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Performance of Salicylic Acid and Hydrogel on Water Use Efficiency and Productivity of Indian Mustard (*Brassica juncea* L.) in Jammu Region

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To study the effect of salicylic acid and hydrogel on water use efficiency and productivity of Indian mustard in Jammu.
Study Design: Randomized Block Design (RBD).
Place and Duration of Study: Oilseed Experimental Area, Research Farm, SKUAST-Jammu, Chatha, Jammu & Kashmir (UT).

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Methodology: The field experiment was conducted during the *rabi* season of 2014-15 and 2015-16 at the Research Farm, Chatha of the Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu which is situated at 32^0 40' N latitude and 74^0 58' E longitude with an altitude of 332 m above mean sea level. The experiment comprised of nine treatments with 3 replications.
Results: The application of Salicylic acid @ 200 ppm at flowering and siliquae formation stage in combination with use of hydrogel @ 2.5 kg/ha resulted in increase in the yield attributes, and seed yield of Indian mustard besides concomitant increase in the rainfall water use efficiency and cumulative water use of Indian mustard and was found to be the most economical treatment than other treatments in comparison.
Conclusion: Based on average of two years of experimentation, application of Hydrogel @ 2.5 kg/ha + Salicylic acid 200 ppm at flowering stage & siliquae stage with maximum average benefit: cost ratio may be recommended for mitigation of moisture stress in Jammu region for obtaining higher crop yield, better rainfall water use efficiency, cumulative water use and profitability due to better average economic returns (2.50) in rainfed areas of Jammu region.

Keywords: Hydrogel; salicylic acid; rainfall water use efficiency; cumulative water use; mustard.

1. INTRODUCTION

Rapeseed mustard is an important oilseed crop grown in *rabi* season in the country, and contributes 23.33 % share in terms of total acreage and 26.24 % share in production among all oilseed crops grown in the country. In India, area, production and productivity of rapeseed-mustard is 6.12 million hectares, 9.26 million tonnes and 1511 kg/ ha, respectively, during 2018-19. In Jammu and Kashmir (UT), rapeseed mustard crops are grown on an area of 55000 hectare (approx.) with an average productivity of 1149 kg/ha [1]. In Jammu region, Rapeseed Mustard crops namely *Brassica compestris* var. Toria, *Brassica napus* and *Brassica juncea* species holds promise as it fits well in cropping systems of the region viz. Maize-Toria-Wheat, Rice-Gobhi Sarson/Mustard, Greengram-Mustard, Blackgram-Mustard, Pearlmillet-Mustard, Maize-Mustard, Sesame-Mustard etc. Frequent dry spells due to climate change over the last few years have affected the production, and productivity of Indian mustard significantly [2]. The Rapeseed Mustard crops suffers moisture stress at various stages of crop growth particularly at the flowering stage and the siliquae formation stage, which are most sensitive to the moisture stress [3,4]. Low soil moisture during the crop growth period due to frequent dry spells at different phases of crop growth results in drastic reduction in the crop yield of Indian mustard thereby resulting in lowered productivity of rapeseed mustard crop [5,6]. The use of hydrogel at the dosage of 2.5 kg to 5.0 kg per hectare have been found promising under rainfed conditions for mitigation of moisture stress at different crop growth stages and have been found to affect the water use efficiency of Indian mustard crop thereby affecting the significant increase in the yield in Jammu region [1]. Also, use of salicylic acid for mitigation of moisture stress post flowering stage have been found to be beneficial in solving the problem of moisture stress through changes in proline accumulation, and ethylene formation under drought stress [1]. Therefore the present study was planned to study the effect of Salicylic acid at variable concentrations i.e. 100 and 200 ppm either alone or in combination with different doses of hydrogel viz. 2.5 kg and 5.0 kg on the Indian mustard for increasing the productivity, and farm income under rain fed agro-ecosystems of Jammu region.

