Indian J. Plant Physiol., Vol. 1, No. 3, pp. 171-174 (July-Sept., 1996)

PHYSIOLOGICAL ANALYSIS OF GROWTH AND DEVELOPMENT IN THREE SPECIES OF RAPESEED-MUSTARD (*BRASSICA JUNCEA*, *B. CAMPESTRIS* AND *B. NAPUS*) UNDER IRRIGATED AND UNIRRIGATED CONDITIONS

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Received on 19 June, 1995, Revised on 18 June, 1996

SUMMARY

The pattern of growth, development and responses of three *Brassica* species, to long term drought stress were examined under field conditions. Depletion in soil moisture content from 16% at sowing to 6% at maturity resulted in reduction of leaf area index, total dry-matter, seed yield and hastening of develpmental processes of all the three cultivars. *B. juncea* and *B. campertris* attained 100% flowering a fortnight earlier than *B. napus* under irrigated and drought treatments, sustained higher pod number, seed size and yielded almost equally but appreciably more than *B. napus*. *B. napus* despite maintaining superior LAI and higher total dry matter at and before 100% flowering under severe drought was susceptible to stress in terms of seed yield and its attributes due to shorter length of reproductive period. The greater length of reproductive period was positively associated with higher seed size and seed yield in these species. The genetic improvement of *B. napus* is highlighted.

INTRODUCTION

In India, rapeseed and mustard are commonly cultivated for their edible oil in semi-arid to arid tropical zones with unassured irrigation and/or limited rainfall. It is, therefore, essential to identify cultivar/species resistant to drought (Chauhan and Bhargava, 1984). Studies on the effect of drought stress on growth and yield components in *Brassica* have been elucidated and their importance sought for selection criterion under drought by many workers (Krogman and Hobbs, 1975; Richards and Thurling, 1978 and Parihar *et al.* 1981). The leaf area index (LAI), crop cycle length and phenology determines the total dry matter production, yield and yield components under drier environments (Silim and Saxena, 1993). The present study was conducted to examine the pattern of growth, development and seed yield of three *Brassica species* viz. *B. juncea*, *B. campestris* and *B. napus* under long term drought stress and to assess the relationship between phenological developments and drought resistance in *Brassica*.

MATERIALS AND METHODS

Brassica juncea cv. Pusa Bold (mustard), *B. campestris* cv. Pusa Kalyani (Brown Sarson) and *B. napus* cv. BO-54 (Canadian rape) were grown in two consecutive seasons in a split plot design with four replications. The plot size of one species was 3x2 m. The seeds were sown on ridges 45 cm apart. The crop received a fertilizer dose of 60 kg N (urea), 40 kg P_2O_5 (single superphosphate) and 40 kg K_2O/ha (mureate of potash) prior to planting. The plant irrigations at 30, 45 and 90 DAS were given to irrigated controls (IRR) while drought was created by witholding these irrigations (DS). Irrigation water of 60 mm (measured with the help of Parshall flume) was allowed to run in IRR plots. Malathion 5% was sprayed at flowering to control aphid attack and weeds were controlled manually.

The soil water content (SWC) between 0 to 60 cm profile was recorded gravimetrically using soil augor. The samples were dried at 105°C for 72h and values are

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expressed as percentage of dry weight. The total rainfall was 34.2 and 79.6 mm in the respective seasons. The total dry-weights were recorded at fortnightly intervals after drying samples at 80°C to a constant weight. The leaf area was measured by automatic leaf area meter (Li 3100, Licor Inc., Nebraska, USA). At maturity of each cultivar, eight adjacent plants were harvested from each plot for yield and yield components. Silique and stems were separated and air dried by keeping them in a glasshouse. These were subsequently oven dried at 80°C, Dried silique were threshed and the seeds obtained were cleaned and weighed.

RESULTS AND DISCUSSION

The mean soil moisture content (SMC) between 0 to 60 cm soil profile recorded in two seasons is presented in Table I. SMC declined steadily from 16% at the time of sowing to 6% at maturity. The rainfall marginally increased SMC at 130 DAS. The magnitude of reduction in SMC increased between 55 to 120 DAS indicating that the demand for water was maximum in these stages of growth. On an average SMC was always 5-7% higher under IRR controls.

With reduction in SMC from 16 to 6%, seed yield and its attributes reduced significantly (Table II). Both mustard

Table I: Soil moisture content of irrigated (IRR) and unirrigated (DS) plots recorded from 0 to 60 cm profile (Mean of two seasons) on dry-weight basis.

Treatment	Days after sowing							
	23	40	55	77*	90**	117	135	150
IRR	16.5	15.4	17.5	13.8	16.5	10.5	14.3	10.8
DS	15.8	12.3	9.6	7.3	4.7	3.4	8.9	5.9
LSD 0.05	NS	1.5	2.7	3.6	5.8	5.2	3.2	3.8

* 100% flowering of brown sarson and mustard cultivars

** 100% flowering of Canadian rape cultivar.

Irrigations

Rainfall.

Table II: Seed yield and its attributes (mean of two seasons), total dry-matter (TDM) and harvest index (HI) calculated on the basis of biomass of *Brassica* species grown under irrigation (IRR) and non-irrigation (DS)

Cultivar	Treatment	Seed yield (t/ha)	TDM (t/ha)	HI (%)	Seed number (m^{-2})	Pod number (m^{-2})	weight (g) 1000 seed
Mustard	IRR	2.82	9.97	28.8	47119	5436	6.09
	DS	2.48	8.51	29.3	42113	4932	5.47
Browm Sarson	IRR	2.69	8.01	33.6	59392	5580	5.47
	DS	2.37	6.63	35.8	55165	4822	4.30
Candian rape	IRR	2.25	9.53	26.6	61168	4061	3.68
	DS	1.82	7.45	24.4	60358	3672	3.01
LSD 0.05 Treatment		0.20	1.04	NS	2209	312	0.14

and Brown Sarson cultivars recorded 13 and 12% depression in yield, respectively, as compared to 20% in Canadian rape cultivar. Similarily, Canadian rape cultivar suffered greater reduction in total dry matter. The harvest index, however, remained stable under drought. Thus the Candian rape cultivar was susceptible to drought in terms of productivity. These results are in contrast to those obtained by Richards and Thurling (1978).

