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EFFECT OF SOIL MOISTURE ON GROWTH ATTRIBUTES, ROOT CHARACTERS AND YIELD OF MUSTARD (*BRASSICA JUNCEA* L.)

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Abstract

Two cultivars of mustard, Sambal and Daulat were grown in soil in polythene bags under well-watered and water-stressed conditions. Soil moisture had significant effect on total dry matter production and leaf area development. In irrigated plants more assimilates were translocated to the reproductive parts. Leaf area ratio (LAR) and leaf weight ratio (LWR) were significantly higher in the well-watered plants. Relative growth rate (RGR), net assimilation rate (NAR), relative leaf growth rate (RLGR) and specific leaf area (SLA) were not affected by soil moisture. Among the root characters, only the number of primary roots was significantly higher in the well-watered plants. Seed yield and some of its components increased by irrigation. Reasons for better performance of Daulat in the water-stressed condition are discussed.

Introduction

Owing to hardy nature and capacity to thrive well under poor soil moisture, mustard is seldom irrigated and is generally raised as a rainfed crop in the Indo-Pak-Bangladesh subcontinent. There are several reports which indicate that irrigation increased production of mustard (Joarder *et al.*, 1979; Khan & Agarwal, 1985; Reddy & Sinha, 1987; Sharma & Kumar, 1989). Plant growth and development are the result of many physiological processes which are influenced by soil moisture (Mondal & Paul, 1992; Begum & Paul, 1993).

Root system is important for water and nutrient absorption in plants. The uptake of water by plants depends considerably on the extent and depth of root growth (Russell, 1957). Study of root growth in relation to soil environment has advanced less rapidly than comparable studies of shoot. The objective of this study was to evaluate the effect of soil moisture on dry matter production and partitioning, leaf area development, growth attributes, root characteristics and yield of mustard.

Material and Methods

Two cultivars of mustard (*Brassica juncea* L.) viz., Sambal and Daulat were used. The experiment was conducted in polyethylene bags of 30 cm long and 6.5 cm diameter during 1990-91. The bags were arranged in a split plot design with 3 replications. The plants were (i) Well-watered (watered daily throughout the whole growing period) and (ii) Water-stressed (watered at 3-4 days intervals when the wilting was observed). Irrigation treatments were considered as main plot and the cultivars were as subplots. Four

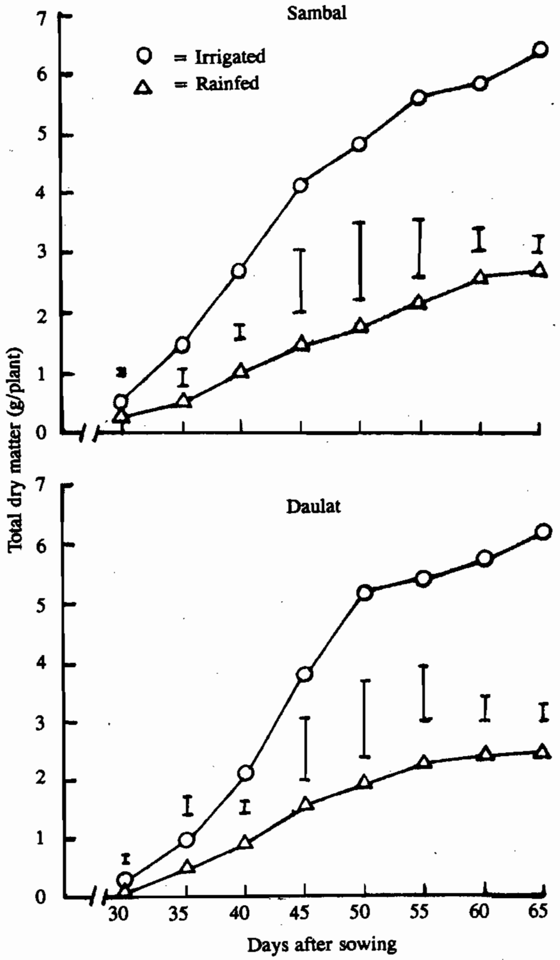

Fig.1. Effect of soil moisture on total dry matter of two mustard cultivars at different stages of growth. Vertical bars denote LSD at $P<0.05$.

seeds were sown in November, 1990 in each bag and finally one seedling was kept.

For growth analysis, 8 harvests were done with 5 days interval. Sampling began 27 days after sowing (DAS). On each sampling day, plants were separated into leaves, stem + petioles, buds + flowers and pods (if present) and dried at 85°C for 24 h. Leaf area was measured by the disc method (Islam & Paul, 1986). From the dry weight and leaf area data various growth attributes were calculated following the classical technique of growth analysis (Radford, 1967). From the dry weights of different plant parts, distribution of dry matter was demonstrated.

