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Multivariate Analysis of Sesame Genotypes under Induced Drought Conditions

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A B S T R A C T

Sesame is one of the oldest oil crop, cultivated in tropical and sub tropical areas. Tolerance to moisture stress is one of the important criteria in the cultivation of sesame in many countries of the world. Hence, experiments were conducted to screen ten ruling varieties of sesame *viz.*, CO1, SVR1, SVPR1, VRI 1, VRI 2, TMV 3, TMV 4, TMV 5, TMV 6 and TMV 7 under induced drought condition using Poly Ethylene Glycol (PEG 6000) @ 3, 6, 9, 12, and 15 percentage concentrations. All the observations from the seedlings namely germination percentage, speed of germination, shoot length, root length and dry matter production were recorded. From the results, it was found that among the genotypes, maximum length of the seedling was noticed in TMV 5 (15.2 cm) followed by VRI 1 (14.5cm) and TMV 7 (13.7cm). A similar trend was observed for other seedling parameters of dry matter production, germination percentage and speed of germination. In general, with the increasing the levels of drought stress, the performance of seedlings in terms of shoot length, root length and dry matter production were found to decrease.

Introduction

Sesame is one of the important oilseed crop cultivated in tropical and sub tropical areas. Among the various stresses, moisture stress and its tolerance is one of the important criteria in the cultivation of sesame. Drought imposes one of the commonest and most significant constraints to agricultural production, seriously affecting crop growth, gene expression, distribution, yield and quality (Yang *et al.*, 2004; Shi *et al.*, 2009). Seed germination and seedling emergence are critical stages for plant establishment in crops grown in arid and semi-arid regions. It is at these critical stages that crop stand density and final yield are determined (Hadas, 1976). It has been reported that water stress can reduce or delay germination or completely prevent germination (Turk *et al.*, 2004). Boureima *et al*. (2011) using some sesame mutants showed that germination, emergence and root length of sesame were reduced under drought. Effects of drought stress reported that emergence was the most and germination was the least affected.

Polyethylene glycol (PEG) has been used to control water potential in seed germination studies to assess plant drought tolerance at germination and seedling stages (Dodd and Donovan, 1999). Water potential can be controlled precisely in this method and a large number of treatments can be performed quickly. PEG with 6000 or higher molecular weight cannot enter the pores of plant cells and PEG is not toxic to plant cells (Verslues *et al*., 2006). The response of germination rate, germination percentage, root length, shoot length and ratio of root length to shoot length (R/S) to stress induced by sodium chloride was different depending on concentrations (Khoshsokhan *et al*., 2012). In order to study the response of sesame varieties to moisture stress, experiments were conducted with PEG to report varieties tolerant to drought.

Materials and Methods

Laboratory experiments were conducted to screen ten ruling varieties of sesame *viz*., CO1, SVR1, SVPR1, VRI 1, VRI 2, TMV 3, TMV 4, TMV 5, TMV 6 and TMV 7 and drought condition was induced by using polyethylene glycol (PEG 6000) @ 3, 6, 9, 12, and 15 percentage concentrations. In this study, mature seeds of sesame were collected. Before starting the experiment, seeds were sterilized with solution of 3% sodium hypochlorite for two minutes. The experimental design was arranged in a completely randomized design (CRD) with four replications of hundred seeds each.

The number of germinated seeds was recorded daily and all the observations from the seedlings namely germination percentage, speed of germination, shoot length, root length, dry matter production, vigour index I and vigour index II were recorded from each replicates and mean was worked out. The data on morphological response of the seedlings due to drought exposure were collected after ten days of treatment with respect to shoot length, root length and biomass. Ten normal seedlings were taken randomly at the end of the germination test and the length from the collar region to tip of the primary root was measured and the mean value was expressed in centimeter for root length and the length between the collar region to tip of the primary shoot was measured and the mean value was expressed in centimeter for shoot length.

Germination percentage (GP) was calculated using this formula.

