefficient of variation were generated for various traits recorded on the sesame germplasm.

Shannon Diversity Index

DIVA-GIS can calculate a number of different diversity indices for each grid cell. Shannon diversity index was selected for diversity index analysis. The formula for the index taken is given below.

Shannon $H' = -\sum pi \ln pi$

ni – number of individuals in the *i*-th class

pi – proportional abundance of the *i* th class = *ni* / *N*

Results and discussion

Sesame germplasm (60 accessions) was collected by National Bureau of Plant Genetic Resources, New Delhi was used for studying the variability. The germplasm accessions originated from eight Indian states covering Gujarat (8), Himachal Pradesh (1), Madhya Pradesh (24), Nagaland (1), Punjab (92), Rajasthan (8) and Uttar Pradesh (3). The geographical coordinates of the sesame collection sites, accession identity and the plant traits used for DIVA-GIS analysis are provided in Table 1. The collection sites were mapped using DIVA-GIS (Fig.1).

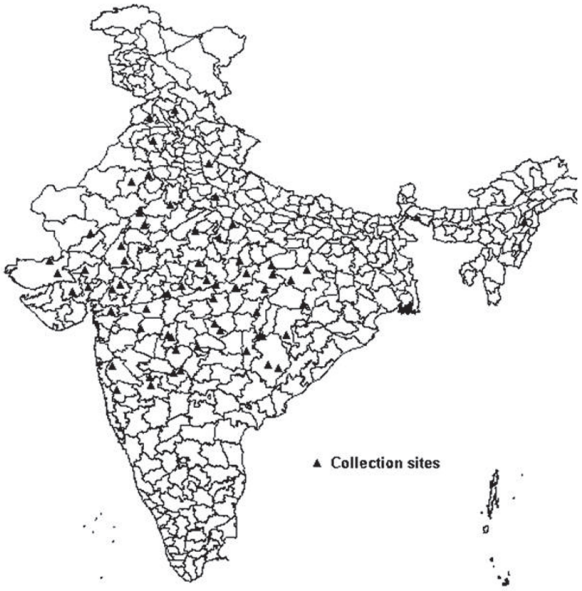

Fig 1. DIVA-GIS map showing geographical origin of sesame germplasm used in the study

Observations on eight traits *viz.*, plant height, internode length, leaves plant^{-1}, number of flowers plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, seed yield and seed weight were recorded. All quantitative characters exhibited variability evident by high CV observed in most of the traits studied. The high CV observed among morphological characters is an indication of the level of diversity within the populations of sesame found growing in these habitats. Moderately low CV values were observed for internode length and for test seed weight.

Diversity Analysis (Shannon diversity index)

Grid maps were generated for diversity analysis of the eight quantitative traits (Fig. 2, 3 & 4) indicated that diverse accessions for all these traits can be sourced from Maharashtra, Gujarat and Madhya Pradesh (partly covering Chattisgarh) states of India. However, highly diverse sesame germplasm accessions for leaves plant^{-1} was sourced from Maharashtra and

Table 1. Observations on the plant traits used as input in the DIVA-GIS to assess the geographical distribution of diversity in Sesame germplasm

