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Response of India Mustard (*Brassica juncea*) to Irrigation Levels and Quality of Irrigation Water

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Abstract

A field experiment was conducted to evaluate the effect of levels of irrigation viz. (one irrigation at 30 days after sowing (DAS), two irrigations at 30 and 60 DAS and three irrigations at 30, 60 and 90 DAS and the quality of irrigation water (EC_{iw}—0.4, 6.66 and 11.63 dS/m). The results revealed that the yield attributes and the seed yield of mustard increased significantly with the increase in number irrigation. Applications of three irrigations significantly increased seed yield by 15.5 and 52.8% over two and one irrigations, respectively. Irrigation with saline water (11.63 dS/m) resulted in 15% yield reduction compared to canal water (non-saline) treatment. The effect of levels and quality of irrigation water on oil content was found to be non-significant. Water use efficiency was 7.11, 6.89 and 6.31kg/ha-mm with one, two and three irrigations, respectively. The maximum salt accumulation was observed in upper soil layers (0—30 cm) when irrigated with EC_{iw} —11.63 dS/m. The mean EC (1:2) values observed with one, two and three irrigations (EC_{iw} 11.63) were 0.52, 1.18 and 1.45 dS/m, respectively. The interactive effects between levels of irrigation and quality of irrigation water were found to be non-significant.
Key words : Indian mustard, Irrigation levels, Oil content, Saline water.

India is the third largest oilseed producing country in the world. Rape seed and mustard group of crops account for 25.3% of area and 32% of the total oil seed production in the country. Indian mustard (*Brassica juncea* L. Czern and Coss) is the second most important edible oil seed crop in India and its sub-continent. The yield ranged from as low as 524 kg/ha in Assam to as high as 1,559 kg/ha in Haryana with over all yield of 1,151 kg/ha. Nearly 34% cropped area of rape seed and mustard is rainfed. The quality of irrigation water is one of the most crucial factors for future agricultural production and its sustainability. Presently agriculture is the major user (89%) of country's good quality water resources (1). Survey on ground water quality in India showed that 32—84% of presently running wells has poor quality of ground water in different states (1). Ground water constitutes the most important source of supplemental irrigation in arid and semi-arid regions in the country. In these parts of the country under ground water is saline and forms the only major source of irrigation (2). Mustard crop is grouped as relatively salt tolerant (3). Much of this rape seed-mustard is grown on soils where salinity problems already exist or may develop. Considerable research has been conducted in the past on the salt tolerance of various crops largely in pot culture with single salt and synthesized water. There is very little published information to study the combined effects of water and salt stresses which arise sometimes when crops irrigated with saline water under arid conditions are exposed to water stress between irrigations due to one or the other reasons.Keeping these points in view present investigation was undertaken to study the effect of irrigation frequency of saline water on Indian mustard in a semi-arid region of Haryana.

Methods

A field experiment was conducted on typic torripsmmant soil during *rabi* seasons of 2001-02 and 2002-03 at Regional Research Station, Balsamand (29°25´ N latitude and 75°44´E longitude, at an altitude of 215.2 m above mean sea level), Chaudhary Charan Singh Agricultural University, Hisar. The soil of the experimental field was sandy having pH 8.5, organic carbon 0.15%, EC (1:2)) 0.2 dS/m, available nitrogen 105 kg/ha, phosphous 12 kg/ha and potassium 224 kg/ha. The average value of bulk density, saturation percentage, field capacity and permanent wilting point were 1.49 Mg/m^3, 27.5, 7.3 and 1.6 % respectively. The total rainfall received during the entire crop seasons of 2001-02 and 2002-03 was 5 and 48 mm, respectively. The treatments comprising of three irrigation levels viz. one irrigation at 30 DAS, two irrigation s at 30 and 60 DAS, three irrigations at 30, 60 and 90 DAS as main plots and three qualities of irrigation water viz. canal water (0.4 dS/m), saline (6.6 dS/m) and saline (11.63 dS/m) as sub-plots were tested in a split -plot design with four replications. Plots were separated by polythene sheets to a depth of 90 cm to prevent horizontal movement of water. Mustard cv RH-30 was sown by hand plough on 20 October 2001 and 19 October 2002. The distance between rows and plant to plant within rows were kept at 30 cm and 10 cm, respectively. Recommended fertilizer applications were made in all the treatments. Nitrogen, phosphorus and potassium were applied at the rate of 80, 60 and 40 kg/ha through urea, SSP and muriate of potash, respectively. One half of N and full dose of phosphorus and potassium were applied at sowing and the remaining nitrogen was applied after first irrigation. Irrigation of 60 mm depths was schedualed based on treatments. Measured quantity of irrigation water was applied with the help of water meter. Soil samples were collected from 0—15, 15—30, 30—60 and 60—90 cm layers from each replication before sowing and after harvest of the crop. The soil samples were dried, ground to pass through a 2 mm sieve and analyzed for electrical conductivity (EC 1 : 2). Soil moisture in different layers of 90 cm profile was determined gravimetrically at sowing and after harvest. Seasonal water use was computed as the sum of irrigation water applied, profile water use (difference in the amount of soil moisture in 0—90 cm profile at sowing and at harvest) and crop season rainfall. Oil content was determined by NMR technique. The crop harvested on 9 March during both the years.

