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# RESPONSE OF NEW SESAME LINES (*SESAMUM INDICUM L.*) TO DEFICIT IRRIGATION UNDER CLAY SOILS CONDITIONS

**Abdelraouf, R. E. [1] and Anter, A.S. [2]**

[1]Water Relations and Field Irrigation Dept., Agricultural and Biological Division, National Research Centre ,33 EL Buhouth St., Dokki, Giza, Egypt,Postal Code: 12622.

[2]Field Crops Research Dept., Agricultural and Biological Division, National Research Centre ,33 EL Buhouth St.,Dokki, Giza, Egypt, Postal Code: 12622.

Corresponding author: tokaeman@gmail.com

## Abstract

Drought is one of the main constrains limiting sesame production in Egypt. It is necessary to develop new varieties of sesame that are more adapted to drought conditions. The aim of this study was to identify sesame lines that are more adapted to drought-prone environments. Experiments carry out at the Agriculture Experiments and Research Station, Faculty Agriculture, Cairo University, Giza, Egypt, during two growth seasons (2016 and 2017). Six sesame lines in $F_8$ and $F_9$ generations evaluated under normal (100% of full irrigation) and drought (50% of total irrigation) conditions. Roots volume in the soil, irrigation requirement, seed yield and water productivity was estimated. The analysis of variance for studied traits revealed the variance was presented for studied traits. The largest volume of roots within the soil sector recoded by line $C_{3.8}$ under two conditions. Two out of six lines ,$C_{1.6}$ and $C_{1.8}$ ,were less in need of water compared to control and other lines, while C $_{6.5}$ was the most in need. Line $C_{3.8}$ achieved the highest value of seed yield and water productivity at every level of irrigation. Therefore, line $C_{3.8}$ will be recommended for preliminary trials as new cultivar suitable aeries proved for drought and /or as parent in other drought breeding programs.

***Keywords:*** Roots volume, Sesame lines, water productivity, drought, Deficit irrigation

## Introduction

Drought is a prime yield-limiting factor over the world (Farooq,et al. 2012),especially under dry land conditions (Narayanan, et al.2014 and Mansour, et al.2017).Sesame crop has promising future in Egypt because withstand water shortage, adaptable to a range of soil types, preserving food and nutritional security and livelihood improvement, an alternative cash crop for smallholders, contains greater oil content % than other oil crops, which contains high ratio of unsaturated to saturated fatty acid, a good source of protein, provide a valuable source of minerals, it contains antioxidative lignans, it has a prolong shelf life and it can be mixed with less firm vegetable oils to mend their stability and longevity and sesame is a resilient crop with a robust adaptation to drought conditio (Kim, et al. 2006, Onsaard, 2012, Islam, et al., 2016 ,Li, et al. 2018 and Dossa, et al.2019). However, drought is important abiotic stress which that limited the spread of sesame cultivation in Egypt. And seed yield of sesame has been stable for a long time (Shabana, et al.2014).In addition to, climate change will have a negative impact on available freshwater for irrigation (Oosten, et al. 2016).Water scarcity is one of the serious and major problems facing crop production in Egypt, and it is necessary to reduce irrigation water consumption by developing drought tolerant cultivars.

The growing vulnerability to drought condition requires that resilient varieties capable of surviving while preserving good yield (Mickelbart,et al.2015). Fortunately,sesame expresses versatile morphological adaptations to resistance of drought including, root growth, increase root to shoot ratio and early maturity (Dissanayake, 2017). Also, Hailu, et al. (2018) pointed that sesame plant is a very important crop with drought-resistant characteristics and suitable for cultivation under drought conditions. Root is a main organ respond, root traits such as root diameter, root length, root area, root angle, and root length density are considered helpful traits for improving plant productivity by maintaining crop yield under drought conditions (Boyer,1996; Opitz,2016;Wasaya, et al.2018).Roots have long been suggested as a prime path of research pathway for increasing crop adaptation to drought conditions (Vadez, 2014). Also, Dossa, et al. (2017) found that the root is preserves morphology characteristics under drought condition through the strong activity of antioxidant machines. Consequently, root system has a main role to face drought conditions. Sanchez-Blanco, et al. (2014) claim that plants under stress root volume is reduced. So direct selection for a high root volume under deficit irrigation would be effect to identity drought-tolerant lines.

