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Effect of irrigation on Indian mustard (*Brassica juncea*) sown on conserved moisture

JAGDEV SINGH, BIKRAM SINGH AND J.S. YADAV

Regional Research Station, Chaudhary Charan Singh Haryana Agricultural University, Bawal, Rewari 123 501

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 1995–96 and 1996–97 on loamy sand soil of Regional Research Station, Bawal, to study the response of Indian mustard [*Brassica juncea* (L.) Czernj & Cosson] to irrigation scheduling. In Indian mustard sown on conserved moisture, application of 2 irrigations, one essentially at initiation of branching (40 days after sowing) and the other either at flowering (60 days after sowing) or pod-development stage (100 days after sowing) resulted in statistically equal yields to 3 irrigations. Water stress during initiation of branching through pod-development stage caused 28% reduction in yield, while stress throughout crop season reduced yield by 35% as compared to no-water stress. The mean net returns were maximum (Rs 14,986/ha) when 2 irrigations were applied at initiation of branching and flowering stages. The benefit : cost ratio in this treatment (2.56) was statistically at par with the maximum value of 2.59 obtained with irrigation applied at initiation of branching. The increasing number of irrigations increased the consumptive use of water but decreased the water-use efficiency.

Key words : Indian mustard, Conserved moisture, Irrigation, Consumptive use, Water-use efficiency, Net returns

Indian mustard is an important winter oilseed crop of Haryana. In southern parts of the state, previously it was being raised as a rainfed crop. But, now with the limited availability of irrigation water farmers have started applying the post-sown irrigations to the conserved moisture-sown crop. At present no scientific information regarding irrigation scheduling in Indian mustard for the zone is available. And, the majority of the soils of southern zone of the state are light textured and climatic conditions are different than rest of the Indian mustard-growing parts of the state. The irrigation requirement of the crop in this zone might be different than other parts of the state. Therefore an experiment was conducted to study the response of Indian mustard to irrigation at different stages of crop growth.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) seasons of 1995–96 and 1996–97 at Regional Research Station, Bawal, on loamy sand soil. The soil was poor in organic carbon (0.22 to 0.26%), medium in available phosphorus (11.6 to 12.4 kg/ha) and rich in potash (326 to 342 kg/ha), with slightly alkaline in reaction (pH 8.2 to 8.4). The field capacity (1/3 atm) and permanent wilting point (15 atm) values were 16.2 and 7.0% respectively. Eight post-sown irrigation treatments were: I_0, no irrigation; I_B, irrigation at initiation of branching (40 days after sowing); I_F, irrigation at flowering stage (60 days); I_{PD}, irrigation at pod-development stage (100 days); I_{B+F}, 2 irrigations at initiation of branching (40 days) and flowering (60 days) stages; I_{B+PD}, 2 irrigations at initiation of branching (40 days) and pod development (100 days) stages; I_{F+PD}, 2 irrigations at flowering (60 days) and pod-development (100 days) stages ; I_{B+F+PD}, 3 irrigations at initiation of branching (40 days), flowering (60 days) and pod-development (100 days) stages.

The experiment was laid out in randomized block design with 3 replications. 'RH 30' Indian mustard was sown in rows 45 cm apart using a seed rate of 5 kg/ha on 30 and 23 October during 1995–96 and 1996–97 respectively. Full dose of fertilizer, i.e. 80 kg N/ha and 30 kg P_2O_5/ha, was applied at the time of sowing. The crop was thinned 3 weeks after sowing by maintaining plant-to plant spacing of 10 cm. The rainfall received was 294.4 and 161.1 mm in September 1995–96 and 1996–97 respectively. As a result of this, 15.9 and 15.4 cm moisture was conserved in 120 cm soil profile in the respective years. The rainfall received was 8.8, 15.2 and 1.8 mm in third, sixth and ninth standard week of 1996 and 8.3, 4.3 and 8.0 mm in third, fifth and thirteenth standard week of 1997 respectively. The pan evaporation values during crop season were 677.3 and 527.1 mm during 1995–96 and 1996–97 respectively. The consumptive use of water was calculated on the basis of soil moisture utilized from 120 cm soil profile + rainfall received in the crop growing period. The crop was harvested on 3 April and 29 March in 1995–96 and 1996–97, respectively.

