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Influence of irrigation and nitrogen on growth, seed and oil yield of Ethiopian mustard (*Brassica carinata*)

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ABSTRACT

The field experiment was conducted at Indian Agricultural Research Institute, New Delhi, during winter season (*rabi*) of 1989–90 and 1990–91 in a sandy-loam alluvial soil on Ethiopian mustard (*Brassica carinata* A. Braun) with 4 levels each of irrigation water : cumulative pan evaporation ratio (unirrigated control and irrigation at IW : CPE ratios of 0.4, 0.6 and 0.8) and nitrogen (0, 50, 100 and 150 kg/ha). The growth and yield attributes, seed and oil yields increased significantly only up to an IW : CPE ratio of 0.6 (2 irrigations). Nitrogen application improved the growth and yield attributes, and also the seed and oil yields significantly up to 100 kg N/ha, but harvested biomass up to 150 kg N/ha. Irrigation and N interacted significantly for plant height, total branches and siliquae/plant, harvested biological and seed yield. Significantly higher seed production (19.8 q/ha) and oil yield (7.7 q/ha) were obtained from the crop irrigated at an IW : CPE ratio of 0.6 fertilized with 100 kg N/ha, but biomass yield (83.3 q/ha) was highest with 150 kg N/ ha at an IW : CPE ratio of 0.8.

Higher productivity of Ethiopian mustard (*Brassica carinata* A. Braun) than that of Indian mustard and Indian repeseed was reported by Katiyar *et al.* (1986) and Labana *et al.* (1987), and specially under delayed sowing by Ganga Saran and Giri (1987). It possesses greater degree of resistance to mustard aphids, indicating a greater prospect in India and more so under multiple irrigated cropping systems. However, most of the studies conducted so far in the country pertain to comparison of different species. The reports related to its water and nitrogen requirements for obtaining higher seed yield are meagre. The present study was therefore undertaken to assess the influence of irrigation and nitrogen on the growth and yield of this species.

MATERIALS AND METHODS

The field experiment was conducted at the Indian Agricultural Research Institute, New Delhi (28° 40' N, 77° 12' E and 218 m altitude), during winter season of 1989—90 and 1990—91 on a sandy-loam alluvial (Ustocrept) soil. The soil was low in available nitrogen (151.2 kg/ha), medium in available phosphorus (23.1 kg P_2O_5/ha) and potassium (111.0 kg K_2O/ha), with pH 7.4. The plant-available water-holding capacity was 18.7 cm/120 cm profile depth. Four irrigation treatments, i.e. unirrigated control and irrigation water depth (IW) : cumulative pan evaporation (CPE) ratio of 0.4, 0.6 and 0.8 were allotted in main plots. A split-plot design was used, replicated 4 times. Four levels of N, viz. 0, 50, 100 and 150 kg/ha, constituted the subplots. Nitrogen as per treatments and a uniform dose of 60 kg P_2O_5 and 40 kg K_2O/ha were applied basal at the sowing time. The seeds of 'RK 8' Ethiopian mustard were drilled by hand in lines,

Table 1. Date of irrigations given to Ethiopian mustard

Irrigation	1989–90	1990–91
Common	2 Nov. 1989	4 Nov. 1990
IW : CPE 0.4	8 Mar. 1989	10 Mar. 1991
IW : CPE 0.6	23 Jan. 1990	2 Feb. 1991
	19 Mar. 1990	23 Mar. 1991
IW : CPE 0.8	14 Jan. 1990	27 Jan. 1991
	8 Mar. 190	10 Mar. 1991
	14 Apr. 1990	30 Mar. 1991

spaced at 40 cm on 24 October 1989 and 27 October 1990. The crop was harvested on 23 and 25 April in the 2 seasons respectively. The crop was thinned at 20—22 days after sowing to maintain approximate distance of 15 cm between plants. During 1989—90, painted bug (*Bagrada hilaris*) and mustard sawfly (*Athalia lugens proxima*), seen at early stages, were controlled by dusting 10% HCH (BHC) @ 15 kg/ha. No pesticide was used against mustard aphids in both the seasons. The crop received 116.4 and 105.4 mm rainfall during 1989—90 and 1990—91 respectively. Besides 1 common post-sowing irrigation to facilitate germination, the crop received 1, 2 and 3 irrigations, each of 60 mm, at IW : CPE ratios of 0.4, 0.6 and 0.8, respectively on the dates given in Table 1.

RESULTS AND DISCUSSION

Growth and yield attributes

Plant height, total branches and siliquae/plant increased progressively and significantly with irrigation up to an IW : CPE ratio of 0.6 (Table 2). The rate of increase was higher for IW : CPE ratio of 0.4 over the unirrigated control compared with ratio of 0.6 over 0.4. This was obvious because moisture availability would influence evapotranspiration more compared to plant growth. Each successive levels of N significantly promoted all these growth characters in both the seasons up to 100 kg N/ha. The first dose of N (50 kg/ha) over the control increased plant height, total number of branches and siliquae/plant on an average by 10.5, 18.0 and 23.4% respectively. Nitrogen is known to influence plant growth but at diminishing rate.

