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PERFORMANCE OF SESAMUM VARIETIES UNDER RAINFED UPLAND CONDITIONS IN THE N-E GHAT ZONE OF ODISHA

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ABSTRACT

Sixteen sesamum genotypes were evaluated for their yield performance as well as inter-relationship among morphological traits and genetic diversity. Very low genetic advance was observed for dry biomass and seed yield showing that expression of both the characters is highly influenced by environment. High heritability coupled with high genetic advance as found in characters like capsules/plant and seeds/capsule indicates that heritability was due to additive gene effects and selection may be helpful. The genotypes differed from each other with respect to their reaction to different insect pests and diseases. Incidence of phyllody was noticed in only 3 genotypes ranging from 0.2% in Kalika to 1.0% in Maghi Local. Significantly high positive correlation was observed between days to 50% flowering and maturity which clearly shows that early flowering types can be chosen for early maturity. Both these characters exhibited significantly high positive correlation with plant height, branches/plant and incidence of phyllody. No significant association was observed for any trait with seed yield although the direction and magnitude of correlation coefficients varied. The local type, Maghi Local was found to be most divergent from rest of the genotypes and thus could be utilized in hybridization-based crop improvement programmes. Two genotypes, OSC-24 (95)-2-1-3 and OSC- 539 were found to be very close to each other showing least divergence. The varieties, Prachi and OSSel 84 produced average seed yield of more than 4.0 q/ha and were, therefore, found most suitable for the N-E Ghat zone of Odisha. Other varieties which exhibited satisfactory yield (about 3.5 q/ha) were Kanak and Nirmala which could also be profitably cultivated in this agro-climatic zone.

Key words: Sesamum, varietal performance, character association, genetic diversity

INTRODUCTION

Sesamum (*Sesamum indicum* L., Family-Pedaliaceae) is perhaps the oldest oilseed known to human beings (Weiss, 1971, Bedigian and Harlan, 1986). It is cultivated from about 40°N latitude to 40°S latitude and is an important annual oilseed crop in the tropics as well as warm subtropics (Ashri, 1989). The genus Sesamum contains over 34 species of which *S. indicum* L. (2n = 26) is the most commonly cultivated (Nayar and Mehra 1970). Sesamum is described as the “Queen of oilseeds” for containing high oil (38-54%), protein (18-25%), calcium, phosphorous, oxalic acid and excellent qualities of seed oil and meal (Prasad, 2002). In India, sesamum seeds are consumed as sweets and used in religious activities. Sesamum oil has long shelf life due to the presence of remarkable quantities of antioxidants which resist oxidation and is used for edible purpose as well as for preparation of ayurvedic medicines and body massage. Sesamum oil has much demand in industries and is used in the preparation of soap, perfume, carbon papers and type writer ribbons (Khan *et al*., 2001). India ranks first in area and production (about one-third of global area and production) among more than fifty sesamum growing countries (mostly under Asia and Africa) in the world. It is predominantly grown in Uttar Pradesh, Rajasthan, Odisha, Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, West Bengal, Bihar and Assam. It can tolerate heat above 40°C, and can grow with as little as 300–400 mm of yearly precipitation in fertile soil, which makes it adjusted to high temperatures and limited rainfall (Weiss 1971). Sesame is well suited to be included in crop rotation, and can be grown in pure or mixed stands, with low fertilization and pesticide inputs (Ashri 1988; Weiss 1983).

It is a crop of choice for upland situation. The crop needs less water for its growth and is harvested in about 90 days. However, the productivity is low in India (312 kg/ha) as compared to world’s average (389 kg/ha) and it is far below as compared to Egypt (1175 kg/ha). One reason for low seed yield is lack of improved varieties. This evidently indicates the potentiality of the crop for improvement in yield which in turn depends upon correlation of important traits with seed yield, variability in yield attributing traits and thorough study on genetic diversity.

