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COMPARATIVE PERFORMANCE OF *BRASSICA NAPUS* AND *ERUCA SATIVA* UNDER WATER DEFICIT CONDITIONS: AN ASSESSMENT OF SELECTION CRITERIA

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Abstract: The comparative performance of *Brassica napus* and *Eruca sativa* was assessed under different water deficit conditions. The study indicated that *B. napus* and *E. sativa* exhibited certain morphological and phenological changes in response to drought. Moreover, the responses of species were distinct with respect to their tolerance to different drought regimes. *E. sativa* appeared to be prone to drought regimes. However, *B. napus* excelled for growth and yield attributes and appeared to possess certain traits that may be considered for the selection of drought resistance. The better performance of *B. napus* under water deficit environment signifies its potential for further selection for drought tolerance. Thus cultivar/ lines of the species can be exploited for those areas of the country, which experience extended periods of drought.

Keyword: *Brassica napus, E. sativa*, metric traits, selection criteria, water deficit.

INTRODUCTION

Drought is one of the major agricultural intimidations in many regions of the world [Link *et al*. 1999]. Adequate water availability is the prime requisite for crop growth and yield [Shakhatreh *et al*. 2001]. Substantial crop losses may attributable to scarcity of water. Major part of Pakistan falls in arid to semi arid location. These areas suffer from periods of serious drought. The vast deserts of the country illustrate this situation [Ashraf and Naqvi 1995].

Several workers have identified crop species that have considerable tolerance to extreme moisture deficit conditions where certain growth and yield attributes can provide selection criteria for drought tolerance [Sari-Gorla *et al.* 1999]. The crop cultivars/ lines, which may show enhanced drought tolerance can be domesticated under such prevailing conditions and can be of great significance for agriculture [Shakhatreh *et al*. 2001]. In the current study water stress tolerance of two oil seed crops was assessed using growth and yield attributes as predictors.

Oils have dietary, industrial and medicinal applications therefore hold significant economic importance [Arnon 1972]. Pakistan imports 68% of edible oil and the country spent 824 million dollars on the import during 1998-99, which is due to the severe shortage of edible oil-seed production in the country [Asad 2001]. Keeping this view in mind, two oil seed crops were chosen for the present study to reveal their water deficit tolerance. The foremost objectives of the study are as follows:

1. The extent to which drought is directly responsible for morphological and phenological changes in two oil seed crops.

2. To reveal the comparative performance of the oil seed species
3. To provide manifestation of those traits that can be used as selection criteria for drought resistance

MATERIALS AND METHODS

GERMINATION AND GROWTH EXPERIMENT

Seeds of the two species were obtained from Ayyub Agricultural Research Center, Faisalabad, Pakistan. A seedling cohort was developed by taking 100 seeds of each species and were germinated in the laboratory at room temperature using labeled Petri dishes (8cm internal diameter) containing Whatman no. 1 filter paper and 10 ml distilled water.

After 15 days, at 2-3-leaf stage, 3 seedlings of each species were transplanted to 18 labeled earthen pots (18 cm internal diameter) filled with 2.5 kg garden compost. There were three treatments and each was replicated three times. The experiment was laid in a Randomized Block manner in a wire netting glass house at the Botanic Garden, Bahauddin Zakariya University Multan. (25±3^{o}C day and 18±3^{o}C night temperature).

Seedlings were allowed to establish for another two weeks, then the drought treatments were started as follows:

T_0 (Control) = Plants were watered regularly as and when required.

T_1 = Watering was withheld until lower 2-3 leaves of plants showed wilting. Then these pots were watered to field capacity (pre determined) level. This constituted one cycle of drought and repeated 6 times.

T_2= The drought cycle was same as in T_1 but consisted of 12 repeated cycles.

The experiment was continued for 16 weeks and then plants were harvested for various growth and yield parameters.

BIOMETRIC TRAIT ANALYSIS

The traits, root length, shoot length, shoot / root ratio and number of leaves for each plant were measured. Leaf area measurements were taken using Delta-T Device area meter. Flowers, which were formed on each plant, were counted daily. Similarly, pod formation was observed each day and seed weight was taken on pod ripening.

STATISTICAL ANALYSIS

Mean values and standard error were calculated for all the parameters. A two-way Analysis of Variance (ANOVA) was carried out using MS Excel 2000 to reveal the main effects of drought treatments on the growth of the species as well as to elucidate differences between character expressions of the two species.