2. MATERIALS AND METHODS

The field experiment was conducted during the *rabi* season of 2014-15 and 2015-16 at the Research Farm, Chatha of the Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu which is situated at 32^0 40' N latitude and 74^0 58' E longitude with an altitude of 332 m above mean sea level. The soil of the experimental field was sandy loam in texture, low in organic carbon (0.37%) and nitrogen (205.2 kg/ha), medium in available phosphorus (12.18 kg/ha) and potassium (133.80 kg/ha) and neutral in pH (7.06). Indian mustard variety "NRCHB 101" was sown in second fortnight of October in rows 30 cm apart and 10$\pm$15 cm plant to plant distance using 5 kg seeds/ha during both the years of experimentation. Recommended dose of 80:40:20:20 kg/ha of $N:P_2O_5:K_2O:S$ was uniformly applied to all the treatments using urea, DAP , MOP and Gypsum as fertilizers. Full dose of P, K and S besides half dose of N were

applied as basal dose at the time of sowing whereas rest of the N was given as 2 split doses during both the years of experimentation. Crop was raised as per recommended package and practices during both the years of experimentation and was harvested during the first week of April during both the years of experimentation. All the observations and soil analysis were done and recorded using standard procedures. The experiment consisted of nine treatment which were arranged in randomized block design with 3 replications. The treatments consisted of Control (T1), Hydrogel@ 2.5 kg/ha (T2), Hydrogel@ 5.0 kg/ha (T3), Salicylic acid 100 ppm at flowering stage & siliquae stage (T4), Salicylic acid 200 ppm at flowering & Siliquae stage (T5), Hydrogel@ 2.5 kg/ha+ Salicylic acid 100 ppm at flowering stage & siliqua stage (T6), Hydrogel@ 2.5 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliqua stage (T7), Hydrogel@ 5.0 kg/ha+ Salicylic acid 100 ppm at flowering stage & siliqua stage (T8), Hydrogel@ 5.0 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliqua stage (T9). The Rainfall use efficiency (RWUE) by dividing mustard grain yield with the total precipitation received during the crop growing season [7].

Rainf all water use efficiency (RWUE) = Mustard yield (kg/ha) / Rainfall (mm)

Whereas, total water use (CWU) was worked out by using Pan evaporation data wherein relationship between ETo and Pan evaporation (PE) with Kc values (0.70) in subtropical areas) based on percent growing season for determination of Etc using the following equation [8].

$$ETc = Kp \times Ep$$

Where

Ep = Pan evaporation (mm day^{-1})
Kp = Pan coefficient

The materials and method section to be recast. It isn't explicit enough and write up stepwise enough for ease of understanding for wider viewers.

For economic evaluation the cost of cultivation, gross returns, net returns and B:C ratio were computed using standard procedure based on minimum support price of Indian mustard The data on recorded observations was analyzed using standard procedures.

3. RESULTS AND DISCUSSION

The seed yield and yield attributes were significantly influenced by application of hydrogel and salicylic acid either alone or in conjunction at variable concentration. Among the treatments, maximum seed yield and yield attributes viz. 1000 seed weight, siliqua per plant, seeds/siliqua in Indian mustard was recorded with application of Hydrogel@ 5.0 kg/ha + Salicylic acid 100 ppm at flowering stage & siliquae stage (T8) though at par with application of Salicylic acid 100 ppm at flowering stage & siliquae stage (T4), Salicylic acid 200 ppm at flowering & Siliquae stage (T5), Hydrogel@ 2.5 kg/ha+ Salicylic acid 100 ppm at flowering stage & siliqua stage (T6), Hydrogel@ 2.5 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliqua stage (T7), and application of Hydrogel@ 5.0 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliqua stage (T9) was found to be significantly higher than application of Hydrogel @ 2.5 kg, Hydrogel @ 5.0 kg per hectare and control plots in comparison during the first year of experimentation (Table 1).

However, during the second year i.e. 2019-20, maximum seed yield and other yield attributes i.e. 1000 seed weight, no. of siliqua per plant , seeds per siliqua and oil yield were obtained with application of Hydrogel@ 2.5 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliqua stage (T7) which was however found to be at par with Hydrogel@ 2.5 kg/ha (T2), Hydrogel@ 5.0 kg/ha (T3), Salicylic acid 100 ppm at flowering stage & siliquae stage (T4), Salicylic acid 200 ppm at flowering & Siliquae stage (T5), Hydrogel@ 2.5 kg/ha+ Salicylic acid 100 ppm at flowering stage & siliqua stage (T6), Hydrogel@ 5.0 kg/ha+ Salicylic acid 100 ppm at flowering stage & siliqua stage (T8), Hydrogel@ 5.0 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliqua stage (T9) respectively (Table 1). This may be due to the fact that application of hydrogel and salicylic acid at variable doses when applied at different intervals resulted in significant effects on the rainfall use efficiency as well as cumulative water use (Table 2). Similar findings were reported by Meena & co-workers [9]. However, lowest seed yield and yield attributes were recorded in control plots (T1) during both the years of experimentation.

