The Effect of Drought Stress on Yield Determination in Oilseed Rape

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INTRODUCTION

Drought stress arises in situations where less than ideal soil moisture conditions prevail. On the Canadian prairies, drought in the latter part of the growing season is a common occurrence. Rapeseed (Brassica napus) cultivars are most sensitive to drought stress at anthesis. Yield, and the yield components of pods per plant, pods per main branch and seed per pod have been shown to be significantly reduced by drought (Richards and Thurling 1978). Early flowering cultivars could potentially avoid some degree of drought stress by flowering prior to the drier portion of the summer. The length of the flowering period is also affected by moisture conditions. Alleviating water stress through irrigation extends the flowering period, allowing the production of more flowers, pods and seeds (Krogman and Hobbs 1975).

The objective of this study was to compare the response of a selection of rapeseed cultivars, using growth analysis, to determine the sequence of growth stages which result in maximum yield under moisture stress.

MATERIALS AND METHODS

Six rapeseed (B. napus) cultivars were chosen to give a wide range of maturities under western Canadian conditions. The Canadian cultivar Westar is an early maturing cultivar; Regent and Pivot, also Canadian cultivars and the Swedish cultivar, Topas, had intermediate maturity and the Swedish cultivars, Global and Karat, were relatively late maturing.

The experiment was conducted over the summers of 1985 and 1986. Two sites were located on a Riverdale floodplain clay situated at the University of Manitoba. Irrigation was available at one site which shall be referred to as the irrigated site. A randomized block design consisting of six replicates of the six cultivars was used. Treatment plots consisted of four rows six m long. A granular insecticide was applied with the seed and fertilizer (16-20-0) was incorporated at the time of seeding.

Soil Measurements: The soil moisture profiles were monitored weekly at each site, initially using gravimetric water content and thereafter using the Troxler neutron probe, which measures volumetric water content directly. Precipitation and water applied by irrigation were measured throughout the season. Bulk density, permanent wilting point and field capacity were also determined. Using these measurements, the moisture available to the plants over the season was calculated for each site.

Plant Measurements: The growth stages were monitored from emergence to harvest on each plot. The revised growth stage key for *B. napus* by Harper and Berkenkamp (1975) was used. The scale divides the life cycle into six growth stages based on the development of the primary stem and influorescence.

Flower and pod development were measured by randomly selecting five plants per plot per cultivar in three of the six replicates at each site. Each individual branch was tagged and numbered. During flowering, the number of buds on each influorescence was counted. The day prior to harvest, the total number of mature pods were counted. The percent pod abortion was determined for each plant by dividing the number of mature pods by the number of buds. Buds which failed to open were included in the count of the aborted pods. The individual tagged plants were harvested and hand threshed to provide a measure of seeds per pod.

Seed yield was determined by harvesting 4.5 m of the inner two rows of the four row plots.

Data sets were analysed as randomized complete block experiments using analysis of variance. Means were compared using Duncan's multiple range tests.

RESULTS AND DISCUSSION

Soil Moisture: The differences in the available moisture at the two sites in 1985 were highly significant (Fig. 1). The irrigated treatment received 55.75 mm of irrigation 63 days after sowing when the soil moisture fell below 70% of field capacity, which was considered to be the point of water stress. Precipitation was unusually high during July and August of 1985, with 133.73 mm of precipitation in the four weeks following the irrigation and no further irrigation was applied.

In 1986, 325 mm of water were applied to the irrigated site 15 days after sowing. The young seedlings were visibly wilting although the plot was not below 70% field capacity. The unusually high precipitation of 1986 eliminated the need for further irrigation and the non-irrigated treatment remained above 70% of field capacity for the remainder of the growing season.

Growth Stages: The vegetative (stages 0 to 3) and reproductive (4 and 5) growth stages of the six cultivars are illustrated for the 1985 season (Fig. 2). The ranking of the cultivars on the basis of time to first flower (the end of growth stage 3) within each treatment corresponded with the maturity rankings. Westar was the first cultivar to flower, 50.3 days after sowing in the irrigated and 51.3 in the non-irrigated, and Karat was the last to flower, 56.0 and 57.3 days in the irrigated and non-irrigated treatments, respectively. Flowering (growth stage 4) occurred during the period of moisture stress in 1985. The irrigated and non-irrigated treatments in 1986 showed no significant differences in the timing of the growth stages (data not shown).

% Pod Abortion: The % pod abortion was lower in all cultivars under the irrigated treatment in 1985 (Table 1) but the differences between treatments were not significant. Within the irrigated treatment, the time to first flower was reflected in the % pod abortion, as the earlier flowering cultivars Westar, Regent and Pivot had significantly higher rates of pod abortion than the later flowering Karat and Topas. Global was the exception, with % pod abortion equal to the early flowering cultivars in both treatments. Similar results were obtained in 1986 within treatments (data not shown).

