Pak. J. Bot., 39(3): 739-746, 2007.

PERFORMANCE OF CANOLA (*BRASSICA NAPUS* L.) UNDER DIFFERENT IRRIGATION LEVELS

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Abstract

A field experiment was carried out to examine the effect of different irrigation levels on growth and yield of canola in 2005-06. The experiment comprised nine irrigation treatments viz., one irrigation at early vegetative stage (21DAS); one irrigation at flower initiation (56 DAS); one irrigation at seed formation (93 DAS); two irrigations, one at early vegetative and second at mid vegetative stage (21 & 35 DAS); two irrigations, one at early vegetative and second at flower initiation (21 & 56 DAS); two irrigations, one at flower initiation and second at seed formation (56 & 93 DAS); three irrigations, one at early vegetation, second at mid vegetation and third at seed formation (21, 35 & 93 DAS); three irrigations, one at early vegetation, second at flowering and third at seed formation (21, 56 & 93 DAS); three irrigations, one at mid vegetation, second at flowering and third at seed formation (35, 56 & 93 DAS). The results showed that maximum crop growth rate, net assimilation rate, number of seeds per siliqua, 1000-seed weight and seed yield were attained with three irrigations at early vegetative, flowering and seed formation (21, 56 & 93 DAS). The oil and protein contents of the seed were not affected significantly by varying irrigation levels.

Introduction

Pakistan is an agricultural country still spending millions of dollars on the import of edible oil, which is a major drain on the foreign exchange reserves of the country. The indigenous oil production of the country could not match the growing demand of population. The domestic edible production has grown @ 2.6% annually over last 20 years, while consumption has increased at 9%. The edible oil consumption was 2.764 million tons of which 0.857 million tons (31%) came from local resources and 1.907 million tons (69%) were imported (Anon., 2006).

Among different oilseed crops rapeseed and mustards contribute 21% towards national oil production but the quality of oil is low due to presence of erucic acid and glucosinolates. Erucic acid decrease the taste and flavour while glucosinolates not only cause the nutritional disorder, goiters but also adversely affect the growth and reproduction of animals if fed at significant level in diet (Vermorel *et al*., 1986). Canola varieties are low in these chemicals and area under canola is increasing rapidly. In 2005 the area under canola was 28,000 hectares with 144,000 tons of oil seed and 52,000 tons of edible oil production. (Anon., 2006). Canola is recent introduction in Pakistan, hence many aspects of its package production technology need to be unveiled. The average yield of canola is less than the potential of the existing cultivars due to many factors which affect the yield but irrigation scheduling is the most important one. Pakistan is facing a shortage of irrigation water now a days and this shortage become serious in winter season. Water is the major factor limiting crop production in many regions of the world. All physiological processes like photosynthesis, cell turgidity, growth of cells and tissue etc., in plant are directly or indirectly affected by water (Reddi & Reddi 1995).

Siliquae per plant, seed and oil yield of canola decreased as water stress increased (Rahnema & Bakhshandeh, 2006). Similarly, increase in seed yield with increase in number of irrigations has been reported by Hati *et al*., (2001). Application of irrigation can increase the seed yield of canola from 41.7 to 62.9% (Panda *et al*., 2004). The present study was, therefore, carried out to examine the yield response of canola to different irrigations scheduling and to determine the suitable irrigation schedule for realizing the maximum yield potential of quality produce.

Materials and Methods

A field experiment was carried out at the agronomic research area University of Agriculture, Faisalabad during winter season 2005-06 on sandy clay loam soil containing 0.87% organic matter, 0.047% available nitrogen, 9.1 ppm phosphorus and 131 ppm potash. The experiment comprised 9 irrigation treatments viz., one irrigation at early vegetative stage (21DAS), one irrigation at flower initiation (56 DAS), one irrigation at seed formation (93 DAS); two irrigations one at early vegetative and second at mid vegetative stage (21 & 35 DAS), two irrigations one at early vegetative and second at flower initiation (21 & 56 DAS), two irrigations one at one at flower initiation and second at seed formation (56 & 93 DAS); three irrigations one at early vegetation, second at mid vegetation and third at seed formation (21, 35 & 93 DAS), three irrigations one at early vegetation, second at flowering and third at seed formation (21, 56 & 93 DAS), three irrigations one at mid vegetation, second at flowering and third at seed formation (35, 56 & 93 DAS). The experiment was laid out in randomized complete block design with three replications with a net plot size of 1.8 x 5 m. The crop was sown on 6th October 2005 using a seed rate of 5 kg ha^{-1} with 30 cm apart rows using single row hand drill. Plant population was maintained by thinning at early growth stages. Nitrogen and phosphorus were applied @ 100 kg ha^{-1} and 90 kg ha^{-1}. Urea and diammonium phosphate were used as a source of nitrogen and phosphorus, respectively. All other agronomic practices were kept normal and uniform for all the treatments.

