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Impact of Hydrogel Application and Foliar Agrochemical sprays on growth and yield of Indian Mustard (*Brassica juncea* L.)

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Abstract— *Indian mustard (Brassica juncea L.), a vital rabi oilseed crop in India, faces significant productivity constraints due to water stress and nutrient limitations, particularly in semi-arid regions like Rajasthan. This study was conducted during the Rabi 2024–25 season at the Agronomy Farm, Nirwan University, Jaipur, to evaluate the impact of hydrogel and foliar-applied agro-chemicals (thiourea, salicylic acid, and NPK 19:19:19) on the growth, physiological parameters, and yield of mustard. The experiment, laid out in a factorial randomized block design with 16 treatment combinations and three replications, revealed that hydrogel application at 7.5 kg/ha significantly improved plant height (194.0 cm), dry matter accumulation (257.5 g/m), branching, chlorophyll content (3.26 mg/g), and seed yield (1829 kg/ha) compared to control. Similarly, foliar spray of thiourea @ 500 ppm consistently enhanced growth and yield attributes, recording the highest CGR (8.3 g/m²/day), RGR (74.9 mg/g/day), and seed yield (1820 kg/ha), followed by salicylic acid and NPK treatments. The results underscore the efficacy of hydrogel and stress-alleviating foliar sprays in improving water-use efficiency, physiological resilience, and mustard productivity under water-limited conditions. The integration of these technologies presents a sustainable approach to address abiotic stress in oilseed production systems.*

Keywords— ***Mustard, hydrogel, thiourea, salicylic acid, NPK 19:19:19, drought stress.***

I. INTRODUCTION

Oilseed crops have gained strategic importance in India due to their critical role in food security, industrial applications, and foreign exchange earnings. In recent years, they have become increasingly relevant amid the global energy crisis, as they serve as potential sources of biofuel and edible oils. Among these, Indian mustard (*Brassica juncea* L.) has emerged as a dominant rabi oilseed crop, contributing nearly one-third of the country's total oilseed output. It is valued not only for its edible oil content (37–49%) used widely in cooking, but also for its multifunctional uses in condiments, medicines, soaps, and as livestock feed in the form of oilcake. India ranks third globally in rapeseed-mustard production, with Rajasthan being the leading state in both area (33.70 lakh ha) and production (54.80 lakh tonnes), though the state still lags behind in realizing the crop's yield potential (2200–2400 kg/ha), primarily due to water stress and nutrient limitations (Reddy & Ramu, 2018; Anonymous, 2024). In semi-arid regions, especially in sandy soils of Rajasthan, limited soil moisture and erratic rainfall hinder crop performance. To address this, advanced crop production technologies, including hydrogels-superabsorbent polymers capable of retaining up to 400 times their weight in water have shown promising results. Hydrogel enhances soil water-holding capacity, reduces evaporation losses, and improves plant water availability during dry spells, thus significantly improving yield and water-use efficiency (Anupama & Parmar, 2012; Dabhi *et al.,* 2013). Similarly, the application of agrochemicals such as thiourea, a sulfhydryl compound, has been effective in improving photosynthesis, canopy development, and grain filling under drought stress. Thiourea helps maintain cellular redox balance, ensuring better physiological function under adverse conditions (Nathawat et al., 2007). Salicylic acid, a naturally occurring phytohormone, further aids in osmotic adjustment, reducing water loss, and enhancing resistance to biotic and abiotic stresses including drought, heat, and chilling (Nasrin *et al.,* 2014). To complement these stress-mitigation strategies, the use of new-generation water-soluble fertilizers like NPK (19:19:19) has become increasingly popular. These fertilizers, when applied as foliar sprays, quickly correct nutrient deficiencies and improve plant health, leading to better growth, reduced dependence on chemical pesticides, and ultimately higher productivity. Their low salt index also makes them suitable for use under stress conditions, where soil nutrient availability is limited. The integration of these technologies offers a holistic and sustainable solution for enhancing mustard productivity, especially in regions facing climatic and environmental challenges (Anonymous, 2024; Reddy & Ramu, 2018).

