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REGULAR ARTICLE

CORRELATION AND HERITABILITY ESTIMATION OF VARIOUS SEEDLING TRAITS IN *BRASSICA NAPUS* L. UNDER WATER DEFICIT CONDITIONS

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ABSTRACT

Brassica napus L. contains edible oil ensuring safe limits for human health. But farmers prefer to use their fertile land for main crops and only marginal lands for oilseed. Those marginal lands usually face water scarcity and other a-biotic stresses that affect the normal growth and development of plant. Here we tested three levels of water deficit stress (control, medium and high) under controlled conditions. Seedlings were analyzed for various seedling traits to measure the relative effect of different levels water deficit stress. Graphical trends depict that increasing level of water deficit stress causes declines in leaf area, root length, shoot length, fresh and dry weight of roots and shoots. Correlation coefficients exposed positive significant correlation of fresh shoot weight with chlorophyll contents, relative water contents, leaf area and shoot length at both genotypic and phenotypic level. Path coefficient analysis displayed high direct effects on fresh shoot weight were due to relative water content, root to shoot ratio. Chlorophyll contents, relative water content, leaf area, root length and shoot length showed high broad sense heritability (h^2_{BS}) coupled with high genetic advance (GA). These traits could be focused while breeding for water deficit conditions.

Keywords: Water deficit stress, Correlation and path, seedling characters, heritability and genetic advance

INTRODUCTION

Water deficit stress has been a widely affecting the growth and development of crops. Plants growing on marginal lands face water shortage problem for longer or shorter period of time. Many physiological and biochemical changes occur in micro environment and body of plant to tolerate the water deficit stress especially during seedling stage [1]. The extent to which water deficit stress can slow down the growth of plant is determined by intesity and duration of water stress [2]. The water deficiency at seedling stage can majorly affect germination, root and shoot length significantly causing great reduction in vigor of plants [3].

Canola was firstly derived from *Brassica napus* L. and contains glucosinolates and erucic acid within safe limit for human consumption. Brassica napus can tolerate water deficit stress and have evolved various mechanisms against high temperature and water shortage [4]. It contains 37-41% protein and 36-41% oil contents in its seed [5]. It is mainly used for cooking, margarine, animal and poultry feed industry. It is considered healthy because of its low saturated and high monounsaturated fatty acids composition. Its profile is considered safe for human consumption as oil containing lower glucosinolates avoids ulcer in stomach. The meal obtained after extraction of oil is being widely processed into poultry feed [6]. It is mostly utilized in cooking and margarine production.

Some countries like Iran and China have paid their attention in breeding toward the development of varieties that are tolerant to drought and water deficit stress. As their cultivated area for oilseed mostly fail to irrigate with abundant supply of water. The oilseed yield could be boosted by providing potentially high yielding varieties to farmer that can tolerate biotic and a biotic stress especially water deficit stress with minimum inputs. Government policies and marketing system should be established properly to ensure fair price of oilseed. Heterosis is being now widely used in china and few other countries to oil and yield [7]. But still germplasm resources are lacking behind in stress tolerating varieties. To fill the gap between consumption and production of oil stress breeding should be focused wisely to cope future challenges

MATERIALS AND METHODS

The present experiment was conducted in the wire house under three water deficit stress levels (moisture contents were maintained at FC, medium “50% of FC “and high “20% of FC”) by using a set of 35 drought tolerant

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genotypes (GT-1, GT-2...GT-35). 4-5 seeds of each cross and parents were sown in the polythene bag containing a mixture of 30% loam and 70% sand. Data were recorded on 35 genotypes from each level.

Chlorophyll contents

Chlorophyll contents were measured by a handheld chlorophyll meter "atLEAF+" with unique characteristics. This device was assembled in the United States.

1. Relative water contents (%)

$$RWC = \frac{\text{Fresh Weight} - \text{Dry Weight}}{\text{Turgid Weight} - \text{Dry Weight}} \times 100$$

2. Emergence rate

Emergence rate was estimated following formula

$$ER = \frac{\text{Total number of seedling emerged}}{\text{Total numbers of seeds sown per bag}} \times 100$$

3. Leaf area (cm^2)

The length and width of leaves from each selected plant was measured. Leaf area was calculated at full turgidity using equation derived by Muller [21] i.e.

