Indian Journal of Agricultural Sciences **88** (2): 212–5, February 2018/Article

Production potential, water productivity and economic feasibility of Indian mustard (*Brassica juncea*) under deficit and adequate irrigation scheduling with hydrogel

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Received: 27 April 2017; Accepted: 27 October 2017

ABSTRACT

An experiment was conducted during *rabi* season of 2013-14 to 2015-16 at Castor-Mustard Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar in the north-Gujarat agro-climatic region. The experiment was laid out in split plot design with 5 irrigation scheduling assigned to main plots and 3 hydrogel levels were allocated in sub-plot and replicated thrice. Irrigation scheduled at 0.8 IW/CPE recorded significantly higher growth and yield attributes, viz. plant height, number of primary branches/plant, number of siliquae/plant, number of seeds/siliqua and seed yield (2539 kg/ha) of mustard (*Brassica juncea* L.). Similarly, oil yield (945.8 kg/ha), monetary returns, production efficiency (19.7 kg/ha/day) and economic efficiency (560.4 ₹/ha/day) were also recorded higher with the irrigation scheduled at 0.8 IW/CPE over rest of the treatments. Water productivity (8.66 kg/ha-mm) was the highest under irrigation scheduled at 0.6 IW/CPE as compared to remaining treatments. Among the hydrogel levels growth parameters, yield attributes, seed yield and oil yield improved with increasing level of hydrogel up to 5.0 kg/ha. The enhanced yield with 5.0 kg/ha hydrogel also resulted in higher production efficiency (15.0 kg/ha/day) and water productivity (8.46 kg/ha-mm).

Key words: Economic feasibility, Hydrogel, Indian mustard, Irrigation scheduling, Production efficiency Water productivity

Rapeseed-Mustard is the most important *rabi* oilseed crops of India and third leading source of vegetables oil in the world. In India, rapeseed and mustard are cultivated on an area about 6.70 m ha with 7.96 million tonnes production and 1188 kg/ha average productivity (Anonymous 2014). In Gujarat, rapeseed and mustard are cultivated on an area of 0.28 million ha with average productivity of 1582 kg/ha (Anonymous 2014). In India mustard is grown mainly in *rabi* season and its productivity is lower than other developed nations generally due to imbalanced fertilization with poor water management. Mustard (*Brassica juncea* L.) is an important oilseed crop grown in soil with low water holding capacity of north Gujarat under irrigated condition. Irrigation scheduling is important factor affecting the mustard yield as too much water application leads to its wastage, whereas scanty water application may lead to reduction in yield. Hence, there is an urgent need for efficient utilization of water resource through enhanced water use efficiency. As water utilization is less in industrial (15%) and domestic (5%) sectors compared to agriculture (85%), and there are no further chances to reduce quantity of water in these sectors, the focus should be on agriculture sector for water saving without compromising on crop production. Hydrogel is natural polymer based backbone. It exhibit maximum absorbency at high temperatures (40-50°C) which is characteristic of semi-arid and arid soils. Absorbs water 400 times of its dry weight and gradually releases the same and stable in soil for a minimum period of one year. Less affected by salts and also low rates of soil application 1-2 kg/ha for nursery horticultural crops and 2.5-5 kg/ha for field crops are required. Thus, the present study was carried out for standardization of irrigation scheduling with hydrogel under north Gujarat agro-climatic region.

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MATERIALS AND METHODS

A field experiment was conducted during three consecutive *rabi* seasons of 2013-14 to 2015-16 at Castor-Mustard Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (24°12' N latitude, 72°12' E longitude and at an altitude of 154.5