With water scarcity crisis and low rainfall levels, it is important to know the crop water requirements and irrigation scheduling to take care of the irrigation demand (Todorovic, 2005 and Ewaid, 2018). The aim of this study was to identify sesame lines that are more adapted to drought-prone environments.

## Material and Method

### Description of study site

Field experiments were conducted during two summer seasons 2016 and 2017 at Faculty farm in Giza region, Giza government (Latitude of 30° 2' 38" North, Longitude of 31° 14' 9" East). It is very important to collect the meteorological data for the site under consideration. There are different other parameters needed such as; ambient temperature, relative humidity and wind speed. Table 1 summarizes the monthly mean climatic data for average two growing seasons for selected site.

**Table 1:** the average data (2016 and 2017) of meteorological data.

| Months | HC Air temperature [°C] | | Relative humidity [%] | | Aver. of Wind speed [m/sec] | Monthly average solar radiation intensity W/m$^2$ |
|---|---|---|---|---|---|---|
| | Maxi. | Mini. | Maxi. | Mini. | | |
| 2016 | | | | | | |
| May | 37.1 | 12.3 | 74.5 | 20.0 | 7.0 | 7030 |
| June | 39.4 | 9.6 | 78.3 | 19.8 | 6.5 | 7350 |
| July | 35.5 | 10.6 | 80.0 | 26.8 | 5.5 | 7410 |
| Aug. | 36.7 | 14.0 | 80.4 | 24.1 | 4.6 | 7390 |
| Seb. | 36.8 | 14.0 | 83.9 | 27.7 | 5.7 | 7080 |
| 2017 | | | | | | |
| May | 38.1 | 13.1 | 75.0 | 21.2 | 7.4 | 7033 |
| June | 39.7 | 10.1 | 77.9 | 20.5 | 6.6 | 7360 |
| July | 36.2 | 10.9 | 81.0 | 27.8 | 5.9 | 7430 |
| Aug. | 35.9 | 14.4 | 80.6 | 23.9 | 4.8 | 7400 |
| Seb. | 37.4 | 15.2 | 84.3 | 28.4 | 6.1 | 7100 |

**Table 2:** The origin, breeding status and description for parents.

| Specific characters | Seed source* | Breeding status | Lines |
|---|---|---|---|
| Early maturity, non branching first capsule set low, 3 capsules/axil. | Cairo Univ.* | $F_8$-hybrid pop | P1(HM19) |
| Early maturity, non-branching, first capsule set low, 3 capsule/axil. | Cairo Univ.* | Mutant line | P2 (EUL90) |
| Branching, 3 capsules /axil. | Cairo Univ.* | Mutant line | P3 (Mutant 48) |
| Heavy seed weight, medium branching, one capsule/axil, long capsule, late maturity. | Ministry of Agric.& Land Reclamation, Egypt | Local cultivar | P4 (Giza 32) |
| Stiff stem, late maturity, one capsule/axil. | India through IAEA** | Exotic line | P5 (NM59) |
| Low branching, 3 capsules/axil, semi- shattering capsules. | Iraq through IAEA** | Exotic variety | P6 (Babil) |

* Advanced breeding materials resulted from the breeding program conducted at Agron. Dept. Fac. of Agric. Cairo Univ. * * Inter. Atomic Energy Agency. Lines $C_{1.5}$ and $C_{1.6}$ resulted from a hybrid $P_1$* $P_2$,line C3.8 resulted from a hybrid $P_1$*$P_3$and lines C6.3 and C6.5 resulted from a hybrid $P_1$ *$P_6$.