RESULTS

ROOT LENGTH

A significant (P<0.001) increase in root length at both drought treatments in both species was observed. However, this increase was more profound in *B. napus* than *E. sativa* (Fig. 1). The responses of the species also differed significantly (P<0.001). A significant Species × Treatment interaction (P < 0.05) is also evident from the statistical analysis (Table 1).

Table 1: Summary of analysis of variance for various growth attributes of *Brassica napus* and *Eruca sativa* (16 weeks old plants) at varying drought regimes

Biometric characters	$M.S_{Spp}$	Significance	$M.S_T$	Significance	$M.S_I$	Significance
Root length (cm)	74.42	***	160.15	***	19.41	*
Shoot length (cm)	3.81	n.s	12.82	n.s	42.45	*
Shoot/root ratio	0	n.s	0.32	***	0.13	**
Number of leaves	16.06	n.s	9.39	n.s	0.72	n.s
Leaf area (cm^2)	2544.22	**	704.22	n.s	84.22	n.s
Number of flowers	2	n.s	17.17	*	2.17	n.s
Number of pods	46.72	**	322.72	***	31.06	*
Seed weight (g)	45.95	*	5.48	*	1.07	n.s

*,**, *** = Significant at 0.05, 0.01 and 0.001 levels of Probability respectively.
$M.S_{Spp}$ = Mean square species, $M.S_T$ = Mean square treatments, $M.S_I$ = Mean square interaction.

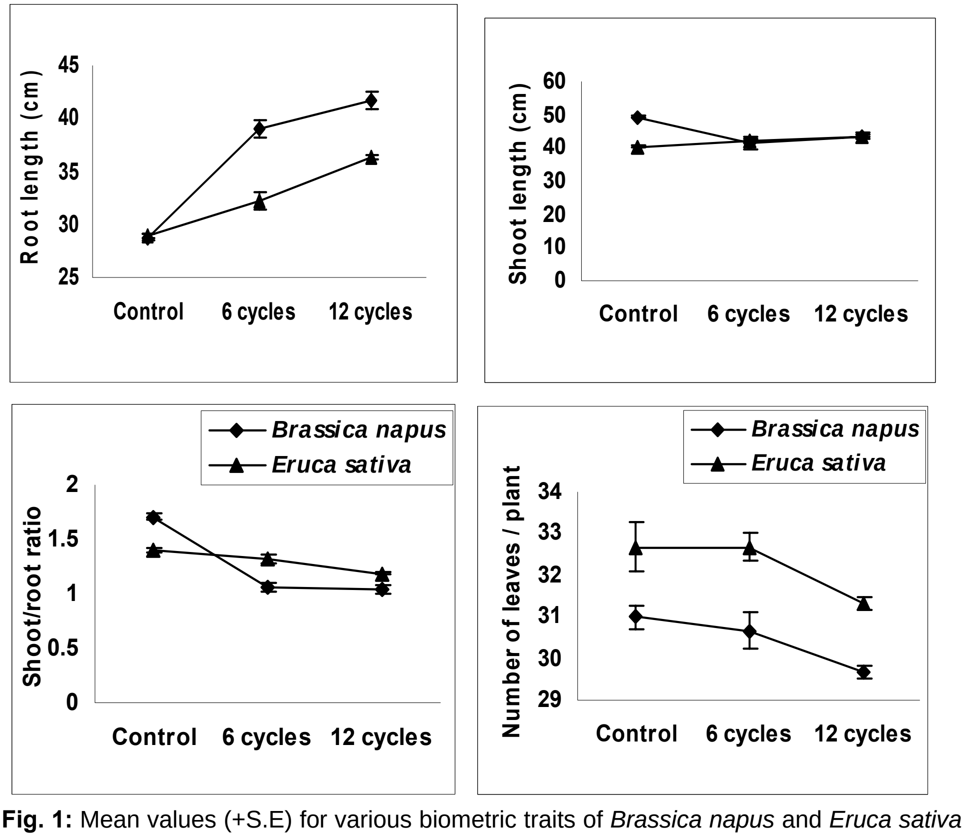

Fig. 1: Mean values (+S.E) for various biometric traits of *Brassica napus* and *Eruca sativa* (16 weeks old plants) at varying drought regimes.

SHOOT LENGTH

A reduction in shoot length in *B. napus* at both drought regimes was observed. However, the greater reduction was observed after 6 cycles of drought. An elongation of shoot was observed in *E. sativa* at both drought cycles as compared to the control but this increase was statistically non significant (Fig. 1). Analysis of variance revealed that increasing drought intensities had not caused any significant effect on shoot growth. Similarly, no variability between two species was observed. However, ANOVA revealed a significant Species x Treatment interaction (Table 1).