Genetic diversity in sesame, based on morphological, biochemical, metabolic, and molecular markers, has been reported by many researchers worldwide (Akbar *et al*. 2011; Bedigian 2010; Cho *et al*. 2011; Furat and Uzun 2010; Isshiki and Umezaki 1997; Kumar *et al*. 2012; Laurentin *et al*. 2008; Nanthakumar *et al*. 2000; Parsaeian *et al*. 2011; Pham *et al*. 2010; Sharma *et al*. 2009; Tabatabaei *et al*. 2011; Vinod and Sharma 2011; Wei *et al*. 2008; Were *et al*. 2001, 2006; Zhang *et al*. 2012). The high level of polymorphism shown suggests that RAPD techniques can also be useful for the selection of parents in sesame *(Sesamum indicum* L.) breeding program and for cultivar differentiation (Pham *et al*., 2009). Interestingly, some geographically distant accessions clustered in the same group indicating involvement of the human factor in the spread of sesame varieties.

India is rich in genetic variability of cultivated sesame. The present investigation was, therefore, formulated (i) to evaluate some sesamum varieties for their yield potential and reaction to insect pests and diseases under the rainfed upland condition particularly in the eastern ghat region of Odisha; (ii) to assess the correlation coefficient among yield attributing characters to aid in selection of elite cultivars; and (iii) to determine genetic diversity of genotypes under study for the purpose of crop improvement using genetically diverse parents.

MATERIALS AND METHODS

Experimental set up: Sixteen sesamum genotypes were evaluated under rainfed upland situation in randomized block design with three replications at the Research Farm of AICRP for Dryland Agriculture, Orissa University of Agriculture & Technology, Phulbani during kharif 2006 to 2008. The soil at the experiment station was sandy loam with field capacity of 13.1%, permanent wilting point of 5.5%, pH of 5.5, organic carbon 0.35%, available P_2O_5 20kg/ha and available K_2O 170 kg/ha. The seeds were sown in lines with row spacing of 30 cm and seed rate of 25 kg/ha during last week of July or first week of August based on appropriate weather and soil moisture situation. All the manures (FYM 5 t/ha) and fertilizers (30-15-15 kg N- P_2O_5-K_2O) were applied before sowing and standard agronomic practices were followed for raising the crop.

Rainfall Scenario during experimentation: There was prominent variation in rainfall during different weeks of the crop growing season from 2006 to 2008 (**Fig. 1**). Sowing between last week of July to first week of August was done to result satisfactory vegetative growth and yield because of high probability of assured rainfall for about three months. However, weekly rainfall variation in different years resulted spectacular variation in biomass (**Fig.2**), seed yield (**Fig.3**) and harvest index (**Fig.4**) since both excess and deficit rainfall during critical growth stages are harmful for the sesamum crop. Cessation of rainfall mostly from last week of October affected seed filling particularly in late maturing local type, Maghi Local (120 days duration).

Observations taken: Data on yield attributes such as days to 50% flowering and maturity, plant height, branches/plant, capsules/plant, seeds/capsule, seed yield, dry biomass and reaction to major insect pests and diseases such as- capsule borer, powdery mildew, Cercospora leaf spot, leaf blight and phyllody were taken. Biometric characters like plant height, branches/plant, capsules/plant and seeds/capsule were recorded based on measurement of 10 plants randomly chosen in fields for each variety and replication. Days to 50% flowering and maturity and reaction to major insect pests and diseases were recorded based on eye estimation.

Data analysis: Means of different sesamum genotypes were compared as per critical difference at p=0.05. Reaction to insect pests and diseases was studied based on 0-9 scale and that of phyllody as %. Transformed (square root) values were considered for data analysis of varietal reaction to major insect pests and diseases. Association between characters was carried out by estimating correlation coefficient values following Gomez and Gomez (1984). Different variability estimates were measured following Singh and Chaudhary (1979).The data on morphological characteristics was used to determine the relationship among genotypes following Jaccard's similarity coefficients (Jaccard Paul, 1912). The non-hierarchial cluster analysis of all response variables was performed based on unweighted pair group method of arithmetic averages (UPGMA) using NTSYSPc.2.10 software to produce the dendrogram (Sneath and Sokal,1973; Rohlf, 2000).

