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RESEARCH ARTICLE

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Studies on consumptive use, water use efficiency and moisture extraction pattern by Indian Mustard as influenced by limited irrigation and nitrogen levels

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ABSTRACT : Field experiments were conducted at Hisar during *Rabi* season of 1999-2000 and 2000-2001 to study the effect of limited irrigation and nitrogen levels on consumptive use, water use efficiency and moisture extraction pattern by Indian mustard varieties. Total consumptive use (CU) of water and water use efficiency (WUE) was higher in the variety Laxmi than RH-9304. However, Laxmi and RH-9304 showed a tendency to extract more or less same amount of moisture from different soil depths. Irrigation levels resulted in marked increase in the total consumptive use of water over no post sowing irrigation. The highest consumptive use of 168.72 and 160.56 mm was found in one irrigation applied at flowering stage during 1999-2000 and 2000-2001, respectively. The WUE decreased with the application of irrigation water over no irrigation. Irrigation levels markedly influenced the soil moisture extraction patterns. The irrigated crop extracted more moisture from upper (0-30 CM) of soil lalyens as compared to unirrigated crop. The highest CU of water was observed at 120 kg Nha^{-1}. However, higher WUE was recorded at 100 kg Nha^{-1}.

KEY WORDS : Consumptive use, Water use efficiency, Moisture extraction pattern, Indian mustard, Limited irrigation, Nitrogen levels

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INTRODUCTION

Indian mustard [*Brassica juncea* (L.)] is the second most important oil seed crop in India next to groundnut. With the limited water supply and constantly increasing cost of fertilizers, it becomes a need of present day to develop suitable irrigation and fertilizer schedule and also to achieve high crop productivity of Indian mustard. Moreover, it is universally accepted that limited irrigation water can best be utilized more efficiently by scheduling irrigation at critical growth stages of the crop. Hence, the present study was conducted to see the effect of limited irrigation and nitrogen levels on consumptive use, water use efficiency and moisture extraction pattern by Indian mustard.

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Table A : Physical constants of the soil of the experimental site

Component	Depth of soil profile (cm)				Method used
	0-30	30-60	60-90	90-120	
Field capacity (moisture per cent at 0.03 MPa)	20.02	19.6	18.2	17.3	Pressure membrane apparatus method (Richards, 1947)
Permanent Wilting point (Moisture per cent at 1.5 Mpa)	9.5	8.8	8.6	8.2	Pressure membrane apparatus method (Richards, 1947)
Bulk density (g/cc)	1.39	1.41	1.42	1.43	Core sampler method (Bodman, 1942)

EXPERIMENTAL METHODS

A field experiment was conducted during *Rabi* seasons of 1999-2000 and 2000-2001 at the Agronomy Research Farm of CCS Haryana Agricultural University, Hisar. The main plot treatments comprised two Indian mustard varieties *viz.*, V_1-RH 9304, V_2-Laxmi and three irrigation levels *viz.*, I_0 – no post sowing irrigation, I_1-one irrigation (60 mm) at flowering stage, I_2 – one irrigation (60 mm) at siliqua development stage and the sub-plot treatments comprised six nitrogen levels *viz.*, No. no nitrogen application, N_1-40 kg Nha^{-1}, N_2-60 kg Nha^{-1}, N_3-80 kg Nha^{-1}, N_4-100 kg Nha^{-1} and N_5-120 kg Nha^{-1}. The experiment was laid out in split plot design with three replications. The soil of the experimental site was sandy loam in texture with 172 and 168 kgha^{-1} available N, 16 and 14 kgha^{-1} available P and 381 and 379 kgha^{-1} available K during 1999-2000 and 2000-2001, respectively. The physical constants of the soil of the experiment (2 years mean) are given in Table A.

The crop was sown in rows 30 cm apart on 14th November and 15th November in 1999 and 2000, respectively. Post sowing irrigations were of 60 mm depth, each given as per requirement of treatments. A rainfall of 19.0 mm in 1999-2000 and 15.0 mm in 2000-2001 was received during the crop growth period. The moisture content of soil was determined from samples taken with 5 cm diameter post hole auger from different soil layers *i.e.* 0-30 cm, 30-60 cm, 60-90 cm of soil depth. Soil samples were taken at the time of sowing, before and 4 days after each irrigation and at harvest. The moisture percentage on dry weight basis was determined by keeping the samples in an oven at 105^{0}C for 24 hours to constant weight and these moisture data were used for calculating per cent moisture extracted from different soil layers, consumptive use and water use efficiency. The consumptive use of water was worked out for different treatments by summing up the soil moisture depleted from the profile for different periods. The periodical effective rainfall was also added to compute the consumptive water use of the corresponding period. Consumptive use of water was calculated using the formula as stated by Michael *et al.* (1977).

$$\text{WUE (kg ha}^{-1}\text{ mm}^{-1}) = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Total consumptive use of water (mm)}}$$

Soil moisture extraction pattern was worked out layer wise for four different layers *viz*., 0-30, 30-60, 60-90, 90-120 cm. and for the period between two successive samplings during the entire crop growth period. The moisture extracted from the different layers during the crop growing seasons was summed up layer wise and total moisture extracted from each layers was worked out. Moisture extraction for each layer was then expressed as percentage of total soil moisture extraction in each period.

