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Research Paper

Effect of irrigation schedules and hydrogel levels on yield and economics of blond psyllium (*Plantago ovata*)

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2018–19 and 2019–20 at Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan to study the effect of hydrogel levels under different irrigation schedules on blond psyllium (*Plantago ovata* Forssk.). The field experiment was conducted in a split-plot design, comprising of 4 irrigation schedule, viz. irrigation water (IW) : cumulative pan evaporation (CPE) ratio 0.20, 0.30, 0.40 and 0.50 in main plots and 4 hydrogel levels, viz. control, 2.5, 5.0 and 7.5 kg/ha in subplots, combinedly having 16 treatment combinations, which were replicated 4 times. The results revealed that an application of irrigation at IW : CPE ratio of 0.50 had significant effect on yield attributes, viz. spike length (3.67 cm), seeds/spike (76.05), test weight (1.744 gm) and yield seed (0.767 t/ha), straw (2.609 t/ha) and biological yield (3.376 t/ha) which was at par with IW : CPE ratio 0.40 and both these ratios significantly improved the yield over IW : CPE ratio of 0.30 and 0.20 during both years. Both IW : CPE ratio 0.40 and 0.50 fetched highest net returns of ₹38,658 and 39,118/ha, with benefit: cost ratio 1.05 and 1.04 respectively. Application of 7.5 kg/ha hydrogel resulted in the highest spike length (3.66 cm), seeds/spike (74.83), test weight (1.766 gm), seed (0.767 t/ha), straw (2.555 t/ha) and biological yield (3.322 t/ha) and was at par with application of 5.0 kg/ha hydrogel and both these levels significantly enhanced blond psyllium crop yield over application of 2.5 kg/ha hydrogel and the control during both the years. Application of hydrogel at 5.0 kg/ha significantly enhanced net returns (₹39,281/ha) and benefit: cost ratio (1.06) as compared to application of 2.5 kg/ha hydrogel and the control; however, further increase in hydrogel level to 7.5 kg/ha caused significant reduction net returns (₹37,726/ha) and benefit: cost ratio (0.96) as compared to application of 5.0 kg/ha hydrogel during both years and pooled analysis.

Key words: Blond psyllium, Economics, Hydrogel, Irrigation schedule, Yield

Blond psyllium or *isabgol* (*Plantago ovata* Forssk.) or isabgol is a winter season medicinal crop. It is cultivated in about 0.336 million ha area in Rajasthan, with a production of 0.193 million tonnes at an average productivity status of 576 kg/ha (DoH, 2018–19). Its cultivation is mainly centralized in northern Gujarat and districts of South-west of Rajasthan namely Jalore, Barmer, Pali, Jaisalmer, Jhalawar and Sirohi. The seed husk is the commercial part and is separated by physical process. It contains colloidal mucilage (30%), mainly consisting xylose, arabinose, galacturonic acid with rhamnose, galactose etc. The husk has the property of absorbing and retaining water. The husk (epicarp) is used against constipation, irritation of digestive tract etc. In addition, these are also used in food industries for preparation of ice-cream, candy etc. (Killedar *et al.,* 2016). Irrigation water is a costly and scarce resource and availability of water to agriculture is expected to reduce. Blond psyllium (*Plantago ovata* Forssk) can tolerate moderate levels of water stress. Soil-moisture stress reduces the rate of photosynthesis and also the rate of translocation of nutrients, which ultimately influences the growth and yield of the crop. Thus, scheduling of irrigation on the basis of irrigation water (IW) : cumulative pan evaporation (CPE) ratio helps determine the time of irrigation.

