WATER REQUIREMENT FOR WINTER RAPESEED IN CENTRAL WASHINGTON

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INTRODUCTION

Rapeseed (Brassica napus) is a relatively new crop for irrigated central Washington. Domestic demand for rapeseed is on the increase and good potential exists for export. Interest in the crop has increased in recent years as it provides a commercially viable and potentially profitable break crop for cereal rotations.

Irrigation information on rapeseed has not been reported in the United States, but it is well recognized that the crop is responsive to irrigation in dry climates. Expansion of rapeseed production should be possible where supplemental irrigation can be provided. Irrigation has been shown to increase seed yield (Stoker and Carter, 1984; Wright et al., 1988). Response varied with the season, but there appeared to be no benefit from applying more than two irrigations (Stoker and Carter, 1984). Rapeseed responded largely to irrigation at the start of flowering (Davidson, 1976). Richards and Thurling (1978) showed three Brassica napus L. cultivars to be most sensitive to drought during pod filling. Bram (1981) showed that a reduction in yield occurred if soil moisture fell below 50% available during the period from flowering to green maturity. In a field study, Munoz and Fernandez (1979) tested 4 levels of irrigation and found that yield began to decline when the total water supply fell below 500 mm. Bhan et al. (1980) found that one irrigation at flower initiation gave higher yields than at pod development. However, irrigation at both stages gave maximum yields.

The effect of irrigation on oil concentration was not clear. In a pot or in a field experiment, various moisture regimes caused no difference in seed oil (Konicka and Kozakievicz, 1978; Munoz and Fernandez, 1979). However, the work of Bhan et al. (1980) showed maximum seed oil content resulted from one irrigation at flower initiation.

The purpose of this study was to calculate the amount of water applied to various winter rapeseed varieties and to record the soil moisture effect on seed yield and oil concentration of each variety. This study also calculates the water use efficiency of each cultivar tested in central Washington.

MATERIALS AND METHODS

Field experiments were conducted on a Warden loam soil (coarse silty, mixed, mesic Xerollic Camborthids) with about 45% sand and 9% clay in the surface. The plots were located at the Irrigated Agriculture Research and Extension Center, Washington State University - Prosser. Fresh cut wheat stubble was disked and rototilled into the ground before a broadcast application 112 kg N and 28 kg P per hectare. Trifluralin was applied at the rate of 1.12 kg a.i. per ha and incorporated into the top 7.5 cm. The ground was then packed and pre-irrigated. Soil moisture was kept optimum for seed germination and plant growth before winter. Two winter canola rapeseed cultivars (Lindora and Santana) were seeded on Aug 31, 1986 and Sept 3, 1987 and Liradonna and Santana were seeded on Sept 7, 1988. The seeding rate was 6.7 kg per ha using a precision cup seeder (Nibex 500[1]). Treatments of 1, 2, 3, 4, and 5 spring irrigations were applied by rill systems as presented in Table 1.

Table 1. Irrigation scheduling for winter rapeseed in 1987, 1988, and 1989 at Prosser, Washington, USA.

Trt	1987	1988	1989
I_0	No spring irrigation	No spring irrigation	No spring irrigation
I_1	NT	April 19	May 01
I_2	April 16 and May 05	April 19 and May 04	May 01 and May 15
I_3	April 16, May 05, and May 13	April 19, May 04, and May 18	May 01, May 15, and May 25
I_4	NT	April 19, May 04, 18, and June 01	May 01, 15 and 25, and June 04
I_5	April 16, May 05, 13, 29, June 10	NT	NT

Each set of irrigation was for 24 hours.
NT: not tested.

Soil moisture was monitored before and after each irrigation with a neutron probe. Water applied was calculated by averaging the flow rates of small "V-notch weirs" over each 24-hr irrigation period. Plots were harvested on 26, 27 and 23 June, 1987, 1988, and 1989, respectively, except plots of treatment I4 in 1989, which were harvested on July 10. Subsamples were cleaned and dried for oil analysis. Oil concentration was determined using a Newport MKIIIA Nuclear Magnetic Resonance (NMR) instrument on 12 g of oven-dried seed obtained from each replication. All samples were analyzed with a 32-second integration period. Samples from 1989 were analyzed using the Soxtec Oil extraction system. Oven-dried samples were ground using a small coffee mill and oil was extracted by hexane which passed through the ground samples in the thimbles. Oil was collected into the extraction cups which were dried and weighed.

Water applied was defined as the sum of water applied through irrigation and total rainfall from the date the treatments started until harvest. The total amount of water used by the crops was the total amount of water applied plus soil water depletion.

RESULTS AND DISCUSSION

Precipitation at this location was very limited and occurred mostly during the fall and winter. Successful crop production was dependent upon supplemental irrigation. Rainfall during the growing season was only 3.1, 4.2 and 1.5 cm for spring 1987, 1988, and 1989, respectively (Table 2). Early plant growth and development used soil moisture accumulated from fall and winter precipitation. First irrigation treatments were started in the spring during blooming or after peak flowering, depending upon available

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[1] Mention of product or company names is for the benefit of the reader and does not imply endorsement of the products or equipment by the University.

soil moisture. The amounts of water applied and water used during all three growing seasons are presented in Table 2. Table 2 shows that the more water we applied to the crop, the less the amount of the total available soil moisture that was used.

Table 2. Water applied and calculated water used by Lindora, Liradonna and Santana rapeseed cultivars during the treatment periods (in cm).