RESULTS AND DISCUSSION

Variation in quantitative traits: Sesamum germplasm exhibits a wide range of morphological distinctiveness in the vegetative, reproductive and ripening phases (Kim *et al*. 2002; Iwo *et al*.,2007). In spite of the limitations for being strongly influenced by environment, morphological characters of vegetative and reproductive phases are most widely used for characterization and identifying natural variations in sesamum (Bedigian *et al*., 1986).

Most of the varieties attained 50% flowering in 38 to 40 days and maturity in 80-85 days (**Table 1**). Significant variation was observed among the genotypes with respect to flowering and maturity duration, plant height, primary fruiting branches/plant, capsules/plant and seeds/capsule. Plant height varied from 95.2 cm in TKG-22 to 143.3 cm in Maghi Local. Number of fruiting branches per plant varied from 2.5 in OSC 560 to 4.9 in

Maghi Local. The variety, Maghi Local, had highest number of capsules/plant (50.5) but lowest number of seeds/ capsule (38.2). Based on the performance of sixteen sesamum genotypes under rainfed upland situation during *Kharif* 2006 to 2008, the average seed yield was found to be the highest in variety 'Prachi' (81 days, 4.32 q/ha) which was 114% higher over the local check, 'Maghi Local' (112 days, 2.02 q/ha).

Maturity duration of Maghi Local was found to be the longest. Days to 50% flowering and maturity exhibited very high heritability but moderate genetic advance which shows considerable impact of environment. The PCV was higher than GCV for all the characters which also indicates that the variation among genotypes was not only due to genotypes but also environment. Very low genetic advance was observed for dry biomass and seed yield showing that expression of both the characters is highly influenced by environment. Heritability of different characters varied from 83.49% in case of branches/plant to 99.17% in case of days to maturity but the genetic advance as % of mean ranged from 1.99% for biomass (q/ha) to 36.13% for branches/plant. High heritability coupled with high genetic advance as found in characters like capsules/plant and seeds/capsule indicates that heritability was due to additive gene effect and selection may be helpful. However, high heritability but low genetic advance found in case of seed yield and dry biomass indicates that high heritability was exhibited due to favorable influence of environment rather than genotype and selection for it may not be helpful. Comparatively lower heritability along with highest genetic advance found in case of branches/plant indicates that low heritability might be due to environmental influence and thus selection for this character would be effective.

The impact of rainfall distribution on seed yield is quite evident in the year 2007 (**Fig.1**). After sowing on 1st August, there was good rainfall during August and September, 2007 that helped in robust vegetative growth. However cessation of rainfall after 28th September coinciding with flowering and seed filling stages resulted in high proportion of unfilled seeds and low yield.

Varietal reaction to insect pests and diseases: The tested genotypes of sesamum differed from each other with respect to their reaction to different insect pests and diseases (**Table 2**). All the sesamum genotypes exhibited leaf and capsule borer (*Antigastra catalaunalis* L.) infestation which differed in degree, least in varieties Uma and Kalika, and highest in Maghi Local. Incidence of powdery mildew was absent in variety Prachi and Maghi Local, low to moderate in 13 genotypes and moderately severe in OSSel 185-1. Reaction to Cercospora leaf spot and leaf blight (*Xanthomonas sesami*) was somewhat similar among most of the genotypes with a mean of about 4.0 on 0-9 scale. Incidence of phyllody was noticed in only 3 genotypes ranging from 0.2% in Kalika to 1.0% in Maghi Local.

Correlation between different traits: Significantly high positive correlation was observed between days to 50% flowering and maturity (**Table 3**) which clearly shows that early flowering types can be chosen for early maturity. Both these characters exhibited significantly high positive correlation with plant height, branches/plant and incidence of phyllody. Plant height had significantly high positive correlation with dry biomass and branches / plant. However, no significant association was observed for any trait with seed yield in the present study although earlier investigations show that number of capsules per plant contributed the most towards seed yield followed by 1000-seed weight and plant height (Khan *et al*., 2001; Mishra *et al.*, 1995). The contrasting result in present investigation might be due to inclusion of Maghi Local in the set of test entries exhibiting maximum plant height and capsules / plant but lowest seed yield. While days to flowering and maturity, plant height and branches/plant exhibited negative association with seed yield, positive association of seed yield was observed with seeds/capsule, capsules/plant and dry biomass. Significant negative association of leaf and capsule borer infestation with Cercospora leaf spot shows inverse relationship between them. Low incidence of phyllody may not be adequate enough to highlight its relation with different traits.