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The application of agro-chemicals is known to play an important role in plant response to stresses. Pusa Hydrogel was developed by the Indian Agricultural Research Institute (IARI), New Delhi (Shikha *et al.,* 2019). Hydrogel are macromolecular cross-linked hydrophilic polymeric chains with the ability to absorb water or aqueous fluids. The main function of this is it can absorb a minimum of 400 times of its dry weight of pure water and gradually release it according to the needs of the crop plant. It acts like a sponge and absorbs water which is released slowly to the crops to get a sustained supply of moisture (Shikha *et al.,* 2019). Keeping in view the above facts, an investigation was carried out to study the response of blond psyllium to hydrogel levels under different irrigation schedules.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) seasons of 2018–19 and 2019–20 at the Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, (24° 35' N, 73° 42' E, 581.35 m above mean sea-level). The region falls under NARP agro-climatic zone IVa (Sub-Humid Southern Plains and Arawali Hills) of Rajasthan. The soils was clay loam in texture, slightly alkaline in reaction, low in available nitrogen (270.60 to 271.30 kg/ha), medium in available phosphorus (18.07 to 18.90 kg/ha) and high in available potassium status (312.70 to 315.40 kg/ha). The experiment was laid out in a split-plot design, with 16 treatment combinations, consisting of 4 irrigation schedules, viz. irrigation water IW : CPE ratio 0.20, 0.30, 0.40 and 0.50, in main plots and 4 hydrogel levels, viz. 0.0, 2.5, 5.0 and 7.5 kg/ha in sub-plots and replicated 4 times. The treatments were allotted randomly in each replication. The plot size was 5.0 m × 3.0 m. The seeds of blond psyllium @ 6.0 kg/ha were sown in furrow manually by dropping the seed in the furrow row-to-row distance of 30 cm. Urea, signal super phosphate and muriate of potash at 15, 22 and 19 g/furrow, respectively, were applied in the already opened furrows before sowing. Half dose of nitrogen and full dose of phosphorus and potash were applied at the time of sowing; remaining nitrogen was top-dressed after the first irrigation. Irrigation was applied as per treatment based on cumulative pan evaporation (CPE) values. The water was conveyed through open field cannel and measured by Parshall flume. The depth of each irrigation was kept 60 mm. The CPE was taken as a sum of daily evaporation from USWB class A pan evaporimeter minus the rainfall since the previous irrigation. A common irrigation of 60 mm was applied uniformly in all the treatment just after sowing for germination of seed. Irrigation channels were presoaked 24 hours before irrigation to avoid seepage losses at the time of irrigation. The whole quantity of hydrogel as per treatment was applied manually in furrows and incorporated into soil at the time of sowing. Other crop-management practices were followed as per recommendation of area. The crop was harvested from net plot at physiological maturity stage.

RESULTS AND DISCUSSION

Effect of irrigation schedules on yield and economics

Irrigation water : cumulative pan evaporation ratio: Scheduling of irrigation through IW : CPE ratio brought about significant variation in spike length, seeds/spike, test weight, seed, straw and biological yields (Table 1). The blond psyllium crop irrigated at IW : CPE ratio of 0.50 recorded highest spike length (3.67 cm), seeds/spike (76.05), test weight (1.744), seed (0.767 t/ha), straw (2.609 t/ha) biological yield (3.376 t/ha) which was found at par with IW:CPE ratio of 0.40 and both these irrigation level significantly increased spike length, seeds/spike, test weight, seed, straw and biological yields over irrigation at IW : CPE ratios of 0.30 and 0.20. The crop irrigated at an IW : CPE ratio of 0.40 gave significantly higher seed, straw and biological yields being 7.60, 15.73 and 6.25, 12.88 and 6.52, 13.52% over IW : CPE ratio 0.30 and 0.20 respectively, while corresponding increase in seed, straw, biological yields due to application of irrigation at IW : CPE ratio of 0.50 was 9.64, 17.60 and 7.43, 13.99 and 7.90, 14.81%. Irrigation scheduling through IW : CPE ratio did not significantly influence the harvest index during both the years as well as on pooled basis. Successive increase in irrigation regime up to IW : CPE ratio of 0.40 significantly increased the net returns as compared to irrigation at IW : CPE ratio of 0.30 and 0.20: however, further increase in IW : CPE ratio from 0.40 to 0.50 though fetched the highest net returns failed to record statistical significance during both the years as well as in pooled analysis. The crop irrigated at IW : CPE ratio of 0.40 and 0.50 fetched the highest net returns of ₹38,658 and 39,118/ha with benefit : cost ratio 1.05 and 1.04 (Table 2), respectively. It is an established fact that, photosynthesis together with availability of assimilates (source) and storage organ (sink) exerts an important regulative function on the complex process of yield formulation (Michael and Beringer, 1980). These processes are not only dependent on nutritional environment, photosynthetic capabilities of the plant but hormonal pattern also plays an important role in the synthesis of yield formation (Michael and Beringer, 1980). Thus, greater supply of moisture under higher irrigation level might have helped in maintaining higher activity of root-system for optimal supply of nutrients/water to the developing reproductive structures of the plant. Besides this, better root activity particularly up to seed filling stage is considered to be important for production of cytokinins and their transport to seed.