Table 1. Effect of hydrogel and salicyclic acid application on Indian mustard under rainfed timely sown conditions

Treatments	Seed yield (kg/ha)		No. of siliqua/ plant		Seeds/Siliqua (no.)		1000-seed weight (g)		Rainfall Water Use Efficiency(kg/mm)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Control	1032.00	1096.67	189.33	195.33	11.33	14.33	3.18	3.25	3.64	2.65
Hydrogel@ 2.5 kg/ha	1142.00	1310.00	214.00	233.00	12.67	15.33	3.65	3.81	4.03	3.16
Hydrogel@ 5.0 kg/ha	1148.00	1316.67	216.33	235.00	12.0	16.00	3.71	3.82	4.05	3.18
Salicylic acid 100 ppm at flowering stage & siliqua stage	1198.667	1316.67	230.00	234.33	14.33	16.33	3.99	3.87	4.23	3.18
Salicylic acid 200 ppm at flowering & Sliqua stage	1195.333	1340.00	229.33	239.33	14.00	16.33	3.85	3.94	4.22	3.23
Hydrogel@ 2.5 kg/ha+ Salicylic acid 100 ppm at flowering stage & siliqua stage	1252.00	1476.67	240.33	263.67	14.33	17.00	4.24	4.03	4.42	3.56
Hydrogel@ 2.5 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliqua stage	1208.00	1490.00	231.33	263.33	14.00	17.67	4.28	4.09	4.27	3.59
Hydrogel@ 5.0 kg/ha+ Salicylic acid 100 ppm at flowering stage & siliqua stage	1332.00	1443.33	255.33	257.67	15.33	16.67	4.37	4.04	4.70	3.48
Hydrogel@ 5.0 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliqua stage	1309.333	1456.67	252.00	259.67	14.33	17.00	4.30	4.11	4.62	3.52
CD (p=0.05)	169.33	202.64	32.63	35.64	1.70	1.72	0.38	0.36	0.60	0.49

Table 2. Effect of hydrogel and salicyclic acid application on economics of Indian mustard under rainfed timely sown conditions

Treatments	Gross returns (INR/ha)		Cost of cultivation (INR/ha)		Net returns (INR/ha)		B:C ratio	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Control	43344	48528	15400	15400	27944	33128	1.81	1.99
Hydrogel@ 2.5 kg/ha	47964	57968	16600	16600	31364	41368	1.89	2.73
Hydrogel@ 5.0 kg/ha	48216	58263	17800	17800	30416	40463	1.71	2.38
Salicylic acid 100 ppm at flowering stage & siliqua stage	50344	58263	16300	16300	34044	41963	2.09	2.42
Salicylic acid 200 ppm at flowering & Sliqua stage	50204	59295	16500	16500	33704	42795	2.04	2.86
Hydrogel@ 2.5 kg/ha+ Salicylic acid 100 ppm at flowering stage & siliqua stage	52584	65343	17500	17500	35084	47843	2.00	2.64
Hydrogel@ 2.5 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliqua stage	50736	65933	17700	17700	33036	48233	1.87	3.13
Hydrogel@ 5.0 kg/ha+ Salicylic acid 100 ppm at flowering stage & siliqua stage	55944	63868	18700	18700	37244	45168	1.99	2.19
Hydrogel@ 5.0 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliqua stage	54992	64458	18900	18900	36092	45558	1.91	2.51