m above mean sea level), Gujarat, India. The soil of the experimental field was loamy sand in texture with pH 7.2, low in available nitrogen, available phosphorus, available potassium and organic carbon. The experiment was laid out in split plot design comprising five irrigation scheduling treatments, viz. no irrigation, 0.4 IW/CPE, 0.6 IW/CPE, 0.7 IW/CPE and 0.8 IW/CPE ratios assigned to main plots. Each main plot was further divided into three subplots to accommodate hydrogel levels, viz. no hydrogel, 2.5 kg/ha and 5.0 kg/ha with replicated thrice. The mustard variety GDM-4 was sown with spacing of 45 cm × 15 cm by using 3.5 kg/ha seed rate. The crop was raised with adopting standard package of practices. The recommended dose of fertilizer for mustard crop was N_{50}, P_{50}, K_0 and S_{40} kg/ha. Full dose of phosphorus, sulphur and half dose of nitrogen fertilizers were drilled just before the sowing as a basal application in the form of urea, DAP and elemental sulphur and remaining half dose of nitrogen was applied at 25-30 DAS. The thinning of experimental plot was done during 25-30 DAS. Uniformly 2 irrigations, one was given just after sowing and another one light irrigation was applied after four days of sowing to Indian mustard for proper germination and crop establishment. The remaining irrigations were applied as per schedule of treatments. Various growth parameters, yield attributes and yield were recorded at harvest. Irrigation water was measured by using a ‘parshall flume’. The quantity of water applied and the depth of irrigation were computed using standard procedure. The input water productivity was computed as the ratio of grain yield to the total water input (irrigation + rainfall) from sowing to harvesting of the crop and expressed as kg/ha-mm. The total rainfall received during rainy season and crop growth period was 1084.0 mm in 2013-14; 628.5 mm in 2014-15 and 931.2 mm in 2015-16, respectively. The cost of cultivation and net returns were calculated by taking into account the prevailing cost of inputs and local market price of produce. The standard analysis of variance (ANOVA) technique prescribed for the split plot design was performed to compare the treatment means for each year separately and was pooled. Treatment means were compared at the 5% level of significance (P=0.05) using least significant difference (LSD) and hence results based on pooled analysis are presented here to draw logical inferences.

RESULTS AND DISCUSSION

Crop growth, yield attributes and yield

Different irrigation scheduling and hydrogel levels significantly influenced crop growth and yield attributes, viz. plant height, no. of primary branches/plant, no. of siliquae/plant, number of seeds/siliqua, length of siliqua, 1000-seed weight and seed yield (Table 1). Significantly higher plant height was recorded under 0.8 IW/CPE which was significantly higher over remaining treatments. The number of primary branches/plant, number of siliquae/plant, number of seeds/siliqua and length of siliqua were significantly higher with 0.8 IW/CPE which was statistically on par with 0.7 IW/CPE and 0.6 IW/CPE, respectively. Whereas, 1000-seed weight was recorded higher with 0.6 IW/CPE and 0.4 IW/CPE treatments. The irrigation applied at 0.8 IW/CPE (2539 kg/ha) out yielded over rest of scheduling treatments and which were performed comparatively at par to 0.7 IW/CPE (Table 1 and Fig 1). The irrigation applied at 0.8 IW/CPE coincides with the water requirement of the crops throughout the growth stages without causing any water stress. This resulted in better growth of crop under 0.8 IW/CPE compared to the rest of the irrigation scheduling. This might be due to the adequate availability of moisture during growing period which increased the availability of nutrients and led to better vegetative growth

Table 1 Effect of irrigation scheduling and hydrogel on growth, yield attributes and yield of Indian mustard (Pooled data of 3 years)

Treatment	Plant height (cm)	No. of primary branches/plant	No. of siliquae/plant	No. of seeds/siliqua	Length of siliqua (cm)	1000-seed weight (g)	Seed yield (kg/ha)
Irrigation scheduling							
No irrigation	156.6	4.0	195.3	12.6	3.9	4.4	699
0.4 IW/CPE	168.2	4.4	241.0	13.8	4.2	5.1	1624
0.6 IW/CPE	176.4	4.9	297.5	14.3	4.3	5.1	2098
0.7 IW/CPE	177.8	5.0	323.3	14.6	4.4	5.0	2381
0.8 IW/CPE	186.0	5.2	346.1	14.6	4.3	4.7	2539
SEm±	2.45	0.16	8.59	0.19	0.07	0.09	57.1
CD (P=0.05)	7.15	0.45	25.06	0.55	0.21	0.26	166.8
Hydrogel (kg/ha)							
No hydrogel	170.5	4.6	270.0	13.6	4.1	4.9	1793
2.5 kg/ha hydrogel	174.3	4.9	283.8	14.2	4.3	4.8	1859
5.0 kg/ha hydrogel	174.3	4.7	288.2	14.2	4.3	4.7	1952
SEm±	1.16	0.08	3.19	0.14	0.03	0.06	23.9
CD (P=0.05)	3.28	0.23	9.04	0.40	0.09	NS	67.7

