

Enhancing water-use efficiency of Indian mustard (*Brassica juncea*) under deficit and adequate irrigation scheduling with hydrogel

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ABSTRACT : Among the oilseeds in India, *Brassica* ranks second in production after soybean. Sowing the crop under rainfed conditions on residual moisture in marginal and sub-marginal lands with limited nutrient use, ranks at the top for low productivity. Retaining moisture in the soil through supply of some water absorbing materials like hydrogel could prove to be a better prospect in this aspect. Keeping this in view, a field experiment was conducted during the *rabi* season of 2013-14 at N. E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar to study the effect of irrigation scheduling and hydrogel levels on the growth, yield attributes, yield, WUE and economics of Indian mustard. Plant height, dry matter accumulation, yield attributes, seed yield, WUE and benefit- cost ratio were influenced significantly with irrigation and hydrogel. Growth parameters, yield attributes and seed yield were higher at 0.6 IW/CPE ratio and hydrogel @ 5 kg/ha.

Key words: IW/CPE ratio, hydrogel, yield, WUE

Rapeseed-mustard (*Brassica* spp.) is a major group of oilseed crops of the world being grown in 53 countries across the six continents with India being the third largest cultivator and producer after Canada and China (DRMR, 2014). India accounts for about 19.3% and 11.1% rapeseed-mustard area and production (2013-14) in world, respectively. Among the oilseeds in India, *Brassica* ranks second in production (2015-16) after soybean (GOI, 2017). Sowing the crop under rainfed conditions on residual moisture in marginal and sub-marginal lands with limited nutrient use, ranks at the top for low productivity. The optimum soil moisture needs to be maintained in the root zone, to meet the crop water requirements for higher yields, which can be achieved through a proper irrigation management. Irrigation influences the growth and yield attributes of Indian mustard by supplementing the water requirement of the crop. Although, during this season, water requirement of mustard is not so high but to exploit full potential of this crop we need to provide sufficient water balance at least at the time of the critical stages of the crop. Although sufficiently higher rainfalls are received in the *tarai* region of Uttarakhand, the *rabi* season often experiences moisture deficit owing to reasonably higher temperatures at the time of sowing of the crop. Retaining moisture in the soil through supply of some water absorbing materials could prove to be a better prospect in this aspect.

Hydrophilic gels called hydrogels are cross-linked materials absorbing large quantities of water without getting dissolved. The hydrogel amendments may improve seedling growth and establishment by increasing water retention capacity of soil and regulation of plants' available water supply. The application of super absorbent polymer could reserve different amounts of water for itself, and increase the soil water storage and preservation. In the event, under water deficiency, it augments the plant water needs improving its growth. Thus, in drought stress, application of super absorbent starch polymer affects the seed yield and harvest index (Moghadam *et al.*, 2009).

Under adequate irrigation conditions too, hydrogel could prove to be beneficial as the number of irrigations could be cut down accordingly in lieu of the moisture retained by the hydrogel in soil. In view of the above, the present study was undertaken for enhancing water-use efficiency of Indian mustard under deficit and adequate irrigation scheduling with hydrogel.

MATERIALS AND METHODS

A field experiment was conducted during the *rabi* season of 2013-14 at N. E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology,