**Plant material:**Breeding materials used in this investigation were 6 elite derived lines of sesame ($F_8$ and $F_9$ genrations) obtained via pedigree selection from agronomy Department, Faculty of Agriculture, Cairo University. And commercial cultivar

,Shandawell, as control (C) from Ministry of Agric.& Land Reclamation. The namely of lines as follows: $C_{1.5}$ $C_{1.6}$, $C_{1.8}$, $C_{3.8}$, $C_{6.3}$ and $C_{6.5}$. The characteristics of parents and C are shown in Table (2).

**Irrigation requirements for sesame crop**

The irrigation requirements were based on the reference evapotranspiration equation of Penman- Monteith uses monthly data of the in site weather station for Giza region and using the following equation.

IRg = [(ETO x Kc ) / Ei] - R + LR ……………..(1)

Where; IRg is gross irrigation requirements (mm/day], ETO is a reference evapotranspiration (mm/day). Kc is a crop factor (FAO 56, 1998), Ei is irrigation efficiency (%), R is water received by plant from sources other than irrigation, for example rainfall, (mm)] and LR is amount of water required for the leaching of salts (mm).

Experimental design: These experiments were conducted at the Agric. Exp. and Res. Station, Fac. Agric. Cairo Univ. Giza, Egypt, two separate experiments under normal "100%FI" and drought "50%FI" conditions during two seasons (15 May, 2016 and 18 May, 2017) in clay soil. Six sesame lines in F8 and F9 generations and C were evaluated under two moisture regimes. In the first, lines will well-watered. In the second, lines received adequate watering from germination to the boot stage. No rain during experiment period. The field experimental design was arranged in a randomized complete block with three replications. The plots consist of 3 rows 3 m long and space 0.50 m apart with a 10 cm plant distance in the rows. The recommendations of Minstery of Agriculture were applied.

Evaluation parameters

Roots volume in the soil: Most plant roots, including sesame, have a conical shape within the soil section. To determine the size of sesame roots within the soil sector, the radius of the horizontal roots was measured in addition to measuring the effective vertical length of roots and then we can calculate the effective root size within the soil sector through the following formula an as shown as in figure (1):

V = (3.14*R2*H)/3 ………………(2)

Where: V: The conical root size, m3, R: Horizontal root radius, cm, H: Effective vertical length of roots, cm

Irrigation requirement of sesame crop based on days to maturity: The water needs of each line will be different from the other, and will be related to the number of ripening days needed for each line.

Seed yield: At harvest, the seed yield/m2 (kg) was recorded on a random sample of ten guarded plants from each plot.

Water productivity of sesame: "WP sesame": It was calculated according to James, (1988) as follows:

WP sesame = Ey/Ir …………………(3)

Where: WP sesame is water productivity (kg sesame m-3 water), Ey is the economical yield (kg); Ir is the amount of applied irrigation water (m3).

Variance analysis

Data of each trait were subjected to a regular analysis of variance of the randomized complete blocks design (RCBD) according to Snedecor and Cochran, (1980). Coefficient of variation (CV%) estimated as follows:

CV= (SD) /X) * 100, where: SD: standard deviation, X: mean of trait. Differences among means of genotypes were tested for significance against the L.S.D. (Least Significant Difference) values according to Snedecor and Cochran (1980) in F8 and F9 generations under normal and drought conditions using the following formula:

LSD 0.05% for genotypes mean = (t). (2 EMS/r)0.5 , Where :

(t) : is the tabulated t value for a stated level of probability.

EMS : is the mean square due to error from the analysis of variance.

r : is the number of replications.

