Multivariate Analysis of Sesame Genotypes under Induced Drought Conditions

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ABSTRACT

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.

Keywords
Sesame, Drought, Seedling parameters

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.

\[
\text{Germination percentage} = \frac{\text{No. of seeds germinated}}{\text{Total no. of seeds sown}} \times 100
\]

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

\[
\text{Vigour index} = \text{Germination percentage} \times \frac{\text{Dry matter in g.}}{\text{total seedling length in cm.}}
\]

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 (14.5 cm) and TMV 7 (13.7 cm) (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 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.

| Genotypes | PEG % | Shoot Length (cm) | Root Length (cm) | Germination % | Total Length (cm) | Dry matter 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          | 15 % PEG       |
| 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               |

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

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|     | Con | TMV-3 | TMV-4 | TMV-5 | TMV-6 | TMV-7 |
|-----|-----|-------|-------|-------|-------|-------|
|     | 3   | 6     | 9     | 12    | 15    | 3     |
|     | 6   | 9     | 12    | 15    | 3     | 6     |
|     | 9   | 12    | 15    | 3     | 6     | 9     |
|     | 12  | 15    | 3     | 6     | 9     | 12    |
|     | 15  | 3     | 6     | 9     | 12    | 15    |

| VR1-2 |     |       |       |       |       |       |
|-------|-----|-------|-------|-------|-------|-------|
|       | 3   | 6     | 9     | 12    | 15    | 3     |
|       | 6   | 9     | 12    | 15    | 3     | 6     |
|       | 9   | 12    | 15    | 3     | 6     | 9     |
|       | 12  | 15    | 3     | 6     | 9     | 12    |
|       | 15  | 3     | 6     | 9     | 12    | 15    |

|     |     |       |       |       |       |       |
|-----|-----|-------|-------|-------|-------|-------|
|     | 3   | 6     | 9     | 12    | 15    | 3     |
|     | 6   | 9     | 12    | 15    | 3     | 6     |
|     | 9   | 12    | 15    | 3     | 6     | 9     |
|     | 12  | 15    | 3     | 6     | 9     | 12    |
|     | 15  | 3     | 6     | 9     | 12    | 15    |
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                                   |
| V              | VRI-2 TMV-6                                   |

Cophenetic Correlation coefficient = 0.69

| Cluster (PEG6) | Genotype                                      |
|----------------|-----------------------------------------------|
| I              | CO1                                           |
| II             | SVR1 TMV-3                                   |
| 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                                   |
| III            | SVPR1                                         |
| IV             | VRI-1 VRI-2 TMV-7                             |
| 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                             |
| V               | TMV-5                                         |

Cophenetic Correlation Coefficient = 0.76
Fig. 2 Clusters of genotypes under study using Euclidian distance matrix at a. PEG8, 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 cophenetic correlation coefficient 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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How to cite this article:
Vignesh, M., M. Prakash, B. Priyadharshini and Anandan, R. 2018. Multivariate Analysis of Sesame Genotypes under Induced Drought Conditions. Int. J. Curr. Microbiol. App. Sci. 7(07): 4062-4070. doi: https://doi.org/10.20546/ijcmas.2018.707.472