Pantnagar, District Udham Singh Nagar, Uttarakhand. The soil of the experimental site was silty clay loam with pH 7.28, organic carbon 0.77%, and medium in available N, P₂O₅ and K₂O. The experiment consisting of 12 treatments, having four levels of irrigation scheduling (No irrigation, irrigation at 0.2, 0.4 and 0.6 IW/CPE ratios) in main plots and three levels of hydrogel (No hydrogel, 2.5 kg and 5.0 kg hydrogel/ha) in sub plots, were studied in split plot design with three replications. Depth of irrigation was 6 cm. Mustard crop was fertilized uniformly with 120:40:20 kg/ha of N, P₂O₅ and K₂O, respectively. Half of the nitrogen along with the full amount of phosphorous and potassium was applied at the time of sowing as basal. The remaining nitrogen was top dressed in two equal splits, at 30 and 45 days after sowing of the crop. The hydrogel was applied in the soil after opening furrows prior to sowing of the crop and was covered with soil immediately. Indian mustard variety 'Krantī' was sown on 23 October in 30 cm apart rows with a seed rate of 5 kg/ha. Irrigation was applied only once at 30 days after sowing because there was sufficient rainfall received in the crop growth period which did not let any further irrigation required after the one applied at 30 days stage. Normal package of practices were carried during the crop growth period. The evaporation rates, however, did not exceed 5.9 cm throughout the crop growth period owing to the rainfall and the low temperatures. Therefore, no further irrigations were required under the three IW/CPE ratios. The water use efficiency (WUE), in kg/ha-cm, was calculated dividing the seed yield with the respective total consumptive water use for the crop period. Data related to growth parameters, yield attributes, yield and quality recorded during the experimental year were statistically analyzed and interpreted as suggested by Gomez and Gomez (2010).

RESULTS AND DISCUSSION

Growth parameters

The plant height and dry matter accumulation both were influenced with irrigation scheduling and hydrogel application. Application of irrigation remained significantly superior over no irrigation in terms of plant height and dry matter accumulation (Table 1). The different levels of IW/CPE scheduling, however, remained statistically at par owing to high rainfall and low evaporation rates subsequently during the crop growth period. Application of hydrogel (5.0 kg/ha) increased the plant height and dry matter accumulation significantly over no hydrogel application. However, it

remained at par with that of 2.5 kg hydrogel/ha. The increase in plant height was due to water supplies with irrigation at a critical stage providing a congenial growth environment which improved the cell elongation, cell turgidity, opening of stomata, and finally the partitioning of photosynthates efficiently to the sink (Chauhan *et al.*, 2002). Shorter plant height with no irrigation might be due to water stress at its critical stage of water requirement. Application of super absorbent increases all agronomic traits of crops (Moghadam *et al.*, 2009). Accumulation of more dry matter with irrigation and hydrogel application could be attributed to the increased plant height and more number of branches per plant (Table 1) arising out of the better growth and development conditions facilitated by desirable moisture supply at its critical stage.

Yield attributes

The yield attributes, *viz.* primary and secondary branches per plant, siliquae per plant and 1000-seed weight were influenced significantly with irrigation and hydrogel application (Table 1).

Irrigation increased the number of branches per plant, siliquae per plant and 1000-seed weight significantly over no irrigation. Irrigation scheduling based on IW/CPE ratio, however, did not differ significantly owing to the reasons stated earlier. These results are in close conformity with that of Sharma (1994). Yield attributes were recorded at maximum with application of 5.0 kg hydrogel/ha, and were significantly superior over that of 2.5 kg hydrogel/ha in terms of siliquae per plant and 1000-seed weight. Irrigation and hydrogel application produced the higher yield attributes over no irrigation and no hydrogel application. This might be due to the better moisture availability that favoured the development of branches by maintaining a better moisture regime. Application of irrigation and hydrogel not only enhanced the growth and development of plants but, also ensured a higher availability of nutrients which produced more number of branches and culminated in a better sink development leading to more number of siliquae per plant. More 1000-seed weight might be due to the better availability of nutrients along with a better translocation of photosynthates from source to sink which, in turn, helped in higher accumulation of photosynthates in the seeds with the application of irrigation and hydrogel. Similar findings have been reported by Padmini *et al.* (1994) and Yadav *et al.* (2010).