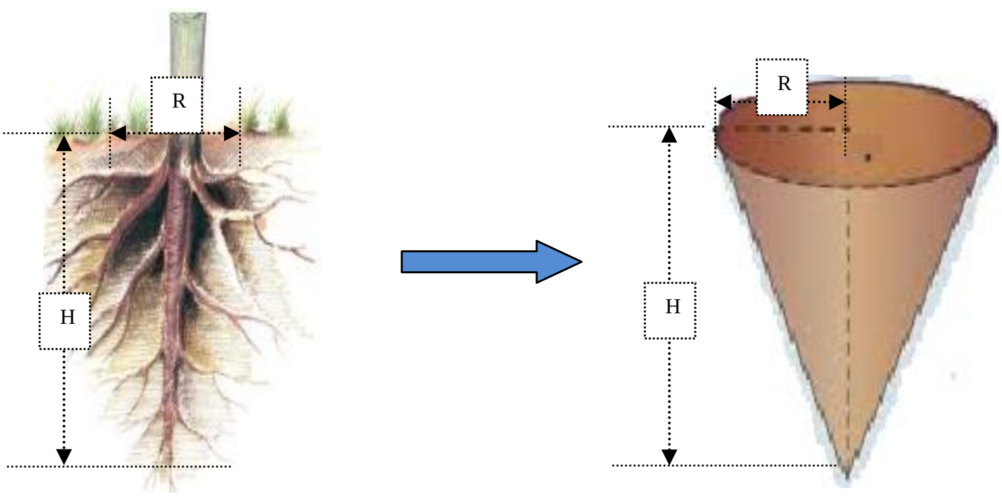


**Figure 1:** The conical root size

## Results and Discussion

Data in Tables 3 and 4 showed that there were significant differences ($p<0.05$) among genotypes for all studied traits in F8 and F9 generations under normal and drought conditions, indicating that genotypes has different responses of studied traits under normal and drought conditions.This provides evidence of the presence of sufficient genetic variability among genotypes that can be exploited in sesame breeding program through selection.

### Roots volume in the soil

Banon, et al. (2003) and Alvarez, (2011) found that, under drought conditions, root volume is reduced, while root density increases. Therefore, direct selection for a high root volume under drought conditions would be effective for identifying drought tolerant lines.

Data in Table 3 showed that the highest values of RV were occurred under irrigation by 100%FI compared with irrigation by 50%FI and this may be due to reducing the wet soil volume when irrigation by 50% FI, which led to the small size of the roots, which spread in the effective area of root growth. In this study, we found that highest value of RV was occurred under line C3.8 it was 523 cm3 at 100%FI and 400 cm3 at 50%FI compared to other genotypes under F8 and the same trend occurred under F9.

**Table 3**. Response of roots volume of genotypes under normal and drought conditions.

| G. | DI | Lines | R, cm | H, cm | V, $cm^3$ |
|---|---|---|---|---|---|
| $F_8$ | 100% FI | $C_{1.5}$ | 5.0 | 18.4 | 480.0 |
| | | $C_{1.6}$ | 5.0 | 18.6 | 485.1 |
| | | $C_{1.8}$ | 5.1 | 16.7 | 455.2 |
| | | $C_{3.8}$ | 5.0 | 20.0 | 523.3 |
| | | $C_{6.3}$ | 5.3 | 16.7 | 490.4 |
| | | $C_{6.5}$ | 5.0 | 17.2 | 450.3 |
| | | C | 4.9 | 20.3 | 510.2 |
| | | P>0.05 | | | ** |
| | | CV% | | | 2.5 |
| | | $LSD_{0.05\%}$ | | | 20.3 |
| | 50% FI | $C_{1.5}$ | 4.0 | 20.9 | 350.3 |
| | | $C_{1.6}$ | 4.2 | 20.1 | 371.2 |
| | | $C_{1.8}$ | 4.0 | 22.6 | 378.2 |
| | | $C_{3.8}$ | 4.1 | 22.7 | 400.1 |
| | | $C_{6.3}$ | 4.0 | 23.7 | 396.2 |
| | | $C_{6.5}$ | 4.0 | 22.9 | 383.2 |
| | | C. | 4.3 | 20.1 | 388.5 |
| | | P>0.05 | | | ** |
| | | CV% | | | 3.0 |
| | | $LSD_{0.05\%}$ | | | 17.2 |
| $F_9$ | 100% FI | $C_{1.5}$ | 4.9 | 17.2 | 432.4 |
| | | $C_{1.6}$ | 4.9 | 18.2 | 457.2 |
| | | $C_{1.8}$ | 5.0 | 17.7 | 462.2 |
| | | $C_{3.8}$ | 4.9 | 19.8 | 498.2 |
| | | $C_{6.3}$ | 5.2 | 16.5 | 465.4 |
| | | $C_{6.5}$ | 4.9 | 17.0 | 428.3 |
| | | C. | 4.8 | 20.1 | 485.4 |
| | | P>0.05 | | | ** |
| | | CV% | | | 2.1 |
| | | $LSD_{0.05\%}$ | | | 12.8 |
| | 50% FI | $C_{1.5}$ | 3.9 | 20.8 | 351.5 |
| | | $C_{1.6}$ | 4.1 | 20.2 | 357.8 |
| | | $C_{1.8}$ | 3.9 | 20.7 | 333.6 |
| | | $C_{3.8}$ | 4.0 | 22.5 | 380.6 |
| | | $C_{6.3}$ | 3.9 | 19.9 | 320.8 |
| | | $C_{6.5}$ | 3.9 | 19.3 | 310.5 |
| | | C | 4.2 | 19.8 | 369.6 |
| | | P>0.05 | | | ** |
| | | CV% | | | 2.6 |
| | | $LSD_{0.05\%}$ | | | 15.3 |

