Physiological and biochemical attributes of *Camelina sativa* (L.) Crantz under water stress conditions

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Abstract

Drought stress is a serious threat for almost all crops including *Camelina*. The present study was consisted of two experiments. The first experiment was conducted in laboratory to screen out the two *camelina* accessions (V_1:611 and V_2:618) under different levels of osmotic stress (0,-0.2, -0.4,-0.6 and -0.8 MPa) created by using Polyethylene glycol 6000. The data regarding mean germination time, 50 % seed germination (T50), germination index and final germination percentage was recorded under normal and water stress conditions. The accession(V_1) 611 was identified as drought sensitive because it took more mean germination time and more time to 50% germination (T50), less germination index and less final germination percentage as compare to accession (V_2) 618 under osmotic stress . The second experiment was carried out in pots under rain-out shelter to investigate physiological and biochemical responses of camelina accessions (V_1:611 and V_2:618) under normal and water stress conditions. The data regarding photosynthetic rate, transpiration rate, stomatal conductance and chlorophyll contents was recorded. The treatment combination (V_2): 618 × 60% (F.C) showed more photosynthetic rate (2.56 μ mol m^{-2} s^{-1}), transpiration rate (0.98 μ mol m^{-2} s^{-1}), stomatal conductance (0.1033 μ mol mol^{-1}) and total chlorophyll contents (1.93 mg g^{-1}f.w.) which was statistically similar to the treatment combination (V_1): 611 × 100% (F.C) .In conclusion from both the experiments the accession (V_2): 618 proved more drought tolerant than accession (V_1) 611.

Keywords

Seed germination,gas exchange, chlorophyll contents, water stress, *Camelina sativa*

Introduction

Camelina sativa, belongs to family Brassicaceae, is a cold tolerant, heat tolerant, drought tolerant (Kyung et al. 2013) and nutrient use efficient crop (Zubr 1997). The growth, yield and oil quality of oilseed crops is affected by their tolerance to abiotic stresses such as heat and drought (Weiss 2000). Water stress is an important limiting factor that significantly affects agricultural productivity throughout the world especially in warm, arid and semi-arid regions. Selection of tolerant genotypes is one possible solution of problems caused by drought in plant production (Waraich et al. 2011). *Camelina*, being drought tolerant crop has the potential to become an important oil seed crop for sub-arid and irrigation water deficit areas (Waraich et al. 2013. *Camelina* crop requires minimum inputs being less responsive towards N, P and K application (McVay & Lamb 2008). Drought stress severely affects both morphology as well as metabolism of the plant (Mark and Antony. 2005). Water shortage induced by drought or osmotic stress changes morphology, gas exchange, water relations and chlorophyll contents which are interlinked with the initiation of defensive mechanisms in plant (Jackson et al. 1996). Learning about physiological mechanisms which enable plants to adapt to water deficit condition and maintain their growth and productivity under stress period could be helpful in screening and selection of tolerant genotypes (Zaharieva *et al*., 2001). Keeping in view the oil demands for Pakistan and big threat of drought stress, the present study was devised to study the response of *Camelina* to drought stress in Pakistan.

Materials and methods

Two experiments (First in laboratory and second in rainout shelter) were conducted to study the physiological and biochemical attributes of *camelina* sativa (L.) crantz under water stress conditions. To study the effects of Polyethylene glycol-6000 (PEG-6000) induced drought stress on seed germination indices of *Camelina*, first experiment was conducted in petri-plates in the stress physiology laboratory of the Department of Crop

Physiology, University of Agriculture, Faisalabad. Seeds of two c*amelina* accessions (V1:611 and V2:618) were obtained from the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. These two accessions of *Camelina* (V1:611 and V2:618) were sown in four concentrations of PEG-6000 @ 0, 5,10 and 15 g were dissolved in water to develop 0, -0.2, -0.4 and -0.6 MPa drought stress treatments. The seeds of two accessions of *camelina* were surface sterilized for five minutes with 10% Sodium hypochlorite solution to prevent any fungal attack and then rinsed thrice with distill water.

Twenty seeds of both *Camelina* accessions (V1:611 and V2:618) were placed in each petri plate between two layers of filter papers. The experiment was carried out in a completely randomized design (CRD) with three replications with (25/220C, day/night) temperature. Ten ml of PEG solution was applied daily in each petri plate to create osmotic stress after washing out the previous solution. Seed germination data was recorded daily for 7 days after the beginning of experiment. Mean germination time was calculated by following the formula of (Moradi et al. 2008): MGT= $\sum Dn/\sum n$

The time to 50% germination (T50) was calculated by the following formula of (Coolbear et al. 1984)
The second experiment was conducted in pots and completely randomized design with three replications was used in the rainout shelter of department of crop physiology, University of Agriculture, Faisalabad. Before sowing sand was sun dried and sieved. Gravimetric method was employed to determine field capacity of sand. Each plastic pot (20cm ×16cm) was filled with 2 kg of sand and 15 seeds of both *Camelina* accessions (V_1:611 and V_2:618) were sown in plastic pots and then irrigated with distilled water. After sowing all pots were kept at field capacity level for obtaining good germination and emergence and then 20 days after sowing the plants were thinned out and uniform size healthy 10 plants were kept in each pot. Later on 10 days after thinning water stress was applied according to the specified drought stress levels (500 ml water for 100% field capacity and 300 ml water for 60% field capacity). Recommended rates of phosphorus and potassium (30 kg ha-1 and 60 kg ha-1 respectively) were applied at the time of sowing. Nitrogen (50 kg ha-1) was applied in two splits. Half nitrogen (25 kg ha-1) was applied at the time of sowing and remaining half was applied after 20 days of sowing.Data was recorded on gas exchange parameters and chlorophyll content.