II. MATERIALS AND METHODS

The field experiment was conducted during the *rabi* season of 2024–25 at the Agronomy Farm, School of Agricultural Sciences, Nirwan University, Jaipur (26° 51′ 42″ N, 76° 6′ 57″ E, 375 m AMSL), located in a semi-arid region with sandy loam soil and limited water availability. The study was laid out in a factorial randomized block design (FRBD) with 16 treatment combinations and three replications, involving four levels of hydrogel (0, 2.5, 5.0, and 7.5 kg/ha) and four foliar spray treatments (control, thiourea @ 500 ppm, salicylic acid @ 100 ppm, and NPK 19:19:19 @ 0.5%). The Indian mustard (*Brassica juncea* L.) variety ‘Giriraj’ was sown on 28th October 2024 using the *kera* method at a spacing of 30 × 10 cm with a seed rate of 4 kg/ha. Hydrogel was incorporated into the soil at sowing, while foliar sprays were applied at pre-flowering and siliqua formation stages. Standard agronomic practices were uniformly followed across all plots. Observations on growth (plant height, branches), physiological traits (chlorophyll content, CGR, RGR), biomass accumulation (dry matter), and yield components (seed, stover, and biological yield) were recorded from five randomly selected plants per plot. Data were analysed statistically using ANOVA, and treatment means were compared using LSD at a 5% significance level.

III. RESULTS AND DISCUSSION

The data presented in Table 1 and 2 clearly demonstrate the significant positive effects of hydrogel application and foliar spray of agro-chemicals on the growth and yield parameters of Indian mustard.

Effect of Hydrogel

The application of hydrogel has shown promising results in enhancing crop performance under water-limited conditions. In table 1, while the plant stand per meter row length was not significantly affected by hydrogel application, a marginal increase was noted at the highest dose (7.5 kg/ha), suggesting improved germination and early seedling establishment. Similar trends have been observed by Abedi *et al.,* (2016), who reported improved seedling emergence and early vigor due to the water-retentive properties of hydrogels. Plant height was significantly influenced by hydrogel application, increasing progressively with dose. The tallest plants (194.0 cm) were recorded with 7.5 kg/ha hydrogel, significantly higher than the control (144.8 cm), attributable to improved soil moisture and reduced drought-induced stress. These findings are consistent with those of Narjary *et al.,* (2012), who highlighted the role of superabsorbent polymers in enhancing plant growth under moisture-stress conditions by maintaining favorable soil-water relations. Dry matter accumulation showed a substantial rise with hydrogel use, with the maximum accumulation (257.5 g/m row length) at the highest dose, representing a 36.6% increase over the control. This aligns with earlier findings by Islam *et al.,* (2011), who observed enhanced biomass accumulation in hydrogel-treated crops due to prolonged water availability and better nutrient absorption. Branching patterns, both primary and secondary, were positively influenced by hydrogel, with secondary branches increasing significantly from 9.9 (control) to 13.3 (7.5 kg/ha). Improved water and nutrient uptake likely promoted enhanced apical dominance and lateral branching, as previously demonstrated by Banedjschafie *et al.,* (2008), who reported increased tillering and branching in cereals under hydrogel treatments. The data demonstrated in table 2, Crop Growth Rate (CGR) and Relative Growth Rate (RGR) showed positive trends with hydrogel. The highest CGR was recorded during 40–80 DAS (8.0 $g/m^2/day$) and 80 DAS–harvest (5.4 $g/m^2/day$) in the 7.5 kg/ha treatment. Although RGR differences were not statistically significant, values remained stable across treatments, reflecting sustained growth—findings consistent with Farooq *et al.,* (2009), who demonstrated that hydrogels help maintain physiological stability under episodic drought. Chlorophyll content was significantly higher in hydrogel-treated plots (3.26 mg/g at 7.5 kg/ha) than in the control (2.75 mg/g), indicating improved photosynthetic capacity. This corresponds with the observations of Kashyap and Panda (2001), who reported that hydrogel application improved leaf water potential and chlorophyll stability under moisture stress. Significant improvements in seed yield (1829 kg/ha), stover yield (3954 kg/ha), and biological yield (5783 kg/ha) were recorded at the highest hydrogel dose, confirming that improved water retention enhances water-use efficiency and yield potential. These results corroborate with the work of *et al.,* (2017), who observed yield enhancement in various crops with polymer-based soil amendments under arid conditions.

