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Irrigation and nitrogen effects on oil yield and nitrogen uptake by Ethiopian mustard (*Brassica carinata*)

S. C. PRAMANIK, N. P. SINGH, SUBEDAR SINGH AND L. M. GARNAYAK

Water Technology Centre, Indian Agricultural Research Institute, Pusa, New Delhi 110 012

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ABSTRACT

An experiment conducted in sandy-loam soil of New Delhi during the winter season (*rabi*) 1989–90 and 1990–91 revealed that oil cotent in seed of Ethiopian mustard (*Brassica carinata* A. Braun) increased up to irrigation water (IW) : cumulative pan evaporation (CPE) ratio of 0.6, but decreased with increasing levels of applied nitrogen. It was inversely related to seed N content. Crop irrigated at an IW : CPE of 0.6 and fertilized with 100 kg N/ha gave the maximum yield (7.7 q/ha), but highest quantity of N (92.5 kg/ha) was accumulated in the plants which received 150 kg N/ha Ethiopian mustard accumulated on an average 45.5 kg N/ha in plant parts to produce 1 tonne seeds/ha, of which about 73% was harvested in seeds.

Ethiopian mustard (*Brassica carinata* A. Braun) has proved better in yield than Indian mustard and Indian rapeseed (Katiyar *et al.*, 1986). It is also suited to late sowings (Jai Kumaran, 1993). Since the influence of agronomic practices, especially irrigation and nitrogen application on oil content, oil yield as well as nitrogen utilization by plants of Ethiopian mustard have not been explored, the present study was therefore initiated to assess the influence of both irrigation and nitrogen application on these aspects.

MATERIALS AND METHODS

The field experiment was conducted at IARI Farm, New Delhi, during winter season (*rabi*) of 1989–90 and 1990–91 in a sandy-loam Ustocrept soil low in available nitrogen (151.2 kg/ha), medium in both available phosphorus (23.1 kg/ha) and potassium (111.0 kg/ha), with pH 7.4. The plant-available water-holding capacity of the soil was 18.7 cm/120 cm profile depth. Four irrigation treatments, viz. unirrigated control and differential irrigations at irrigation water (IW : cumulative pan evaporation (CPE) ratio of 0.4, 0.6 and 0.8, were allotted to the main plots in split-plot design, replicated 4 times. Four nitrogen treatments (0, 50, 100 and 150 kg/ha) constituted the subplots. Nitrogen as per the treatments and a uniform dose of 60 kg P_2O_5 and 40 kg K_2O were applied as basal dose. Seeds of strain 'RK 8' were sown in line on 24 October 1989 and 27 October 1990 and the crop was harvested on 23 and 25 April in 2 seasons respectively. Rainfall received during the corresponding growing periods was 116.4 and 105.4 mm. Besides 1 common post-sowing irrigation to facilitate germination, the crop received 1, 2 and 3 irrigations, each of 60 mm at IW : CPE ratio of 0.4, 0.6 and

Table 1. Influence of irrigation and nitrogen on seed oil content and oil yield of Ethiopian mustard

Treatment	Oil content (%) at					Oil yield (q/ha) at				
	N_0	N_{50}	N_{100}	N_{150}	Mean	N_0	N_{50}	N_{100}	N_{150}	Mean
					1989–90					
Irrigation (IW : CPE ratio)										
Control*	38.53	37.68	37.41	36.77	37.60	4.44	5.16	5.47	5.66	5.18
0.4	38.71	38.14	37.27	36.94	37.76	5.50	6.41	6.67	6.83	6.35
0.6	40.28	39.48	38.95	37.83	39.13	6.04	6.79	7.79	7.81	7.11
0.8	39.26	38.64	38.32	37.22	38.36	6.20	6.84	7.74	7.82	7.15
Mean	39.19	38.48	37.99	37.19		5.54	6.30	6.92	7.03	
	I	*N*	*I within N*	*N within I*		*I*	*N*	*I within N*	*N within I*	
CD (P = 0.05)	1.03	0.26	1.31	0.53		0.49	0.26	NS	NS	
Irrigation (IW : CPE)										
					1990–91					
Control*	38.99	38.26	37.86	37.05	38.03	4.44	4.97	5.15	5.20	4.94
0.4	38.86	38.15	38.05	37.11	38.04	5.32	6.22	6.73	6.72	6.25
0.6	39.88	39.53	38.92	37.31	38.91	6.10	7.03	7.60	7.50	7.06
0.8	38.99	38.33	37.61	37.57	38.12	6.16	7.01	7.18	7.17	6.88
Mean	39.18	38.57	38.10	37.26		5.50	6.31	6.68	6.66	
	I	*N*	*I within N*	*N within I*		*I*	*N*	*I within N*	*N within I*	
CD (P = 0.05)	0.80	0.45	1.07	0.90		0.61	0.23	NS	NS	

I, Irrigation, N, nitrogen, NS, not significant
*Unirrigated

0.8 respectively. The ground water-table remained below 4.0 m in both the seasons during crop growth.