Yield and Yield Components: The results for pods per plant and seeds per pod (Table 1) suggested compensation among these two yield components. Within both treatments, pods per plant were significantly higher and seed per pods significantly lower in the later cultivars Global and Karat compared to Westar. This relationship between maturity and yield components was maintained in 1986 (data not shown). Seed yields were significantly higher in the non-irrigated vs. irrigated treatment for the cultivars Westar and Pivot and not significantly different for the other cultivars.

Krogman and Hobbs (1975) studied the effect of irrigation on yield and yield components and reported that irrigation more than doubled yields by promoting plant growth with more pods, more seeds per pod and larger seeds. Another study by Clarke and Simpson (1978) concluded that pods per plant and seeds per pod were increased by irrigation while branches per plant were not affected.

Our results indicate that the moisture stress imposed at flowering did not affect the determination of yield components. Later flowering cultivars tended to have a lower rate of pod abortion and higher pods per plant under both high and low soil moisture. However, this was not reflected in higher yields in the later maturing cultivars as there was apparent compensation among yield components. One of the highest yielding cultivars, Westar, had the highest % pod abortion, lowest pods per plant and highest seeds per plant. The yield component 1000 seed weight was not measured in 1985 but in 1986, Westar had significantly higher 1000 seed weight than the other five cultivars under both irrigated and non-irrigated treatments (data not shown). Clarke and Simpson (1978) also noted this correlation between yield and 1000 seed weight in the cv. Tower under different treatments.

REFERENCES

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4) Richards, R.A. and N. Thurling (1978). Variation between and within species of rapeseed (Brassica campestris and Brassica napus) in response to drought stress 1. Sensitivity at different stages of development. Australian Journal of Agricultural Research 29:469-467.

Table 1. % Pod abortion, the yield components pods plant^{-1} and seeds pod^{-1}, and seed yield for the six B. napus cultivars on the irrigated (I) and non-irrigated (NI) treatments in 1985.

	1. % Pod Abortion		2. Pods Plant^{-1}		3. Seeds Pod^{-1}		4. Seed Yield	
Cultivar	I	NI	I	NI	I	NI	I	NI
Westar	55.47 abc*	59.46 ab	59.47 c	58.20 c	18.57 bcd	26.76 a	559.55 bcd	690.62 a
Regent	53.33 bcde	54.02 abcd	95.60 ab	74.80 abc	21.61 bc	22.14 b	586.92 abcd	591.88 abcd
Pivot	52.57 bcde	52.72 abcd	76.93 abc	74.53 abc	21.24 bc	27.13 a	502.45 d	698.78 a
Topas	47.58 ef	48.73 def	82.40 abc	73.07 bc	17.14 d	20.39 bcd	631.35 abc	613.80 abcd
Global	54.99 abc	56.43 ab	97.67 ab	103.13 a	21.30 bc	21.69 bc	673.53 ab	604.05 abcd
Karat	46.01 f	49.77 cdef	97.6[illegible] ab	99.93 ab	17.09 d	18.01 cd	529.52 cd	555.92 bcd

*Values followed by the same letter(s) within 1, 2, 3 and 4 above are not significantly different P 0.05.