Leaf area = length x breadth x 0.74

4. Root length (cm)
5. Shoot length (cm)
6. Root to shoot ratio
7. Fresh root weight (mg)
8. Fresh shoot weight (mg)
9. Dry root weight (mg)
10. Dry shoot weight (mg)

Path coefficient analysis was computed using computer software according to Dewey and Lu [8], where fresh shoot weight was as response variable and all remaining seedling traits as predicate variables. Genotypic and phenotypic coefficients of variation were computed statistically by using "R" software.

Broad sense heritability (h^2_{BS}) = V_g/V_p.

GA = $\sigma_p \times h^2 \times i$

h^2 = heritability (Broad sense)

σ_p = standard deviation (phenotypic)

i = Constant "1.75" at 10% selection intensity (10%)

RESULTS

Chlorophyll contents

Under control, medium and high water deficit stress conditions, the mean values of chlorophyll contents were 40.95, 30.2 and 24.5 respectively. Genotype GT-31 showed maximum chlorophyll contents with mean value 41.35, while GT-10 showed minimum chlorophyll contents, of 26.0 mean value. Chlorophyll content is significantly correlated with fresh shoot weight (r=0.24) as well as with relative water contents (r=0.60) (Table 1). PCV (22.85) is slightly higher than the genotypic coefficient of variation (22.26) (Table 3). High broad sense heritability (0.97) coupled with high genetic advance was observed for Chlorophyll contents (Table 3).

Relative water contents

Under control, medium and high water deficit stress conditions, the mean values of relative water contents were 78.4, 58.6 and 56.2% respectively. Maximum relative water contents were observed in GT-31. It is obvious from the means value (Graph 2) that the relative water contents decrease gradually, as the water deficit stress level increases. Leaf area (r= 0.539), shoot length (r= 0.4), fresh root weight (r= 0.755), showed significant correlation with relative water contents (Table 1). High broad sense heritability (0.95) coupled with high genetic advance was found for relative water contents. (Table 3).

Emergence rate

The mean values of emergence rate were 29, 25 and 20 % under control, medium and high water deficit stress conditions, respectively. Maximum emergence rate was observed for GT-31. All the traits were non-significant with emergence rate except root length. Medium broad sense heritability (0.5) coupled with medium genetic advance was observed for emergence rate (Table 3).

Leaf area (cm^2)

From the analyzed data, the mean values for control, medium and high water deficit stress were 6.045, 5.25 and 3.75 cm^2 respectively. GT-6 and GT-31 showed maximum leaf area with mean value 6.8 cm^2, while GT-24 possessed minimum leaf area, with mean value 1.75 cm^2. It is obvious from the means value (Graph-1D) of leaf area decreases gradually, as the water deficit stress level increases. Leaf area has significantly correlated with relative water contents (r= 0.53), as well as with chlorophyll contents (Table 1). Medium broad sense heritability (0.57) along with medium genetic advance was noticed for the trait under investigation (Table 3).

Root length vs. shoot length (cm):

The average values of root length were 7.4, 6.1 and 3.75 cm under control, medium and high water deficit stress conditions, respectively. While mean values of shoot length were 14, 11.7 and 8.3 cm found under control medium and high water deficit stress conditions, respectively. Genotype GT-26 and GT-31 showed maximum root length with mean value 7.5 cm. A line ZM8 showed maximum shoot length with mean value 16.5 cm. It is obvious from the means value (Graph-1E) of root and shoot length decreases gradually, as the water While root length has a significant correlation with chlorophyll contents (r= 0.357) and leaf area (r= 0.615) High broad sense heritability (0.71) and (0.70) for both traits respectively, accompanied with high genetic advance was observed (Table 3).