Oil content in seed samples was determined by Pulse Nuclear Magnetic Resonance (NMR) technique at the Nuclear Research Laboratory, IARI, New Delhi and was multiplied by the respective per ha seed yields to get oil yield/ha. N content in seeds and stover was determined by modified micro-Kjeldahl method and was multiplied by respective yields to obtain the corresponding uptake values. Total N uptake was obtained by summing up the amount of N removed in seed and stover.

RESULTS AND DISCUSSION

Oil content in seeds

Two differential irrigations applied at IW : CPE ratio 0.6 significantly enchanced

Table 2. Influence of irrigation and nitrogen on nitrogen content and uptake in seed and stover of Ethiopian mustard at harvest

	Seed			Stover		
	1989–90	1990–91	Mean	1989–90	1990–91	Mean
			N content (%)			
Irrigation (IW : CPE ratio)						
Control*	3.28	3.29	3.28	0.32	0.34	0.33
0.4	3.31	3.34	3.32	0.35	0.36	0.36
0.6	3.32	3.33	3.32	0.34	0.36	0.35
0.8	3.32	3.33	3.32	0.32	0.33	0.32
CD (P = 0.05)	0.02	0.03		0.01	0.01	
N (kg/ha)						
0	3.23	3.22	3.22	0.31	0.33	0.32
50	3.29	3.31	3.30	0.33	0.34	0.34
100	3.35	3.36	3.36	0.34	0.35	0.34
150	3.37	3.39	3.38	0.36	0.37	0.36
CD (P = 0.05)	0.1	0.01		0.01	0.01	
			N uptake (kg/ha)			
Irrigation (IW : CPE ratio)						
Control*	45.42	42.84	44.13	18.43	18.34	18.38
0.4	55.82	55.02	55.42	20.72	21.92	21.32
0.6	60.58	60.56	60.57	20.69	22.06	21.38
0.8	61.95	60.21	61.08	19.83	20.69	20.31
CD (P = 0.05)	3.26	4.25		0.77	0.32	
N (kg/ha)						
0	45.66	45.34	45.50	17.11	17.87	17.49
50	53.56	54.13	53.84	19.91	20.43	20.17
100	60.87	58.74	59.80	20.84	22.01	21.42
150	63.69	60.41	62.05	21.91	22.70	22.30
CP (P = 0.05)	1.60	1.11		0.04	0.14	

*Unirrigated

the oil content in seeds compared with unirrigated control and IW : CPE ratio of 0.4 (Table 1). It was slightly decreased with more irrigations at IW : CPE ratio of 0.8, but remained on par with 0.6 ratio in both the seasons. This reflects that seeds formed late in case of indeterminate crop of Ethiopian mustard were able to develop and mature properly with adequate soil water availability under IW : CPE ratio of 0.6, but more water was of little consequence. Ganga Saran and Giri (1986) also observed increase in seed oil only up to a certain limit when water availability to plants was increased with irrigation.

Nitrogen applied to the crop in doses 50, 100 and 150 kg/ha decreased oil content in seeds linearly by 0.66, 1.44 and 1.96% respectively compared with unfertilized control. The rate of depression in oil content was 1.14–1.32%/100 kg N applied/ha. Higher N supply to plants promotes protein synthesis in oilseeds and thus creating a potential deficiency of carbohydrates to be transformed in oil and fats. (Taylor *et al.*, 1991). Irrigation and nitrogen interacted significantly. Oil in seeds was improved with irrigation at all N levels only up to IW : PCE ratio of 0.6, but rate declined as more N was added. Seeds of unfertilized crop irrigated at IW : CPE ratio of 0.6 contained the maximum oil (40.08%) and those of unirrigated crop fertilized with 150 kg N/ha contained the least amount (36.91%). This further reflects that greater proportion of carbohydrates was utilized in soil synthesis in adequately irrigated but N-deficient plants, whereas, it was reversed in favour of protein synthesis in case of N supplied but moisture stressed plants. However, at higher levels of both the inputs, plants continued their growth for longer time due to luxury consumption of nitrogen that encouraged comparatively more the total protein synthesis but depressed oil content of late-formed seeds.

