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Physiogenetic Aspects of Drought Tolerance in Canola (*Brassica napus*)

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ABSTRACT

Ten varieties of canola (*Brassica napus*) *viz*. Oscar, Hyola-401, Rainbow, Bulbul, Range, Dunkled, Zafar-2000, Tarnab-1, Tarnab-2 and Tarnab-3 were evaluated for different morphological and physiological traits under drought as well as normal irrigation conditions, using two factorial randomized complete block design with three replications. Under normal conditions varieties exhibited significant differences for all the plant traits studied except stomatal conductance. While under drought conditions, varieties showed non-significant differences for 1000-seed weight, number of days to 50% flowering, number of days to 50% silique formation and number of days to 50% maturity. Seed yield per plant was highly significantly and positively correlated with plant height, number of siliquas per plant, number of primary branches per plant, number of secondary branches per plant under drought conditions. Harvest index was positively and highly significantly correlated with number of siliquas per plant, seed yield per plant and dry matter yield under both normal and water stress conditions. Oscar, Range and Tarnab-2 were more tolerant to drought having minimum susceptibility index and high performance under drought for plant height, number of siliquas per plant, number of secondary branches per plant, seed yield per plant, 1000-seed weight and harvest index. Number of primary branches per plant, number of secondary branches per plant and number of siliquae per plant can be used for indirect selection of high yielding canola genotypes under water stress. Oscar, Range and Tarnab varieties of canola can further be used in the breeding programmes aiming at the development of drought tolerant brassica varieties.

Key Words: *Brassica napus;* Drought; Susceptibility index; Correlation

INTRODUCTION

Pakistan requires 1.95 million tones of edible oil annually. Only 29% of this quantity is met through the local resources and rest of 71% is met through import. Consequently a large portion of the national budget ($ 800 million) is spent every year to import edible oil (Govt. of Pakistan, 2002). So there is dire need to increase the production of oilseed crops to bridge up this huge gap. Brassicas are very important among the oilseed crops in our country and rank second in the total production of edible oil. Brassicas with the introduction of canola quality, being indigenous species (*Brassica napus*) has good potential to combat the situation. Drought is a major factor that limits the area under cultivation and yield of the crops. Canola has been developed in the areas with high rainfall and performs poorly in the areas with low rainfall (Resketo & Szabo, 1992; Richards, 1978). Drought is also observed in the irrigated areas due to insufficient supply of water and canal closure. In response to the water stress plant faces physiological changes including loss of cell turgor, closing of stomata, reduction in cell enlargement and reduced leaf surface area. All these abnormalities ultimately decrease photosynthesis and respiration (Human *et al*., 1990; Hall *et al*., 1990) and as a result overall production of crop is reduced. Maliwal *et al*. (1998) and Patel (1999) have reported reduced yield in Brassicas in response to water stress.

It is the need of the time to develop varieties which can tolerate water stress to increase area and yield of the oilseed crops. The present study was proposed to achieve these goals and to identify the varieties of canola which can withstand drought spell and also to estimate correlation among different traits. The information derived from the study will be helpful in breeding Brassicas for drought tolerance and early selection of genotypes with the desirable traits to be used in the breeding programmes.

MATERIALS AND METHODS

The experiment was conducted in the research field of the Department of Plant Breeding and Genetics at the Post-graduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad. The experimental material comprised of ten varieties of canola (*Brassica napus*) viz. Oscar, Hyola-401, Rainbow, Bulbul, Range, Dunkled, Zafar-2000, Tarnab-1, Tarnab-2 and Tarnab-3 collected from different sources.

The experiment was laid out in a randomized complete block design following two factorial arrangements with three replications. The two factors used were the varieties and irrigation treatments i.e. normal and drought. Drought was simulated by withholding water throughout the growing season, whereas, under normal conditions the crop was irrigated according to the standard practices. Plant to plant and row to row distances were maintained 20 cm and 60 cm, respectively, each row being 6 meters long accommodating about 30 plants.