Table 1. Effect of irrigation scheduling and hydrogel levels on yield attributes and economics of blond psyllium or *isabgol* (Data pooled over 2 years)

Treatment	Spike length (cm)	Seeds/ spike	Test weight/gm	Yield (t/ha)			Harvest index	Net return (₹/ha)	Benefit: cost ratio
				Seed	Straw	Biological			
IW : CPE ratio									
0.20 (I_1)	3.26	70.28	1.669	0.632	2.244	2.876	22.03	29,324	0.86
0.30 (I_2)	3.47	72.00	1.707	0.693	2.415	3.109	22.25	34,181	0.96
0.40 (I_3)	3.66	75.26	1.760	0.750	2.576	3.326	22.50	38,658	1.05
0.50 (I_4)	3.67	76.05	1.744	0.767	2.609	3.376	22.68	39,118	1.04
SEm±	0.03	0.27	0.006	0.08	0.23	0.25	0.36	762	0.02
CD (P=0.05)	0.10	0.80	0.019	0.25	0.69	0.74	NS	2,265	0.06
Hydrogel levels (q/ha)									
Control (H_0)	3.31	70.90	1.667	0.626	2.310	2.936	21.37	30,238	0.92
2.5 (H_1)	3.46	73.11	1.720	0.686	2.435	3.121	22.00	34,035	0.97
5.0 (H_2)	3.63	74.75	1.758	0.763	2.545	3.308	23.04	39,281	1.06
7.5 (H_3)	3.66	74.83	1.766	0.767	2.555	3.322	23.06	37,726	0.96
SEm±	0.02	0.15	0.004	0.04	0.14	0.16	0.29	351	0.01
CD (P=0.05)	0.05	0.41	0.011	0.11	0.41	0.45	NS	986	0.03

IW: CPE, Irrigation water: cumulative pan evaporation

Thus, improvement in source-sink relationship under the influence of irrigation regime IW : CPE ratio of 0.40 seems to have resulted in production of higher seed yield. Further crop behaviour under the higher level of irrigation frequency, i.e. IW : CPE ratio 0.50 indicates inefficient inherent capabilities of the blond psyllium plants to maintain optimum balance between source-sink relationship towards formation of higher yield. Though the crop under aforesaid irrigation regime showed improvement in various growth and yield component but these increases were not to the extent to reach significant level. The observed crop behaviour under higher irrigation levels is in conformity with finding of Bhunia *et al.,* (2005), Bhunia *et al.,* (2006), Chouhan *et al.,* (2006), Sumathi *et al.,* (2007), Kunapara (2013) and Harisha *et al.,* (2017), who reported that blond psyllium crop under irrigation IW : CPE ratio of 0.40 recorded significantly higher spike length, seeds/spike, seed, straw, biological yields and test weight but further increase in irrigation level to IW : CPE ratio of 0.50 failed to record statistical significance.

