Morpho-physiological responses of oilseed rape (*Brassica napus* L.) genotypes to drought stress

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Oleiferious *Brassicas* are generally raised under rainfed conditions and as such are prone to water stress during various crop growth stages in many arid and semi-arid regions of the world. Genetic variation for tolerance to water stress has not been adequately exploited in *Brassicas*. In India, *Brassica* species, mostly grown on light textured soils using water conserved from monsoon rains, suffer from moisture stress during advance growth stages particularly reproductive phase. Irrigation water is becoming scarce due to its increasing demand for other sectors. There is also increasing concern over the effect of climate change on water resources and prudence dictates that water is used effectively in order to increase and sustain productivity. With the availability of international germplasm under ACIAR aided project on oilseed *Brassica* improvement in India, China and Australia, studies were conducted to assess variation in canola *Brassica napus* for drought tolerance, and to identify associated morpho-physiological traits.

Material and Methods

An assembled set of 30 genotypes of *Brassica napus* was field evaluated for drought tolerance under conditions of restricted irrigation. Three irrigation modules (i) no irrigation, (ii) one need based irrigation (45 days after sowing) and, (iii) two need based irrigations (one at 45 DAS and second at 85 DAS) comprised the main plots whereas genotypes were allocated to sub plots in three replications. These irrigation modules had water equivalence of 56.2 mm, 116.2 mm and 176.2 mm respectively after accounting for the cumulative rainfall (56.2 mm) during the season. All the genotypes were evaluated for chlorophyll fluorescence and photosynthesis at 90 DAS, for root (length, diameter, area and perimeter), leaf (length, width, perimeter, area, ratio) at 100 DAS and seed yield components at physiological maturity using standard protocols. Drought tolerance index (DTI) was computed as $Ypi*Ysi/Ypi^2$ where Ypi is cultivar seed yield under non stress/irrigated condition and Ysi is cultivar seed yield under stress condition.

Results and Discussion

The investigated genotypes differed in their responses to varying degrees of moisture stress. Drought Tolerance Index (DTI) ranged between 0.200 and 0.815 (mean 0.490) with one irrigation applied at 45 DAS and from 0.088 to 0.507 (mean 0.305) following two irrigations applied at 45 and 85 DAS. AV-Opal (0.815) and Banjot (0.752) were identified as the most tolerant genotypes to drought under one irrigation. With two irrigations, GSC 6 (0.545) and Ruby (0.507) were found to be most drought tolerant; whereas 21 genotypes were observed to be moderately drought tolerant (0.251 - 0.500) and the remaining seven as highly sensitive (DTI<0.250). DTI for promising genotypes was higher (0.569) under one irrigation than at two irrigations (0.438). Interestingly, EC 609310, Hyola 75 and EC 609301 had similar DTI under both the irrigation regimes.
Under moisture stress, EC 609302, EC 609305, EC 609310, Hyola 75, Ruby, Tarcolla and GSC 6 seemed promising on the basis of seed yield. Leaf area ranged from 7.91 (GSC 6) to 17.5 cm^2 (EC609302). Root length is an important trait for drought tolerance. Root length was 1257.4 in Ruby and 541.1 mm in GSC 6. Root area was 1131.1 in EC 609310 and 2275.4 mm^2 in Ruby. Root diameter varied from 1.08 to 2.19 mm in EC 609310 and EC 609305 respectively. Mean values of leaf area and root traits in these elite genotypes are presented in Fig1.under stress and irrigation regimes.