At the maturity ten plants per replication of each variety in each treatment were marked randomly and data were recorded for plant height (cm), number of siliquas per plant, number of primary branches per plant, number of secondary branches per plant, seed yield (g) per plant, dry matter weight (g), 1000-seed weight (g), stomatal conductance (cm/sec), days to 50% flowering, days to 50% silique formation, days to 50% maturity and harvest index. The siliquae collected from marked plants were manually threshed and seed obtained was weighed in grams with the help of an electric balance to obtain seed yield per plant. For dry matter weight the whole biomass of marked plants including stem, branches and siliqua's waste was chopped and weighed in grams using an electric balance. It did not include seed weight. 1000- seed weight was recorded by bulking the seed from the marked plants of an accession in a replication and counting 1000 seeds from the lot weighing in grams using an electric balance in the laboratory. Stomatal conductance was measured from tagged plants during bright sunny days using AP-4 porometer (Bragg *et al*., 1991) at flowering stage. The instrument was calibrated before the start of actual readings. Distilled water dipped filter paper was placed on calibration plate and data were collected from all the six positions of calibration plate. It was recalibrated on any severe change in weather. Turgid leaves of similar physiological maturity were used for recording the data. The observations were recorded from lower surface of leaf near the petiole avoiding midrib during mid-day. Number of days to flowering was recorded after the appearance of 50% flowering on the marked plants and number of days to siliquae formation was recorded after the formation of 50% siliquae on the marked plants. Number of days to 50% maturity was recorded from sowing until 50% of plants were matured. Maturity was defined in terms of change in the colour of siliquae from green to brown. Plant was considered mature when 50% siliquae turned brown. Harvest index as a ratio of economic produce and total dry weight of each plant under both conditions i.e., normal and drought, was calculated as

$$Harvest\ index = \frac{\text{Seed yield per plant}}{\text{Plant dry weight}} \times 100$$

The data recorded were subjected to the analysis of variance following Steel and Torrie (1980). Pairs of means were compared using Duncan's New Multiple Range Test. Susceptibility index for various traits was computed following Fischer and Maurer (1978). Correlations among different traits were also worked out under drought and normal conditions.

RESULTS

The varieties were significantly different for all the traits except for number of days taken to 50% maturity (Table I). Treatments were significant for all the characters under study. Variety x treatment interaction was also significant for all the traits except 1000-seed weight and number of days taken to 50% maturity. Under normal conditions varieties exhibited significant differences for all the plant traits studied except stomatal conductance (Table II). While under drought conditions, varieties showed non-significant differences for 1000-seed weight, number of days to 50% flowering, number of days to 50% silique formation and number of days to 50% maturity.

Seed yield per plant was highly significantly and positively correlated with plant height (r = 0.38), number of siliquas per plant (r = 0.43), number of primary branches per plant (r = 0.17), number of secondary branches per plant (r = 0.25) and harvest index (r = 0.84) under drought conditions (Table III). Positive and non-significant correlation of seed yield per plant was observed with number of days to 50% flowering (r = 0.03), number of days to 50% siliquae formation (r = 0.06) and number of days to 50% maturity (r

Table I. Mean squares and their significance from analysis of variance of different plant traits under drought and normal conditions

Characters	Replications	Varieties (V)	Treatment (T)	V x T	Error
DF	2	9	1	9	413
PH	383.68	1811.80**	592706.57**	750.85**	59.41
NSPP	43910.20	72990.67**	10640713.30**	30992.88**	4983.24
NPB	16.66	35.56**	2327.21**	19.29**	6.60
NSB	189.15	133.84**	5406.54**	76.24**	33.72
SYPP	106.88	406.60**	29857.22**	112.19**	17.20
DMY	238.76	1341.69**	67958.78**	2125.18**	84.83
TSW	0.02	0.04*	3.49**	0.01	0.01
SC	0.38	8.51**	100.25**	7.14*	3.45
NDF	0.15	7.28**	2442.75**	6.96**	0.81
NDSF	0.12	8.83**	2372.05**	6.69**	0.90
NDM	27.25	56.97	1474.39**	63.33	50.54
HI	226.12	1032.98**	73499.30**	164.17*	79.05

*.**significant at 0.05 and 0.01 probability levels, respectively; PH = Plant Height; NSPP = Number of siliquas per plant; NPB = Number of primary branches per plant; NSB = Number of secondary branches per plant; SYPP = Seed yield per plant; DMY = Dry matter yield; TSW = 1000-seed weight; SC = Stomatal conductance; NDF = Number of days to 50% flowering; NDSF = Number of days to 50% silique formation; NDM = Number of days to 50% maturity; HI = Harvest index

Table II. Mean squares and their significance from analysis of variance of different plant traits under normal (upper value) and drought (lower value) conditions