Effect of hydrogel levels on yield and economics

Increasing levels of hydrogel application up to 5.0 kg/ha significantly enhanced spike length (3.63 cm), seeds/spike (74.75), test weight (1.758 gm), seed (0.763 t/ha), straw (2.545 t/ha) and biological yield (3.308 t/ha) over applica-

Table 2. Treatment-wise cost of cultivation, yield and economic return (pooled data)

Treatment combination	Yield (q/ha)		Gross return (₹/ha)	Net returns (₹/ha)	Cost of cultivation (₹/ha)	Benefit: cost ratio
	Seed	Straw				
I_1H_0	5.68	21.74	57,538	26,270	31,268	0.84
I_1H_1	6.31	22.33	63,477	30,209	33,268	0.91
I_1H_2	6.67	22.94	66,885	31,617	35,268	0.90
I_1H_3	6.63	22.76	66,467	29,199	37,268	0.78
I_2H_0	6.23	23.06	62,927	30,509	32,418	0.94
I_2H_1	6.72	23.77	67,596	33,178	34,418	0.96
I_2H_2	7.27	24.92	72,926	36,508	36,418	1.00
I_2H_3	7.50	24.86	74,947	36,529	38,418	0.95
I_3H_0	6.32	23.08	63,774	30,206	33,568	0.90
I_3H_1	7.10	25.52	71,516	35,948	35,568	1.01
I_3H_2	8.39	27.28	83,731	46,163	37,568	1.23
I_3H_3	8.19	27.16	81,882	42,314	39,568	1.07
I_4H_0	6.82	24.51	68,685	33,967	34,718	0.98
I_4H_1	7.32	25.76	73,521	36,803	36,718	1.00
I_4H_2	8.17	26.67	81,556	42,838	38,718	1.11
I_4H_3	8.37	27.43	83,581	42,863	40,718	1.05

Details of I_1, I_2, I_3, I_4, H_0, H_1, H_2 and H_3 are given in Table 1 tion of 2.5 kg hydrogel/ha and control (Table 1). Further increase in hydrogel level from 5.0 to 7.5 kg/ha though increased the spike length, seeds/spike, test weight, seed, straw and biological yields but failed to attain statistical significance. Application of 5.0 kg hydrogel/ha significantly increased seed, straw and biological yield by 10.09, 17.95 and 4.32, 9.23 and 5.65, 11.24% over application of 2.5 kg hydrogel/ha, respectively. Irrespective of years as well as pooled basis, hydrogel levels failed to record significant variation on harvest index. Application of hydrogel at 5.0 kg/ha significantly enhanced the net returns (₹39,281/ha) and benefit : cost ratio (1.06) as compared to application of 2.5 kg hydrogel/ha, however, further increase in hydrogel level to 7.5 kg/ha significantly reduced net returns (₹37,726/ha) and benefit : cost ratio (0.96) as compared to application of 5.0 kg hydrogel/ha during both years and pooled analysis (Table 1). In fact, hydrogel improves cell membrane development by balancing nutrient substances and higher CO_2 fixation through prolonged stomata opening ascribed to the increase in yield attributes. Further hydrogel provides reservoir of soil water in the root zone by preventing leaching and deep percolation layers (Sow *et al.,* 1997). Greater accumulation of biomass at each stage subscribe to the view that the plant under the influence of hydrogel maintained adequate supply of metabolites/ nutrients matching demand of reproductive structure for their growth. Thus, greater assimilating surface at reproductive development and improvement in nutritional conditions of seed under higher level of hydrogel seems to have provided congenial environment for seed growth because of adequate supply of metabolites and nutrients (Tyagi *et al.,* 2015). Hence, marked increase in seed, straw yield with hydrogel application seems to be owing to exploitation of crop genetic potential for vegetative and reproductive growth up to the highest level. The results of the present investigation indicated positive response of *isabgol* crop to hydrogel application confirming the findings of Patil *et al.,* (2014), Patro and Ray (2016), Burondkar *et al.,* (2018), Tripathi (2020) and Rathore *et al.,* (2020).

It is concluded that under prevailing agro-climatic condition of South Rajasthan, blond psyllium (*Isabgol*) crop should be irrigated at an IW : CPE ratio of 0.40 along with application of 5.0 kg/ha hydrogel as this practice resulted in 839 kg/ha seed yield with net returns of ₹46,163/ha and B : C ratio of 1.23.

REFERENCES

Bhunia, S.R., Chauhan, R.P.S. and Yadav, B.S. 2005. Effect of nitrogen and irrigation on water use, moisture extraction pattern, nutrient uptake and yield of fennel (*Foeniculum vulgare*). *Indian Journal of Agronomy* **50**(1): 73–76.