The reduction in seed yield was due to the differential response of yield contributing traits to drought stress (Table II). While both mustard and Brown Sarson cultivars maintained higher test weight, the Canadian rape cultivar suffered 19% reduction in test weight, parallel to the extent of reduction in its yield. The Canadian rape cultivar reduced its pod number while increased the seed number per pod. Thus the despression in seed yield in Canadian rape cultivar was largely due to significant decrease in test weight and pod number while in other two cultivars it was due to reduction in number of seeds and pods.

The number of days taken to 100 % flowering were least for mustard and Brown Sarson cultivars and highest for the Canadian rape (Table III). Consequently, the

Table III. Number of days from sowing to 100% flowering (DF), maturity (DM) and length of reproductive period (LR) (mean of two seasons) in Brassica species grown under irrigation (IRR) and non-irrigation (DS)

Cultivar	Treatment	DF	DM	LR
Mustard	IRR	76	154	78
	DS	70	145	75
Brown	IRR	77	152	75
Sarson	DS	69	140	71
Canadian	IRR	87	157	70
rape	DS	82	146	64
LSD 0.05 (Treatment)		4.05	4.85	2.75

length of reproductive period was highest for the mustard and Brown Sarson cultivars and lowest for Canadian rape since the total growth duration was almost equal in the three cultivars. Drought hastened 100% flowering time by about a week. The mustard and Brown Sarson cultivars flowered at higher SMC than Candain rape cultivars. The post-flowering phase of growth was curtailed more in Candian rape apparently due to low SMC and increasing temperature in the later part of the season.

The developmental patterns and phenology of the three cultivars largely accounted for their variation in leaf area index (LAI) attained and total dry matter (TDM) production (Fig, la, b). The LAI and TDM depressed from 55DAS onwards in these cultivars. The growth between 40 to 80 DAS was comparatively slower in Canadian

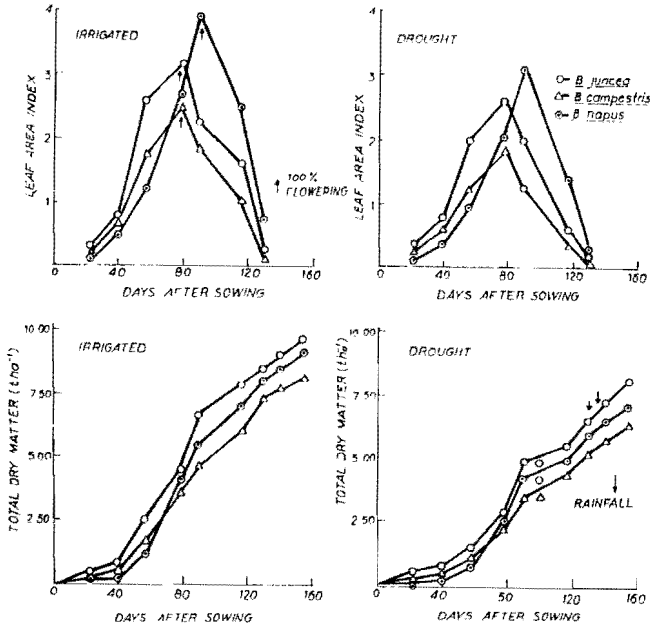

Fig. 1 a,b. Leaf area index and total dry-matter production of irrigated and unirrigated rapeseed-mustard (mean of two seasons).

rape, quite consistent with the leaf area development and SMC under drought stress, However, the Candian rape cultivar attained the highest LAI and TDM at its 100% flowering phase followed closely by the mustard cultivar. The higher dry matter accumulation in Canadian rape coupled with superior LAI indicated the higher photosynthetic rates in the foliage at vegetative and 100% flowering stages of growth under both treatments (Gill and Verma, 1988). Despite the fact that all cultivars were morphologically determinate, dry matter continued to accumulate even during reproductive phase, a period coincided with declining phase of LAI (Fig 1a.b). During this period the mustard and Brown Sarson cultivars accumulated more than 50% of total dry-matter as against 38% in Canadian rape. Thus LAI was positively related to TDM production until 100% flowering. The subsequent

increase in TDM until maturity was due to the accumulation of dry-matter in pods since they have photosynthetic capability (Singal *et al.* 1987).

Both seed yield and weight per 1000 seeds were significantly and positively correlated to the greater length of *campestris* and were found resistant to drought stress due to their early flowering behaviour and greater length of reproductive period. These cultivars maintained higher seed yield due to higher test weight and pod number. On the other hand *B. napus* maintained higher seed number per pod but the proportion of decrease in test weight and shorter length or reproductive period reduced its yield at maturity.

B. napus exhibited certain desirable traits such as higher LAI and TDM at flowering under severe soil moisture stress. An efficient plant type should include a combination of these characters. However, its poor partitioning of biomass to seeds coupled with shorter post-flowering phase shadowed its desirable traits. The productivity potential of B. napus can be enhanced in semi-arid tropics if the germplasm is further screened for a combination of traits such as early flowering, greater length of reproductive period coupled with higher weight per 1000 seeds.

ACKNOWLEDGEMENTS

The senior author expresses his gratitude to IARI for awarding the Senior Research Fellowship during the course of this investigation.

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