G: generations, C:commerical cultivar, FI: Full Irrigation, R: Radius of the horizontal roots, H: Effective vertical length of roots,V: Roots volume in the soil,**:significant level at 0.05%,CV%: coefficient of variation, $LSD_{0.05}$: least significant difference

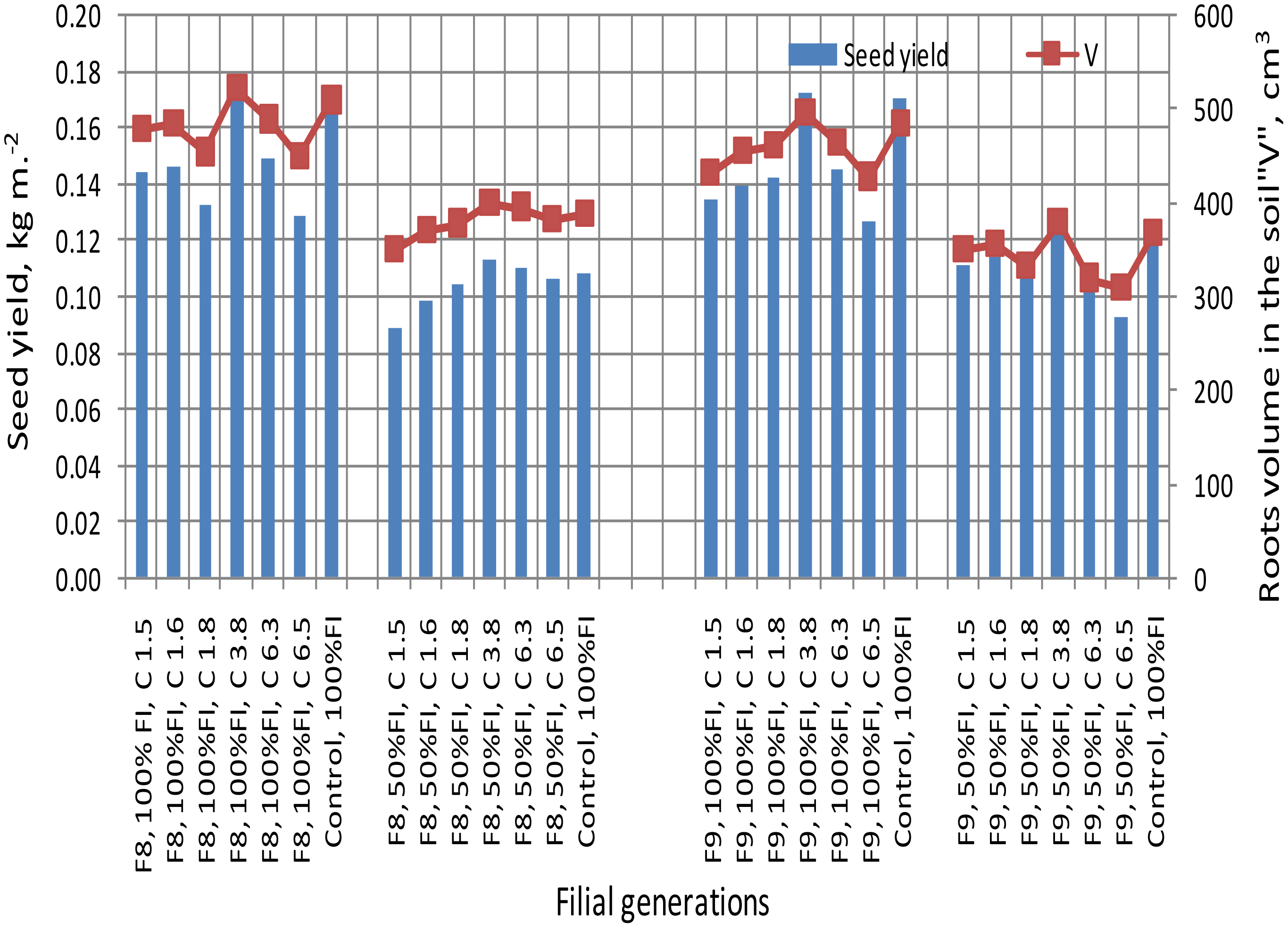


**Fig. 2.** The relationship between the roots volume in the soil and seed yield for different sesame varieties in F8 and F9 generations

This line may be able to maintain a gradient of water to absorb water under drought conditions (Sanchez-Blanco, et al. 2014). There is a strong relationship between the widths of the horizontal roots "R" and the length of the vertical roots "H" in the active root zone and the amount of irrigation water added. The H increased at 50%FI compared to irrigation by 100%FI and this may be due to increase the growth of the roots down in search of water when irrigating with 50% of total irrigation. Conversely, when irrigating with 100% of full irrigation, the growth of the roots will be horizontal rather than vertical.

Irrigation requirement of sesame crop based on days to maturity, Agriculture production is the prime consumer of water, and the crop water requirements and irrigation scheduling to take care of the irrigation demand (Al-Ansari,2013 and Ewaid,2018).

The water needs of the genotypes under study are combined based on the number of days needed to reach maturity. The number of days required for ripening sesame lines is affected based on the genetic status of each line and also on the conditions of water stress that these lines are exposed to when irrigating at 50% of the water requirements needed for irrigation. Exposure of different lines of sesame to water stress from irrigation with 50% of