Oil yield

Irrigation increased oil yield significantly only up to the IW : CPE ratio of 0.6 and it was levelled off thereafter during 1989–90, but was slightly depressed in 1990–91 (Table 1). The increase in average oil yield over the control was 24.5, 40.0 and 38.7% due to irrigation at IW : CPE ratios of 0.4, 0.6 and 0.8 respectively. It was expected because the oil yield depends on both seed yield (Table 3) and their oil content. In the present study, both of these increased significantly only up to an IW : CPE ratio of 0.6 and the latter decreased appreciably at higher IW : CPE ratio of 0.8. Oil yield was significantly increased due to N fertilization only up to 100 kg/ha and it levelled off thereafter. Oil yield followed the pattern of seed yield (Table 3) which was increased with N application up to 150 kg/ha; though 100 and 150 kg levels were at par. The depressing effect of N on oil content in seeds though decreased it to some extent, but still the differences persisted upto the 100 kg N level.

Nitrogen in seed and stover

Nitrogen content in seed was significantly improved in irrigated crop compared with unirrigated one, but irrigation treatments were on par amongst themselves (Table 2). Stover N was improved with irrigation at IW : CPE ratios of 0.4 and 0.6 which were at par, but plants contained significantly more N than those unirrigated or irrigated at an IW : CPE ratio of 0.8 in both the seasons. Increase in moisture availability improves the N absorption from soil and its use by plants and deficit effects adversely. This probably resulted in lower N concen-

Table 3. Influence of irrigation and nitrogen on seed and biomass yields (q/ha) of Ethiopian mustard

Treatment	Nitrogen (kg/ha)									
	1989–90					1990–91				
	N_0	N_{50}	N_{100}	N_{150}	Mean	N_0	N_{50}	N_{100}	N_{150}	Mean
				Seed yield (q/ha)						
Control*	11.5	13.7	14.6	15.4	13.8	11.4	13.0	13.6	14.0	13.0
IW : CPE 0.4	14.2	16.8	17.9	18.5	16.8	13.7	16.3	17.7	18.1	16.5
IW : CPE 0.6	15.0	17.2	20.0	20.6	18.2	15.3	17.8	19.5	20.1	18.2
IW : CPE 0.8	15.8	17.7	20.2	21.0	18.6	15.8	18.3	19.1	19.1	18.1
Mean	14.1	16.3	18.2	18.8		14.0	16.3	17.5	17.8	
	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		1.5	0.6	1.8	1.3	
				Biomass yield (q/ha)						
Control*	63.7	70.6	73.4	73.9	70.4	61.0	67.7	70.4	71.3	67.6
IW : CPE 0.4	69.4	75.9	78.2	79.1	75.7	69.2	75.7	80.2	81.0	76.5
IW : CPE 0.6	71.6	77.9	81.4	82.5	78.4	71.1	78.9	82.8	84.2	79.2
IW : CPE 0.8	72.5	79.2	82.0	83.3	78.2	72.2	80.1	83.0	84.7	80.0
Mean	69.3	75.9	78.8	79.7		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)	1.7	0.5	2.2	1.0		1.7	0.7	2.1	1.3	

*Unirrigated

tration in stover and seeds of the unirrigated plants. However, at an IW : CPE ratio of 0.8 availability of soil moisture encouraged excessive plant growth and thereby diluted its N contents (Rood *et al.*, 1984; Ogunlela *et al.*, 1990).

Nitrogen application invariably improved significantly and progressively its content in both seed and stover up to 150 kg/ha in both the seasons. This is obvious as N availability to crops was increased with fertilizer N application and the plants utilized them more luxuriously at higher levels. Nitrogen in seeds, in general, was about 10 times more compared with stover. This reflects that most of the N absorbed by plants was transferred to seeds from different plant parts (Zhang *et al.*, 1991).