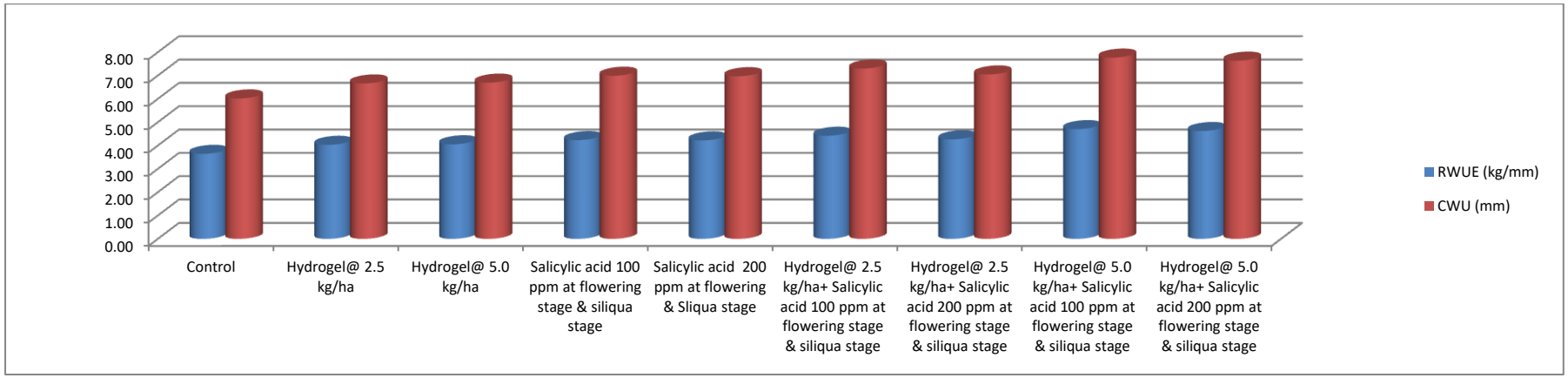

Fig. 1. Effect of hydrogel and salicylic acid on Rainfall Water Use Efficiency (kg/mm) and Cumulative Water Use (kg/mm) of Indian mustard during 2018-19

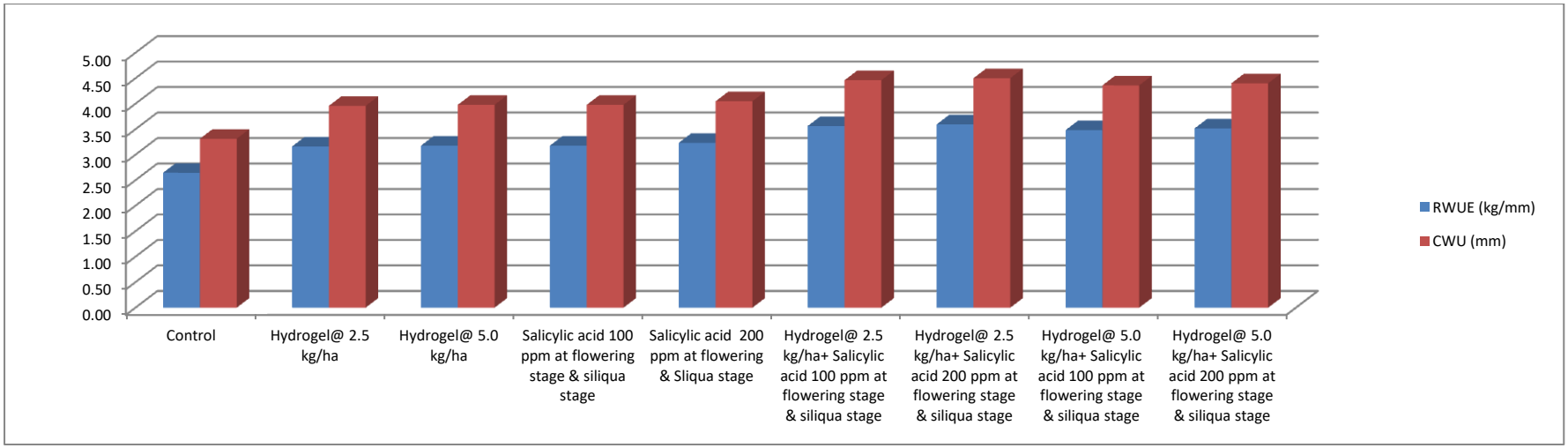

Fig. 2. Effect of hydrogel and salicylic acid on Rainfall Water Use Efficiency (kg/mm) and Cumulative Water Use (kg/mm) of Indian mustard during 2019-20

Also, application of hydrogel may have resulted in absorption/storage of moisture during the period of abundant supply viz. field capacity for release at subsequent crop growth stages by thereby ensuring sufficient moisture supply during the entire vegetative and reproductive phases thereby increasing the cumulative water use and rainfall water use efficiency to increase photosynthesis of Indian mustard crop which resulted in significant increase in the seed yield as well as yield attributes in Indian mustard crop during both the years of experimentation (Fig. 1). Similar, views have been expressed by bharat and co-workers [5] However, application of application of Salicylic acid 100 ppm at flowering stage & siliqua stage (2.09) and application of Hydrogel @ 2.5 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliqua stage with maximum benefit:cost ratio (3.13) was found to be the most economical treatment during both the years of experimentation respectively.

4. CONCLUSION

Based on average of two years experimentation, application of Hydrogel @ 2.5 kg/ha+ Salicylic acid 200 ppm at flowering stage & siliquae stage with maximum average benefit:cost ratio may be recommended for mitigation of moisture stress in Jammu region for obtaining higher crop yield, better rainfall water use efficiency, cumulative water use and profitability due to better average economic returns (2.50) in rainfed areas of Jammu region.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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