Diversity among varieties: Since genetic diversity plays an important role in the exploitation of heterosis as well as for transgressive segregation, a non-hierarchial cluster analysis of 16 sesamum genotypes based on 13 important characters was carried out. Genetic diversity in sesamum based on morphological characters has not been spectacular always; some studies have reported extremely narrow genetic divergence (Nurul *et al*., 2014) while others reported wide range of morphological distinctiveness in vegetative, reproductive and ripening phases (Kim *et al*., 2002). In our study, the local type, Maghi Local was found to be most divergent from rest of the genotypes (**Fig.5**). Among the 15 improved types, variety Kalika showed maximum divergence from the others except OSSel-185-1 and Vinayak (**Table 4**). Two genotypes, OSC-24 (95)-2-1-3 and OSC- 539 were found to be very close to each other showing least divergence. The variety Prachi exhibited considerably higher genetic divergence from variety TKG-22. Other variety pairs showing satisfactory genetic divergence were found to be OSSel 185-1 and Prachi, OSSel 185-1 and Usha, Nirmala and TKG-22, OSC-540 and OSSel 185-1, Kanak and Prachi, TKG-22 and Vinayak, and Kanak and OSC-540 and thus could be attempted in genetic improvement programmes, either for obtaining transgressive segregants or hybrids.

The centre of origin of sesame has long been a debatable issue, but Bedigian (1981) reviewed various types of evidences available and concluded that sesame originated in India. Africa has most of the wild species but lacks variability of cultivated sesame. Genetic and chemical data demonstrate the difficulty of accepting an African origin of the crop (Bedigian, 2003). Indian accessions showed a good amount of genetic divergence (Benson *et al*.,2013). Among the Indian accessions, the collections from Rajasthan and North-Eastern states were highly diverse (Bhat *et al*., 1999). The high level of genetic diversity prevalent among the Indian collections is probably indicative of the nativity of this crop species. Similarly, the relatively lower level of polymorphism in exotic germplasm could be ascribed to the comparatively recent introductions of limited germplasm of this crop into some of the non-traditional sesame growing countries.

India is very rich in the genetic variability of cultivated sesame where it is grown and used since time immemorial. The extent of genetic diversity was greater in the collections from Indian subcontinent as compared to the exotics. Remarkable divergence of Maghi Local from the improved ones in the present investigation does highlight the possibility of exploitation of local germplasm in crop improvement programmes.