Bhunia, S.R., Chauhan, R.P.S., Yadav, B.S. and Bhati, A.S. 2006. Effect of phosphorus, irrigation and *Rhizobium* on productivity, water and nutrient uptake in fenugreek (*Trigonella foenum-graecum*). *Indian Journal of Agronomy* **51**(3): 239–241.

Burondkar, S.S., Sharma, R., Singh, A.S. and Akshay, S.M. 2018. Efficacy of pusa hydrogel and chitosan on wheat (*Triticum aestivum* L.) growth and yield under water deficit condition. *Journal of Pharmacognosy and Phytochemistry* **7**(5): 501–505.

Chouhan, G.S., Joshi, A. and Padiwal, N.K. 2006. Response of blond psyllium (*Plantago ovata* Forsk.) to irrigation and nitrogen fertilization. *International Journal of Agricultural Science* **2**(1): 177–179.

Directorate of Horticulture (Statistics), 2018–19. Lagura Street, Jaipur, Rajasthan.

Harisha, C.B., Honnappa, A., Singh, R., Meena, N.K. and Lal, G. 2017. Irrigation management for higher productivity in seed spices–A review. *International Journal of Current Microbiology and Applied Sciences* **6**(6): 2,334–2,345.

Killedar, S.G., More, Harinath, Nadaf, S. and Pishawikar, S. 2016. Optimization of method for determination of swelling factor of *ispaghula* seeds. *Journal of Drug Metabolism and Toxicology* **7**(3): 1–7.

Kunapara, A.N. 2013. Conjugate assessment of drip system configuration and irrigation regimes on productivity of cumin. M. Tech. Thesis, Junagadh Agricultural University, Junagadh, Gujarat (Unpublished).

Michael, G. and Beringer, H. 1980. The role of hormones in yield formation. Physiological aspects of crop productivity. International Potash Institute, Switzerland, pp. 85–116.

Patil, D., Mani, I., Kumar, A. and Varghese, C. 2014. Role of hydrogel granules in increasing wheat productivity by maintaining soil moisture at root zone depth. *Green Farming* **5**(4): 559–562.

Patro, H. and Ray, M. 2016. Effect of mulching, hydrogel and nutrient management on productivity of summer groundnut. *Asian Journal of Environmental Science* **11**: 156–159.

Rathore, S.S., Shekhawat, K., Dass, A., Premi, O.P., Rathore, B.S. and Singh, V.K. 2020. Deficit irrigation scheduling and superabsorbent polymer hydrogel enhance seed yield, water productivity and economics of Indian mustard under semi arid ecologies. *Irrigation and Drainage* **68**: 531–541.

Shikha, A.G., Yewale, Kumari, K. and Paliwal, A. 2019. Productivity and profitability of urd (*Vigna mungo* L.) as influenced by pusa hydrogel under rainfed condition in hilly region of Uttarakhand. *International Archive of Applied Sciences and Technology* **10**(4): 81–84.

Sow, A.A., Hossner, L.R., Unger, P.W. and Steward, B.A. 1997. Tillage and residue effects on root growth and yield of grain sorghum following wheat. *Soil Tillage Research* **4**: 121–129.

Sumathi, V. and Koteswara Rao, D.S. 2007. Effect of organic and inorganic sources of nitrogen with different irrigation schedules on growth and yield of sunflower (*Helianthus annuus*). *Indian Journal of Agronomy* **52**(1): 77–79.

Tripathi, A. 2020. Effect of irrigation scheduling and hydrogel on growth and yield of wheat (*Triticum aestivum* L.). M.Sc. Thesis, Acharya Narandra Deva University of Agriculture and Technology, Ayodhya, Utter Pradesh, India (Unpublished).

Tyagi, V., Singh, R.K. and Nagargade, M. 2015. Effect of hydrogel, NPK and irrigation levels on yield, nutrient uptake and water use efficiency of wheat (*Triticum aestivum* L.). *Research on Crop* **16**(4): 653–656.