Indian Journal of Agronomy 55(1): 56–59 (March 2010)

Yield and quality of Indian mustard (*Brassica juncea*) as influenced by irrigation and nutrient levels

R.P. YADAV, M.L. TRIPATHI AND S.K. TRIVEDI[1]

Rajmata Vijayaraje Sciendia Krishi Vishwavidyalaya, Zonal Agricultural Research Station, Morena, Madhya Pradesh 476 001

Received: August 2008

ABSTRACT

Field experiments were carried out on sandy loam soil at Morena, during the winter (*rabi*) seasons of 2005-06, 2006-07 and 2007-08 to study the effect of irrigation and levels of NPK nutrients (% of recommended dose) on growth, yield, economics and quality parameters of Indian mustard [*Brassica juncea* (L.) Czernj and Cosson]. Irrigation at flower initiation and seed development stage achieved the maximum growth and yield attributes, resulting in 8.78% and 24.18% higher seed yield over one irrigation applied at flower initiation stage and siliquae development stage respectively. The application of 125% recommended dose of NPK fertilizers (RDF) induced significantly higher growth and yield characters, water use efficiency, protein and oil yield over other treatments and yielded 29.03%, 19.59% and 8.30% more seed yield over 50, 75 and 100% RDF, respectively.

Key words : *Brassica juncea*, Irrigation scheduling, Nutrient, Plant growth substances, Quality, Seeds yields

Oilseeds play vital role in Indian economy, accounting for 5% of the gross national product and 10% of the value of agricultural product. Rapeseed - mustard account for 21% (5.39 million ha) of the total oilseed area and 23% (6.20 million tonne) of the total oilseed production next to groundnut and soybean (Anonymous, 2005). However, its productivity is only 1,151 kg/ha as against the world average 1,557 kg/ha. The rapeseed – mustard yield can be increased to 2 to 2.5 t/ha by adopting the improved agronomic practices. Sowing the crop under rainfed conditions on residual moisture in marginal and sub-marginal land with limited nutrient use rank at the top for low productivity. The optimum soil moisture need to be maintained in the root zone, to meet the crop water requirements for higher yields. It can be achieved best through the improved irrigation practices. Fertilizer management has an important role to play for increasing the productivity of mustard, which can be realised by providing plant nutrients in balance amount along with suitable agronomic package to the crop. In view of the above, the present study was under taken to find out the effect of irrigation and nutrition on growth, yield, economics and quality of mustard.

Corresponding author: (E mail: sudhir_trivedi@rediffmail.com)

[1]**Correspondence address**: College of Agriculture, Gwalior, Madhya Pradesh 474 002.

MATERIALS AND METHODS

Field experiment was conducted during winter seasons of 2005-06 to 2007-08 on sandy clay loam soil at Morena, Madhya Pradesh. The soil of experimental field was low in available nitrogen (135.5 kg/ha), medium in available phosphorus (14.30 kg/ha) and potash (224 kg/ha) with pH 7.6. The experiment was laid out in split-plot design with 4 replications. Twelve treatment combinations, comprising 3 irrigation schedules *viz.,* irrigation at siliquae formation stage (60 DAS), flower initiation stage (40 DAS) and flower initiation stage + seed development stage (40 and 70 DAS) in main plots and four fertility levels *i.e.* 50, 75, 100 and 125% recommended dose of fertilizer 40:8.8:8.3, 60:13.2: 12.5, 80:17.6:16.7 and 100:22.0:20.8 N:P:K kg/ha in sub-plots. Half of the N and full dose of P and K were applied as per treatments before sowing of the crop. The remaining N was applied after first irrigation. The crop received 7 cm water during each irrigation. Mustard 'Jawahar mustard-3' was sown in 3rd week of October and harvested in last week of February. The crop was sown in rows 30 cm apart with a seed rate of 5 kg/ha. Pre-sowing irrigation was applied for land preparation and germination of seed. The water use efficiency (WUE) in kg/ha - cm was calculated by dividing the seed yield with the respective total consumptive water use for the crop period. The nutrient use (kg/kg of seed) was calculated by dividing the seed yield with total nutrient applied to the crop.

RESULTS AND DISCUSSION

Growth and yield

The growth and yield components of mustard varied significantly due to irrigation schedules (Table 1). The maximum plant height, branches/plant, dry weight/plant, pods/plant, seed weight/plant, seeds/siliqua and 1,000 seed weight were noticed with 2 irrigation applied at flower initiation and seed development stage, which was significantly superior to one irrigation applied at flower initiation stage or pod development stage. Such increase in growth and yield attributes were due to more water supplies with two irrigations providing congenial growth environment which improved the cell turgidity, opening of stomata and finally the partitioning of photosynthates efficiently to the sink (Chauhan *et al.,* 2002). There was a progressive decline in all the growth and yield attributing characters due to delayed irrigation (pod formation stage) which might have exposed the crop to relatively more water stress at flower initiation stage and reproductive phase and pulled down the yield components when compared with earlier irrigation (Mohapatra, 1993).