the water requirements needed for irrigation accelerated the ripening period of the crop and reduced the number of days required for ripening (Table 4). Two out of six lines ,C1.6 and C1.8 ,were less in need of water compared to C and other lines, while C 6.5 was the most in need, suggesting that both are more suitable for suitable for very dry areas. In general, the water requirements needed to irrigate the genotypes during the second season increased slightly from that during the first season, and this was probably due to an increase in air temperature during the second season than during the first season (Table1), which led to an increase in the rate of evapotranspiration of the cultivated plants during the second season.

Seed yield (SY)

Seed yield and secondary traits as selection criteria were used for selecting new crops with stand drought stress (Lafitte, et al.2003). Sserumaga, et al.(2018) point that direct selection for high potential yield in normal condition may be improves yield in stress condition. The data in the Table 4 showed that the overall mean of lines for SY trait in the case of normal was higher than the drought during two successive seasons while the overall mean of C for SY trait exceeded the overall mean of lines during the two seasons under normal and drought conditions. During two seasons the line, C3.8 achieved the highest SY trait than other lines under both normal and drought conditions and almost equal with C under optimum-moisture and exceeded under drought condition (Anter and Ashraf, 2018 and Anter, 2019). While on the contrary the line C6.5. Thesis results indicated that C3.8 more tolerance drought than commercial variety and other lines during two seasons by switching genes for drought tolerant.