Fresh shoot weight vs. dry shoot weight (mg)

The mean values of weight were fresh shoot weight were (150, 135 and 121 mg) and dry shoot (89, 77 and 63 mg) found under control, medium and high water deficit stress conditions, respectively. Notably, genotype excelling in leaf area and shoot length GT-26 also showed also relatively high (174.6 mg) shoots weight. Fresh shoot weight has a significant correlation with relative water contents (r= 0.755), leaf area (r= 0.421), shoot length (r= 0.7). High broad sense heritability (0.89) and (0.97) for both traits respectively, accompanied with high genetic advance was measured for the traits under study (Tabel-3).

Fresh root weight vs. Dry root weight (mg)

The mean values of fresh root weight were (110, 97 and 87 mg) and dry weight were (87, 76 and 45 mg) found under control, medium and high water deficit stress conditions, respectively. Cross GT-32 showed maximum fresh root weight with mean value 127.5 mg. While GT-26 showed 101 mg of fresh shoot weight. It is evident from the means value (Graph-1F) of fresh and dry root weight decreases gradually, as the water deficit stress level increases. Fresh root weight indicated high broad sense heritability (0.9) supplemented with higher genetic advance and dry root weight displayed low broad sense heritability (0.45) along with low genetic advance (Table 3).

Path coefficient analysis

High direct effects on water deficit stress were caused by relative water contents; root to shoot ratio, fresh root weight, and dry shoot weight, and shoot length had 1.34, 0.885, 0.75, and 0.540 values, respectively (Table 2). Interestingly, root length showed negative direct effect on fresh shoot weight. But has indirect positive effect via shoot length and leaf area.