Growth and yield contributing characters of mustard were influenced significantly with increasing levels of fertilizer application from 50 to 125% RDF (Table 1). The maximum plant height, branches/plant, dry weight/ plant, pods/plant, seed weight/plant, seed/siliqua and 1,000 seed weight were observed under 125% RDF, which were significantly higher over other doses. Such improvement in yield components was owing to increased availability of nutrients. On other side, lowest growth and yield parameters were registered with 50% RDF. Several workers have reported the positive response of fertilizer application on different growth and yield attributes of mustard (Jain and Sharma, 2000 and Reager *et al.,* 2006).

The seed and straw yields of mustard were significantly affected due to irrigation regimes in all the 3 years (Table 2). The irrigation applied at flower initiation and seed development stage showed best performance in increasing the seed yield (2.29 tonne/ha) and straw production in all the 3 years and pooled analysis. The application of 2 irrigation induced 24.18% and 8.78% increase in seed yield and 20.13% and 12.35% in straw yield over 1 irrigation applied at pod development stage and flower initiation stage, respectively. Such a response with 2 irrigation might be ascribed to adequate supply of the moisture to the crop at growth and reproductive phase, favourably induced number of physiological process *viz.,* transpiration, photosynthates, translocation of nutrient to sink, conversion of chemical energy input and building of food material resulted in higher production when compared with 1 irrigation applied at flower initiation stage or siliquae development stage. Mahapatra (1993) and Chauhan *et al.* (2002) also obtained similar results.

Significant improvement in seed yield as well as in straw yield was observed with successive increase in level of nutrient from 50 to 125% in all the 3 years and pooled data. The mean response due to 125% RDF was 30.03, 19.59 and 8.30% in seed yield and 42.20, 24.02 and 11.40 % in straw yield over 50, 75 and 100% RDF, respectively (Table 2). The significant increase in seed and straw yields of mustard were largely a function of improved growth and the consequent increase in different yield components due to adequate supply of major plant nutrient under successive increase in nutrient doses which finally resulted in higher seed yield. Such increased trends were also reported by Jain and Sharma (2000) and Roul *et al.* (2006).

Table 1. Influence of irrigation and fertilization levels on growth and yield attributes of mustard (Pooled over 3 years)

Treatment	Plant height (cm)	Branches/ plant (No)	Dry weight/ plant (g)	Siliquae/ plant (No)	Seeds/ siliqua (No)	Seed weight/ plant (g)	1,000-seed weight (g)
Irrigation schedule							
Siliquae development stage	168.6	5.99	28.89	196.1	10.95	10.49	4.52
Flower initiation stage	179.9	7.00	34.06	254.4	12.08	12.07	4.90
Flower initiation + Seed development stage	188.5	8.36	42.26	307.1	13.49	14.09	5.05
SEm ±	3.19	0.55	2.25	17.9	0.40	0.64	0.08
CD (P=0.05)	9.60	1.64	6.81	53.7	1.23	1.90	0.26
Recommended dose of fertilizer (%)							
50	170.9	5.87	28.49	200.6	10.30	10.31	4.38
75	176.0	6.68	32.91	248.9	11.56	11.53	4.57
100	181.6	7.46	36.80	257.6	12.76	12.95	5.05
125	187.5	8.50	40.63	270.3	14.06	13.98	5.31
SEm ±	1.88	0.27	12.30	7.7	0.39	0.44	0.09
CD (P=0.05)	5.62	0.86	3.70	23.1	1.24	1.30	0.31

Economics

The net returns and benefit: cost ratio were affected by various treatments (Table 2). Highest net returns (Rs 29,320 /ha) and B:C ratio (3.46) were realized with two irrigations. Further, the maximum returns (Rs 31,275 /ha) and B:C ratio (3.25) were recorded in 125% RDF. This might be due to higher productivity in this treatment. Roul *et al*. (2006) reported highest monitory advantage from 100% RDF blended with FYM.

Quality

Irrigation and nutrient management had significant impact on quality of mustard (Table 3). Irrigation applied at siliquae development stage had significant higher oil content (40.80%). The probable reason for low oil content under irrigation applied at 40 or 40+70 DAS than 60 DAS may be adequate supply of moisture that help in the greater uptake of nitrogen which in turn, lower the oil content in seed. However, the maximum oil yield were produced with irrigation at flower initiation + seed development stage, which might be owing to higher yield. The results are in agreement with the findings of Chauhan *et al.* (2002).