At the time of final harvest (94 DAS), maximum root length, number of primary roots, total root length and shoot-root ratio were taken. Total root length was measured by the modified formula of Tennant (1975). Seed yield and its components (Table 3) were measured. Data were analysed statistically.

Results and Discussion

Effect of soil moisture on total dry matter (TDM) and leaf area of two mustard cultivars at different stages of growth are shown in Figs. 1 and 2, respectively. TDM and leaf area were significantly higher in the well-watered plants than in the water-stressed plants at all the stages of growth. Similar results were reported by Khan & Agarwal (1985), Sharma & Kumar (1989), Mondal & Paul (1992) and Begum & Paul (1993) in mustard, and by Paul & Kundu (1991) in rape.

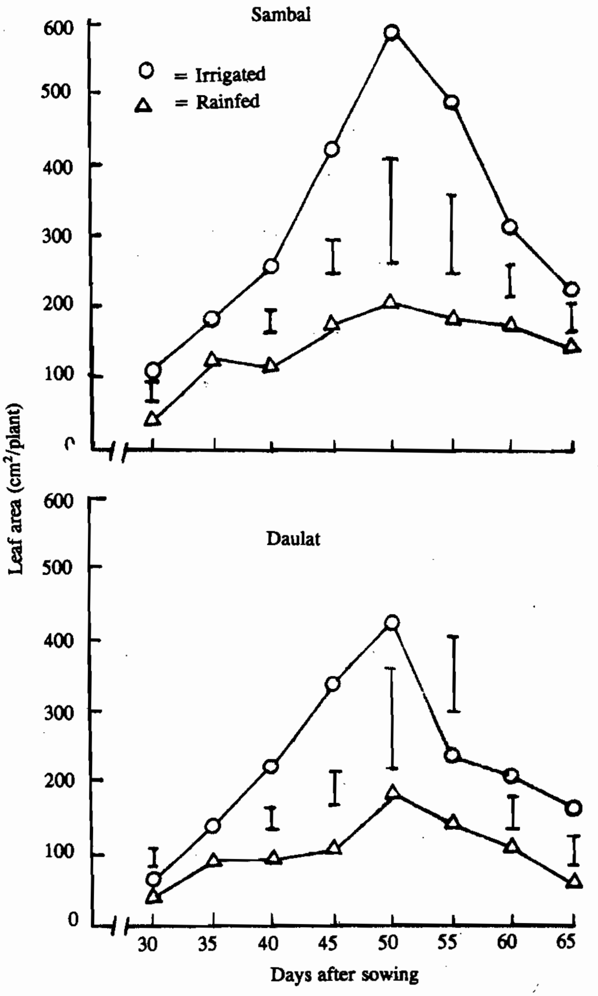

Fig.2. Effect of soil moisture stress on leaf area of two mustard cultivars at different stages of growth. Vertical bars denote LSD at $P<0.05$.