Acc Id	State	Latitude	Longitude	capsules/ plant	Plant height	Internode length	leaves/ Plant	Flowers/ plant	Seed weight	Seed yield	Seeds/ capsule
IC14163	Gujarat	21.6677	73.5195	55.4	25.2	3.2	103.5	50.0	3.02	6.9	40.8
IC43169	Gujarat	22.804	73.6183	23.2	23.8	4.2	43.2	25.3	2.6	3.612	59.4
IC43171	Gujarat	22.9028	72.3831	28.0	21.0	3.6	39.6	35.6	2.9	3.66	37.3
IC43177	Gujarat	23.0017	74.0135	70.6	26.4	4.2	105.6	71.0	2.3	4.5	28.2
IC43179	Gujarat	23.5945	70.8516	47.8	24.6	3.5	68.2	38.6	2.92	4.77	52.4
IC43181	Gujarat	22.6558	71.5926	56.8	23.5	4.0	125.4	57.0	2.9	8.45	30.4
IC43185	Gujarat	24.1874	70.4069	43.2	26.6	3.6	67.8	41.6	2.4	5.36	77.0
IC43217	Gujarat	23.7427	72.2349	38.2	23.6	3.2	55.2	39.2	2.6	5.2	53.0
IC96079	Himachal Pradesh	31.7959	76.7309	29.0	14.3	2.6	60.3	29.3	2.6	4.97	66.0
IC14329	Madhya Pradesh	20.482	81.0786	33.6	23.2	3.8	82.0	35.4	2.6	5.55	63.6
IC21705	Madhya Pradesh	21.6183	80.8809	36.0	26.8	4.0	60.0	37.2	2.8	4.14	40.6
IC23233	Madhya Pradesh	22.0135	83.2524	56.0	26.6	4.0	55.0	57.2	2.8	8.4	54.0
IC23271	Madhya Pradesh	23.2487	82.6101	35.2	30.4	4.0	67.2	35.8	2.9	7.59	74.4
IC23321	Madhya Pradesh	20.804	75.0511	41.8	31.6	4.0	74.6	42.6	2.8	5.3	45.8
IC23325	Madhya Pradesh	25.719	77.8178	46.0	27.3	4.0	68.8	46.8	2.9	4.7	35.8
IC23327	Madhya Pradesh	24.0886	77.966	52.3	30.6	4.0	115	53.6	2.7	8.33	33.5
IC23332	Madhya Pradesh	23.5945	80.3869	19.5	25.5	3.5	48.5	20.0	2.85	2.77	50.0
IC23335	Madhya Pradesh	18.9998	81.4738	33.2	24.5	4.0	77.6	34.2	2.17	3.84	53.4
IC23341	Madhya Pradesh	23.0017	78.8059	40.5	24.2	3.9	65.7	41.4	2.79	5.845	48.0
IC23346	Madhya Pradesh	24.1874	80.041	51.4	17.0	4.0	51.3	52.6	2.06	2.75	26.0
IC41932	Madhya Pradesh	22.9522	77.1261	39.4	27.6	4.0	100.8	40.2	2.7	5.06	47.6
IC41948	Madhya Pradesh	22.31	78.7071	17.2	15.8	3.8	50.8	17.8	2.6	2.1	47.0
IC41953	Madhya Pradesh	21.8159	75.2981	30.4	20.5	3.8	72.6	31.2	2.7	2.7	33.0
IC41962	Madhya Pradesh	22.557	76.4344	55.2	25.2	4.0	111.2	56.2	2.74	4.82	31.9
IC41964	Madhya Pradesh	20.4325	81.1774	39.0	22.5	4.0	125.0	40.0	2.9	2.34	55.0
IC41966	Madhya Pradesh	18.8022	82.0173	31.0	21.6	4.0	53.2	31.6	2.62	3.7	43.4
IC42200	Madhya Pradesh	20.482	82.4125	51.4	23.3	3.6	87.8	52.2	2.6	8.04	60.2
IC52585	Madhya Pradesh	22.804	81.3256	47.2	25.8	3.5	81.4	48.8	2.6	5.3	43.2

Cont.....