Effect of Agro-Chemicals (Foliar Sprays)

Among the foliar-applied agro-chemicals, thiourea at 500 ppm consistently outperformed other treatments across growth and yield parameters. At harvest, plants treated with thiourea recorded a height of 192.6 cm, significantly exceeding the control (148.0 cm), indicating thiourea's role in enhancing metabolic activities under abiotic stress. Similar effects have been reported by Srivastava *et al.,* (2013), who found that thiourea enhances enzymatic activity, nitrogen metabolism, and antioxidant defense, leading to improved plant stature and productivity. Dry matter accumulation (257.9 g/m) was also highest in thiourea-treated plants, followed by salicylic acid (248.5 g/m) and NPK (237.9 g/m), likely due to improved assimilate partitioning and stress tolerance mechanisms. These findings support previous studies by Arfan *et al.,* (2007) and Ashraf *et al.,* (2010), who demonstrated the efficacy of salicylic acid and thiourea in improving water-use efficiency and metabolic resilience under stress. Thiourea also led in branching metrics, with the highest number of primary (5.1) and secondary branches (13.2) per plant. Its stress-mitigating capacity through redox regulation and enhanced photosynthate mobilization has been previously reported by Rani and Srivastava (2012). CGR and RGR were highest in thiourea treatment (8.3 and 5.5 g/m²/day for CGR; 74.9 and 26.0 mg/g/day for RGR), indicating more effective biomass accumulation and resource use. Chlorophyll content was also highest under thiourea (3.18 mg/g), further supporting its role in maintaining physiological stability under water deficit (Khan *et al.,*2015). Yield attributes mirrored these physiological improvements, with thiourea yielding 1820 kg/ha, followed by salicylic acid (1769 kg/ha) and NPK (1710 kg/ha). The effectiveness of salicylic acid (100 ppm) in improving chlorophyll content (3.10 mg/g) and CGR (8.0 g/m²/day) aligns with the findings of Hayat *et al.,* (2010), emphasizing its role in osmotic adjustment, ion homeostasis, and enhanced photosynthesis. The NPK (19:19:19) @ 0.5% spray also significantly improved growth and yield, confirming that balanced foliar nutrition is critical during critical crop stages (Fageria *et al.,* 2009).

Table 1: Effect of hydrogel and foliar spray of agro-chemicals on growth parameters of Indian mustard

Treatment	Plant stand /m row length		Plant height (cm)			Dry matter accumulation (g /m row length)			Number of primary branches /plants			Number of secondary branches /plants		
	At 29 DAS	At harvest	At 40 DAS	At 80 DAS	At harvest	At 40 DAS	At 80 DAS	At harvest	At 40 DAS	At 80 DAS	At harvest	At 40 DAS	At 80 DAS	At harvest
Hydrogel														
Control	10.0	9.3	41.8	130.4	144.8	53.5	123.7	188.4	2.5	3.3	4.0	6.8	7.0	9.9
2.5 kg/ha	10.1	9.4	51.2	161.1	171.3	67.5	155.2	235.8	2.6	3.9	4.7	7.0	8.5	11.9
5.0 kg/ha	10.2	9.5	57.3	178.8	190.8	72.4	166.1	252.8	2.7	4.2	5.0	7.2	9.3	12.9
7.5 kg/ha	10.3	9.6	57.5	182.1	194.0	73.1	169.1	257.5	2.7	4.3	5.2	7.3	9.5	13.3
SEm±	**0.57**	**0.10**	**1.2**	**3.9**	**4.3**	**1.5**	**3.2**	**5.5**	**0.05**	**0.10**	**0.11**	**0.16**	**0.23**	**0.30**
CD at 5%	**NS**	**0.29**	**3.4**	**11.2**	**12.3**	**4.2**	**9.3**	**15.8**	**NS**	**0.28**	**0.32**	**NS**	**0.66**	**0.86**
Agro-chemicals (Foliar spray)														
Water spray	10.0	9.3	50.6	138.0	148.0	64.2	125.9	190.3	2.6	3.4	4.0	6.8	7.2	10.1