SHOOT / ROOT RATIO

The results presented indicated a decline in shoot / root ratio under varying cycles of drought in both species. This ratio was the lowest for *B. napus* at the maximum drought intensity. The ratio also decreased after 6 cycles of drought but *E. sativa* exhibited the greater ratio than the other species (Fig. 1). ANOVA (Table 1) revealed that the responses of species were insignificantly variable. However, the drought regimes differ significantly ($P< 0.001$). The interaction between two main factors was also found to be significant ($P<0.01$).

NUMBER OF LEAVES

Increasing water deficit conditions had induced a reduction in leaf formation. The lowest number of leaves was produced at 12 cycles of drought for *B. napus*. A reduction in leaf number was also observed for *E. sativa* in response to drought regimes (Fig. 1). The maximum reduction was statistically non significant in both species (Table 1).

LEAF AREA

A decline in leaf area was observed in relation to increasing moisture stress and the lowest values were observed at the highest drought regime in both species. Fig. 2 clearly showed that *B. napus* had significantly more leaf area than the other species. A decrease in leaf area was observed in *E. sativa* but this reduction was not significant when compared to it control (Fig. 2). Analysis of variance (Table 1) revealed a significant contrast between two species with respect to their leaf area. However, drought treatments had not significantly influenced this attribute.

NUMBER OF FLOWERS

In both species, flower production was significantly ($P<0.05$) inhibited at both drought regimes and the maximum reduction was observed at the highest drought intensity (Fig. 2). The extent of decline in number of flowers was more profound for *B napus*. But statistically found to be significantly invariable (Table 1).

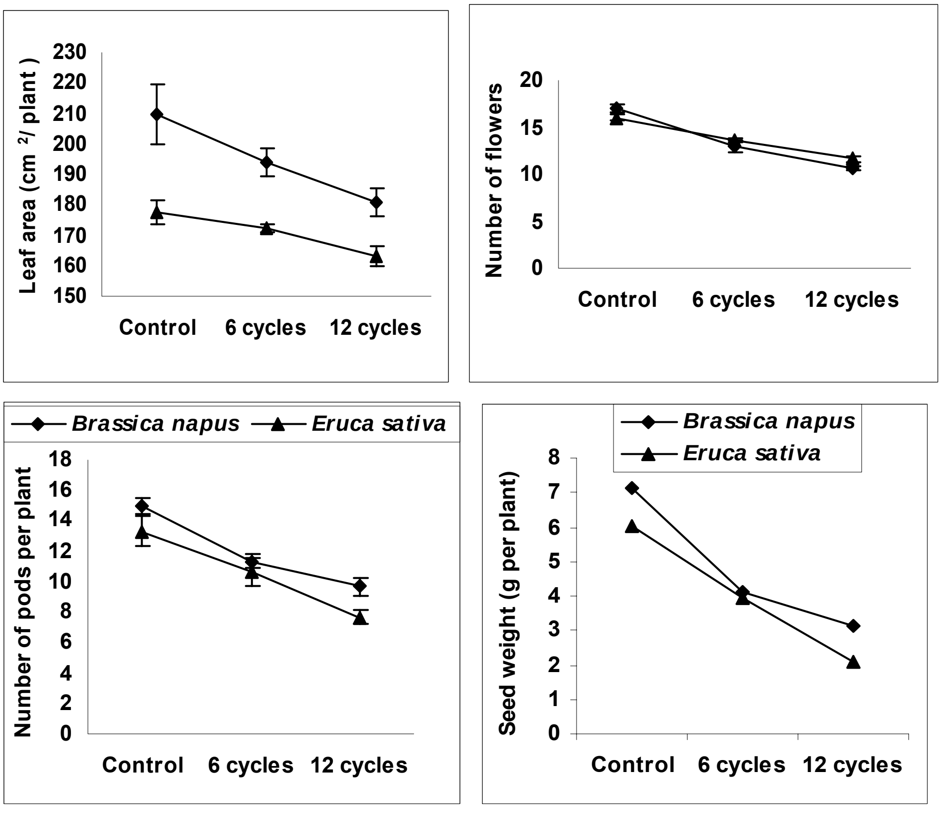

Fig. 2: Mean values (+S.E) for various biometric traits of *Brassica napus* and *Eruca sativa* (16 weeks old plants) at varying drought regimes.