RESULTS AND DISCUSSION

Growth and yield attributes

The mean values of plant height, branches and siliquae/plant, seeds/siliqua and 1,000-seed weight with all irrigation treatments were significantly higher over no irrigation (Table1). Application of 3 irrigations resulted in taller plants, more branches/plant and seeds/siliqua than no irrigation (I_0) and 1 irrigation applied at pod-development (I_{PD}) stage but was statistically at par to rest of the irrigation treatments. However, siliquae/plant and 1,000-seed weight under 2 and 3 irrigation treatments were statistically at par and significantly more than no and 1 irrigation treatments. Favourable effect of irrigation on growth and yield attributes of mustard was also reported by Phogat *et al.* (1997).

Yield

Application of irrigation significantly

Table 1. Effect of irrigation levels on growth, yield attributes, yield, crop-susceptibility factor and economic returns of Indian mustard

Post-sown irrigation regime	Plant height (cm)	Branches/ plant	Siliquae/ plant	Seeds/ siliqua	1,000-seed weight (g)	Seed yield (q/ha)			Crop susceptibility factor	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	Benefit : cost ratio
						1995–96	1996–97	Mean					
I_0	144	10.8	137	9.4	5.2	14.61	15.42	15.02	0.35	16,334	6,955	9,379	2.35
I_B	155	13.3	182	12.3	5.4	19.83	19.26	19.55	0.16	21,261	8,205	13,056	2.59
I_F	154	13.1	178	12.1	5.4	19.28	18.66	18.97	0.18	20,630	8,205	12,425	2.51
I_{PD}	150	12.4	164	11.4	5.4	17.28	16.39	16.84	0.27	18,314	8,205	10,109	2.23
I_{B+F}	159	14.0	199	12.8	5.7	21.98	23.19	22.59	0.03	24,566	9,580	14,986	2.56
I_{B+PD}	157	13.8	193	12.9	5.6	21.48	22.64	22.06	0.05	23,990	9,580	14,410	2.50
I_{F+PD}	156	13.7	190	12.5	5.6	20.15	21.81	20.98	0.10	22,816	9,580	13,236	2.38
I_{B+F+PD}	161	14.1	201	13.0	5.7	23.15	23.38	23.27		25,306	10,893	14,413	2.32
CD (P = 0.05) 0.20		7	1.7	9	1.4	0.2	1.97	2.12	1.60		1,846		1,741

Details of irrigation regimes are given in text

increased the seed yield (Table 1). Among 1 irrigation treatments, irrigation at initiation of branching (I_B) resulted in significantly higher mean seed yield than irrigation at pod development (I_{PD}) but was statistically at par to irrigation at flowering (I_F) stage. The increase in mean yield over no irrigation (I_0) was 30.2, 26.3 and 12.1 % with 1 irrigation treatments I_B, I_F and I_{PD} stages respectively. Application of 2 irrigations, first at initiation of branching and second either at flowering or pod development resulted seed yield at par with 3 irrigations (I_{B+F+PD}). However, when 2 irrigations were applied at flowering and pod development (I_{F+PD}), the yield decreased significantly compared to 3 irrigations. The increase in mean yield over I_0 was 50.4, 46.9, 39.7 and 54.9% with 2 irrigations treatment I_{B+F}, I_{B+PD} and I_{F+PD} and 3 irrigations treatment I_{B+F+PD} respectively. The above results indicated that application of the first irrigation at initiation of branching (I_B) was the most critical in Indian mustard sown on conserved moisture. Whereas second irrigation applied either at flowering or pod-development stage produced equal beneficial effect on yield of Indian mustard. The beneficial effect of these treatments (I_{B+F}, I_{B+PD}) in the light soils is mainly attributed to greater moisture availability throughout crop-growth period, which in turn resulted in better growth, yield attributes and ultimately the seed yield. Similar advantages of irrigations at 30 and 60 days after sowing by Prasad and Ehsanullah (1988) and at pre-flowering and siliqua-development stages by Sharma (1984) and Yadav *et al.* (1999) were reported for mustard crop.