Statistical analysis: All data was analyzed using software package of Statistix-9.1software. The mean values of plant responses were compared statistically by using least significant difference (LSD) test.

Results:Data pertaining to the effect of PEG induced osmotic stress on mean germination time, germination index, time taken to 50% germination and final germination percentage is presented in Table (1). Maximum mean germination time and T50 were recorded in the treatment combination -0.6MPa and 611genotype. Minimum value of mean germination time and T50 value were observed in 618 genotype under non-stress conditions. Maximum germination index and final germination % of (100%) were recorded in the 618 genotype under non-stress conditions while minimum germination index and final germination % were recorded in the 611genotype at -0.6 MPa.

Table No.1: Mean germination time (MGT), germination index (GI), time to 50% germination (T50) and final germination percentage of *Camelina* sativa genotypes under water stress conditions.

Parameters	Osmotic Stress	Genotypes		LSD 0.05
		V1:611	V2:618	
Mean Germination Time (MGT) Days	Control	4.16e	3.82c	0.63
	- 0.2 MPa	4.96c	4.47cd	
	-0.4 MPa	5.88b	4.95c	
	-0.6 MPa	6.28a	5.61b	
	-0.2 MPa	4.05b	4.10b	
	-0.4 MPa	3.30c	3.46bc	
	-0.6 MPa	3.19c	3.45bc	

Time taken to 50%Germination (T50) Days	Control	3.42c	3.23c	1.36
	-0.2 MPa	4.32bc	3.39c	
	-0.4 MPa	5.34b	4.10bc	
	-0.6 MPa	6.76a	4.13a	
Final Germination Percentage	Control	100a	100a	5.85
	-0.2 MPa	88.33cd	93.33bc	
	-0.4 MPa	91.67c	93.33bc	
	-0.6 MPa	85d	90.33cd	

Data for various gas exchange attributes are presented in Table (2). The data revealed that photosynthetic rate (*A*) , transpiration rate (*E*), stomatal conductance(*gs*) and sub-stomatal CO_2 concentration (*C*i) produced by accession V_2: 618 under drought stress (60% Field capacity (F.C) condition was statistically similar to camelina accession V_1 :611 under the well-watered conditions. Minimum *A*, *E*, *g*s and *C*i were recorded in camelina accession V_1 :611 under 60% field capacity (F.C).

Table.2: Net CO_2 assimilation rate, transpiration rate, stomatal conductance and substomatal CO_2 concentration of *Camelina sativa* genotypes under water stress conditions.

Parameters	Water Stress	Genotypes		LSD 0.05
		V_1:611	V_2:618	
Net CO_2 assimilation rate (µ mol CO_2 m^{-2} s^{-1})	100%FC	3.85a	2.99a	1.13
	60%FC	1.75b	2.56a	
Transpiration rate (m mol H_2O m^{-2} s^{-1})	100%FC	1.07a	0.97a	0.25
	60%FC	0.33b	0.98a	
Stomatal conductance (mol m^{-2} s^{-1})	100%FC	0.10a	0.10a	0.02
	60%FC	0.06b	0.10a	
Substomatal CO_2 Concentration (µ mol mol^{-1})	100%FC	385.33a	377.32a	10.45
	60%FC	344.29b	376.23a	

Data for chlorophyll contents showed that chlorophyll *a*, *b* and total chlorophyll contents recorded in accession V_2: 618 at 60% Field capacity (F.C) were statistically at par with accession V_1 :611 under the normal watering. However minimum chlorophyll *a*, *b* and total chlorophyll contents were recorded in accession V_1 :611 under drought stress conditions (60% FC) (Table 3).

Table.3: Chlorophyll *a*, *b* and total chlorophyll contents of *Camelina sativa* genotypes under water stress conditions.

Parameters	Water Stress	Genotypes		LSD 0.05
		V_1:611	V_2:618	
Chlorophyll a (mg g^{-1} f.wt.)	100%FC	1.88a	1.85a	0.10
	60%FC	1.69b	1.83a	
Chlorophyll b (mg g^{-1}f.wt.)	100%FC	0.81a	0.75a	0.09
	60%FC	0.63b	0.74a	
Total Chlorophyll Contents	100%FC	1.98a	1.91a	0.10
	60%FC	1.56b	1.93a	

Discussion

In the present study seed germination indices were calculated under various levels of osmotic stress created by using PEG-6000 in the laboratory. The most important and critical stage in the life cycle of plants is germination (Ahmed et al. 2009). In our study PEG induced osmotic stress reduced seed germination percentage and it is according to the finding of Gamze et al. (2005). Water stress not only affects seed germination but also increases mean germination time in crop plants (Willanborb et al. 2004). The results of our second experiment showed that drought limits the photosynthesis by reducing the stomatal conductance in camelina. Similar results were also reported by Lawson et al. (2003). In water deficit situation reduction in chlorophyll contents especially in older leaves due to dehydration could be another reason of reduced photosynthesis under water deficit situations (David et al. 1998). Decrease in chlorophyll contents due to water stress is expected because it causes loss of pigments and disorganization of thylakoid membranes (Ladjal et al. 2000). Reduced lamellar content of the light harvesting chlorophyll **a/b** protein might cause reduction of chlorophyll content in water stressed plants (Randall et al. 1977).

Conclusion

This study revealed that under PEG induced water stress *camelina accession* V_2: 618 showed good germination and proved more drought tolerant as compared to *accession* V_1: 611. Similar trend was observed in the second experiment when *Camelina* was grown in pots under rainout shelter. *Camelina accession* V_2: 618 performed better under drought stress because gas exchange, chlorophyll contents and water relation parameter values were statistically at par with non-stress conditions. Consequently under drought stress conditions *accession* V_2: 618 was more drought tolerant as compared to *accession* V_1: 611.

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