Five plants were harvested after 15 days interval for recording leaf area index, leaf area duration, crop growth rate and net assimilation rate. Ten plants were selected randomly at harvested for recording plant height, number of branches per plant, number of siliquae per plant and number of seeds per siliqua. Five representative samples were taken from each plot for recording 1000-seed weight. Seed yield was recorded on per plot basis and was converted to kg ha^{-1}. Seed and oil contents were determined by following the official methods of analysis (Anon., 1990). The data collected was subjected to statistical analysis using Fisher's analysis of variance technique and least significant difference test was applied for comparison of treatment means (Steel *et al*., 1997).

Results

Plant population: Effect of different irrigation levels on plant density of canola was non-significant. The plant density, however, varied from 15.24 to 15.91 among different treatments.

Leaf area index and dry matter production: Irrigation levels significantly affected the leaf area index and dry matter production of canola (Fig. 1). The maximum leaf area index and dry matter production was recorded where three irrigations were applied at early growth stage, flowering and seed formation (21, 56 & 93 DAS) whereas, the minimum leaf area index and dry matter production was recorded with one irrigation at early vegetative growth stage (21 DAS). There was a linear increase in the leaf area index and dry matter over the time (Figs. 1&2). The maximum leaf area index was obtained on 17th January 2006 while maximum dry matter was recorded on 3rd February, 2006 thereafter a sharp decline in leaf area index and dry matter was observed.

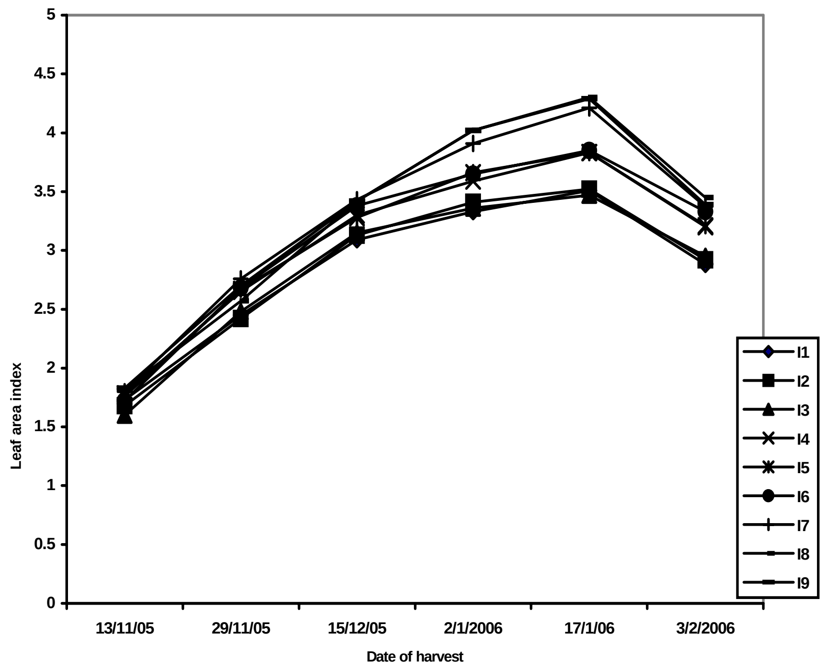

Fig. 1. Effect of irrigation levels on leaf area index of canola
I1= One irrigation at early vegetative stage (21DAS)
I2= One irrigation at flower initiation (56 DAS)
I3= One irrigation at seed formation (93 DAS)
I4= Two irrigations, one at early vegetative and second at mid vegetative stage (21 & 35 DAS)
I5= Two irrigations, one at early vegetative and second at flower initiation (21 & 56 DAS)
I6= Two irrigations, one at flower initiation and second at seed formation (56 & 93 DAS)
I7= Three irrigations, one at early vegetation, second at mid vegetation and third at seed formation (21, 35 & 93 DAS)
I8= Three irrigations, one at early vegetation, second at flowering and third at seed formation (21, 56 & 93 DAS)
I9= Three irrigations, one at mid vegetation, second at flowering and third at seed formation (35, 56 & 93 DAS).