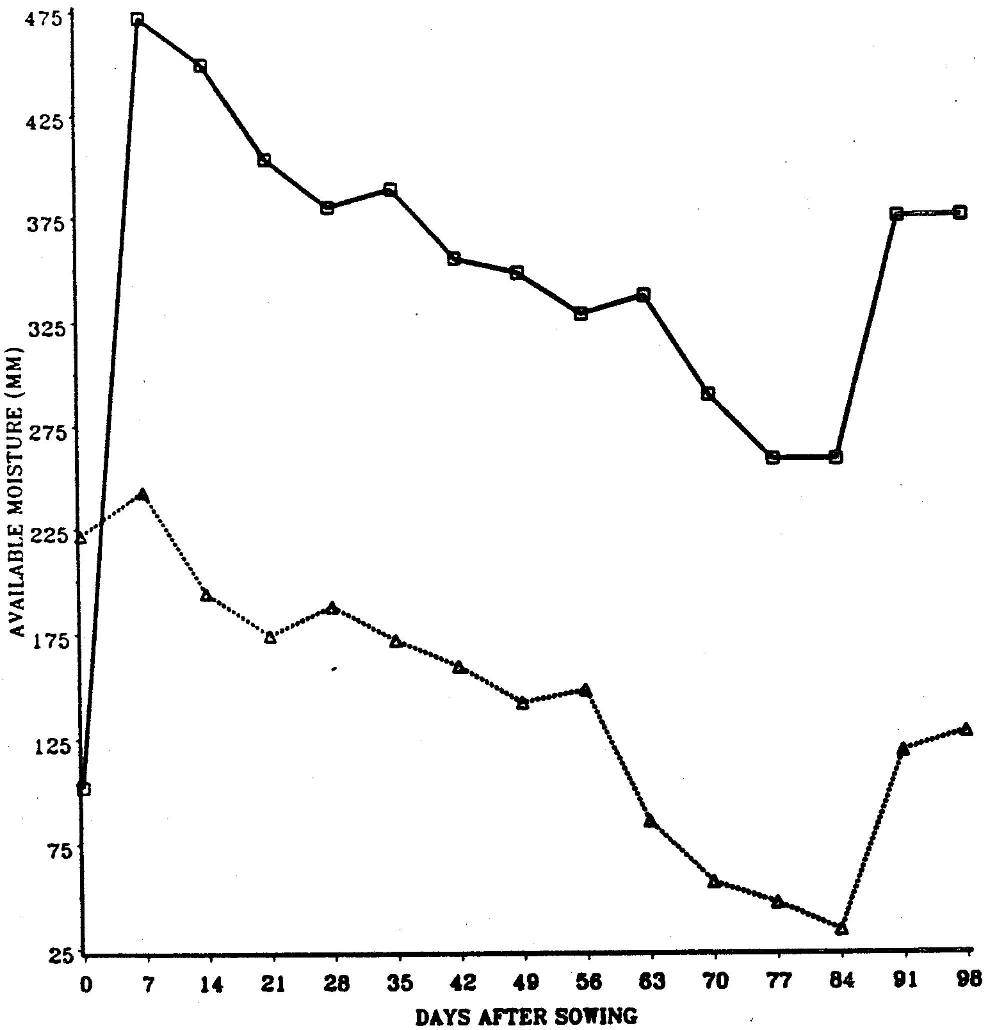

Fig. 1. Available soil moisture for the irrigated (-) and non-irrigated (---) treatments 1985.

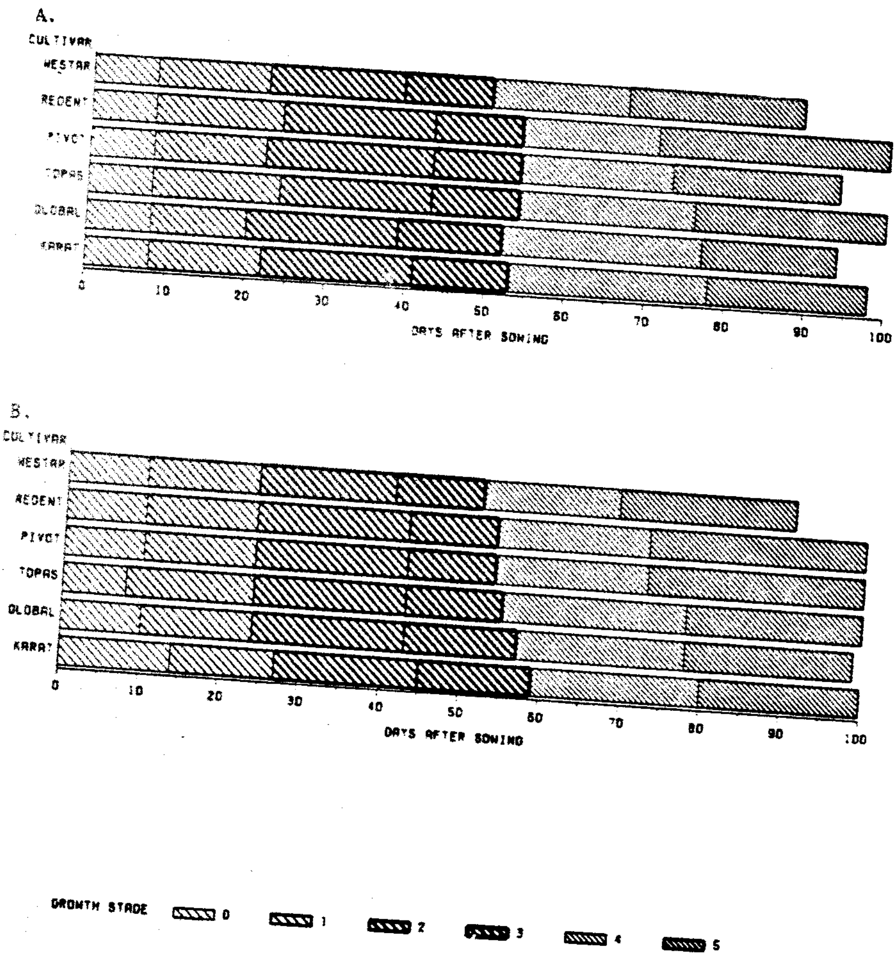

Fig. 2. Growth stages for the six *B. napus* cultivars under the A. Irrigated and B. non-irrigated treatments 1985.