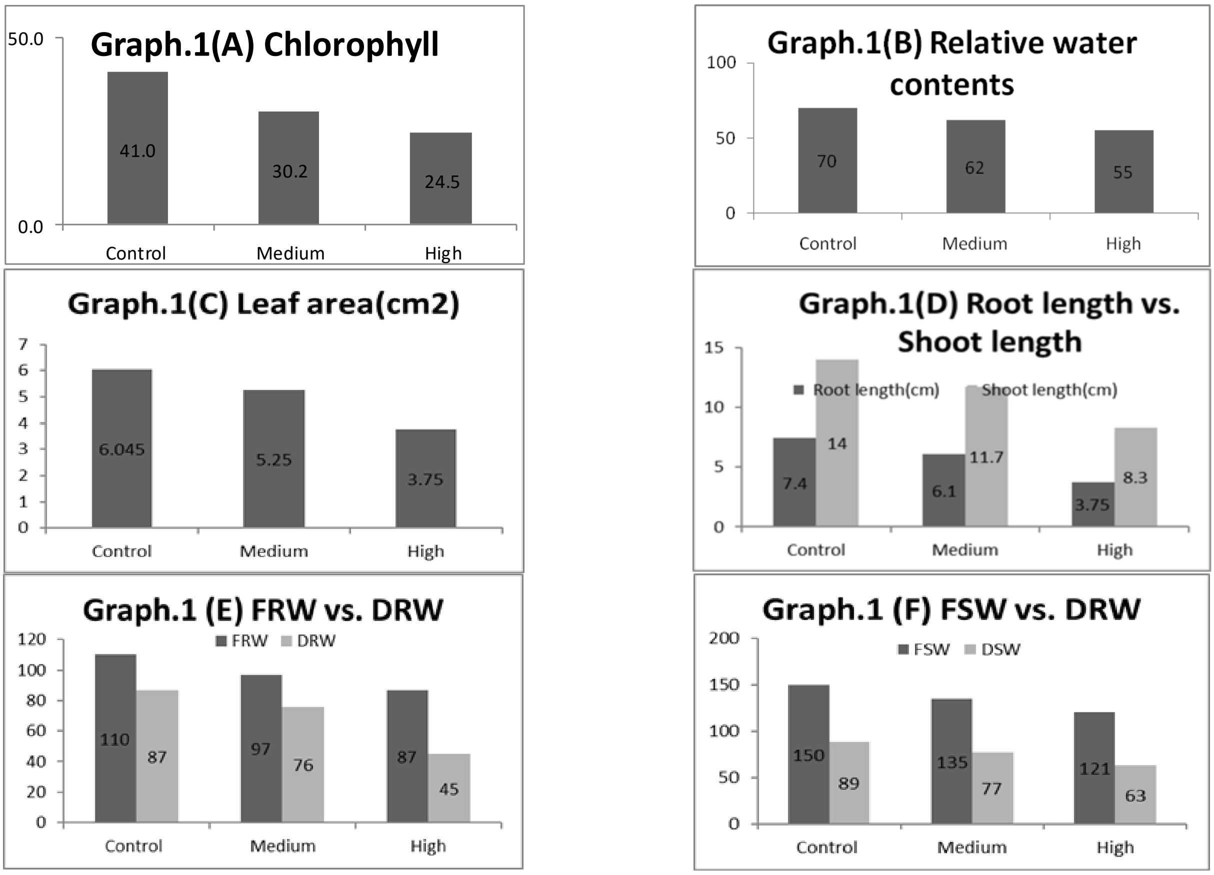

Table 1: Genotypic and phenotypic correlations of various seedling traits

Traits	R	Chl. C	RWC	EMR	LA	RL	SL	RTR	FRW	DSW	DRW	FSW
Chl. C	G	1.000	0.034ns	0.236	0.60**	0.357**	-0.081ns	0.050	-0.320	-0.320*	-0.438*	0.240*
	P	1.000	0.029	0.174	0.017	0.047	-0.082	0.056	-0.307	-0.309	-0.260	0.214
RWC	G		1.000	-0.209	0.539*	0.190	0.400*	-0.409	0.348	-0.674*	0.097	0.755*
	P		1.000	-0.199	0.374	0.316	0.155	-0.305	0.331	-0.564	0.055	0.756
EMR	G			1.000	-0.533	0.236*	0.122	0.017	-0.079	0.05*	0.397*	-0.407ns
	P			1.000	0.173	0.150	0.089	0.025	-0.058	0.079	0.158	-0.303
LA	G				1.000	0.615**	0.770	0.076	-0.294	0.310ns	0.338	0.421*
	P				1.000	0.007	0.097	-0.076	-0.262	0.200	0.099	0.311
RL	G					1.000	0.330*	0.690*	-0.035	0.091	0.371ns	0.155*
	P					1.000	0.275	0.652	-0.041	0.054	0.323	-0.125
SL	G						1.000	-0.439	0.343	-0.008	0.262	0.70*
	P						1.000	-0.503	0.254	-0.003	0.115	0.140
RTR	G							1.000	-0.368	0.224	0.112	-0.278
	P							1.000	-0.275	0.161	0.178	-0.205
FRW	G								1.000	0.039*	0.365	0.476*
	P								1.000	0.041	0.277	0.436
DSW	G									1.000	0.113	-0.077
	P									1.000	0.072	-0.053
DRW	G										1.000	0.192
	P										1.000	0.099
FSW	G											1.000
	P											1.000

P-value of Genotypic and phenotypic Correlation is significant if P-Value is<0.05

Table 2: Direct (diagonal) and Indirect (off-diagonal) effects of all seedling traits on fresh shoot weight

Traits	**Chl. C**	**RWC**	**EMR**	**LA**	**RL**	**SL**	**RTR**	**FRW**	**DSW**	**DRW**
Ch. C	0.218	-0.046	-0.059	0.002	-0.041	-0.04	0.044	-0.055	-0.227	-0.031
RWC	-0.007	1.34*	0.052	-0.108	0.138	0.138	0.366	0.060	-0.479	0.006
EMR	0.051	0.051	-0.250	0.107	-0.171	-0.171	0.015	-0.013	0.040	0.028
LA	0.002	0.002	-0.133	0.201	0.211	0.011	0.067	-0.051	0.221	0.024
RL	0.012	0.012	-0.059	-0.003	-0.724*	0.544	0.611	-0.006	0.065	0.026
SL	-0.017	-0.017	-0.030	-0.014	0.339	0.540	-0.389	0.059	-0.006	0.018
RTR	0.011	0.011	-0.004	0.015	-0.500	-0.23	0.885*	-0.060	0.195	0.008
FRW	-0.069	-0.069	0.019	-0.059	0.025	0.185	-0.326	0.750*	0.028	0.026
DSW	-0.070	-0.070	-0.014	0.062	-0.060	-0.004	0.198	0.006	0.7108	0.008
DRW	-0.956	-0.956	-0.099	0.068	-0.269	0.141	0.100	0.063	0.080	0.071ns