Table 1: Growth parameters, yield attributes, seed yield, harvest index, water use efficiency (WUE) and economics of Indian mustard as influenced by irrigation levels and hydrogel application

Treatment	Plant height(cm)	Dry matter accumulation per plant (g)	Primary branches per plant	Secondary branches per plant	Siliquae per plant	1000 seed weight per plant	Seed yield (kg/ha)	Harvest index %	WUE (kg/ha-cm)	B: C ratio
Irrigation level										
No irrigation	178.6	37.0	6.3	9.3	187	3.20	1,278	17.1	45.3	0.44
0.2 IW/CPE	184.6	40.5	7.6	11.6	229	3.41	1,844	21.5	64.1	0.97
0.4 IW/CPE	186.0	40.7	7.7	11.7	230	3.45	1,867	21.7	64.8	1.00
0.6 IW/CPE	187.3	40.9	7.9	11.9	232	3.49	1,891	21.9	65.2	1.02
SEM±	1.4	0.4	0.2	0.1	3	0.04	62	0.4	2.0	0.06
CD (5%)	4.9	1.2	0.6	0.4	11	0.13	213	1.4	7.0	0.22
Hydrogel application (kg/ha)										
No hydrogel	180.3	38.1	6.3	9.9	195	3.23	1,539	19.8	54.6	0.96
2.5	183.7	40.1	7.5	11.3	222	3.42	1,700	20.2	59.2	0.83
5.0	188.3	41.2	8.2	12.3	241	3.51	1,921	21.6	65.8	0.79
SEM±	1.9	0.7	0.3	0.4	2	0.02	48	0.2	1.8	0.05
CD (5%)	5.7	2.0	1.0	1.1	6	0.07	144	0.6	5.4	NS

Yield studies

Seed yield was influenced significantly with irrigation and hydrogel application (Table 1). Application of irrigation increased the seed yield significantly over no irrigation. The differences among the various treatments on irrigation scheduling based on IW/CPE ratio were not recorded significant as those treatments stood out to be practically same owing to sufficient rainfall received in the crop growth period, which did not let any further irrigation be required after the one applied at 30 days stage. Application of hydrogel increased the seed yield significantly over no hydrogel, and the maximum seed yield was recorded with 5.0 kg hydrogel/ha which remained significantly superior over that of 2.5 kg hydrogel/ha. Significant improvement in seed yield might be a consequence of the increased number of siliquae per plant and the 1000-seed weight (Dobariya and Mehta, 1995). Harvest index was also influenced significantly with irrigation and hydrogel application. The highest harvest index was recorded with irrigation at 0.6 IW/CPE which remained significantly superior over no irrigation but remained at par with the other IW/CPE ratio. Application of hydrogel (5.0 kg /ha) increased the harvest index significantly over the other treatments. No significant difference was found between no hydrogel application and hydrogel at 2.5 kg /ha.

Water use efficiency

The WUE was influenced significantly by irrigation scheduling and hydrogel application (Table 1). Irrigation increased the WUE significantly over no irrigation. The irrigation scheduling based on IW/CPE did not differ

statistically as the low levels of evaporation did not leave a scope for any further irrigation as stated earlier. Application of hydrogel up to 5.0 kg increased the WUE significantly. Water-use efficiency depends on the seed yield and the consumptive use of water by the crop plants. Accordingly, the increase in water-use efficiency might be due to the greater yields with irrigation and 5.0 kg hydrogel/ha over no irrigation and no hydrogel application, respectively. Similar views have been opined by Moghadam *et al.* (2009).

Economic studies

Application of irrigation registered significantly higher benefit-cost ratio (B: C ratio) over that of no irrigation (Table 1). Highest B: C ratio was observed with irrigation scheduling at 0.6 IW/CPE, too, which remained significantly superior over no irrigation. However, there was no significant difference among the various IW/CPE levels. Application of hydrogel could not influence the benefit-cost ratio significantly.

CONCLUSION

With the results obtained during the course of investigation, it could be concluded that the irrigation scheduling based on IW/CPE ratio does not hold significance in the *tarai* region of Uttarakhand as the rains are received invariably in sufficient intensities and the evaporation rates do not exceed beyond the required limits particularly during the *rabi* season. However, irrigation at the critical stage remains a beneficial practice for getting higher seed yield of Indian mustard. Using a starch polymer like hydrogel could be helpful in

improving soil moisture and obtaining higher seed yield but, its usage shall be optimized owing to its higher costs.

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