Thiourea @500 ppm	10.3	9.5	53.1	178.7	192.6	68.3	167.9	257.9	2.7	4.3	5.1	7.3	9.5	13.2
Salicylic acid @100 ppm	10.1	9.4	51.5	163.9	175.7	67.5	163.5	248.5	2.6	4.1	4.9	7.2	9.0	12.7
NPK (19:19:19) @0.5 %	10.2	9.5	52.6	171.7	184.5	66.6	156.8	237.9	2.6	3.9	4.7	7.0	8.6	12.0
SEm±	**0.3**	**0.2**	**1.2**	**3.9**	**4.3**	**1.5**	**3.2**	**5.5**	**0.05**	**0.10**	**0.11**	**0.16**	**0.23**	**0.30**
CD at 5%	**NS**	**NS**	**NS**	**11.2**	**12.3**	**NS**	**9.3**	**15.8**	**NS**	**0.28**	**0.32**	**NS**	**0.66**	**0.86**

Table 2: Effect of hydrogel and foliar spray of agro-chemicals on CGR, RGR, Chlorophyll content and Yield (kg/ha) of Indian mustard

Treatment	**Crop growth rate (g /m^2 /day)**		**Relative growth rate (mg /g /day)**		**Chlorophyll content (mg /g)**	**Yield (kg/ha)**		
	At 40 - 80 DAS	**At 80 DAS - at harvest**	**At 40 - 80 DAS**	**At 80 DAS - at harvest**	**At 55 DAS**	**Seed yield**	**Stover yield**	**Biological yield**
Hydrogel								
Control	5.8	3.9	69.1	25.5	2.75	1400	2857	4257
2.5 kg/ha	7.3	4.9	68.9	25.3	3.06	1674	3542	5215
5.0 kg/ha	7.8	5.3	68.8	25.4	3.22	1797	3863	5660
7.5 kg/ha	8.0	5.4	69.4	25.4	3.26	1829	3954	5783
SEm±	**0.2**	**0.2**	**1.4**	**0.7**	**0.04**	**40**	**90**	**100**
CD at 5%	**0.6**	**0.5**	**NS**	**NS**	**0.11**	**115**	**259**	**290**
Agro-chemicals (Foliar spray)								
Water spray	5.1	3.9	70.9	25.0	2.77	1399	2924	4323
Thiourea @500 ppm	8.3	5.5	74.9	26.0	3.18	1820	3897	5717
Salicylic acid @100 ppm	8.0	5.2	73.8	25.4	3.10	1769	3795	5564
NPK (19:19:19) @0.5 %	7.5	4.9	71.4	25.1	3.23	1710	3601	5311
SEm±	**0.2**	**0.2**	**1.4**	**0.7**	**0.04**	**40**	**90**	**100**
CD at 5%	**0.6**	**0.5**	**NS**	**NS**	**0.11**	**115**	**259**	**290**

IV. CONCLUSION

The study clearly demonstrates that both hydrogel application and foliar agro-chemical treatments significantly enhance crop growth, physiological efficiency, and yield under water stress conditions. The application of hydrogel, particularly at 7.5 kg/ha, improved plant height, dry matter accumulation, branching, and chlorophyll content by maintaining better soil moisture and reducing drought-induced stress. Similarly, foliar application of thiourea at 500 ppm proved most effective among the agro-chemicals, enhancing crop growth rate, chlorophyll content, and yield components by supporting physiological and biochemical resilience under limited water availability.

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