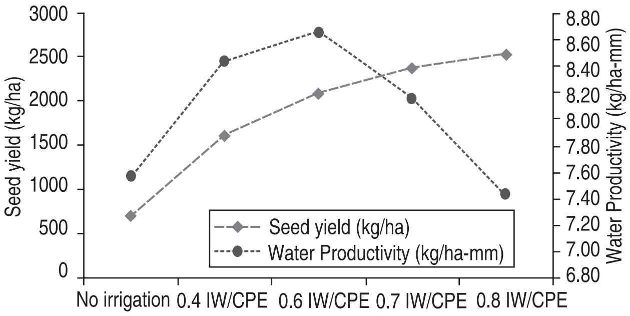

Fig 1 Effect of irrigation scheduling on seed yield and water productivity of Indian mustard (Average value of 3 years)

that ultimately produced higher yield attributing characters due to increased absorption of mineral nutrients under adequate moisture conditions. Growth characters were highest which contributed for highest yield attributes due to increased photosynthetic activity and translocation of photosynthates from source to sink. These results are in close conformity with the finding of Singh *et al.* (2014). Application of hydrogel proved significantly higher growth and yield attributes over without hydrogel. However, 1000-seed weight was not influenced significantly due to various levels of hydrogel. Production of higher number of growth and yield attributes, viz. plant height, number of primary branches/plant, number of siliquae/plant, number of seeds/siliqua and length of siliqua with application of 5.0 kg/ha as compared to without hydrogel and it resulted statistically at par with 2.5 kg/ha hydrogel. This might be due to hydrogel absorb a minimum of 400 times of their dry weight of pure water and gradually release according to crop needs and it has also improved the soil physical properties, i.e. porosity, soil permeability, infiltration rate with increasing water holding capacity of soil (Bhaskar *et al.* 2013) and efficient utilization of soil bind water (Choudhary *et al.* 2014) which help plants withstand extended moisture stress by delaying the onset of permanent wilting point and reducing irrigation requirements of crops due to reduced water loss through evaporation. All of these beneficial aspects of hydrogel proved significantly higher seed yield (1952 kg/ha) with application of 5.0 kg/ha over rest of treatments (Table 1 and Fig 2). The corresponding increases of seed yield of mustard due to application of 5.0 kg/ha hydrogel to the tune of 5.00% and 8.86% as compared to 2.5 kg/ha and without hydrogel, respectively. These results are supported by Kalhapure *et al.* (2016).

Oil content and oil yield

Irrigation scheduling had resulted significant variation on oil content and oil yield of mustard (Table 2). Irrigation applied to mustard at 0.7 IW/CPE recorded significantly higher oil content (38.6%) and it was statistically at par with 0.6 IW/CPE. However, oil yield was recorded significantly higher with 0.8 IW/CPE which was comparatively at par with

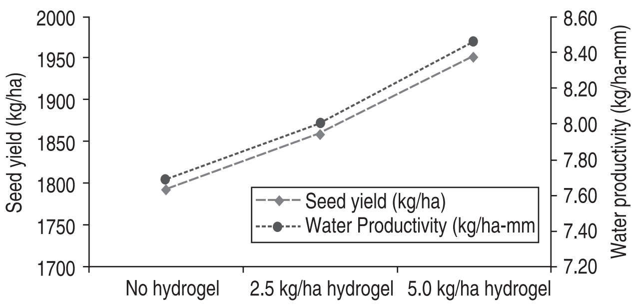

Fig 2 Effect of hydrogel on seed yield and water productivity of Indian mustard (Average value of 3 years)

Table 2 Effect of irrigation scheduling and hydrogel on oil content, oil yield, economics, production and economic efficiency of Indian mustard (Pooled data of 3 years)

Treatment	Oil content (%)	Oil yield (kg/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio	Production efficiency (kg/ha/day)	Economic efficiency (₹/ha/day)
Irrigation scheduling								
No irrigation	36.7	261.9	23591	27454	3863	1.18	5.4	30.2
0.4 IW/CPE	37.0	606.1	25091	63728	38637	2.58	12.3	290.4
0.6 IW/CPE	38.1	805.0	25841	82334	56493	3.24	16.2	435.5
0.7 IW/CPE	38.6	918.0	26591	93461	66870	3.58	18.4	516.8
0.8 IW/CPE	37.4	945.8	27341	99658	72318	3.69	19.7	560.4
SEm±	0.36	21.68		2242.7	2242.68	0.09	0.44	17.30
CD (P=0.05)	1.06	63.28		6545.9	6545.92	0.25	1.29	50.49
Hydrogel (kg/ha)								
No hydrogel	37.5	675.9	21191	70384	49193	3.26	13.9	379.6
2.5 kg/ha hydrogel	37.7	707.7	25691	72962	47271	2.80	14.3	363.5
5.0 kg/ha hydrogel	37.6	738.4	30191	76635	46444	2.51	15.0	356.9
SEm±	0.17	10.25		939.42	939.42	0.04	0.19	7.58
CD (P=0.05)	NS	29.01		2657.5	NS	0.10	0.55	NS