Treatment	Rainfall (1)	Water applied	Soil-water used (2)	Total water used (3)
	1987			
	cm	cm	cm	cm
I_0	2.50	0	5.03	7.53
I_2	2.50	6.37	-0.07	8.80
I_3	2.50	10.68	-3.19	9.99
I_5	2.50	13.36	-6.24	9.62
	1988			
I_0	3.39	0	1.86	5.25
I_1	3.39	3.12	1.28	7.79
I_2	3.39	6.24	-1.89	7.74
I_3	3.39	9.37	-4.72	8.04
I_4	3.39	12.49	-5.12	10.76
	1989			
I_0	1.17	0	2.33	3.50
I_1	1.17	3.18	1.95	6.30
I_2	1.17	6.35	-0.81	6.71
I_3	1.17	9.52	-2.85	7.84
I_4	1.17	12.80	-5.39	8.58

(1) Estimated at 80% of actual rainfall.

(2) Soil-water used: soil moisture before starting treatment - soil moisture at harvest.

(3) Total water used = water applied + rainfall + soil moisture.

Seed Yield

In Australia, rapeseed responded very well to irrigation (Richards and Thurling, 1978). However, the crop does not require a lot of water. In 1987, optimum yields of both Lindora and Santana were obtained on plots receiving the greatest amount of water. However, in 1988 and 1989, yields were optimized with only 1 or 2 irrigations when applied at blooming or at early pod development. Differences between treatments receiving 2 and 3 or 4 irrigations were very small and had no beneficial effects on seed yields (Table 3). This lack of positive response to additional water may be due to the loss of nutrients through leaching or runoff. In 1988 and 1989, data indicated that 3 irrigations were detrimental to seed yields, particularly with Santana. This agrees with Stoker and Carter (1984). During our three-year study, yields increased with up to 5 irrigations for both cultivars in 1987 when air temperatures were higher than normal. The heat unit accumulation for the month of blooming and flower fertilization was 191°C with more than 10 days at maximum temperatures of 26.7°C or higher. In 1988, there were only 2 days with maximum temperature of 26.7°C or higher. Accumulated heat units during this same period were only 96°C. Weather was less extreme in 1989 than either 1988 or 1987, with only one day of 28°C, with accumulated heat units 137°C. This study found that irrigation was necessary if the temperature was higher than 26°C. Cool nights may help to overcome daytime heat stress. The study also ascertained that rapeseed is a cool season crop with pods that could not properly develop under high temperatures.

Oil Concentration

The effects of irrigation on oil concentrations was inconsistent. During the first year, the timing and amount of water applied did not affect oil concentration in the seed. Oil concentrations remained high under all treatments for both cultivars. In the second year, supplemental irrigation treatments did not yield the highest oil concentrations. The more water applied to the crop, the lower the oil concentration in the seed. In the third year, supplemental irrigation in the spring did not decrease oil concentration in the seed of both Liradonna and Santana, possibly due to more rapid seed development. Oil concentration in the seed kept on increasing with irrigation water up to a maximum of 3 spring irrigations and then slightly decreased with 4 spring irrigations. Again, data showed that the amount of water applied may or may not increase the oil concentration of rapeseed.

Water Use Efficiency

The maximum amount of water that winter rapeseed used during the spring was about 10 cm. More water applied resulted in lower water use efficiency. The crop used residual soil moisture when irrigation water was not supplied during the growing season (Table 2). Water use efficiency, which was calculated using yield and water applied, decreased with the increase in amount of water applied. Failure to irrigate the crop will result in the use of soil moisture and produce a crop more efficiently than a crop irrigated for maximum yield (Table 3).

Table 3. Seed yield, oil concentration, and water use efficiency of winter rapeseed during the 3-year experiment at Prosser, Washington.

	Seed yield	Oil conc.	Oil yield	Water use eff.	Seed yield	Oil conc.	Oil yield	Water use eff.
Trt	kg ha-1	%	kg ha-1	kg ha-1 cm-1	kg ha-1	%	kg ha-1	kg ha-1 cm-1
				1987				
	cv. LINDORA				cv. SANTANA			
I_0	1643 c	44.2	726	657	1383 c	43.2	597	553
I_2	3776 b	45.0	1699	426	3854 b	44.9	1730	434
I_3	3873 b	44.8	1735	294	3996 b	44.7	1786	303
I_5	5029 a	43.6	2193	317	5149 a	43.9	2260	325
Mean	3580	44.4	1588	423	3595	44.2	1593	404
Lsd (.05)	919	NS			919	NS		
				1988				
	cv. LINDORA				cv. SANTANA			
I_0	4366 bc	44.5 a	1943	1288	5764 b	44.7 a	2576	1700
I_1	4320 bc	41.3 c	1784	663	5363 bc	40.8 b	2188	824
I_2	5222 a	42.6 bc	2224	542	7879 a	41.6 b	3278	818
I_3	5125 ab	39.4 d	2019	402	4704 c	41.0 b	1929	369
I_4	4171 c	43.4 ab	1810	263	4980 bc	43.7 a	2176	314
Mean	4640	42.2	1956	631	5738	42.4	2429	805
Lsd (.05)	546	1.1			546	1.1		
				1989				
	cv. LIRADONNA				cv. SANTANA			
I_0	1954 c	38.6 c	755	1670	3661 bc	40.3 c	1474	3129
I_1	5580 a	43.4 ab	2422	1283	5304 a	44.53 ab	2362	1219
I_2	4693 ab	43.9 ab	2062	624	5010 ab	45.0 ab	2253	666
I_3	3619 b	45.4 a	1642	338	3161 c	46.0 a	1453	296
I_4	4263 ab	44.8 a	1909	305	3607 bc	45.6 ab	1644	258
Mean	4022	43.2	1758	844	4148	44.3	1637	1113
Lsd (.05)	936	2.8			936	3.1		

Each value is the average of 4 replications.

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