Germination percentage =

$$\frac{\text{No. of seeds germinated}}{\text{Total no. of seeds sown}} \times 100$$

Ten normal seedlings used for growth measurement were placed in a paper cover and dried under shade for 24 hrs. Then kept in a hot air oven maintained at 60°C for 24 hrs. The dried seedlings were cooled in a desiccator for 30 minutes and then dry weight was recorded per 10 seedlings and expressed in gram.

Vigour index values were computed using the formula suggested by Abdul-Baki and Anderson (1973) and expressed in whole number.

Vigour index = Germination percentage × total seedling length in cm.

Vigour index = Germination percentage × Dry matter in g.

The statistical analyses of morphological data were done using SPSS 16.0 for Windows STAR statistical software. Clusters of genotype were identified by using sequential multivariate statistical techniques cluster analysis (Ding, 2004).

Results and Discussion

From the results, it was found that among the genotypes, maximum length of the seedling was noticed in TMV 5 (15.2 cm) followed by VRI 1 (14.5cm) and TMV 7 (13.7cm) (table 1). A similar trend was observed for other seedling parameters of dry matter production, germination percentage and speed of germination. In general, with the increasing the levels of drought stress, the performance of seedlings in terms of shoot length, root length and dry matter production were found to be decrease. With increasing levels of drought, germination % was found to decrease from 90 % (control) to 30 % (15 % PEG) and seedling length was also found to decrease from 15.2 cm (control) to 4.9 cm (15 % PEG). A similar trend was noted in all the seedling parameters studied.

When analyzing the effects of different proportions of drought on sesame, it shows gradual decrease in seedling characters. Since sesame is generally cultivated in marginal areas where they face water stress, development of varieties with higher tolerance to moisture stress and water use efficiency will benefit both sesame cultivation and production. On the other hand, PEG had lesser inhibitory effect on seed germination than seedling growth, This result agrees with that of Zraibi *et al*. (2011) having evaluated different safflower varieties under drought and salt stress. Contrarily, these stresses had less inhibitory effect on seedling growth than seed germination, for white and black seeds characterizing the accessions. A similar finding was reported in sunflower (Kaya *et al*., 2006).

Table.1 Response of sesame varieties to moisture stress condition

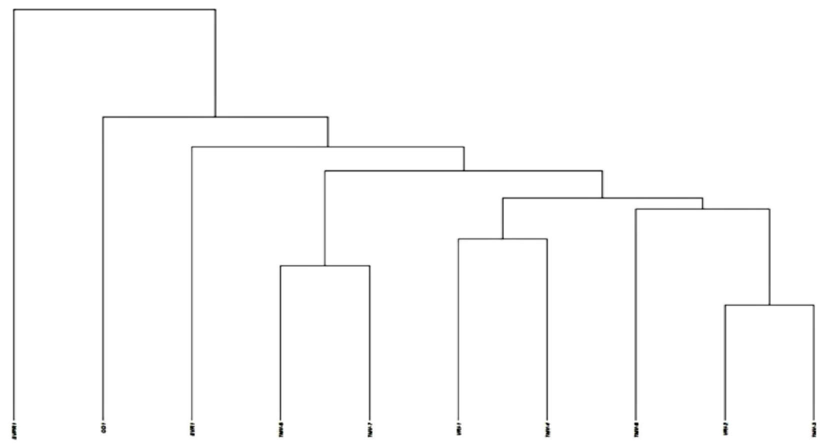
Genotypes	PEG %	Shoot Length (cm)	Root Length (cm)	Germination %	Total Length (cm)	Drymatter Per 10 Seedling	Vigour Index 1	Vigour Index 2	Speed Of Germination
CO1	Con	10.0	1.9	95	11.9	0.090	1130.5	8.55	2.781
	3	9.2	1.6	90	10.8	0.078	972.0	7.02	2.670
	6	8.3	1.3	80	9.6	0.044	768.0	3.52	2.560
	9	8.0	1.1	70	9.1	0.041	637.0	2.87	1.866
	12	7.2	0.9	50	8.1	0.037	405.0	1.85	1.110
	15	5.1	0.6	40	5.7	0.012	228.0	0.48	0.866
SVR1	Con	6.5	5.6	100	12.1	0.069	1210.0	6.90	2.826
	3	6.0	5.3	90	11.3	0.067	1017.0	6.03	2.750
	6	5.2	4.6	80	9.8	0.058	784.0	4.64	2.125
	9	5.0	3.0	70	8.0	0.051	560.0	3.57	2.070
	12	4.8	2.6	60	7.4	0.044	444.0	2.67	1.565
	15	4.5	1.9	50	6.4	0.031	320.0	1.55	1.520
SVPR1	Con	6.5	1.9	95	8.4	0.058	798.0	5.51	1.495
	3	6.0	1.8	90	7.8	0.054	702.0	4.86	2.655
	6	5.4	1.2	80	6.6	0.051	528.0	4.08	2.500
	9	5.0	1.0	60	6.0	0.047	120.0	2.82	2.150
	12	4.8	0.8	50	5.6	0.043	280.0	2.15	2.110
	15	4.3	0.6	40	4.9	0.039	196.0	1.56	1.905
VR1-1	Con	9.0	5.5	95	14.5	0.079	1377.5	7.50	1.905