Oil content decreased significantly with increasing levels of nutrient up to 125% RDF and recorded maximum (40.68%) under 50% RDF. The oil production enhanced significantly with each successive levels of applied nutrient. Oil content in seed showed the inverse relationship with levels of fertility. The oil content decrease with increasing fertility levels could be due to increasing availability of nitrogen which increase the proportion of proteinous substance in seed and hence oil content was low (Panda *et al.,* 2000 and Piri and Sharma, 2006).

Table 2. Influence of irrigation and fertilization levels on yield and economics of mustard

Treatment	Seed yield (t/ha)				Straw yield (t/ha)				Net returns (Rs/ha)	B:C ratio
	2005-06	2006-07	2007-08	Pooled	2005-06	2006-07	2007-08	Pooled		
Irrigation schedule										
Siliquae development stage	1.86	1.88	1.79	1.84	4.70	4.30	4.13	4.17	21,792	2.91
Flower initiation stage	2.21	2.02	2.06	2.10	5.37	4.72	4.70	4.91	26,490	3.32
Flower initiation + Seed development stage	2.39	2.24	2.23	2.29	5.52	5.23	5.00	5.25	29,320	3.46
SEm ±	0.07	0.04	0.02	0.04	0.26	0.14	0.16	0.18		
CD (P=0.05)	0.25	0.12	0.06	0.13	NS	0.44	0.46	0.54		
Recommended dose of fertilizer (%)										
50	1.78	1.72	1.66	1.72	4.48	4.08	3.81	4.12	20,028	2.82
75	2.03	1.91	1.90	1.95	4.92	4.56	4.29	4.59	23,675	3.07
100	2.33	2.17	2.17	2.22	5.50	4.95	4.89	5.11	28,132	3.36
125	2.42	2.41	2.38	2.42	5.89	5.42	5.46	5.59	31,275	3.52
SEm ±	0.08	0.03	0.03	0.02	0.10	0.14	0.01	0.16		
CD (P=0.05)	0.23	0.08	0.08	0.08	0.27	0.44	0.04	0.49		

Table 3. Influence of irrigation and fertilzation levels on quality, WUE, production efficiency and nutrient use of mustard

Treatment	Oil content (%)	Oil yield (kg/ha)	Water use efficiency (kg/ ha-cm)	Production efficiency (kg/ha/day)	Nutrient use (kg/kg of seed)
Irrigation schedule					
Siliquae development stage	40.80	746.3	130.1	14.92	16.48
Flower initiation stage	39.71	835.7	141.8	16.23	15.48
Flower initiation + seed development stage	40.01	916.8	104.1	17.57	19.93
SEm ±					
CD (P=0.05)	0.30	4 6.2	8.1	1.05	2.25
Recommended dose of fertility (%)					
50	40.68	707.7	106.1	13.30	24.82
75	40.38	787.6	119.6	15.03	18.57
100	39.94	888.4	130.4	17.14	16.26
125	39.48	950.4	142.9	18.60	14.20
SEm ±					
CD (P=0.05)	0.22	42.6	6.4	0.84	1.40

Efficiencies

The effect of different irrigation schedules on water use efficiency, production efficiency and nutrient use efficiency were found significant (Table 3). The maximum water use efficiency (141.8 kg/ha-cm) was achieved in 1 irrigation applied at flowering initiation stage, which was significantly higher than 1 irrigation applied at pod developed stage and 2 irrigations applied at flower initiation and seed development stage. Water use efficiency in terms of seed yield was highest at flower initiation stage as under such conditions plants would use available soil moisture most economically and therefore, increase in water use with additional irrigation would not be proportional to seed yield. The lower WUE associated with higher soil moisture status was due to proportionately more increase in evopotranspiration than the increase in yield. The higher production efficiency and nutrient use under two irrigation may be due to higher productivity. These results are in consonance with those of Panda *et al*. (2000).

The successive increase in fertilizer levels from 50% to 125% RDF significantly improved the WUE and production efficiency. Highest WUE (142.9 kg/ha-cm) and production efficiency (18.60 kg/ha/day) were seen with 125% RDF. The superiority of this treatment over rest of the treatments might be ascribed to higher seed yield coupled with more proportionate increase in seed yield due to higher availability of major nutrients to crop under 125% RDF and improved transpiration efficiency. These results are in close conformity with those of Roul *et al.* (2006). The significant reduction in nutrient use was observed with increasing levels of nutrient. The maximum nutrient use (24.82 kg/kg seed) was obtained with 50% RDF, which is inversely related.

Consequently integration of 2 irrigations at flower initiation and seed development stage with 125% RDF in mustard can be used to achieve higher yield and better resource utilization with maximum profit in irrigated conditions.

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