Table 1. Effect of irrigation levels and quality of irrigation water on growth and yield attributes of Indian mustard (pooled data of two years).

Treatments	Plant height (cm)	Siliquae/ plant	Seeds/ siliqua	Test weight
Irrigation Levels				
One, 30 DAS	123.9	90	9	4.85
Two, 30 and 60 DAS	139.8	118	11	5.25
Three, 30, 60 and 90 DAS	151.3	128	12	5.40
CD (*P*=0.05)	8.7	9.4	0.6	0.38
Quality of Water				
Canal water (0.4 dS/m)	142.5	122	10.8	5.43
Saline (6.6 dS/m)	139.4	113	10.6	5.50
Saline (11.63 dS/m)	133.4	102	10.4	5.57
CD (*P*=0.05)	6.0	6.2	NS	NS

Results and Discussion

Growth and Yield

Irrigation treatments exerted significant influence on the pooled values of plant height, siliquae/plant, seeds/siliqua, test weight, seed and stover yield of Indian mustard (Tables 1 and 2). Three irrigations scheduled at 30, 60 and DAS exhibited significantly taller plants than those with two irrigation scheduled at 30 and 60 DAS, and one irrigation scheduled at 30 DAS. Plants with three irrigations attained 8.2 and 22.1% more plant height than those under two and one irrigation, respectively. Numbers of siliquae per plant recorded under three irrigations (30, 60 and 90 DAS) were 8.5 and 42.2% more than obtained under two and one irrigation, respectively. Three irrigations brought about significant increase in number of seeds/siliqua. One irrigation (30 DAS) produced 18.2 and 25% less seeds/siliqua when compared with two and three irrigations, respectively. Test weight of mustard increased significantly upto two irrigations (30 and 60 DAS). These results are in consonance with earlier reports (4). The marked reduction in yield attributes viz. silique/plant and seeds/siliqua under one irrigation might be due to water stress condition that could not meet the atmospheric evaporative demand. Pooled analysis revealed that three irrigations significantly influenced the seed and stover yield of Indian mustard (Table 2). The seed and stover yield was significantly higher under three irrigations than those obtained under two and one irrigation, respectively. Two irrigations resulted in 32.3% increase in seed yield over one irrigation. It increased further by 15.5% with the application of three irrigations. This

Table 2. Effect of irrigation levels and quality of irrigations water on seed yield, stover yield, oil content and oil yield of mustard (pooled data of two years).

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)	Consumptive use (mm)	WUE (kg/ha mm)
Irrigation Levels						
One, 30 DAS	1194	2980	37.9	452	168	7.11
Two, 30 and 60 DAS	1580	4160	37.7	595	229	6.89
Three, 30, 60 and 90 DAS	1825	4750	38.0	693	289	6.31
CD (*P*=0.05)	108	243	1.8	42		
Quality of Water						
Canal water (0.4 dS/m)	1630	4296	38.0	622	224	7.28
Saline (6.6 dS/m)	1592	4269	37.8	602	228	6.98
Saline (11.63 dS/m)	1379	3334	37.6	517	235	5.87
CD (*P*=0.05)	86	212	NS	37		

might be ascribed to the improvement in the growth and yield attributes (mainly siliquae/plant and seeds/ siliqua) of Indian mustard under enhanced water supply with two and three irrigations. In the present study maximum seed and stover yields are obtained with three irrigations. This might be due to accelerated photosynthesis and translocation of photosynthates towards reproductive structures due to adequacy of soil moisture in the rhizosphere of mustard crop in sandy soils coupled with low rainfall. While working at Jobner a significant increase in seed yield of mustard with three post-sowing irrigation was reported earlier (4).

The growth of mustard measured in terms of plant height decreased significantly with saline water irrigation (EC_{iw} 11.63dS/m, Table 1). The mustard under high saline water irrigation had taller plants than those under canal water and moderate saline water irrigation (EC_{iw} 6.62 dS/m). The better growth under canal water and moderate saline water supply might be attributed to favorable growth conditions and better nutrient availability. The reduction in plant height with the use of saline water irrigation has been reported in earlier (5). However, the differences in seeds/siliqua and test weight remained statistically non-significant except for number of siliquae/plant. It may probably be due to the deleterious effects of salinity induced diminished initial growth, resulting in smaller plants which in turn able to produce lesser assimilates for their conversion to seeds. These findings are corroborated from earlier reports (5).