Leaf area duration: Significantly maximum leaf area duration (Table 1) was recorded with three irrigations at early vegetative, mid vegetative and seed formation stage (21, 56 & 93 DAS). Among treatments where three irrigations were applied, water stress at early vegetative stage (irrigations at 35, 56 & 93 DAS) or seed formation stage (irrigation at 21, 35 & 56 DAS) resulted in lower leaf area duration. Three irrigations resulted in significantly higher leaf area duration than two or one irrigation. Minimum leaf area duration was recorded with one irrigation at flowering (56 DAS).

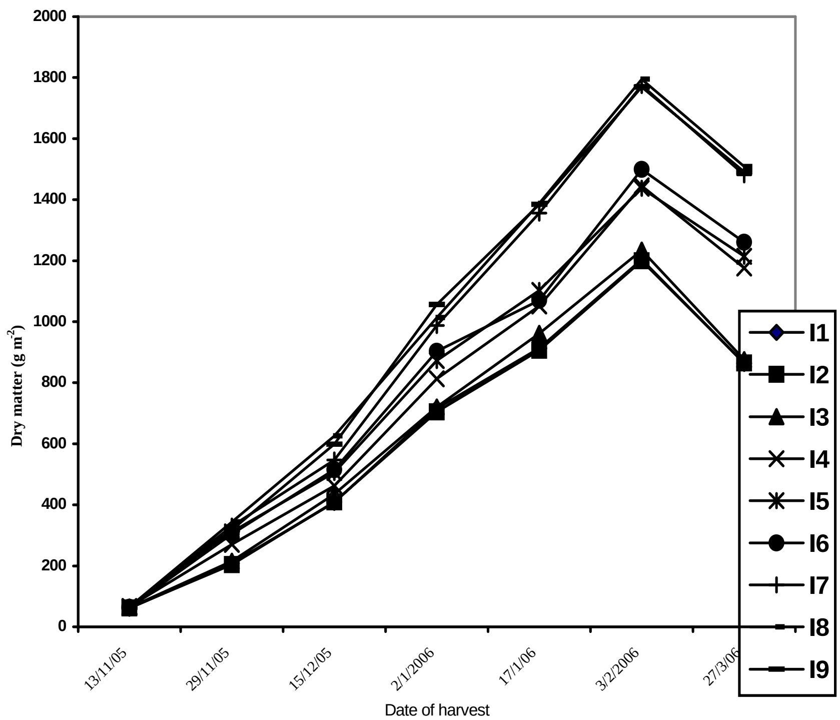

Fig. 2. Effect of irrigation levels on dry matter production of canola.
I1= One irrigation at early vegetative stage (21DAS)
I2= One irrigation at flower initiation (56 DAS)
I3= One irrigation at seed formation (93 DAS)
I4= Two irrigations, one at early vegetative and second at mid vegetative stage (21 & 35 DAS)
I5= Two irrigations, one at early vegetative and second at flower initiation (21 & 56 DAS)
I6= Two irrigations, one at flower initiation and second at seed formation (56 & 93 DAS)
I7= Three irrigations, one at early vegetation, second at mid vegetation and third at seed formation (21, 35 & 93 DAS)
I8= Three irrigations, one at early vegetation, second at flowering and third at seed formation (21, 56 & 93 DAS)
I9= Three irrigations, one at mid vegetation, second at flowering and third at seed formation (35, 56 & 93 DAS).

Crop growth rate and net assimilation rate: The crop growth rate and net assimilation rate were affected significantly by different irrigation levels (Table 1). The maximum crop growth rate and net assimilation rate were recorded with three irrigations at early vegetation, flowering and seed formation (21, 56 and 93 DAS) but was statistically at par with other three irrigation treatments. The minimum crop growth rate and net assimilation rate were obtained with one irrigation at early vegetative growth stage (21 DAS). The crop growth rate and net assimilation rate increased significantly with increase in number of irrigations.