IC52586	Madhya Pradesh	23.9898	81.622	42.0	15.3	4.2	68.4	44.6	2.6	6.77	62.0
IC52592	Madhya Pradesh	23.2487	78.3612	21.5	15.6	4.2	45.5	21.6	2.7	3.5	62.0
IC52593	Madhya Pradesh	23.7427	83.45	23.2	21.1	4.0	57.8	23.6	2.7	3.6	58.0
IC52599	Madhya Pradesh	22.8534	79.8434	28.0	25.0	4.5	99.0	29.5	2.86	4.3	55.0
IC52600	Madhya Pradesh	23.5451	81.7208	43.4	27.8	4.1	49.2	44.8	2.86	5.8	76.0
IC16225	Maharashtra	19.8891	77.9166	37.0	22.7	3.8	63.8	37.8	2.64	3.7	47.2
IC16236	Maharashtra	18.6045	76.6814	15.5	19.0	4.0	58.0	16.2	2.6	1.96	39.7
IC16238	Maharashtra	17.9623	75.5451	59.0	30.2	4.0	97.0	60.4	2.82	9.18	55.6
IC16243	Maharashtra	19.7409	76.8297	32.0	21.0	4.0	57.8	33.6	2.4	3.03	47.2
IC16248	Maharashtra	18.3575	75.4957	33.0	18.0	4.0	59.6	34.3	2.6	4.68	54.6
IC16249	Maharashtra	19.6421	80.3869	47.0	18.0	4.0	47.5	48.0	3.0	9.7	69.0
IC16250	Maharashtra	20.729	79.0529	48.0	27.0	4.0	58.0	48.7	2.9	9.93	68.5
IC41906	Maharashtra	20.482	76.4344	67.6	19.0	4.0	79.2	68.2	2.6	7.17	40.8
IC41910	Maharashtra	18.7033	77.0273	42.2	25.4	4.0	58.6	43.2	2.74	6.7	59.0
IC41911	Maharashtra	21.0748	78.7565	31.0	22.7	3.7	54.2	31.2	2.7	4.51	54.0
IC41912	Maharashtra	20.3831	76.5826	36.8	24.6	4.5	47.0	36.8	2.75	2.9	29.4
IC41978	Maharashtra	17.7152	73.8159	56.3	23.8	4.0	86.0	57.3	2.7	6.99	46.0
IC751	Maharashtra	18.9504	73.6183	29.2	22.8	3.7	63.2	30.6	2.6	4.2	54.6
IC20156	Nagaland	26.1636	94.4181	38.0	22.2	4.1	57.6	39.0	2.68	2.08	53.4
IC16832	Punjab	31.4006	75.4957	54.0	20.3	4.2	73.6	54.8	2.7	3.91	43.2
IC31379	Punjab	30.2643	75.6933	44.2	19.8	3.6	47.8	45.2	2.7	2.5	27.2
IC14080	Rajasthan	27.0529	76.5332	28.3	21.8	4.0	44.3	28.7	2.5	4.89	69.2
IC14106	Rajasthan	26.0154	75.1993	49.8	25.4	3.8	65.0	50.6	2.9	4.75	36.4
IC14135	Rajasthan	24.2368	74.2112	54.6	29.6	4.4	72.6	55.2	2.58	4.7	43.5
IC14155	Rajasthan	24.9779	74.0629	54.2	27.4	4.0	69.6	54.6	2.52	6.07	44.8
IC14174	Rajasthan	28.1893	74.557	38.8	29.0	3.4	44.0	39.2	2.92	2.09	51.0
IC26303	Rajasthan	25.5708	72.482	47.6	28.4	4.6	96.8	48.0	2.6	5.89	47.6
IC42965	Rajasthan	26.6083	74.9522	66.4	28.6	4.0	92.2	67.2	2.8	12.19	65.6
IC42987	Rajasthan	28.5351	75.4463	69.2	33.2	4.2	151.4	70.8	2.9	11.8	59
IC96098	Uttar Pradesh	26.0648	79.6952	41.4	22.4	3.4	69.6	42.4	2.62	2.3	70.8
IC96109	Uttar Pradesh	27.4482	78.8059	41.4	24.2	4.4	86.2	42.4	2.93	4.04	62.2
IC96113	Uttar Pradesh	29.0786	78.4601	33.2	22.9	3.9	46.4	34.4	2.6	2.28	45.6