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under the following heads :

Consumptive use of water :

The consumptive use of water by different varieties did not vary markedly (Table 1), though it was slightly higher in Laxmi (150.81 mm and 142.45 mm) than the variety RH-9304 (147.67 mm and 141.39 mm) in 1999-2000 and 2000-2001, respectively. Irrigation levels resulted in marked increase in the total consumptive use of water over no post sowing irrigation (I_0). Mean data of two years (Table 1) indicated that irrigation levels I_1 and I_2 led to 45.97 and 41.24 per cent higher total consumptive use of water over no post sowing irrigation (I_0) treatment, respectively. Thakral *et al.* (1997) also reported higher consumptive use under irrigated crop than unirrigated one and observed that higher availability and higher rate of evaporation to meet the vapour pressure gradient were mainly responsible for higher values under irrigated environment. Increase in nitrogen levels increased total consumptive use (Table 1). The highest consumptive use of water was observed at 120 kg Nha^{-1} (N_5) during both the years. The increase in consumptive use of water may be due to increased higher leaf area and vegetative growth by the application of nitrogen which is responsible for higher rate of transpiration and thus increased consumptive use. These findings confirm the results of Katole and Sharma (1991)

Water use efficiency :

The water use efficiency differed among mustard varieties (Table 1). Highest water use efficiency was observed in V_2 (9.97 and 10.01 kg ha^{-1} mm^{-1} as compared to V_1 (9.67 and 9.65 kg ha^{-1} mm^{-1}) in first and second years of investigation, respectively. Application of irrigation resulted in decrease in water use efficiency during both the years (Table 1). The water use efficiency was highest (11.25 and 11.25 kgha^{-1}mm^{-1}) in I_0 followed by I_1 (9.63 and 9.59 kgha^{-1}mm^{-1}) and lowest in I_2 (9.01 and 9.07 kgha^{-1}mm^{-1}) in 1999-2000 and 2000-2001, respectively. This may be because, the increase in seed yield due to irrigation could not compensate for the total consumptive use of water under irrigated conditions. Whereas plants under unirrigated conditions used water more rationally due to limited availability. The present

Table 1 : Effect of varieties, irrigation and nitrogen levels on consumptive water use and water use efficiency of Indian mustard

Treatments	Consumptive water use (mm)			Water use efficiency (kg ha-mm^{-1}) of water		
	1999-2000	2000-2001	Mean	1999-2000	2000-2001	Mean
Varieties						
V_1	147.67	141.39	144.53	9.67	9.65	9.66
V_2	150.81	142.45	144.63	9.97	10.01	9.99
Irrigation schedule						
I_0	115.26	110.32	112.79	11.25	11.25	11.25
I_1	168.72	160.56	164.64	9.63	9.59	9.61
I_2	163.74	154.88	159.31	9.01	9.07	9.04
Nitrogen levels						
N_0	128.16	123.18	125.67	8.14	8.25	8.19
N_1	137.45	131.46	134.46	9.64	9.59	9.62
N_2	147.57	138.58	143.08	9.97	10.10	10.04
N_3	155.38	147.40	151.39	10.16	10.16	10.16
N_4	159.42	153.35	156.39	10.51	10.34	10.43
N_5	167.48	157.52	162.50	10.17	10.22	10.20

Table 2 : Effect of varieties, irrigation and nitrogen levels on soil moisture extraction pattern (%) by Indian mustard

Treatments	1999-2000				2000-2001			
	0-30	30-60	60-90	90-120	0-30	30-60	60-90	90-120
Varieties								
V_1	43.92	25.72	19.63	10.73	41.28	26.85	20.54	11.33
V_2	44.46	25.76	19.65	10.13	42.15	26.87	19.62	11.36
Irrigation schedule								
I_0	36.25	29.58	21.55	12.62	34.30	28.46	22.82	14.42
I_1	45.87	27.42	16.54	10.17	43.76	26.34	17.56	12.34
I_2	40.82	28.61	19.24	11.73	38.52	27.50	20.63	13.35
Nitrogen levels								
N_0	46.24	25.61	17.87	10.28	45.17	25.72	18.85	10.26
N_1	42.29	27.42	19.69	10.60	42.15	26.79	19.87	11.19
N_2	40.46	27.64	21.25	10.65	40.17	27.98	20.88	10.97
N_3	39.12	27.81	21.79	11.28	39.50	28.16	21.18	11.16
N_4	39.00	27.90	21.11	11.99	39.18	28.48	21.22	11.12
N_5	38.56	28.68	21.28	11.48	39.00	28.76	21.24	11.00

findings are in agreement with Hossain (1999). A marked increase in the water use efficiency was noticed with the increase in nitrogen levels. However, higher water use efficiency was observed at 100 kg Nha^{-1} (N_4). This might be due to fact that the nitrogen levels increased the seed yield in higher proportion than the consumptive use of water. This findings are accordance with the results of Dongale *et al.* (1990) and Kumar *et al.* (2000).

Soil moisture extraction pattern :

Indian mustard varieties slightly varied with respect to their moisture utilization pattern from different soil depths during both the years of investigation (Table 2). V_1 (RH-9304) and V_2 (Laxmi) showed a tendency to extract more or less same amount of moisture from different soil depths probably because of their similar rooting habits. Irrigation levels markedly influenced the soil moisture extraction pattern. The irrigated crop(I_1 and I_2) extracted more moisture from upper (0-30 cm) soil layers (Table 2) as compared to unirrigated crop which might be the result of more availability of water and better ramification of roots in the upper soil layers under irrigated condition. While unirrigated condition (I_0) decreased the amount of water in upper soil layers, root penetrate more deeply in soil thereby extracted higher moisture from deeper soil layers (60-90 and 90-120 cm) were subjected to more moisture depletion under no post sowing irrigation (I_0). The present findings are in accordance with that of Thakral *et al*. (1997) and Hati *et al.* (2001). Nitrogen levels did not influence the moisture extraction pattern markedly, though crop showed a tendency to extract more moisture from deeper soil layers with increase in nitrogen levels (Table 2). This might be due to the fact that fertilizer application helped in vigorous root development and thus extracted more moisture from deeper soil layers. The corroborative findings were also reported by Vyas *et al*. (1995).

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