Irrigation and N significantly interacted for most of the growth characters in both the seasons. Irrigation at IW : CPE of 0.8 and N @ 150 kg N/ha affected the most. Plant height and siliquae/plant did not improve significantly on application of 50 kg N/ha without irrigation, but up to 100 kg N/ha when irrigated. The rate of response to applied water at IW : CPE ratio of 0.4 for branches/plant at different N levels was more marked compared with other ratios, probably because of supressing effect of taller plants with more canopy formation and shading effect at higher IW : CPE ratios. However, more dry mater is partitioned into leaves on N application, which influences potential number of flowering branches in the leaf axils (Mendham and Scott, 1975) and potential pod density (Habekotte, 1993).

Maximum or near-maximum siliqua length and seed weight were obtained with 2 irrigations at IW : CPE of 0.6 (Table 3). In case of indeterminate crops like rapeseed and mustard water availability to plants influences favourably and for a longer period the growth and the developmental phases and hence larger siliquae with more grains (Jaikumaran, 1993) and once near-optimum level was reached further addition was not so effective.

Seed and harvested biomass yield

Irrigation at IW : CPE ratio of 0.8 (3 irrigations) though produced the maximum seed (18.3 q/ha) and harvested biomass

Table 2. Influence of irrigation and nitrogen on plant height, total number of branches and siliquae/plant at harvest of Ethiopian mustard

Irrigation	Nitrogen (kg/ha)									
	1989–90					1990–91				
	0	50	100	150	Mean	0	50	100	150	Mean
				Plant height (cm)						
Control	166	176	179	181	176	162	174	180	184	175
IW : CPE 0.4	173	180	186	187	182	179	191	197	201	192
IW : CPE 0.6	178	184	191	192	186	187	198	204	208	199
IW : CPE) 0.8	179	185	190	193	187	190	200	206	207	201
Mean	174	181	187	188		180	191	197	200	
	I	*N*	*I x N*	*N x I*		*I*	*N*	*I x N*	*N x I*	
CD (P = 0.05)	1.4	0.8	2.0	1.7		3.1	1.3	3.4	2.6	
				Total number of branches/plant						
Control	42.7	47.0	48.5	49.5	46.9	38.5	43.7	45.7	47.5	43.9
IW : CPE 0.4	47.5	51.0	53.	54.2	51.6	43.5	48.5	53.0	55.2	50.1
IW : CPE 0.6	50.0	53.2	56.5	58.5	54.6	46.5	50.5	54.7	56.7	52.1
IW : CPE 0.8	51.0	54.5	56.5	59.0	55.2	47.0	51.2	55.0	57.5	52.7
Mean	47.8	51.4	53.7	55.3		43.9	48.5	52.1	54.2	
	I	*N*	*I x N*	*N x I*		*I*	*N*	*I x N*	*N x I*	
CD (P = 0.05)	2.5	1.0	2.9	2.0		3.1	1.1	3.2	2.1	
				Number of siliquae/plant						
Control	280	311	314	315	305	264	294	296	297	288
IW : CPE 0.4	323	357	359	360	350	300	336	343	344	330
IW : CPE 0.6	345	384	410	412	388	320	361	379	383	361
IW : CPE 0.8	346	387	413	413	389	324	364	383	384	364
Mean	324	360	374	375		302	339	350	352	
	I	*N*	*I x N*	*N x I*		*I*	*N*	*I x N*	*N x I*	
CD (P = 0.05)	2.6	1.5	3.0	2.9		3.1	1.7	4.3	3.4	

I, Irrigation; N, nitrogen

Table 3. Influence of irrigation and nitrogen on yield attributes and oil yield of Ethiopian mustard

Treatment	Length of siliqua (cm)			Seeds/siliqua			1,000-seed weight (g)			Oil yield (q/ha)		
	1989–90	1990–91	Mean	1989–90	1990–91	Mean	1989–90	1990–91	Mean	1989–90	1990–91	Mean
Irrigation												
Control	5.35	5.06	5.20	16.75	16.88	16.82	3.34	3.39	3.36	5.18	4.94	5.06
IW : CPE 0.4	6.42	6.11	6.26	16.87	17.13	17.00	3.44	3.48	3.46	6.35	6.25	6.30
IW : CPE 0.6	6.43	6.13	6.28	17.31	17.94	17.62	3.46	3.50	3.48	7.11	7.06	7.08
IW : CPE 0.8	6.44	6.13	6.28	17.36	18.13	17.74	3.46	3.50	3.48	7.15	6.88	7.02
CD (P = 0.05)	0.02	0.04		NS	NS		0.02	0.02		0.49	0.61	
N (kg/ha)												
0	5.37	5.08	5.22	16.62	16.63	16.62	3.35	3.41	3.38	5.54	5.50	5.52
50	6.42	6.11	6.26	17.00	17.31	17.16	3.44	3.47	3.46	6.30	6.31	6.30
100	6.43	6.13	6.28	17.25	17.88	17.56	3.45	3.50	3.48	6.92	6.68	6.80
150	6.43	6.13	6.28	17.42	18.25	17.34	3.45	3.50	3.48	7.03	6.66	6.84
CD (P = 0.05)	0.01	0.02		0.26	0.60		0.01	0.01		0.26	0.23	