Comparable seed yields of mustard were obtained with canal (non-saline) and moderate salinity (6.66 dS/m) of irrigation application. Higher saline water (EC_{iw} = 11.63 dS/m) resulted in 15% reduction in seed yield of mustard as compared to that obtained with non-saline irrigation treatment. The differences in seed yield between moderate salinity and saline water (11.63 dS/m) were also significant. Stover yield also followed almost similar trend. The decline in seed yield was mainly due to significant reduction in siliquae/plant and seeds/siliqua (Table 1). The significant reductions in seed yield might have resulted from a combination of ion-toxicity, in sufficient nutrient ion availability/or imbalances and altered water relations. Suppression of the photosynthetic capacity of different plant species by salinity has been reported earlier (6). The reduction in photosynthesis by increased salinity could be due to lower stomatal conductance, depression in specific metabolic processes in carbon uptake, inhibition in photochemical capacity or a combination of these (7).

Oil Content and Oil Yield

The oil content in the mustard crop increased with the increase in irrigation levels but the effect of irrigation was not significant (Table 2). It confirmed the earlier findings (8). But three irrigations increased the oil yield significantly compared with one and two irrigations due to improvement in seed yield. The oil yield increased by 31.6 and 53.3% with two and three irrigations, respectively when compared with one irrigation. Oil content in mustard seed did not vary significantly due to saline water irrigation (Table 2) which was also documented earlier (9). However, oil yield decreased significantly at 11.63 dS/m salinity of irrigation water water because of reduction in seed yield.

Water Use

The mean seasonal consumptive use of water was markedly higher with three irrigations than those with one and two irrigations (Table 2). This might be due to the reason that under more frequent wetting cycles with three irrigations, evaporation was at its potential rate due to availability of more water (soil moisture) than the crop irrigated at wider intervals. Averaged over irrigation treatments seasonal consumptive use of water by mustard crop was recorded to be maximum (289 mm) under three irrigations and minimum (168 mm) with one irrigation.

The water-use efficiency was higher with one irrigation and decreased with the more frequent irrigation water application (Table 2). The lower water use efficiency associated with enhanced water supply might be due to a greater expense of water by evapo-transpiration and comparatively less seed yields. There was marginal variation in water use due to the application of saline water irrigations. Water use efficiency decreased with the increase in salinity of irrigation water due to the reduction in seed yield. Highest WUE of 7.28 kg/ha-mm was noticed under non-saline treatment and minimum 5.87 kg/ha-mm was recorded with saline water irrigaion of 11.63 dS/m.

Soil Salinity

Salinity build up under different irrigation treatment is shown in Figure 1. There was as increase in the build up of salinity in the soil with the application canal water (0.4 dS/m) to saline water i.e. moderate (6.0 dS/m) and higher (11.63dS/m) saline water and also from one to three irrigations. Under one irrigation, EC build up was 0.21, 0.36 and 0.52 dS/m in canal, moderate and higher saline water, respectively. Whereas under two irrigations it was 0.20. 0.62 and 1.18 dS/m in canal water, moderate and higher saline

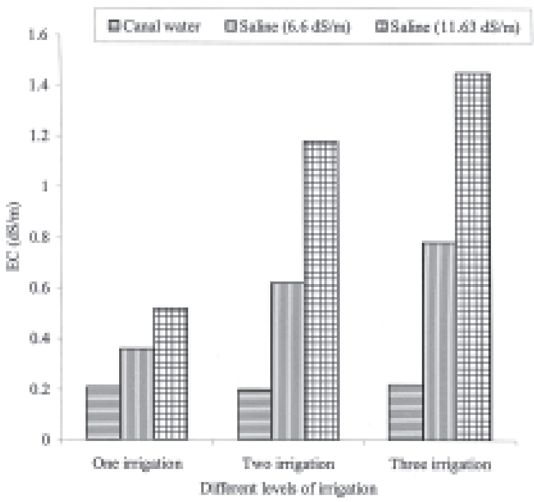

Figure 1. Effect of different saline waters and irrigation levels on salt build up in soil.

water treatment, respectively. With three irrigations EC build up was the highest i.e. 0.22, 0.78 and 1.45 dS/m under canal water, moderate and higher saline water treatment, respectively. The irrigation with saline water tended to increase the salt accumulation in the soil. This was generally more in top 0—30 cm upper layer as compared to deeper layers and decreased generally upto 90 cm soil depth. This trend was observed in all the irrigation treatments. The reason being long dry spell (about 45—50 days) before harvest of the crop might have favoured upward movement of salts. The build up of salts increased with the increasing salinity level of irrigation water and was maximum in plots irrigated with 11.63 dS/m irrigation water. These results are in agreement with earlier findings (10).

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