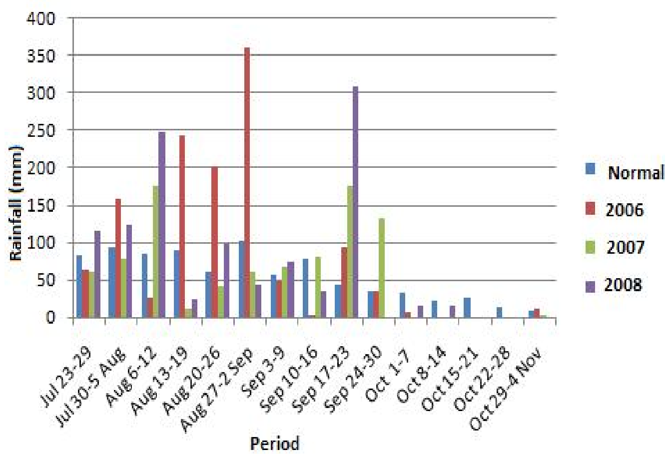

Fig.1. Weekly rainfall (mm) over years during cropping season

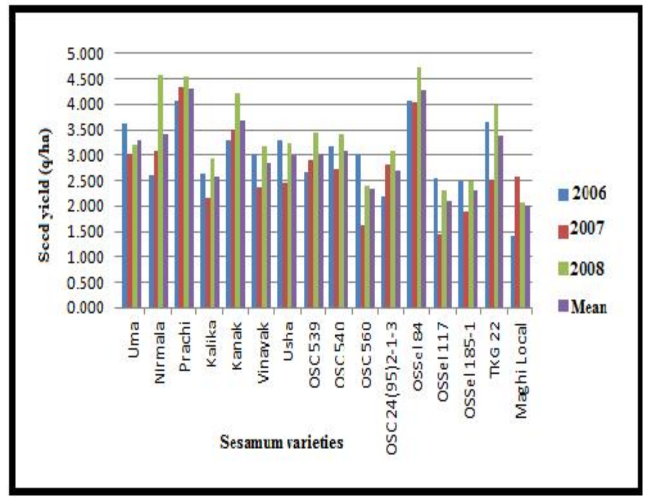

Fig.2. Year-wise variation in biomass of sesamum varieties

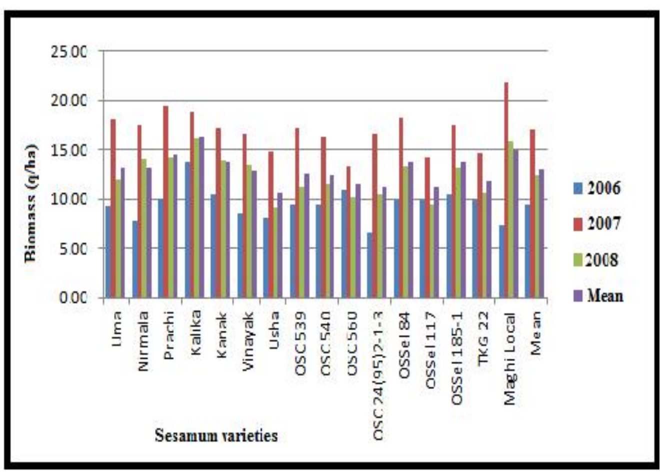

Fig.3. Year-wise variation in seed yield of sesamum varieties

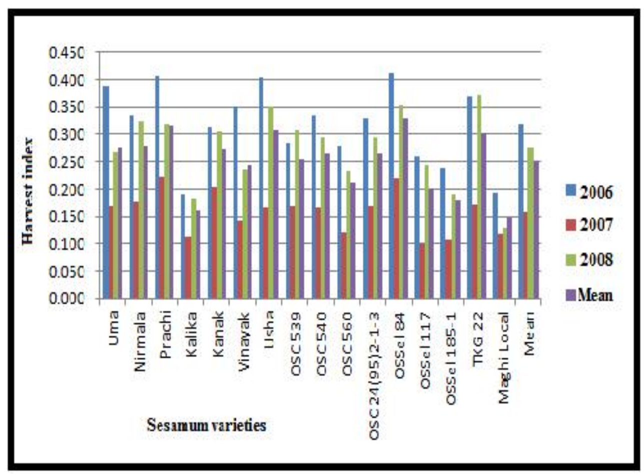

Fig.4. Year-wise variation in harvest index of sesamum varieties

Table 1. Performance of sesamum varieties at Phulbani for yield and yield attributes.