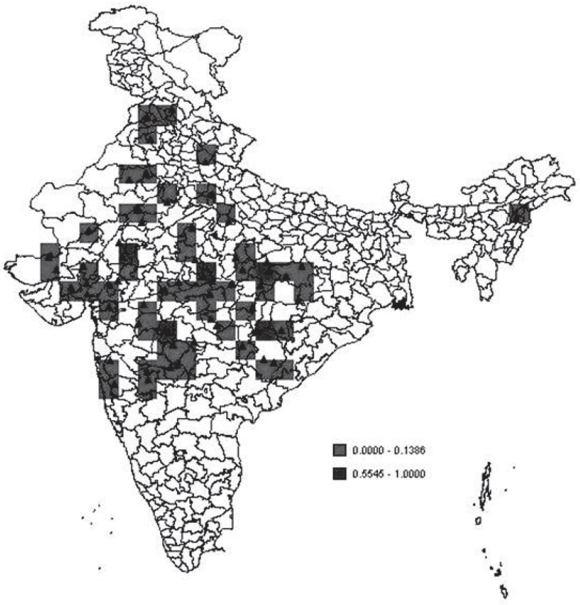

Fig 2. Diversity index for number of capsules per plant in sesame

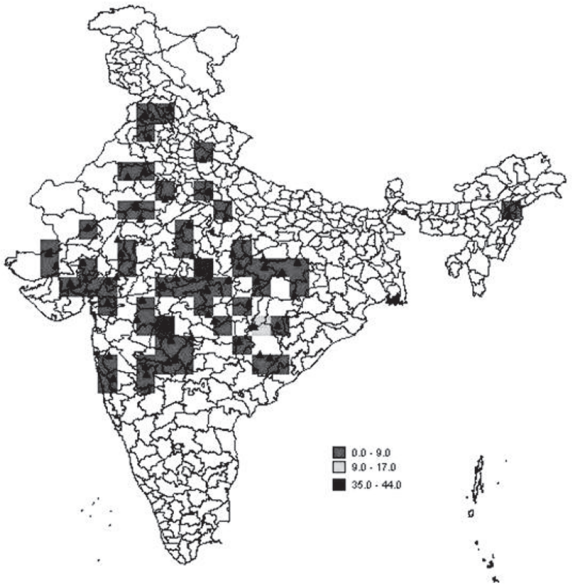

Fig 3. Coefficient of variation (%) for number of capsules per plant

Madhya Pradesh only. The Shannon diversity index ranged from 0.55–1.0 for germplasm accessions sourced from Gujarat, Madhya Pradesh and Maharashtra states. Among the sesame germplasm sourced from eight Indian states, and based on DIVA-GIS analysis it can be concluded that Gujarat, Madhya Pradesh

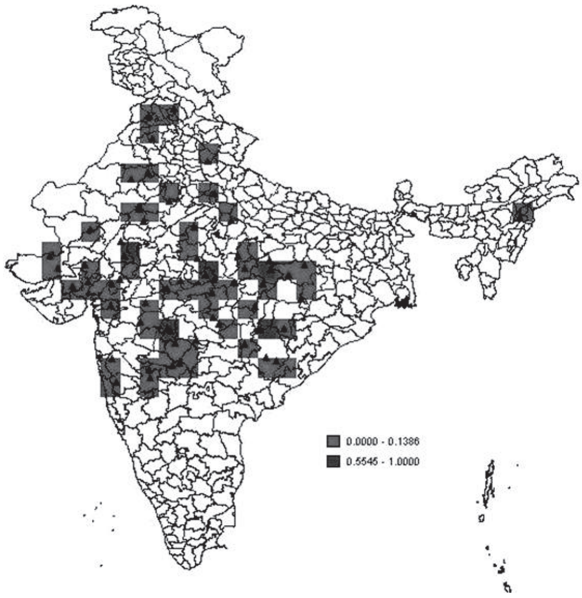

Fig 4. Diversity index for seed yield in sesame

and Madhya Pradesh are diversity rich pockets for sesame.

Coefficient of variation

High coefficient of variation for plant height (25.0–42.0%) was found in accessions from Madhya Pradesh, followed by a moderate CV% range of 14.0–25.0% in Maharashtra. However, low CV% (up to 8.0%) was recorded on sesame germplasm accessions from other states. Gujarat and Maharashtra recorded low to moderate CV% for the quantitative trait of internode length, which indicated that diversity is less for this trait. Grids with high CV% for the traits, number of leaves plant^{-1} (29.0–37.0%) and number of flowers plant^{-1} were stretched in Madhya Pradesh and Maharashtra. Germplasm accessions augmented from Gujarat, Madhya Pradesh and Maharashtra recorded highest CV% (35.0–44.0%) for number of capsules plant^{-1}. Accessions with maximum CV (18.0–23.0%) recorded for seeds capsule^{-1} originated from Maharashtra, while moderate CV value of 9.0–18.0% was possessed by the germplasm accessions from Madhya Pradesh. Grid map generated for seed weight indicated a lower CV% value (2.0–8.0%) for the accessions studied. This indicated less variability among the accessions. However, maximum CV% value

(6.0–8.0%) was recorded for Madhya Pradesh collections. The seed yield recorded the highest CV% (48.0–60.0%) among all the plant traits studied.

The present study revealed that diverse germplasm accessions of sesame were dispersed all over the eight states (Gujarat, Himachal Pradesh, Madhya Pradesh, Nagaland, Punjab, Rajasthan and Uttar Pradesh) but region where the diverse genotypes most likely to found are Maharashtra, Madhya Pradesh and Gujarat as high diversity indices and CV% were recorded for all the traits studied. It may be concluded that Maharashtra, Madhya Pradesh and Gujarat states are most suitable for future germplasm collection missions. The present study would be the first of its kind in India by integrating DIVA-GIS for the study of diversity analysis in sesame.

GIS mapping may be 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. GIS mapping has been successfully used in assessing biodiversity and in identifying areas of high diversity in *Phaseolus* bean (Jones *et al*. 1997), wild potatoes (Hijmans & David *et al*. 2001), horsegram (Sunil *et al*. 2008), *Jatropha curcas* (Sunil *et al*. 2009), linseed (Sivaraj *et al*. 2009), blackgram (Babu Abraham *et al*. 2010), *Canavalia* fatty acids (Sivaraj *et al*. 2010), medicinal plants (Varaprasad *et al*. 2007), *Piper* (Utpala *et al*. 2006) and agrobiodiversity (Varaprasad *et al*. 2008).

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