0.7 IW/CPE. Application of hydrogel recorded increasing oil content and oil yield but it was does not reach at level of significance in respect to oil content. Significantly higher oil yield was observed with the application of 5.0 kg/ha hydrogel followed by 2.5 kg/ha this might be due to production of higher seed yield with increasing level of hydrogel. These results are in agreement with the finding of Kalhapure *et al.* (2016).

Economics

Highest gross returns, net returns and benefit: cost ratio were recorded with 0.8 IW/CPE. Pooled analysis revealed that irrigation applied at 0.8 IW/CPE earned maximum net profit of ₹ 72318/ha, which was found 8.15, 28.01 and 87.17% higher than the net returns values of irrigation scheduled at 0.7, 0.6 and 0.4 IW/CPE. Irrigation scheduled at 0.8 IW/CPE showed mark improvement in seed yields and thus gaining more profit in terms of net returns and benefit: cost ratio over rest of scheduling treatments. Application of 5.0 kg/ha hydrogel showed significantly higher gross returns over rest of the treatments. It gave ₹ 3673/ha and ₹ 6251/ha higher gross returns over the 2.5 kg/ha hydrogel and without hydrogel. Net returns were not increases significantly due to various treatments of hydrogel. While, higher benefit: cost ratio was noted higher under without hydrogel probably owing to more cost of hydrogel which increased the cost of cultivation resulted less net returns and benefit: cost ratio.

Production and economic efficiency

Production and economic efficiency were significantly higher in 0.8 IW/CPE as compared to rest of treatments but comparatively on par with 0.7 IW/CPE (Table 2). Application of 5.0 kg/ha hydrogel resulted significantly higher production efficiency which was 4.89 and 7.91% more over 2.5 kg/ha hydrogel and without hydrogel, respectively.

Water productivity

Among the irrigation scheduling treatments, 0.6 IW/CPE recorded significantly higher water productivity (8.66 kg/ha-mm) which was statistically at par with 0.4 and 0.7 IW/CPE ratio (Fig 1). Water productivity concomitantly increased with increasing hydrogel levels up to 5.0 kg/ha (8.46 kg/ha-mm) on three years pooled data basis, respectively (Fig 2).

This might be due to its large water absorption capacity and gradually release it according to crop needs. Hydrogel help plants to reducing irrigation requirements of crops due to reduced water loss through evaporation. The water held in root zone of crop and leaching of nutrients in the soil also reduced, all of which improve in yield and water use efficiency of crop. Similar results were reported by Kalhapure *et al.* (2016).

Thus, on the basis of three years pooled results it can be concluded that irrigation was applied at 0.8 IW/CPE to Indian mustard variety GDM-4 for obtaining higher yield and economic returns. Application of hydrogel proved advantageous to obtain higher yield of Indian mustard under north Gujarat agro-climatic region.

REFERENCES

Anonymous. 2014. Agricultural statistics at a glance, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India.

Bhaskar N, Aggarwal P, Kumar S and Meena M D. 2013. Significance of hydrogel and its application in agriculture. *Indian Farming* **62**(10): 15–7.

Choudhary S K, Jat A L, Upadhyay P K and Singh R K. 2014. Hydrogel: The potentialities to produce more crops per drop in agriculture. *Popular Kheti* **2**(4): 154–8.

Kalhapure A, Kumar R, Singh V P and Pandey D S. 2016. Hydrogels: a boon for increasing agricultural productivity in water-stressed environment. *Current science* **111**(11): 1773–9.

Rushima L, Brar A S, Deol J S and Singh G. 2014. Seed yield, oil yield and water use of Indian mustard (*Brassica juncea* L.) cultivars as influenced by sowing time and irrigation schedules. *Crop Research* **47**(1, 2 & 3): 46–9.

Singh A K, Singh R R, Singh A K and Singh, P K. 2014. Influence of date of sowing and irrigation scheduling on growth and yield of mustard. *International Journal of Farm Sciences* **4**(2): 80–5.