	3	8.0	5.0	80	13.0	0.065	1040.0	5.2	1.710
	6	7.6	4.2	60	11.8	0.063	708.0	3.78	1.610
	9	7.0	4.0	50	11.0	0.060	550.0	3.00	1.580
	12	6.5	3.3	45	9.8	0.058	441.0	2.61	1.340
	15	6.0	2.1	40	8.1	0.053	324.0	2.12	0.930
VR1-2	Con	8.8	2.2	100	11.0	0.078	1100.0	7.80	2.030
	3	8.2	1.9	80	10.1	0.074	808.0	5.92	1.250
	6	8.0	1.6	60	9.6	0.071	576.0	4.26	1.000
	9	7.5	1.2	55	8.7	0.054	478.5	2.97	0.910
	12	7.1	0.9	45	8.0	0.049	360.0	2.05	0.945
	15	6.0	0.6	40	6.6	0.042	267.0	1.68	0.945
TMV-3	Con	7.9	4.1	100	12.0	0.081	1200.0	8.10	2.101
	3	7.8	3.2	90	11.0	0.074	990.0	6.66	1.930
	6	7.2	2.7	85	9.9	0.062	841.5	5.27	1.685
	9	6.6	2.0	80	8.6	0.057	688.0	4.56	1.690
	12	6.3	1.3	70	7.6	0.050	532.0	3.50	1.670
	15	5.5	1.0	50	6.5	0.042	325.0	2.10	1.660
TMV-4	Con	7.8	4.2	95	12.0	0.071	1140.0	6.74	1.965
	3	6.0	3.7	80	9.7	0.062	776.0	4.96	1.955
	6	5.3	2.6	70	7.9	0.060	553.0	4.20	1.280
	9	5.0	3.2	50	8.2	0.058	410.0	2.90	0.910
	12	4.5	1.5	40	6.0	0.054	240.0	2.16	0.851
	15	4.0	1.2	30	5.2	0.024	156.0	0.72	0.670
TMV-5	Con	7.6	7.6	100	15.2	0.090	1520.0	9.00	1.980
	3	6.5	6.1	80	12.6	0.082	1008.0	6.56	1.790
	6	6.3	5.5	75	11.8	0.073	885.0	5.47	1.735
	9	6.0	5.1	70	11.1	0.059	777.0	4.13	1.640
	12	5.6	4.1	50	9.7	0.041	485.0	2.05	1.325
	15	5.3	3.9	40	9.2	0.033	368.0	1.32	0.770
TMV-6	Con	7.6	3.5	95	11.1	0.091	1054.5	8.65	1.515
	3	6.4	2.7	80	9.1	0.086	728.0	6.88	1.345
	6	6.0	2.5	70	8.5	0.072	595.0	5.04	1.240
	9	5.5	2.1	60	7.6	0.070	456.0	4.20	1.120
	12	5.0	1.9	50	6.9	0.061	345.0	3.05	0.895
	15	4.7	1.2	45	5.9	0.053	265.5	2.38	0.360
TMV-7	Con	7.6	5.8	100	13.7	0.081	1340.0	8.10	1.651
	3	7.2	4.9	80	12.1	0.073	968.0	5.84	1.590
	6	6.5	4.0	60	10.1	0.065	606.0	3.60	1.235
	9	6.0	3.3	55	9.3	0.058	511.5	3.19	1.226
	12	5.6	2.2	50	7.8	0.047	390.0	2.35	0.870
	15	5.3	1.2	40	6.5	0.041	260.0	1.64	0.870