**Table 4.** Response of irrigation requirement, yield and water productivity of six sesame lines in F8 and F9 generations to deficit irrigation under clay soils conditions

| Filial generations | Drought stress | Lines | May | June and July | Aug., | Sept., | TD | SIR of sesame, $m^3\ m^{-2}$ | Seed yield, $M^2$ (Kg) | WP $_{Sesame}$, Kg. $m^{-3}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| F8, 2016 | 100% FI | **$C_{1.5}$** | 15 | 61 | 30 | 10 | 116.0 | 0.765 | 0.152 | 0.19 |
| | | **$C_{1.6}$** | 15 | 61 | 30 | 2 | 1080. | 0.713 | 0.154 | 0.21 |
| | | **$C_{1.8}$** | 15 | 61 | 29 | | 105 | 0.693 | 0.140 | 0.19 |
| | | **$C_{3.8}$** | 15 | 61 | 30 | 10 | 116 | 0.765 | 0.184 | 0.23 |
| | | **$C_{6.3}$** | 15 | 61 | 30 | 12 | 118 | 0.778 | 0.157 | 0.19 |
| | | **$C_{6.5}$** | 15 | 61 | 30 | 13 | 119 | 0.785 | 0.136 | 0.16 |
| | | Con. | 15 | 61 | 30 | 8 | 114 | 0.752 | 0.180 | 0.23 |
| | | **$p > 0.05$** | | | | | ** | | ** | ** |
| | | CV% | | | | | 3.0 | | 2.36 | **5.8** |
| | | LSD $_{0.05}$ | | | | | 6.8 | | 0.07 | **0.015** |
| | 50% FI | **$C_{1.5}$** | 15 | 61 | 24 | | 100 | 0.330 | 0.093 | 0.27 |
| | | **$C_{1.6}$** | 15 | 61 | 22 | | 98 | 0.323 | 0.104 | 0.31 |
| | | **$C_{1.8}$** | 15 | 61 | 23 | | 99 | 0.327 | 0.109 | 0.32 |
| | | **$C_{3.8}$** | 15 | 61 | 28 | | 104 | 0.343 | 0.119 | 0.33 |
| | | **$C_{6.3}$** | 15 | 61 | 29 | | 105 | 0.346 | 0.115 | 0.32 |
| | | **$C_{6.5}$** | 15 | 61 | 26 | | 102 | 0.673 | 0.122 | 0.32 |
| | | Con. | 15 | 61 | 26 | | 102 | 0.336 | 0.122 | 0.32 |
| | | **$p > 0.05$** | | | | | ** | | ** | ** |
| | | CV% | | | | | 4.1 | | 8.4 | 6.1 |
| | | LSD $_{0.05}$ | | | | | 4.4 | | 0.015 | 0.011 |
| F9, 2017 | 100% FI | **$C_{1.5}$** | 15 | 61 | 30 | 12 | 118 | 0.778 | 0.142 | 0.17 |
| | | **$C_{1.6}$** | 15 | 61 | 30 | 2 | 108 | 0.713 | 0.146 | 0.20 |
| | | **$C_{1.8}$** | 15 | 61 | 30 | 5 | 111 | 0.732 | 0.150 | 0.20 |
| | | **$C_{3.8}$** | 15 | 61 | 30 | 21 | 127 | 0.838 | 0.196 | 0.23 |
| | | **$C_{6.3}$** | 15 | 61 | 30 | 11 | 117 | 0.772 | 0.153 | 0.19 |
| | | **$C_{6.5}$** | 15 | 61 | 30 | 7 | 113 | 0.745 | 0.133 | 0.17 |
| | | Con. | 15 | 61 | 30 | 9 | 115 | 0.759 | 0.179 | 0.22 |
| | | **$p > 0.05$** | | | | | ** | | ** | ** |
| | | CV% | | | | | 2.1 | | 3.2 | 4.4 |
| | | LSD $_{0.05}$ | | | | | 4.0 | | 0.01 | 0.013 |
| | 50% FI | **$C_{1.5}$** | 15 | 61 | 25 | | 101 | 0.333 | 0.117 | 0.33 |
| | | **$C_{1.6}$** | 15 | 61 | 24 | | 100 | 0.330 | 0.120 | 0.35 |
| | | **$C_{1.8}$** | 15 | 61 | 22 | | 98 | 0.323 | 0.117 | 0.34 |
| | | **$C_{3.8}$** | 15 | 61 | 30 | 4 | 110 | 0.363 | 0.140 | 0.35 |
| | | **$C_{6.3}$** | 15 | 61 | 23 | | 99 | 0.327 | 0.117 | 0.34 |
| | | **$C_{6.5}$** | 15 | 61 | 26 | | 102 | 0.336 | 0.097 | 0.27 |
| | | Con. | 15 | 61 | 27 | | 103 | 0.340 | 0.125 | 0.34 |
| | | **$p > 0.05$** | | | | | ** | | ** | ** |
| | | CV% | | | | | 3.4 | | 6.2 | 8.2 |
| | | LSD $_{0.05}$ | | | | | 4.2 | | 0.011 | 0.014 |