Plant height and number of branches per plant: Plant height and number of branches of canola varied significantly due to different irrigation treatments. The maximum plant height and number of branches were recorded with three irrigations at early vegetation, flowering and seed formation (21, 56 and 93 DAS) but was statistically at par with three irrigations at late vegetative, flowering and seed formation (35, 56 & 93 DAS). The minimum plant height was recorded when one irrigation was applied at seed formation stage (93 DAS) and was statistically similar to one irrigation at flowering (56 DAS).

Number of siliquae per plant: Different irrigation levels had a significant effect on number of siliquae per plant (Table 2). The significantly maximum number of siliquae and number of seeds per siliqua were obtained with three irrigations at early vegetative, flowering and seed formation (21, 56 & 93 DAS) and was followed by three irrigation at early vegetative, mid vegetative and seed formation (21, 35 & 93 DAS) and three irrigation at mid vegetative, flowering and seed formation (35, 56 & 93 DAS). The minimum number of siliquae per plant were recorded with one irrigation at early seed formation stage (93 DAS) and was statistically similar to one irrigation at early vegetative stage (21 DAS). However, minimum number of seeds per siliqua were recorded with one irrigation at early vegetative stage (21 DAS) which did not differ statistically from one irrigation at early flower stage (93 DAS) and one irrigation at seed formation stage (93DAS). In general increase in number of irrigation showed a linear increase in number of siliquae per plant and number of seeds per siliqua.

1000-seed weight: Effect of different irrigation levels on 1000-seed weight was significant. The maximum 1000-seed weight was recorded with three irrigation at early vegetative, flowering and seed formation (21, 56 & 93 DAS) which was statistically similar to three irrigation at early vegetative, mid vegetative and seed formation (21, 35 & 93 DAS), three irrigation at mid vegetative, flowering and seed formation (35, 56 & 93 DAS) and two irrigation at flowering and seed formation (56 & 93 DAS). The minimum 1000-seed weight was recorded in one irrigation at early vegetative stage (21 DAS) which was statistically at par with one irrigation at early vegetative stage (93 DAS). The 1000-seed weight increased significantly with each increased irrigation number.

Seed yield: Seed yield showed significant differences due to different irrigation levels, the maximum seed yield was recorded with three irrigation at early vegetative, flowering and seed formation (21, 56 & 93 DAS) which was statistically at par with other treatment where three irrigations were applied. The minimum was recorded where only one irrigation was applied at seed formation (93 DAS) which did not differ significantly from one irrigation at early vegetative stage (21 DAS) and flowering stage (56 DAS).

Seed oil and protein contents: Seed oil and protein contents were not affected significantly with difference time and number of irrigation (Table 2). Oil and protein contents, however, ranged from 44.32 to 44.85% and 20.02 to 20.48% among different irrigation levels, respectively.

Discussion

The non-significant differences for plant population can be attributed to maintaining uniform inter row as well as intra row spacing by using uniform seed rate and thinning out extra plants after the germination when seedlings were high enough to escape the mortality. This sharp decline in the leaf area index can be attributed to senescence of the leaves at this stage. Cheema *et al.*, (2001) have also reported same trend in leaf area index of canola. Increase in leaf area index with increase in number of irrigations might have been due to the better growth of the crop plants, more number of leaves and plant height. Bikram *et al.*, (1994) have also reported higher leaf area index at higher irrigation levels.

Table 1. Effect of different irrigation levels on the growth of canola.

Irrigation levels	Plant population m^{-2}	Leaf area duration (days)	Crop growth rate ($g\ m^{-2}\ d^{-1}$)	Net assimilation rate ($g\ m^{-2}\ d^{-1}$)
One irrigation 21DAS	15.24	220.56 e	5.79 f	3.91 e
One irrigation 56 DAS	15.71	222.03 e	5.94 ef	3.89 e
One irrigation 93 DAS	15.55	221.30 e	6.02 e	3.95 e
Two irrigation 21 & 35 DAS	15.85	237.89 d	8.21 d	4.93 d
Two irrigations 21 & 56 DAS	15.81	238.70 d	8.51 c	5.08 c
Two irrigations 56 & 93 DAS	15.57	241.56 c	8.85 b	5.21 b
Three irrigation 21, 35 & 56 days after sowing	15.88	253.41 b	10.49 a	5.84 a
Three irrigations 21, 56 & 93 days after sowing	15.67	256.01 a	10.68 a	5.88 a
Three irrigations 35, 56 & 93 days after sowing	15.91	254.88 ab	10.59 a	5.84 a
LSD	NS	2.29	0.212	0.08

Values followed by the same letters within a column do not differ significantly at 5% probability level.