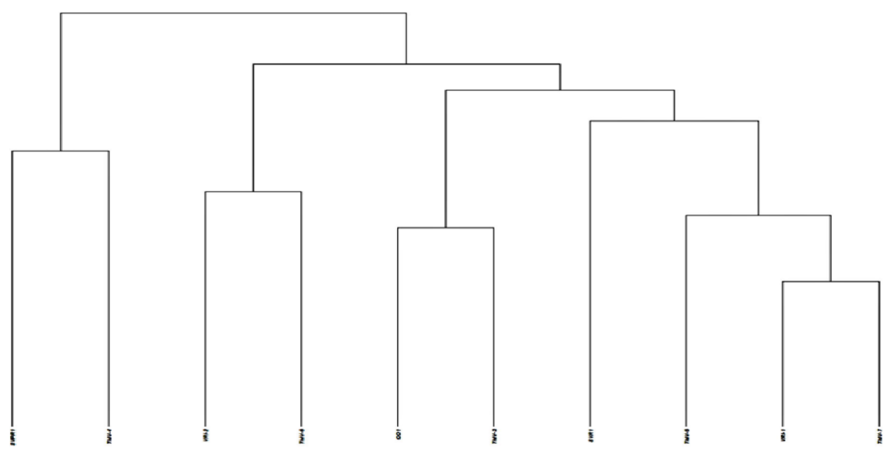
Table.2 Clusters of genotypes under study using Euclidian distance matrix at different drought levels

Cluster(CON)	Genotype
I	CO1
II	SVR1
III	SVPR1
IV	VRI-1 VRI-2 TMV-3 TMV-4 TMV-6
V	TMV-5 TMV-7
Cophenetic Correlation Coefficient = 0.792	
Cluster(PEG3)	Genotype
I	CO1 TMV-3
II	SVR1
III	SVPR1 TMV-4
IV	VRI-1 TMV-5 TMV-7
V	VRI-2 TMV-6
Cophenetic Correlation coefficient = 0.69	
Cluster(PEG6)	Genotype
I	CO1
II	SVR1 TMV-3 TMV-5
III	SVPR1
IV	VRI-1 VRI-2 TMV-7
V	TMV-4 TMV-6
Cophenetic Correlation Coefficient = 0.789	
CLUSTER(PEG9)	GENOTYPE
I	CO1
II	SVR1 TMV-3 TMV-5
III	SVPR1
IV	VRI-1 VRI-2 TMV-7 TMV-4
V	TMV-6
Cophenetic Correlation Coefficient = 0.77	
CLUSTER(PEG12)	GENOTYPE
I	CO1 VRI-2 TMV-7
II	SVR1 TMV-3
III	SVPR1
IV	VRI-1 TMV-5
V	TMV-4 TMV-6
Cophenetic Correlation Coefficient = 0.63	
CLUSTER(PEG15)	GENOTYPE
I	CO1 TMV-4
II	SVR1 TMV-3
III	SVPR1
IV	VRI-1 VRI-2 TMV-6 TMV-7
V	TMV-5
Cophenetic Correlation Coefficient = 0.76	

(a)



(b)