Chl. C= Chlorophyll contentsLA = Leaf area RTR = Root to shoot ratio, RWC= Relative water contents RL= Root length FRW = Fresh root weight, EMR= Emergence rateSL= Shoot length DSW = Dry shoot weight, Effects are significant if P-Value is<0.05

Table 3: Genotypic, phenotypic, environmental coefficient of variation and heritability of seedling traits

	Chl. C	**RWC**	**EMR**	**LA**	**RL**	**SL**	**RTR**	**FRW**	**DSW**	**DRW**	**FSW**
Genotypes	45.11	62.38	463.19	2.01	3.35	8.84	0.06	210.61	176.86	33.76	200.79
Significance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CV%	2.39	1.87	19.01	17.50	14.83	13.68	19.55	2.08	1.85	5.38	2.21
Genotypic V.	22.26	30.34	164.71	0.73	1.39	3.64	0.02	101.76	86.96	10.41	94.74
Phenotypic V.	22.85	32.04	298.49	1.28	1.96	5.20	0.04	108.85	89.90	23.36	106.05
Environ. V.	0.58	1.70	133.78	0.55	0.57	1.56	0.01	7.09	2.94	12.95	11.32
Heritability	0.97	0.95	0.55	.57	0.71	0.70	0.64	0.93	0.97	0.45	0.89

Chl. C= Chlorophyll contentsLA = Leaf area RTR = Root to shoot ratio, RWC= Relative water contents RL= Root length FRW = Fresh root weight, EMR= Emergence rateSL= Shoot length DSW = Dry shoot weight FSW = Fresh shoot wei

DISCUSSION

The extent of heritability and correlation in any crop is considered to be necessary for selection of superior genotypes. In the present study a set of 35 drought tolerant genotypes were studied to assess their association among important drought related traits and heritability. In the present research work, positive and significant correlation indicated that selection would be more fruitful for several related drought traits. However, the effectiveness of selection is related to the extent of traits transmissibility and genetic advance [9]. Genetic advance is necessary with estimation of heritability for effective breeding program based on phenotypes. High value of phenotypic variance that genotypic variance for chlorophyll contents indicated that the phenotypic variation is not affected by environment [10] and [11]. Regarding the relative water contents more attention should be given to those traits which have positive association to cope with water deficit conditions. Similar finding has been reported by Jajarmi *et al.* [12]. High emergence rate has good selection criteria in the improvement of brassica breeding programs, as GT-31 have high emergence and hence selection of this will be fruitful. As Rate of photosynthesis is directly proportional to leaf area and therefore, the selection of high leaf area genotypes will be rewarding. Similar findings have been reported by previous workers [13-15]. Root length is a measure of index in plants to cope with abiotic stresses especially water deficit stress and hence preference will be given to those genotypes which showed high root length. Similar results have been reported earlier [10-20]. Path coefficient analysis is an indirect selection criterion in developing drought stress tolerant brassica varieties and hence selection on this base will be of vital importance.

CONCLUSIONS

GT-26 showed maximum root length, shoot length, fresh and dry root weight, while GT-31 showed high emergence rate, relative water contents and leaf area. Hence, genotypes that have a potential to cope with water deficit stress conditions could be used in subsequent stress tolerant brassica breeding programs. Fresh shoot weight, root length, shoots length and leaf area are key traits to develop and should be focused to develop water deficit verities.

Fresh shoot weight has a significant correlation with relative water contents, leaf area, shoot length and chlorophyll contents are characters that could be focused to increase the biomass of cultivars. Root to shoot ratio and relative water contents showed high direct effect on fresh shoot weight. Chlorophyll content, relative water content, leaf area, root length and shoot length showed high broad sense heritably. So these traits are of vital importance while breeding for water deficit stress.

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