Variety	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches / plant	Capsules / plant	Seeds / capsule	Seed yield (q/ha)	Dry biomass (q/ha)
Uma	39.0	81.5	104.4	2.8	37.4	63.5	3.293	13.128
Nirmala	38.0	82.0	104.3	3.1	42.9	50.75	3.422	13.113
Prachi	39.0	80.5	111.5	3.5	45.2	43.5	4.320	14.568
Kalika	43.0	87.5	127	3.9	32.0	60.75	2.566	16.239
Kanak	39.5	82.0	101.8	2.9	31.4	64.5	3.669	13.840
Vinayak	39.0	85.5	111.5	2.6	38.0	53.2	2.852	12.906
Usha	39.0	82.0	103.5	3.9	45.5	52.8	2.989	10.710
OSC 539	38.0	82.5	99.6	3.9	35.7	49.15	3.015	12.627
OSC 540	38.0	80.0	98.1	3.0	32.6	40.15	3.091	12.445
OSC 560	38.0	81.5	107	2.5	29.7	53.4	2.346	11.516
OSC 24(95)2-1-3	39.0	81.0	96.4	3.6	33.9	55.75	2.697	11.231
OSSel 84	38.0	81.5	100.1	2.9	34.6	57.55	4.272	13.825
OSSel 117	39.5	82.0	104.6	2.6	36.7	50.95	2.095	11.175
OSSel 185-1	39.0	86.0	114.3	2.7	26.7	57.95	2.297	13.712
TKG 22	39.0	83.0	95.2	3.2	30.6	62.15	3.381	11.766
Maghi Local	47.5	112.0	143.2	4.9	50.5	38.2	2.016	14.997
Mean	39.53	84.41	107.66	3.25	36.46	53.39	3.020	12.987
Range	38-47.5	80-112	95.2-143.2	2.5-4.9	26.7-50.5	38.2-64.5	2.016-4.32	10.71-16.239
SEm ±	0.22	0.49	2.64	0.20	1.40	1.17	0.12	0.38
CD (0.05)	0.67	1.48	7.95	0.59	4.23	3.53	0.36	1.16
Genotypic variance	5.90	58.10	145.67	0.389	41.118	60.99	0.003889	0.018
Phenotypic variance	5.99	58.58	159.61	0.466	45.054	63.72	0.004128	0.0205
Heritability (%)	98.36	99.17	91.27	83.49	91.26	95.71	94.20	87.80
Genetic advance (% of mean)	12.55	18.52	22.06	36.13	34.61	29.48	4.13	1.99
GCV (%)	6.14	9.03	11.21	19.20	17.59	14.63	22.67	11.33
PCV (%)	6.19	9.07	11.73	21.02	18.41	14.95	23.36	12.09

Table 2. Performance of sesamum varieties at Phulbani for reaction to major insect pests and diseases,

Variety	Reaction to powdery mildew (0-9 Scale)	Reaction to leaf & capsule borer (0-9 Scale)	Reaction to Cercospora leaf spot (0-9 Scale)	Reaction to leaf blight (0-9 Scale)	Reaction to phyllody (%)
Uma	3(1.87)*	1(1.22)	5 (2.35)	4(2.12)	0.0 (0.71)
Nirmala	1 (1.22)	2(1.58)	3(1.87)	3(1.87)	0.0 (0.71)
Prachi	0 (0.71)	4(2.12)	4(2.12)	3(1.87)	0.0 (0.71)
Kalika	1(1.22)	1(1.22)	6 (2.55)	4(2.12)	0.2 (0.84)
Kanak	2 (1.58)	2(1.58)	4(2.12)	3(1.87)	0.0 (0.71)
Vinayak	1(1.22)	2(1.58)	4(2.12)	3(1.87)	0.0 (0.71)
Usha	3(1.87)	3(1.87)	4(2.12)	3(1.87)	0.0 (0.71)
OSC 539	2(1.58)	3(1.87)	3(1.87)	4(2.12)	0.3 (0.89)
OSC 540	1(1.22)	3(1.87)	4(2.12)	4(2.12)	0.0 (0.71)
OSC 560	1(1.22)	2(1.58)	4(2.12)	5(2.35)	0.0 (0.71)
OSC 24(95)2-1-3	1(1.22)	2(1.58)	5(2.35)	4(2.12)	0.0 (0.71)
OSSel 84	2(1.58)	2(1.58)	4(2.12)	3(1.87)	0.0 (0.71)
OSSel 117	3 (1.87)	3(1.87)	5(2.35)	4(2.12)	0.0 (0.71)
OSSel 185-1	4 (2.12)	3(1.87)	4(2.12)	3(1.87)	0.0 (0.71)
TKG 22	3(1.87)	4(2.12)	4(2.12)	4(2.12)	0.0 (0.71)
Maghi Local	0(0.71)	6(2.55)	3(1.87)	3(1.87)	1.0 (1.22)
Mean	1.75(1.50)	2.69(1.79)	4.13(2.15)	3.56(2.01)	0.1 (0.76)
Range	0-4 (0.71-2.12)	1-6(1.22-2.45)	3-6(1.87-2.45)	3-5(1.87-2.35)	0-1 (0.71-1.22)

* Figures in parentheses indicate transformed (square root) values

Table 3. Correlation coefficient values between important traits of sesamum.