Nitrogen uptake in seed and stover

Nitrogen removed through seed was maximum when crop received irrigation at an IW : CPE ratio of 0.8, but it was on par with IW : CPE ratio of 0.6 (Table 2). This resulted because both seed yield (Table 3) and N content in them under both these ratios were statistically similar. N uptake in stover at IW : CPE ratios of 0.4 and 0.6 were at par, but was significantly more than the unirrigated control and IW : CPE ratio of 0.8. Plant growth was very much less under moisture-stress condition (Table 3) which

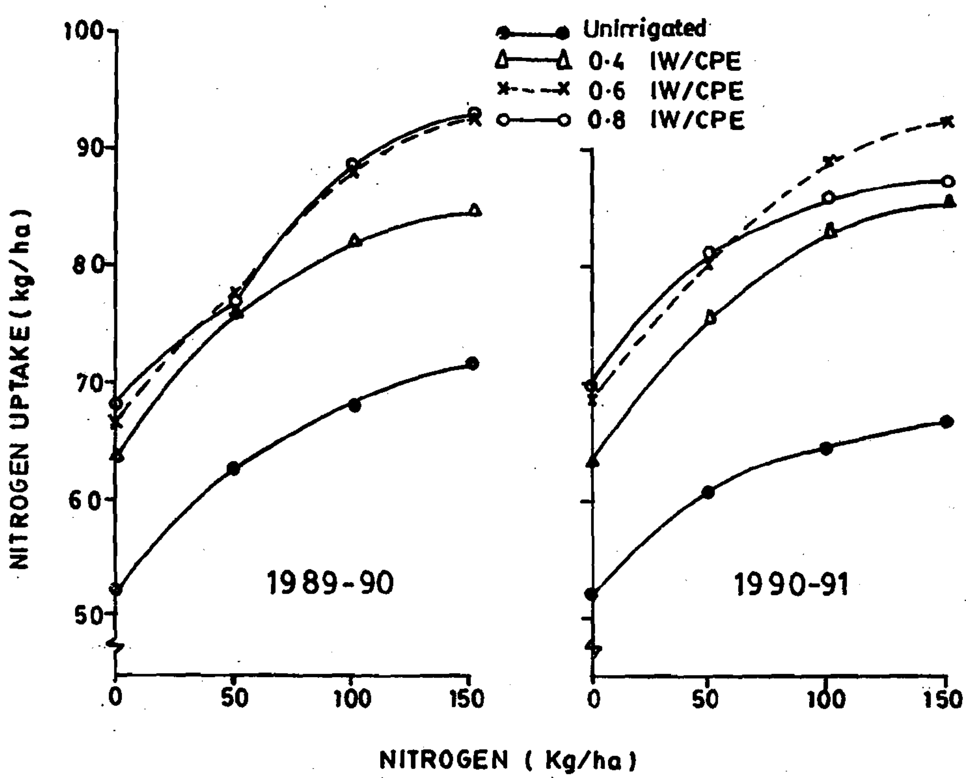

Fig. 1. Effect of irrigation and nitrogen on tatal N uptake in Ethiopian mustard at harvest

leads to low N uptake in unirrigated crop. Stover yield with IW : CPE ratio of 0.8 was equal to that with IW : CPE ratio of 0.6, but former was appreciably deficient in N content which resulted in lesser amount of N removal in stover. Uptake of N by seeds as well as stover was significantly enhanced by its application up to 150 kg/ha owing to its greater concentration in plant parts (seed and stover) and their greater production.

Irrigation and N interacted significantly during 1990–91 only. The differential N uptake in seeds and stover was more between 0 and 50 kg levels at all the irrigation regimes, which decreased as N levels were increased to 100 and 150 kg/ha. Similarly, rate of response — differences due to irrigation at respective N levels — also decreased as more water became available to plants. Irrigation at an IW : CPE ratio of 0.8 even decreased N uptake by seeds at 100 and 150 kg N/ha.

Total N harvested in plants (seeds + stover) increases significantly with irrigation only up to an IW : CPE ratio of 0.6 and thereafter either levelled off (1989–90) or even decreased slightly (1990–91). The difference was more distinct between IW : CPE ratio of 0.4 and unirrigated control (Fig. 1) compared with other irrigation treatments. However, total N uptake progressively and significantly increased up to 150 kg N/ha, which was in conformity with that values for seeds and stover. The difference in total N uptake between control and IW : CPE ratio of 0.4 further increased as more N was added. A slight decrease in total N uptake was under an IW : CPE ratio of 0.8 at 100 and 150 kg N/ha during 1990–91 following the N uptake pattern in seed and stover.

Ethiopian mustard accumulated on an average 44.7, 45.4, 45.6 and 46.1 kg N in the plant parts to produce 1.0 tonne seed/ha with 0, 50, 100 and 150 kg/ha of N application respectively. This implied that seed yield per unit of N uptake (utilization efficiency) decreased with more N application and as a consequence its concentration in seeds and stover increased.

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