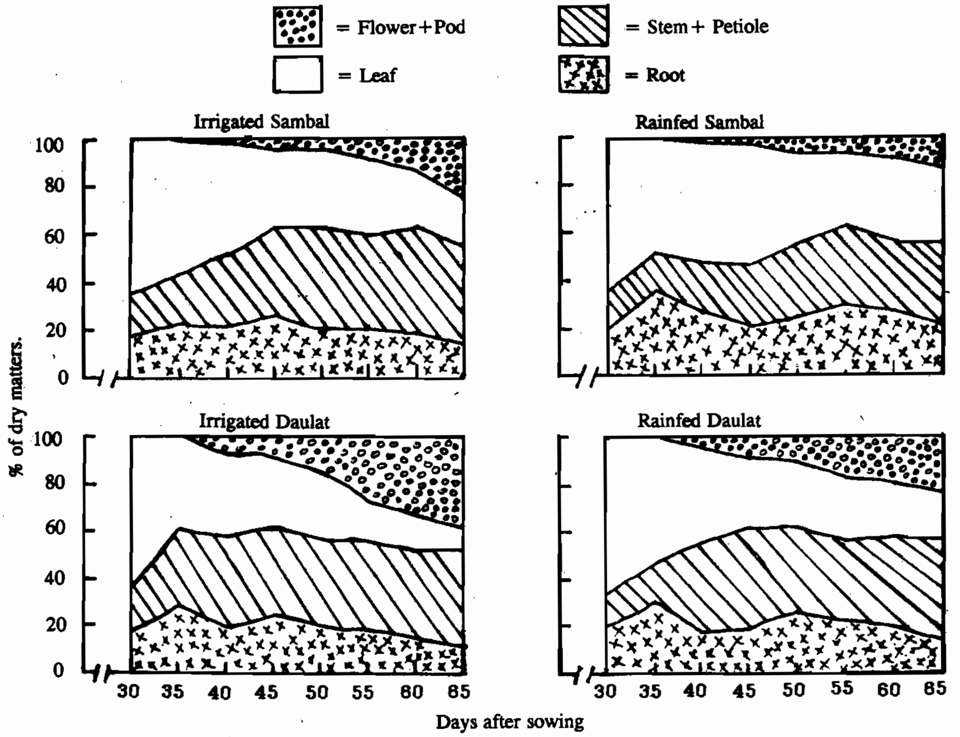

Fig.3. Effect of soil moisture stress on distribution of dry matter of two mustard cultivars at different stages of growth.

Rate of dry matter production was higher in the well-watered plants of both the cultivars and continued to increase until the last sampling date. Maximum leaf area was attained at about 50 DAS in all the treatments which declined thereafter. Decline of leaf area was more in the well-watered plants. Since yellow flowers and green pods absorbed and reflected as much as 60% of the incident radiation (Mendham *et al.*, 1981), the leaves intercepted less light and hence leaf senescence was accelerated.

Effect of soil moisture on distribution of dry matter at different stages of growth is shown in Fig.3. Distribution of dry matter was higher in flowers + pods in the well-watered plants of both the cultivars, as compared to stem + petioles found only in Sambal. Higher dry matter distribution was found in roots and leaves of the water-stressed plants of both the cultivars. These results indicate that more assimilates of the well watered plants were translocated to the reproductive parts than that of the water-stressed plants. Dry matter partitioning decreased in roots and leaves, but increased in stem + petioles and flowers and pods with increasing age. The decreased partitioning of dry matter in roots and leaves with increasing age indicated that assimilates were retranslocated from roots and leaves into the reproductive parts at the later stages of growth.

Table 1. Growth attributes of two mustard cultivars as influenced by soil moisture.

Treatment	RGR (g g^{-1} day^{-1})			NAR (g cm^{-2} day^{-1}) x 10^{-4}		
	Sambal	Daulat	Mean	Sambal	Daulat	Mean
Well-watered	0.069	0.084	0.077	6.27	8.12	7.42
Water-stressed	0.075	0.069	0.072	5.51	6.77	6.14
Mean	0.072	0.077		5.89	7.45	
LSD 5%	(a)NS,(b)NS,(c)0.0009			(a)NS,(b)0.76,(c)1.08,(d)0.77		
	LAR (cm^2 g^{-1})			RLGR (cm^2 cm^{-2} day^{-1})		
	Sambal	Daulat	Mean	Sambal	Daulat	Mean
Well-watered	102	84	093	0.019	0.023	0.021
Water-stressed	131	97	114	0.025	0.012	0.019
Mean	117	91		0.022	0.018	
LSD 5%	(a)14,(b)8,(c)11,(d)8			(a)NS,(b)NS,(c)0.011,(d)0.008		
	SLA (cm^2 g^{-1})			LWR (g g^{-1})		
	Sambal	Daulat	Mean	Sambal	Daulat	Mean
Well-watered	245	274	260	0.38	0.32	0.35
Water-stressed	277	267	272	0.42	0.37	0.40
Mean	261	271		0.40	0.35	
LSD 5%	(a)NS,(b)NS,(c)31,(d)20			(a)0.02,(b)0.01,(c)0.01,(d)0.01		

LSD (a) for difference between soil moisture means, (b) for cultivar means, (c) for within cultivar between soil moisture means and (d) for within soil moisture between cultivar means. NS = Non-significant for all tables.

LAR and LWR were significantly higher in the well-watered plants, but RGR, NAR, RLGR and SLA were not affected by soil moisture (Table 1). Sharma & Kumar (1989) reported that soil moisture significantly increased RGR, NAR, LAR and RLGR of mustard. Significant increase of pre-flowering RGR, NAR and RLGR by irrigation was reported by Mondal & Paul (1992). Paul & Kundu (1991) found that NAR increased and LAR and SLA decreased by irrigation in rape. Significantly higher LAR and LWR and lower NAR was found in Sambal than in Daulat (Table 1).

Among the root characters, only the number of primary roots was significantly higher in the well-watered plants, but root weight, maximum root length, total root length/plant and shoot-root ratio were not affected by soil moisture (Table 2). No significant effect of moisture regime on root length was found in mustard (Bajpai *et al.*, 1981). Root dry weight increased, while tap root and lateral root lengths decreased with irrigation in rape (Raja & Bishoni, 1990). The shoot-root ratio generally decreased by water stress, although the absolute weight of roots usually decreased (Kramer, 1983).