	Days to Maturity	Plant Height.cm	Branches / Plant	Capsules / Plant	Seeds / Capsule	Seed Yield q/h	Dry Biomass	Powdery Mildew	Leaf & Capsule Bor	Cercospora Leaf Spot	Leaf Blight	Phyllody
Days to 50% Flowering	0.927**	0.894**	0.709**	0.441	-0.275	-0.454	0.557*	-0.428	0.455	-0.081	-0.174	0.868**
Days to Maturity		0.867**	0.659**	0.476	-0.397	-0.477	0.459	-0.404	0.594*	-0.368	-0.274	0.924**
Plant Height (cm)			0.547*	0.425	-0.336	-0.455	0.680**	-0.457	0.349	-0.115	-0.277	0.776**
Branches / Plant				0.598*	-0.419	-0.152	0.332	-0.496*	0.500*	-0.299	-0.168	0.796**
Capsules / Plant					-0.589*	0.085	0.122	-0.557*	0.484*	-0.449	-0.481	0.490*
Seeds / Capsule						0.166	-0.029	0.659**	-0.616**	0.538*	0.128	-0.478
Seed Yield (q/ha)							0.162	-0.071	-0.074	-0.035	-0.348	-0.411
Dry Biomass (q/ha)								-0.378	0.038	0.023	-0.355	0.454
Powdery Mildew									-0.389	0.259	0.062	-0.488*
Leaf & Capsule Borer										-0.572*	-0.300	0.559*
Cercospora Leaf Spot											0.365	-0.455
Leaf Blight												-0.114

*,** Significant at 5% and 1%, probability respectively. [Table value of r (df.=15) at 5% and 1% probability are 0.482 and 0.606, respectively]

Table 4. Dissimilarity matrix in sesamum.

	Kalika	Kanak	Maghi-Local	Nirmala	OSC-24(95)	OSC-539	OSC -540	OSC-560	OSSel -117	OSSel-185-1	OSSel -84	Prachi	TKG-22	Uma	Usha	Vinayak
Kalika	0.00															
Kanak	7.50	0.00														
Maghi-Local	10.19	15.59	0.00													
Nirmala	6.77	3.95	13.57	0.00												
OSC-24(95)	7.65	2.55	15.31	3.10	0.00											
OSC-539	7.80	3.16	14.85	2.59	2.17	0.00										
OSC-540	8.27	5.16	15.08	3.90	3.56	2.83	0.00									
OSC-560	6.16	3.85	14.49	3.76	3.28	3.17	3.57	0.00								
OSSel-117	7.63	3.63	15.19	3.69	2.97	2.38	3.10	2.67	0.00							
OSSel-185-1	3.89	4.58	12.55	4.62	4.78	4.75	5.34	3.00	4.67	0.00						
OSSel-84	7.80	2.86	15.48	4.25	2.76	3.01	3.90	3.81	2.63	4.85	0.00					
Prachi	7.58	5.30	14.00	2.85	4.67	3.60	4.11	4.64	3.77	5.78	5.00	0.00				
TKG-22	7.93	3.85	16.14	5.37	3.55	4.19	4.62	3.43	3.51	4.79	2.89	6.55	0.00			
Uma	6.47	2.60	14.68	3.20	2.96	3.51	4.72	3.26	3.39	3.88	3.26	4.61	3.65	0.00		
Usha	8.17	3.95	15.27	2.76	3.50	2.59	4.29	3.87	2.68	5.65	4.07	3.05	4.96	3.51	0.00	
Vinayak	4.71	4.34	12.09	2.40	4.00	3.62	4.56	3.16	4.06	2.76	4.69	3.86	5.29	3.19	4.05	0.00