Characters	Replications	Varieties	Error
DF	2	9	288
PH	45.30	67.19*	33.30
	2045.69	1010.85**	93.75
NSPP	57765.90	90572.76**	6973.78
	274.92	7313.31**	173.72
NPB	6.30	19.08*	7.89
	13.71	23.67**	3.63
NSB	72.10	80.95*	42.58
	167.25	101.37**	12.70
SYPP	109.60	404.18**	24.49
	8.81	1.40**	0.23
DMY	292.40	1765.29**	105.52
	4.91	1746.41**	36.81
TSW	0.003	0.01**	0.0028
	0.05	0.04	0.02
SC	4.26	4.52	53.95
	3.78	11.12**	1.48
NDF	0.12	1820**	0.83
	0.05	1.92	0.78
NDSF	0.04	19.43**	0.98
	0.87	1.89	0.71
NDM	2.40	20.93**	3.90
	53.63	110.54	159.2
HI	165.60	708.60**	112.04
	75.49	37.91**	2.85

*.** = significant at 0.05 and 0.01 probability levels, respectively; PH = Plant Height; NSPP = Number of siliquas per plant; NPB = Number of primary branches per plant; NSB = Number of secondary branches per plant; SYPP = Seed yield per plant; DMY = Dry matter yield; TSW = 1000-seed weight; SC = Stomatal conductance; NDF = Number of days to 50% flowering; NDSF = Number of days to 50% silique formation; NDM = Number of days to 50% maturity; HI = Harvest index

= 0.04). Seed yield per plant exhibited negative and non-significant correlations with dry matter yield (r = -0.13), 1000-seed weight (r = -0.02) and stomatal conductance (r = -0.06) under water stress condition. Under normal conditions highly significant and positive correlations were observed with number of siliquae per plant (r = 0.41), plant dry matter yield (r = 0.22) and harvest index (r = 0.70). Number of primary branches, number of secondary branches, 1000-seed weight and stomatal conductance exhibited positive while plant height, number of days to 50% flowering, number of days to 50% siliquae formation and number of days to 50% maturity exhibited negative and non-significant correlation with seed yield per plant under normal irrigation conditions. Harvest index was positively and highly significantly correlated with number of siliquae per plant, seed yield per plant and dry matter yield under both normal and water stress conditions.

Susceptibility index estimates suggested that the accessions with least drought susceptibility indices for traits were drought tolerant. Oscar, Range and Tarnab-2 were more tolerant to drought having minimum susceptibility index and high performance under drought for plant height, number of siliquas per plant, number of secondary branches per plant, seed yield per plant, 1000-seed weight and harvest index (Table IV).

DISCUSSION

A considerable reduction in almost all the traits under study was observed as a result of water stress. The most drastic effect was observed in the number of siliques per plant. Positive correlation of number of siliques per plant with seed yield indicated that lesser number of siliquas per plant result in low seed yield (Behl *et al*., 1994; Patel, 1999). Therefore, seed yield per plant can be increased by increasing number of siliquae per plant (Surender *et al*., 1999). Number of primary and secondary branches also had significant and positive association with seed yield. So these were the most important characters contributing to seed yield (Joshi *et al*., 1992; Ramani *et al*., 1995; Yadave & Singh, 1996). Dry matter was reduced under drought

Table III. Correlation among various traits of canola (*Brassica napus*) under drought (lower diagonal values) and normal (upper diagonal values) conditions

Character	PH	NSPP	NPB	NSB	SYPP	DMY	TSW	SC	NDF	NDSF	NDM	HI
PH	-	0.06	-0.07	-0.04	-0.03	0.11	0.08	0.00	-0.09	-0.06	-0.01	0.05
NSPP	0.22**	-	0.13	0.15**	0.41**	0.23**	0.10	-0.58	-0.07	-0.05	-0.07	0.20**
NPB	0.15	0.15	-	0.84**	0.05	0.10	-0.03	-0.08	-0.02	-0.04	-0.04	-0.02
NSB	0.25**	0.30**	0.70**	-	0.06	0.11*	-0.03	-0.07	-0.03	-0.05	-0.02	-0.02
SYPP	0.38**	0.43**	0.17*	0.25**	-	0.22**	0.09	0..09	-0.06	-0.06	-0.02	0.70**
DMY	.10	-0.34**	-0.06	0.02	-0.13	-	-0.21	-0.02	-0.21**	-0.28**	-0.12**	-0.48**
TSW	0.53	0.19	0.28	0.33	-0.02	0.03	-	0.02	0.05	0.00	-0.06	0.29
SC	0.99	-0.09	-0.04	-0.01	-0.06	0.51	-0.15	-	0.05	0.06	0.03	0.02
NDF	0.25**	0.15	0.04*	-0.03	0.03	0.05	-0.01	0.03	-	0.92**	0.55**	0.10
NDSF	0.23**	0.14	-0.02	-0.02	0.06	0.05	-0.04	0.07	0.86**	-	0.60**	0.14*
NDM	-0.02	-0.08	-0.10	0.08	0.04	-0.09	-0.04	-0.14	0.17*	0.21*	-	0.07
HI	0.25**	0.53**	-0.14	0.16*	0.84**	-0.53**	0.03	-0.11	0.02	0.04	0.07	-