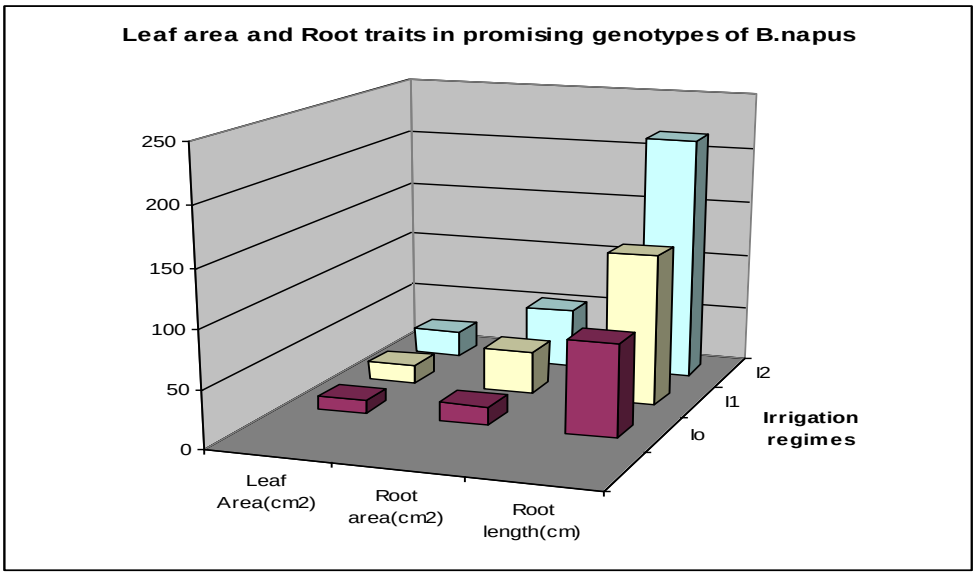

Fig. 1 Leaf area and root characteristics in promising *B. napus* genotypes

Initiative fluorescence (F_0) showed significant variation among the genotypes, indicating different efficiencies of chlorophyll receptors in PSI. Reduction in photochemical efficiencies (PSII, measured as Fv/F_M) led to decrease in the electron transfer (F_M, high) as depicted in Fig 2. However, the adverse effect of water stress was less on the photochemical efficiencies of EC 609305 and GSC 6 but the electron transfer was inhibited to the maximum in GSC 6 as compared to EC 609302 and EC 609305. With irrigation, stress was alleviated as indicated by reduction in Fv/F_M ratio which implies a protective mechanism for light absorption for enhancing photosynthesis.

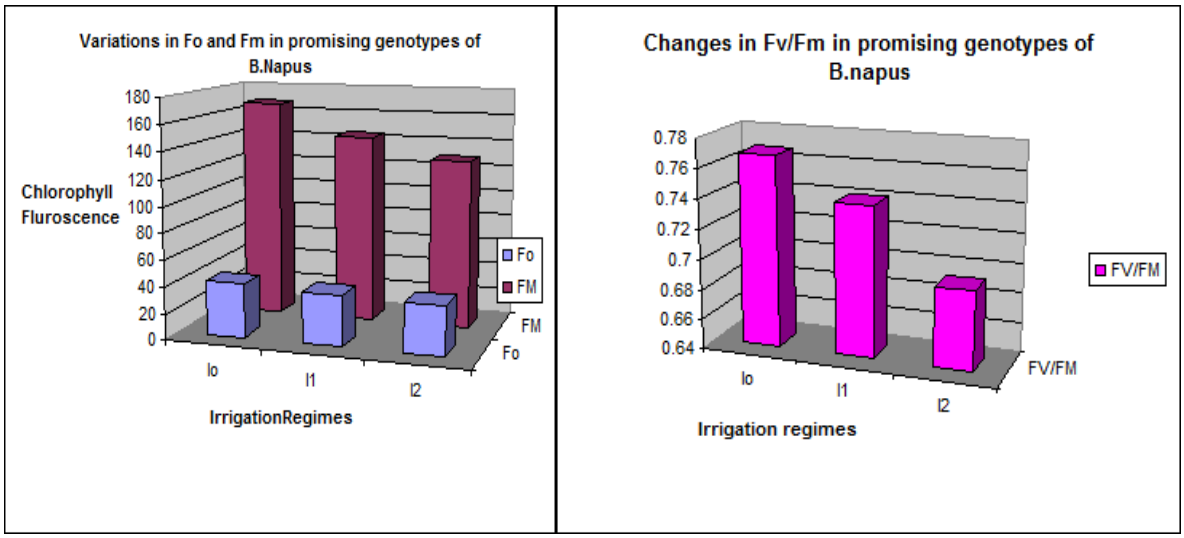

Fig.2 Chlorophyll fluorescence in the promising genotypes

Under no irrigation, Pn was low (8.4 $\mu molm^{-2}s^{-1)}$ due to lower stomatal conductance (2.05 $mmolm^{-2}s^{-1}$) and transpiration (4.08 $mmolm^{-2}s^{-1}$). However the elite genotypes seems to be water use efficient (Fig 3). Within the promising genotypes, Hyola 75 registered the highest photosynthetic rates and Tarcolla the lowest.