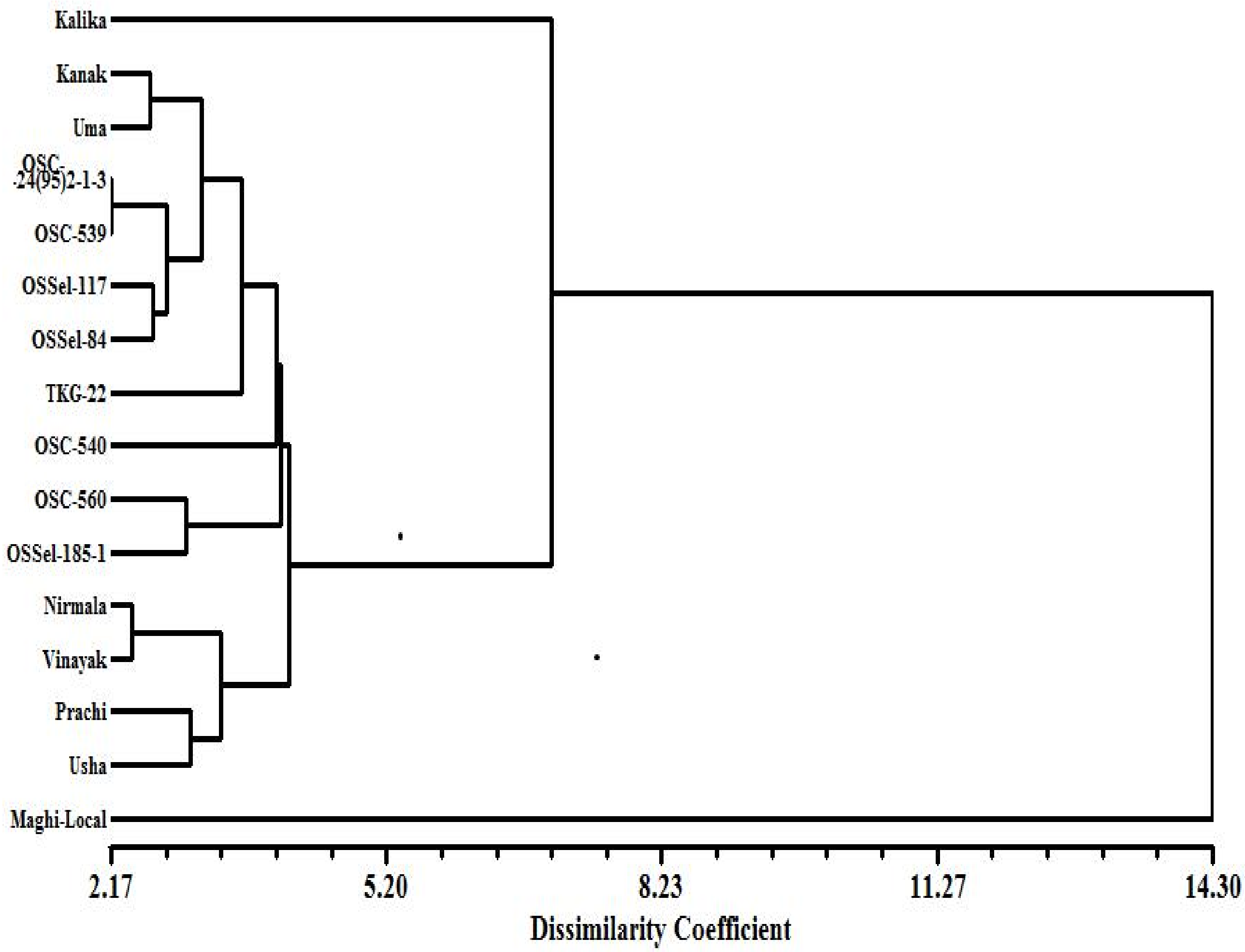

Fig. 5. Dendrogram based on dissimilarity coefficient values

Conclusion: The varieties, Prachi and OSSel 84 produced average seed yield of more than 4.0 q/ha and are thus most suitable for the N-E Ghat zone of Odisha. Other varieties which yielded satisfactory yield (about 3.5 q/ha) were Kanak and Nirmala which could also be profitably cultivated in this agro-climatic zone. Very low genetic advance observed for dry biomass and seed yield shows that expression of both the characters is highly influenced by environment. Local types like Maghi Local with high genetic divergence from improved ones can be included in sesamum crop improvement programme.

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