Daulat had significantly higher maximum root length and shoot-root ratio than Sambal (Table 2). Plant height, number of branches/plant, number of pods/plant, number of seeds/pod, seed-husk weight ratio and seed yield were significantly higher in the well-watered plants (Table 3). Similar results were reported by Joarder *et al.*, (1979), Reddy & Sinha (1987), Sharma & Kumar (1989) and Mondal & Paul (1992) in mustard and Paul & Kundu (1991) in rape. But Chaniara & Damor (1982) and Bhati & Rathor (1982) found no significant effect of soil moisture on plant height, number of branches/plant and 1000-seed weight in mustard. Sambal had significantly higher plant height, but signficantly lower number of branches/plant, number of seeds/pod and harvest index than Daulat.

Of the two cultivars, Daulat appears to be less drought-susceptible, as seed yield reduction of Daulat (48%) was less than Sambal (70%). This lower seed of Sambal in the water-stressed condition was due to the reduction of the number of branches (62%), number of pods/plant (66%) and harvest index (30%). Higher seed yield of Daulat in the water-stressed condition may be due to higher NAR (Table 1). In the water-stressed condition, the maximum root length of Daulat was higher than Sambal, but a reverse situation was observed for the number of primary roots and total root length (Table 2).

Table 2. Root characteristics of two mustard cultivars as affected by soil moisture (at 94 DAS).

Treatment	Root weight/plant (g)			Maximum root length (cm)		
	Sambal	Daulat	Mean	Sambal	Daulat	Mean
Well-watered	1.5	1.2	1.4	27	36	32
Water-stressed	1.2	0.8	1.0	24	31	28
Mean	1.4	1.0		26	34	
LSD 5%	(a)NS,(b)NS,(c)NS,(d)NS			(a)NS,(b)2.6(c)3.6,(d)3.7		
	Number of primary roots/plant			Total root length/plant (cm)		
	Sambal	Daulat	Mean	Sambal	Daulat	Mean
Well-watered	25	22	24	277	212	245
Water-stressed	21	16	19	225	159	192
Mean	23	19		251	136	
LSD 5%	(a)3,(b)NS,(c)NS,(d)5			(a)NS,(b)NS,(c)NS,(d)NS		
	Shoot-root ratio					
	Sambal	Daulat	Mean			
Well-watered	3,94	4.35	4.15			
Water-stressed	2.71	4.13	3.42			
Mean	3.33	4.24				
LSD 5%	(a)NS,(b)0.54,(c)0.76,(d)0.57					

Table 3. Seed yield and its components of two mustard cultivars as influenced by soil moisture.

Treatment	Plant height (cm)			Number of branches/plant		
	Sambal	Daulat	Mean	Sambal	Daulat	Mean
Well-watered	85	61	73	6.5	7.0	6.8
Water-stressed	62	37	50	2.5	4.0	3.3
Mean	74	49		4.5	5.5	
LSD 5%	(a)16,(b)15,(c)21,(d)14			(a)1.2,(b)0.6,(c)0.8,(d)0.6		
	Number of pods/plant			Number of seeds/pod		
	Sambal	Daulat	Mean	Sambal	Daulat	Mean
Well-watered	89	70	80	11.5	14.0	12.8
Water-stressed	30	54	42	11.0	12.0	11.5
Mean	60	62		11.3	13.0	
LSD 5%	(a)11,(b)NS,(c)10,(d)7			(a)0.08,(b)0.70,(c)0.98,(d)0.70		
	1000-seed weight (g)			Seed-husk weight ratio		
	Sambal	Daulat	Mean	Sambal	Daulat	Mean
Well-watered	1.97	2.16	2.07	1.24	1.19	1.22
Water-stressed	2.18	1.89	2.04	0.78	0.94	0.86
Mean	2.08	2.03		1.01	1.07	
LSD 5%	(a)NS,(b)NS,(c)NS,(d)NS			(a)0.14,(b)NS,(c)NS,(d)0.13		
	Harvest index (%)			Seed yield/plant (g)		
	Sambal	Daulat	Mean	Sambal	Daulat	Mean
Well-watered	22.32	24.90	23.61	1.70	1.55	1.63
Water-stressed	15.65	22.50	19.08	0.50	0.80	0.65
Mean	18.99	23.70		1.10	1.18	
LSD 5%	(a)NS,(b)2.89,(c)4.00,(d)2.79			(a)0.81,(b)NS,9C,(c)0.27,(d)0.05		

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