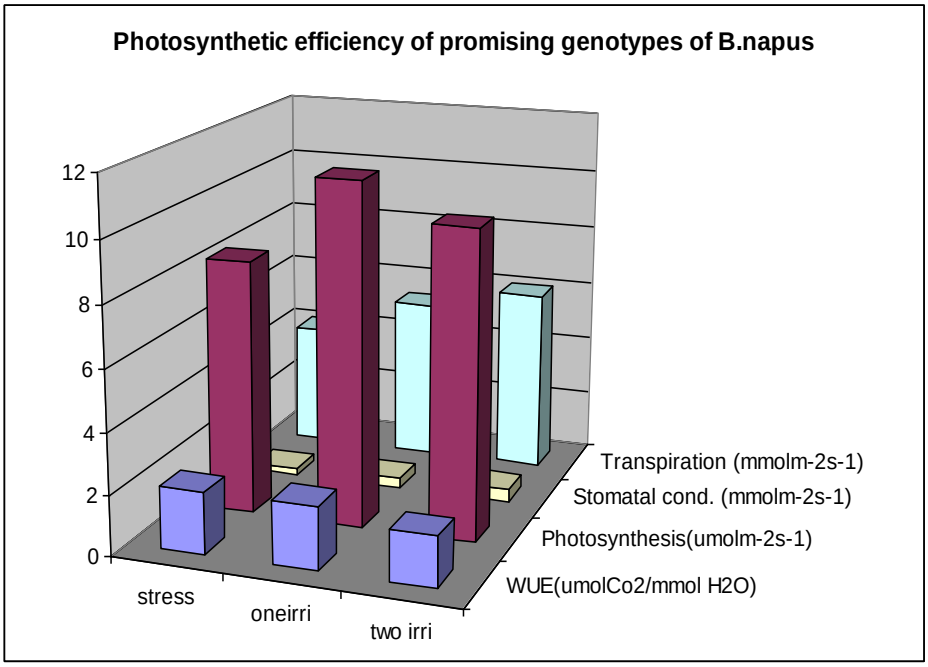

Fig 3 Photosynthetic traits in elite genotypes of *B. napus*

There was singnificant effect of application of irrigations on growth, yield and yield attributes of *B. napus* (Table 1). Interactive effect of irrigation levels and genotypes was also significant for various growth , yield attributes and seed yield.

Table 1. Variation in growth parameters, yield attributes and yield of elite genotypes of *B. napus*

Treatments	Plante (cm)	MSL* (cm)	Branches*		Siliquae		Seeds per siliqua	Seeds wt. (g)	Seed yield per plant (g)
			P	S	Main shoot	Total			
No irrigation	73	33	3.9	5.0	24.2	120	19.2	2.6	4.99
One irrigation	97	42	4.2	6.3	33.4	166	21.3	2.8	8.15
Two irrigations	105	50	4.9	7.4	39.9	219	24.4	3.0	10.13
C.D ($p \leq 5\%$)	7.1	4.9	0.48	1.1	5.07	22.6	1.95	0.24	1.81

*MSL: Main shoot length, P: Primary, S: Secondary

Amongst the 30 genotypes of *B.napus*, genotype Barra registered maximum root length (1654.5 mm) and root area (3582.7 mm^2) under no irrigation and highest root perimeter (4477.8mm) under one irrigation. Under, no irrigation, RT 117 produced maximum root diameter (2.58) and primary branches (5.0) but showed least reduction in leaf area and leaf ratio. It was also promising for seed size, yield and root area. Garnet had highest leaf area (23.5cm^2) with no irrigation and one irrigation (26.6cm^2) and Summit with two irrigations (33.5cm^2). GSC 6 and Summit showed least reduction in number of seeds per siliqua under no irrigation. Ruby produced higher seed yield under stress and one irrigation than other genotypes. Superior performance of Ruby could be attributed to appreciable photosynthesis, lesser damage to PSII, higher leaf area, root area, root length, DTI, main shoot length and total number of siliquae per plant. However with two irrigations, 9 genotypes produced higher yield than Ruby.

Study leads to the conclusion that water restrictions reduced productivity but there existed genotypic variation for drought tolerance. Root length is an important trait under moisture stress. Chlorophyll fluorescence coupled with photosynthesis and DTI are the reliable indicators to monitor stress.