Table 4. Influence of irrigation and nitrogen on seed and harvested biomass yield of Ethiopian mustard

Irrigation	Seed yield (q/ha)					Harvested biomass yield (q/ha)				
	N_0	N_{50}	N_{100}	N_{150}	Mean	N_0	N_{50}	N_{100}	N_{150}	Mean
				1989–90						
Control	11.5	13.7	14.6	15.4	13.8	63.7	70.6	73.4	73.9	70.4
IW : CPE 0.4	14.2	16.8	17.9	18.5	16.8	69.4	75.9	78.2	79.1	75.7
IW : CPE 0.6	15.0	17.2	20.0	20.6	18.2	71.6	77.9	81.4	82.5	78.4
IW : CPE 0.8	15.8	17.7	20.2	21.0	18.6	72.5	79.2	82.0	83.3	78.2
Mean	14.1	16.3	18.2	18.8		69.3	75.9	78.8	79.7	
	I	*N*	*I x N*	*N x I*		*I*	*N*	*I x N*	*N x I*	
CD (P = 0.05)	1.1	0.7	1.6	1.4		1.7	0.5	2.2	1.0	
				1990–91						
Control	11.4	13.0	13.6	14.0	13.0	61.0	67.7	70.4	71.3	67.6
IW : CPE 0.4	13.7	16.3	17.7	18.1	16.5	69.2	75.7	80.2	81.0	76.5
IW : CPE 0.6	15.3	17.8	19.5	20.1	18.2	71.1	78.9	82.8	84.2	79.2
IW : CPE 0.8	15.8	18.3	19.1	19.1	18.1	72.2	80.1	83.0	84.7	80.0
Mean	14.0	16.3	17.5	17.8		68.4	75.6	79.1	80.3	
	I	*N*	*I x N*	*N x I*		*I*	*N*	*I x N*	*N x I*	
CD (P = 0.05)	1.5	0.6	1.8	1.3		1.7	0.7	2.1	1.3	
				Pooled						
Control	11.4	13.4	14.1	14.7	13.3	62.3	69.2	71.9	72.6	69.0
IW : CPE 0.4	14.0	16.5	17.8	18.3	16.6	69.3	75.8	79.2	80.1	76.1
IW : CPE 0.6	15.2	17.4	19.8	20.4	18.2	71.4	78.4	82.1	83.3	78.8
IW : CPE 0.8	15.8	18.0	19.6	20.0	18.3	72.4	79.6	82.5	84.0	79.6
Mean	14.1	16.3	17.8	18.3		68.8	75.9	78.9	80.0	
	I	*N*	*I x N*	*N x I*		*I*	*N*	*I x N*	*N x I*	
CD (P = 0.05)	1.0	0.7	2.0	1.4		4.3	1.3	4.8	2.6	

I, Irrigation; N, nitrogen

(79.6 q/ha) yields, were on par with those at 0.6 ratio (Table 4). The average increase in seed due to irrigation at 0.4, 0.6 and 0.8 ratios was respectively 24.8, 36.8 and 37.6% over unirrigated control. The corresponding increase in biomass yield was 10.3, 14.2 and 15.4%. Applied N increased biomass significantly up to 150 kg/ha, but seed yield only up to 100 kg/ha.

Irrigation and N application interacted significantly. The differences in seed and harvested biological yields were higher between unirrigated control and IW : CPE ratio of 0.4 compared with other ratios at all N levels. The rate was decreased with more water application and practically levelled-off between 0.6 and 0.8 ratios. Increase in seed yield was significant only up to 50 kg N/ha under unirrigated control and IW : CPE ratio of 0.4, but up to 100 kg/ha under IW : CPE ratio of 0.6 and 0.8. Crop responses to applied N is well known to depend on moisture supply, because it increases the availability, absorption and utilization of N by the plants which results in higher leaf area, prolonged leaf-area duration, greater photosynthesis and thereby better crop-growth rate (Gill and Narang, 1993).

Oil yield

Irrigation increased the oil yield significantly only up to IW : CPE ratio of 0.6 (Table 4). Oil yield depends on seed yield and oil content in them, the former increased significantly only up to IW : CPE ratio of 0.6 only, whereas the latter was not adversely influenced by the higher IW : CPE ratio. Significant improvement in oil yield owing to N application was recorded up to 100 kg/ha and a slight depression was noted at 150 kg N/ha, because oil content in seeds was decreased at this level compared with 100 kg/ha.

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