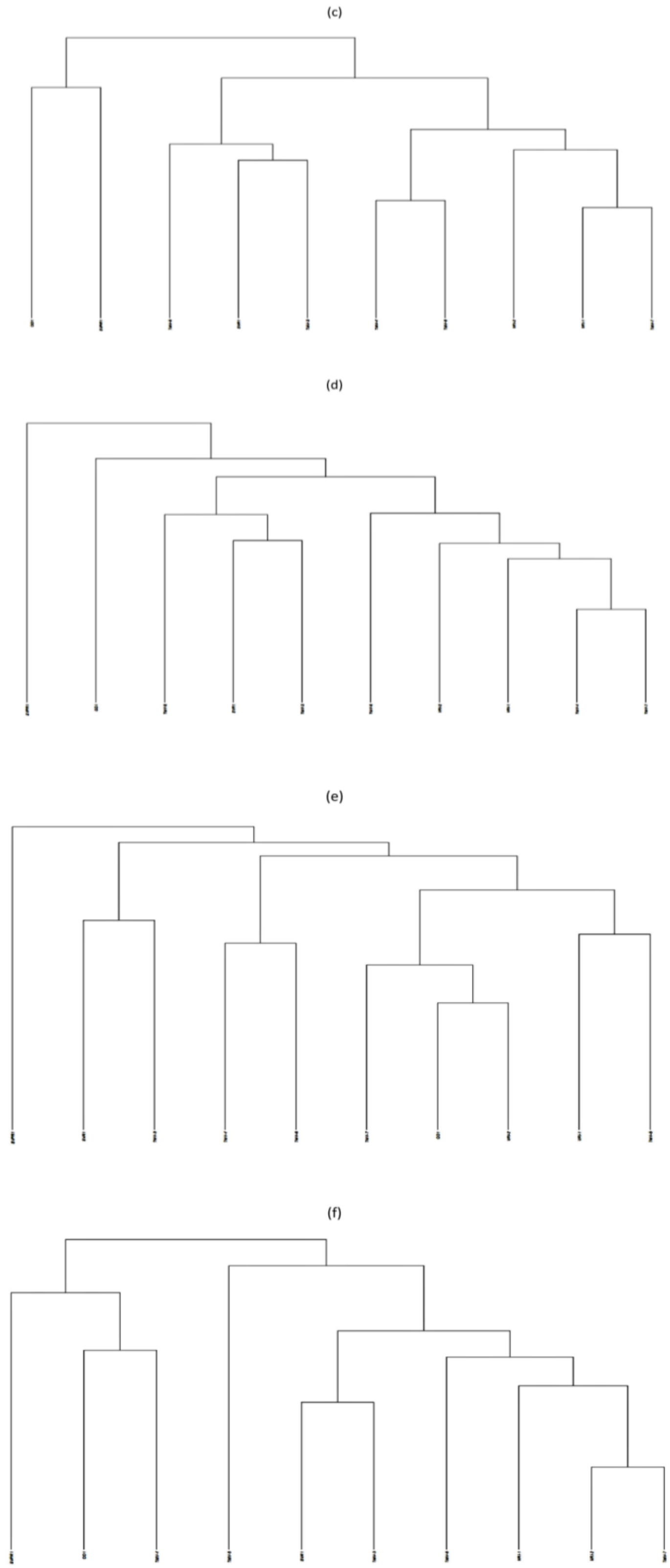


Fig. 2 Clusters of genotypes under study using Euclidian distance matrix at a. PEG0, b. PEG3 c. PEG6, d. PEG9, e. PEG 12 and f. PEG15

Agglomerative cluster analysis using Euclidean Distance as distance measure was done for grouping the germplasms suitably. On the basis of dendrogram (Fig. 1 and table 2) constructed by UPGMA, five clusters were formed at different levels of drought. In the rest of the drought level, the cophenotic correlation co- efficient was highest in 0.79(Control), followed by 0.78(PEG 6%), 0.77 (PEG 9% & PEG 15%). In the cluster analysis, the genotype CO1 presented in first cluster at all the drought levels followed by SVR1 and SVPR1 presented in clusters II & III. Differences in clustering pattern and swapping of genotypes among different clusters in different methods of diversity analysis have been reported in a number of studies (Suh *et al*., 1997, Han-yong *et al*., 2004, Thanh *et al*., 1999, Taran *et al*., 2005)

Seedling growth was more affected by drought stress than seed germination for sesame cultivars, and thus root length and/or shoot length could be relevant selection criteria in sesame breeding program for drought tolerance at early growth stages.

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