Table 2. Effect of different irrigation levels on yield, yield components and quality of canola.

Irrigation levels	Plant height (cm)	Branches per plant	Siliquae per plant	Seeds per pod	1000-seed weight (g)	Seed yield ($kg\ ha^{-1}$)	Oil content (%)	Protein content (%)
One irrigation 21DAS	132.79e	14.49 d	148.28ef	19.79d	2.89f	1.64c	44.58	20.07
One irrigation 56 DAS	113.36f	13.60 de	155.86e	20.02d	3.32de	1.70c	44.66	20.21
One irrigation 93 days after sowing	112.66f	11.69 e	145.86f	20.31d	3.01ef	1.61c	44.32	20.22
Two irrigation 21 & 35 days after sowing	155.86c	17.72 c	241.06c	24.77c	3.55cd	2.47b	44.80	20.08
Two irrigations 21 & 56 days after sowing	160.18c	17.37 c	228.25d	23.07c	3.57bcd	2.54b	44.72	20.13
Two irrigations 56 & 93 days after sowing	148.69d	16.79 c	241.15c	24.75c	3.66abcd	2.57b	44.44	20.26
Three irrigation 21, 35 & 56 days after sowing	173.24b	18.61 bc	314.89b	28.56b	3.82abc	3.62a	44.56	20.48
Three irrigations 21, 56 & 93 days after sowing	184.14a	24.02 a	328.01a	32.60a	3.94a	3.71a	44.85	20.37
Three irrigations 35, 56 & 93 days after sowing	180.66a	20.03 b	318.54b	31.12ab	3.93ab	3.65a	44.38	20.52
LSD	6.07	2.22	7.89	2.58	0.36	0.41	NS	NS

Values followed by the same letters within a column do not differ significantly at 5% probability level.

Increase in leaf area duration with increased irrigation number might have been due to better supply of the moisture through out the growth period resulting on delayed senescence of the leaves. The results are supported by the finding of Bikram *et al*., (1994) have also reported higher leaf area duration with increase irrigation. The leaf area duration decreased in those treatment where stress was given at early vegetative stage or at seed formation. The stress at early stages might have resulted in weaker plants and stress at seed formation might have resulted in accelerated senescence both lead to less leaf area duration.

Increase in crop growth rate and net assimilation rate with increase in number of irrigation can be attributed to better supply of moisture through out the growth period resulting in higher leaf area index and leaf area duration. Moisture stress at different growth stages adversely effect leaf area index and leaf area duration resulting in lower crop growth rate and net assimilation rate. The results are in line with those of Majid & Simpson (1997) who also reported maximum crop growth rate and net assimilation rate with three irrigations in canola.

In general plant height and number of branches increased with increase in number of irrigations. This increase in plant height and number of branches might have been due to more availability of moisture, higher crop growth rate and net assimilation rate at irrigation frequencies. The results are supported by the findings of Rathore & Patel (1990).

More number of siliquae per plant and number of seeds per siliqua can be attributed to greater plant height, number of branches per plant and net assimilation rate (Table 1). These findings are supported by those of Rathore & Patel (1990) who reported higher number of siliquae and number of seeds per siliqua at higher irrigation frequencies. The results are however, contradictory to those of Rahnema & Bakhshandeh (2006) who reported non-significant difference among irrigation treatments for number of seeds per siliqua. These contradictory results can be attributed to difference in fertility status and genetic makeup of the crop plants.

Higher leaf area index, crop growth rate and net assimilation rate resulted in the greater photosynthetes which were stored in the sink (Seed) resulting in higher seed weight at higher irrigation frequencies.

The increase in number of irrigation resulted in significant increase in seed yield. Increase in seed yield can be attributed to higher number of siliquae per plant, number of seeds per siliqua and 1000-seed weight. Increase in seed yield with increase in number of irrigations has been reported by Hati *et al*., (2001) and Panda *et al*., (2004). Non-significant effect of irrigation level on protein and oil contents have also been reported by Parveen *et al*., (1996) and Padmani *et al*., (1992), respectively.

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(Received for publication 8 March 2006)