Susceptibility of crop to water deficit

Crop susceptibility was calculated as the fractional yield reduction from no stress treatment, i.e. $C_{Si} = (X–Xi)/X$, where X is the yield from no stress (3 irrigations) treatments and Xi is the treatment that was stressed during the growth stage. A water deficit had the greatest detrimental effect on yield when it occurred during initiation of branching through pod-development stage. Water stress prior to pod-development stage caused 28% reduction in yield. However, in treatments receiving 1 irrigation either at initiation of branching and flowering stages, the reduction in yield was 16 and 18% respectively. Treatments with 2 irrigations at I_{B+F} and I_{B+PD} were as good as no stress (3 irrigations) treatment. The driest treatment with no irrigation yielded 35% lesser than no-stress (3 irrigations) treatment.

Economic returns

The gross as well as net returns obtained with 2 irrigations treatments I_{B+F} and I_{B+PD} were statistically at par with 3 irrigations (I_{B+F+PD}) treatment (Table 1). But, the gross returns were the maximum with 3 irrigations treatment, whereas the net returns were maximum with 2 irrigations applied at I_{B+F} stages. This was mainly due to higher cost of production of Indian mustard with 3 irrigations compared to 2 irrigations. On the other hand, the benefit : cost ratio was maximum when irrigation was applied at I_B stage (Table 1). It was statistically at par with treatment I_F, I_{B+F} and I_{B+PD}, but was significantly better than rest of the irrigations treatments. The benefit : cost ratio in irrigation treatment I_{PD} and 3

Table 2. Effect of irrgation levels on consumptive use of water (120 cm soil profile) and water-use efficiency of Indian mustard

Post-sown irrigations	Consumptive use (mm)		Water-use efficiency (kg/ha-mm)	
	1995–96	1996–97	1995–96	1996–97
I_0	134.8	130.6	10.83	11.80
I_B	196.8	188.6	10.07	10.21
I_F	193.8	185.6	9.94	10.05
$I_{PD.}$	188.8	181.6	9.15	9.02
I_{B+F}	237.8	233.6	9.24	9.93
I_{B+PD}	233.8	229.6	9.19	9.86
I_{F+PD}	230.8	225.6	8.73	9.66
I_{B+F+PD}	277.8	269.6	8.33	8.67

Details of irrigation and given in text

irrigations treatment were even low compared to no irrigation treatment. Thus application of irrigation at pod-development stage in Indian mustard sown on conserved moisture was not found much economical as compared to other irrigation treatments.

Consumptive use of water and water-use efficiency

The consumptive use of water from 120 cm profile increased with increasing number of irrigations and it was highest with 3 irrigations and minimum in control treatment in both the years (Table 2). No appreciable difference in consumptive use of water was obtained in treatments where similar number of irrigation was applied irrespective of the growth stage. The highest value of mean water-use efficiency was obtained under no-irrigation treatment with a mean yield of 15 q/ha and mean consumptive use of 133 mm from 120 cm soil profile. This might be due to minimized loss of stored soil moisture as evaporation from the soil surface and transpiration through weeds because in unirrigated treatment dust mulch was created on soil surface and weeds were checked completely by repeated hoeing. Secondly, under stress condition, the crop might have developed a deep-root system and have utilized some moisture from soil layer > 120 cm and achieved higher yield as well as water-use efficiency. The mean seed yield of 16.6 q/ha and water-use efficiency of 18.02 kg/ha-mm were also obtained with a mean consumptive use value of 91.4 mm by Yadav *et al.* (1999). But, still the highest value of water-use efficiency in the control treatment was not found desirable from yield and economic point of view in comparison to 1 irrigation treatments I_B and I_F. The values of water-use efficiencies in I_{PD}, I_{F+PD} and I_{B+F+PD} treatments were lower than I_{B+F} and I_{B+PD} treatments. The lower values of water-use efficiencies in I_{PD} and I_{F+PD} were mainly attributed to lower yield in these treatments, whereas in irrigation treatment I_{B+F+PD}, the

water-use efficiency was lower mainly due to higher consumptive use of water without significant increase in yield.

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