NUMBER OF PODS

Fig. 2 depicted a profound drop in pod formation in *E. sativa* than *B. napus.* Analysis of variance (Table 1) revealed the significant adverse effects of drought on pods formation in these species ($P < 0.001$). The inter-specific variability was found to be highly significant. Similarly, a significant Species × Treatment interaction is also evident ($P < 0.05$).

SEED WEIGHT PER PLANT

Drought treatments had significantly ($P < 0.05$) affected mean seed weight per plant and a considerable decline was observed in response to increasing drought regimes in both species (Table 1). *B. napus* produced significantly ($P < 0.05$) greater seed weight than *E. sativa* (Fig. 2).

DISCUSSION

Drought is one of the major stresses that can render arable lands unproductive in arid and semi-arid regions of the world [Link *et al.* 1999]. The potential to cope with water deficit conditions varies among different plant species. Plants may develop various morphological characters that may have some adaptive significance for tolerance to low water availability to plants [Parolin 2001]. Thus, these attributes can be indicative of selection criteria for crop species to such stress environment. Therefore, the exploration of this variability seems to be of great value for the economic exploitation of drought-hit areas.

The present study considers the performance of two oilseed crops in relation to varied moisture stress. The responses of the species varied considerably for several growth attributes, which were used as predictor for the assessment of drought tolerance.

The study revealed that the root length was significantly greater for *B. napus* under varying drought regimes. The longer roots of *B. napus* under moisture stress conditions appears to be a xeromorphic character as it has been well documented that plants growing in water deficit environment may produce longer roots thus thereby bringing rapid and efficient conduction of water whenever it becomes available [Munns 2002]. While considering the shoot length, the two species appeared insignificantly variable at varying cycles of drought. Thus, drought regime did not seem to influence this attribute significantly. It has been argued by Parolin [2001] that drought can cause a state of rest in aerial parts of plants therefore they may exhibit stunted growth and our results are in lines with the above worker.

Plants have different strategies for biomass allocation to cope with the variability of environment and several workers [Bell and Sultan 1999, Fernandez and Reynolds 2000] used shoot /root ratio as a predictor for biomass partitioning strategy. Those plants, which produced longer roots might show stunted shoots and vice versa. Thus there can be a trade off between two traits. This study clearly depicted that *E. sativa* has greater shoot/ root ratio as compared to *B. napus*. These ratios clearly indicated that *B. napus* produced longer roots but did not possess well-developed shoots while the reverse was true for *E. sativa*. The lower ratios in *B. napus* are an indicative of its deep root system, which seems to have an adaptive advantage to moisture deficit conditions.

Plants of xeric habitat are known to possess special leaf morphology either they have fewer leaves or modification of leaves may take place [Parolin 2001]. A greater decline in leaf number in *B. napus* as compared to *E.sativa* at the maximum drought stress can be considered as selective advantage under prevailing drought. Thus the alteration in leaf number can definitely be related with the water economy and is responsible for an overall decrease in transpiring surfaces especially when water is scarcely available. The similar strategy has also been reported by Taiz and Zeiger [2002] for drought resistance. A profound reduction in leaf area occurred in *B. napus* than the other species. There seems to exist a positive relation between leaf area and number of leaves. The reduction of leaf attributes can be considered as adaptive traits for drought tolerance as both contribute towards the prevention of water loss through transpiration [Salisbury and Ross 1992].

It has been well documented for several species that sustainable water availability is crucial for plants at their reproductive stages [Frova *et al*. 1999, Sari-Gorla *et al*. 1999]. This study also revealed that flowering appeared to be more prone to increasing drought intensities in both species, thus supports the above findings. Mogensen [1980] described that drought had a significant influence on pod synthesis. The results for pod formation also indicated a decline in pod development. Moreover, pod formation was lower in *E. sativa* as compared to *B. napus*. Similarly, the later species showed sustainability for seed development despite moisture deficit conditions and produced greater seed weight per plant.

Based on the traits studied here in relation to varied moisture stress for two oilseed species it can be concluded that inter-specific response were found to be significantly variable. Where *B. napus* appeared to be more drought tolerant than *E. sativa*. It can be affirmed that the development of extensive root system, reduction in leaf number and leaf area, along with the ability to sustain pod formation seems to be the characters that might have enabled *B. napus* to cope with moisture stress and certainly provide selection criteria for drought resistance. It would be appropriate to suggest that further intra-specific selection of the germplasm of *B. napus* should be carried out for the economic utilization of drought hit areas of the country.

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