*.** = significant at 0.05 and 0.01 probability levels, respectively; PH = Plant Height; NSPP = Number of siliquas per plant; NPB = Number of primary branches per plant; NSB = Number of secondary branches per plant; SYPP = Seed yield per plant; DMY = Dry matter yield; TSW = 1000-seed weight; SC = Stomatal conductance; NDF = Number of days to 50% flowering; NDSF = Number of days to 50% silique formation; NDM = Number of days to 50% maturity; HI = Harvest index

Table IV. Susceptibility index of Canola (*Brassica napus*) for different traits

Varieties	PH	NSPP	NPB	NSB	SYPP	DMY	TSW	SC	NDF	NDSF	NDM	HI
Oscar	0.80	0.88	0.76	0.30	0.96	0.87	0.81	2.46	0.92	0.87	0.58	1.03
Hyola-401	1.10	1.02	1.19	1.20	1.01	1.40	0.33	1.53	1.24	1.24	1.53	0.99
Rainbow	1.03	1.09	1.07	1.32	1.03	0.78	1.20	1.45	0.79	0.76	0.59	1.07
Bulbul	1.23	1.00	0.84	1.19	1.01	1.54	0.73	2.10	0.56	0.60	0.78	0.94
Range	0.97	0.93	0.43	0.48	0.98	1.10	0.98	0.55	1.18	1.16	1.40	0.95
Dunkled	1.05	1.09	1.14	1.05	1.02	0.37	0.96	1.09	0.96	1.00	0.48	1.07
Zafar-2000	0.84	1.05	0.94	1.17	1.00	1.12	1.13	-0.27	1.14	1.12	1.38	1.01
Tarnab-1	0.96	0.89	1.12	1.06	1.00	1.50	1.09	0.86	1.18	1.20	1.48	0.92
Tarnab-2	1.01	1.00	1.22	0.83	0.99	1.05	0.89	0.86	0.96	1.08	1.17	0.98
Tarnab-3	0.99	1.01	1.28	1.40	0.99	0.75	1.21	0.88	0.95	0.97	1.20	1.03

PH = Plant Height; NSPP = Number of siliquas per plant; NPB = Number of primary branches per plant; NSB = Number of secondary branches per plant; SYPP = Seed yield per plant; DMY = Dry matter yield; TSW = 1000-seed weight; SC = Stomatal conductance; NDF = Number of days to 50% flowering; NDSF = Number of days to 50% silique formation; NDM = Number of days to 50% maturity; HI = Harvest index

environment indicating that most of the photosynthates produced were translocated to the seed (Salisbury & Ross, 1992). In water stress conditions leaf expansion rate decreases (Kumar *et al*., 1993), stomata close and photosynthesis rate reduces leading to the production of smaller seeds resulting in reduced 1000-seed weight (Mondal & Khajuria, 2000).

CONCLUSION

The plant performance is reduced significantly under water stress environment. Seed yield per plant under drought conditions can be improved by improving number of primary branches, secondary branches and number of siliquas per plant. Plant characters including number of primary branches per plant, number of secondary branches per plant and number of siliquae per plant can be used for indirect selection of high yielding canola genotypes under water stress. Oscar, Range and Tarnab, having high performance for number of secondary branches, number of siliquas per plant, seed yield per plant, 1000-seed weight and harvest index are more tolerant to drought conditions. These varieties of canola can further be used in the breeding programmes aiming at the development of drought tolerant brassica varieties.

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