$F_8$ and $F_9$ : filial generations, C: commerical cultivar, FI: Full Irrigation, TD: total days to maturity, days, SIR: Seasonal Irrigation Requirement, WP Sesame:Water productivity of sesame.,**: significant level at 0.05%, CV: Coefficient of variation, $LSD_{0.05}$: least significant difference among means.

Fig.2 demonstrated the strong relationship between the roots volume in the soil and seed yield for different genotypes in F8 and F9 generations. This may be due to the fact that increasing the volume of the root system within the root zone extends the capacity of the sesame plant roots to absorb the water reserves and nutrients at a greater rate than was ultimately reflected in the affirmative and the increase in productivity. Line C3.8 achieved the largest volume of roots within the soil sector, whether at irrigation with 50% or 100% of complete irrigation in comparison with other lines and C. Also, Anter, (2019) found that line C3.8 achieved the highest root length under drought condition, suggesting this line was able to absorb water from deep soil depth, thus completing its life naturally. In this study, we found that high roots volume under drought conditions associated with high seed yield; therefore, a direct selection for high volume under drought conditions can be used as selection criterion

Additionally, Su, et al. (2019) found that root biomass contributed significantly to increasing sesame seed production.

**Water productivity of sesame for F8 and F9**

Water productivity is one of the most important criteria for evaluation under conditions of irrigation deficiency in dry areas, including Egypt, (Abdelraouf, et al. 2012). Table 4 showed that there are differences between the water productivity values for sesame genotypes under study at each level of irrigation and during both seasons.

Line C3.8 achieved the highest value of water productivity at every level of irrigation. Although the highest values of aqueous productivity of sesame were achieved at irrigation at 50% of full irrigation during the two seasons of the study, it does not count or take these values as long as there are significant moral differences between the high productivity values when irrigation at 100% of full irrigation.The final outcome of this study, the line $C_{3.8}$ was more flexibility among genotypes under drought conditions because achieved the highest root volume, the highest seed yield and the highest water productivity, so classified as promising line recommended for yield trials in drought-prone environments.

## Conclusion

Six promising lines of sesame in $F_8$ and $F_9$ generations were evaluated in field trials under normal (100%FI ) and drought (50%FI) conditions in two growing seasons based on root volume, Irrigation requirement, seed yield/$m^2$ and water productivity to identify lines more adapted to drought conditions. All traits showed considerable variation under normal and drought conditions. Our results demonstrated line $C_{3.8}$ classified as drought tolerant, because recorded the highest value of RV, the highest seed yield/$m^2$ and the highest value of water productivity in $F_8$ and $F_9$ generations under normal and drought conditions. Finally, we recommend line $C_{3.8}$ as a parent in drought tolerant breeding programs

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