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Novel Herbal Hydrogel '*Tragacanth-Katira* Gel' and Farmer's Friendly Seed Priming-Hydrogel Coating Technology for Water Saving, Making Agriculture Sustainable and Resilient to Climatic Variability

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ABSTRACT: *The main reasons for low crop yield in rainfed agriculture is poor seed germination, seedlings and plant growth, dry-matter accumulation, leaf expansion and less moisture maintenance in root zone as compared to moisture-managed intensive agriculture. Hydrogels provide effective solutions to the problems of moisture stress by maximizing land and water productivity. Though, synthetic polymers (hydrogels) were introduced in India for agricultural uses in early 1980's but has not become popular in high volume major crops due to their prohibitive cost (> '2000/kg) and poor delivery system to root zones by recommended soil application which has been now improved with the use of cost effective ('300/kg) herbal hydrogel Tragacanth-Katira gel coupled with farmer's friendly seed priming cum hydrogel coating technology developed by Lather et al.2015 which has shown promises for mitigation of sub-optimal moisture stresses, water saving and maximizing the water productivity for production of more crop per drop of water by making agriculture sustainable and resilient to climatic variability.*

Key words: *Herbal hydrogel, Tragacanth-Katira gel, Seed priming cum hydrogel coating technology, Sustainable Agriculture, Moisture Stresses.*

The reasons of poor crop yield in moisture stress agriculture is reduction in seed germination, seedlings-plant growth, dry-matter accumulation, leaf expansion and less moisture maintenance in root zone as compared to moisture-available agriculture. Hydrogel (polymers) provide solutions to the problems of moisture stress agriculture by maximizing land and water productivity without threatening the environment and natural resources. Superabsorbent hydrogels potentially influence soil permeability, density, structure, and texture and evaporation-infiltration rates of water through the soils. Hydrogel can be natural, semi synthetic, synthetic polymers which consist of Polyvinylalcohols / Polyacrylamides. Synthetic hydrogels were introduced in India for agricultural uses in early 1980's but with limited success confined their use only to nursery, micro-plots and green house pots etc.

Pusa hydrogel, which absorbs about 80 g of water/gram of xerogel helped in conserving soil moisture in root zone, plants to withstand extended moisture stress, delays onset of permanent wilting point, reduction in irrigation and fertigation requirements of the crops (Patil et al. 2014). The farmer's field studies shown that Pusa hydrogel application @ 2.5 kg/ ha save two irrigations in wheat with comparable yield (17.7q/acre) against the recommended normal six irrigations (ICAR 2014). Rathore *et al.* (2015) observed significant effect of hydrogel application on seed, biological and oil yield and production efficiency of Indian mustard under different irrigation scheduling. Despite usefulness, the synthetic hydrogel has not become popular in high volume major crops due to prohibitive cost (₹2000 / kg/acre) and poor delivery system to root zones by the recommended soil application which now is improved by use of cost effective (₹300/kg) herbal hydrogel *Katira* gel coupled with seed priming cum hydrogel coating technique developed by Lather *et al.* 2015. However, the presale hydrogel seed coating through industrial processes will block further application of seed priming and other seed treatments and also increased the malpractices in seed trade as seed would not be identifiable after hydrogel coating to its true form, kind or variety which is gross violation of Section-7(a) of The Seed Act-1966 which

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legally ensure that "*No person shall carry on the business of selling or supplying any seed of any notified kind or variety, unless such seed is identifiable as to its kind or variety*".

Rice is biggest users of world's fresh water resources and posing big challenge to improve its irrigation water productivity (WPIW) to arrest the declining surface and ground water resources. The cconventional tillage methods such as puddle transplanting in the rice-wheat system in the Indo-Gangetic Plains (IGP) require a large amount of water and labour of which both are now increasingly becoming scarce and expensive. Normally, puddle transplanting required 35 to 40% more irrigation water than no-tillage direct-seeded rice but with an associated yield loss of 14 to 25%. Nevertheless, water use efficiency (WUE) in the rice-wheat system was higher with direct-seeded rice (0.45 g L^{-1}) as compare to transplanted rice (0.37–0.43 g L^{-1}) reported by Bhushan et al. 2013. Direct seeded rice gave higher crop and water productivity, net return, shorten the crop duration and maturity and comparable grain quality than the transplanted rice (Gill *et al.* 2014). Poor germination is a main constraint for getting higher yield in sub-optimal moisture stress conditions. Seed priming can be viable option for improving germination and to maintaining optimum plant population by reducing the time to radical emergence but also raised upper-temperature limit for germination. Soaking of seeds in 5% solution of KCl recorded 22.8% higher seed yield of chickpea than that of unprimed treatment. Alternate wetting and drying irrigation (AWD) can significantly reduce the amount of irrigation water input up to 35% without yield penalty. Further, farmer's friendly hydro priming cum hydrogel seed coating provide the efficient delivery system of hydrogel to root zone of the crop plants as compared to the conventional soil application which showed better tolerance against sub-optimal moisture stresses and improved seed germination, seedling and plant growth in crop plants (Lather *et al.* 2015).

Recently, ICAR-IARI, Regional Station, Karnal has identified a novel eco-friendly and cost effective (₹300/kg),herbal hydrogel '*Katira* gel'(dried sap of plant *Tragacanth sp.* referred as E-413 on human food label in international market and locally known as '*Gond Katira*' and developed farmer's friendly seed priming cum hydrogel coating technology for DSR, wheat, pulses, oilseeds and other crop plants for efficient delivery system of hydrogel to the root zone which mitigates suboptimal moisture stress with improved seedling survival-growth and water use efficiency by saving water and making agriculture more sustainable and resilient to climatic variability. Water absorption capacity of herbal hydrogel '*Katira* Gel' is comparable to the commercial Pusa hydrogel i.e. about hundred times to its weight in normal tap water under room conditions (Fig. 1c). For hydrogel seed coating, the grind powder of *Katira* dry gum is used but excessive loading and coating of *Katira* gel powder on seed (>10% or >100g / kg seed) negatively affected the seed germination in all the crops(Fig-1b). The Seed priming cum hydrogel coating technology is Eco-farmer's friendly as all the ingredients (Jiggery, Gums Katira and Acacia) used in the technology are herbal products and locally available throughout world at the sustainable cost ('300-1000/ha/ depending on seed rate of the crop) .

Procedure for Farmer's Friendly Seed Priming cum Hydrogel Coating Technology

(i) Hydro-prime the seed by seed soaking in water for 6-24 hours depending on the crop followed by air drying for 6 hours for summer (*Kharif)* crops and 12 hours for winter (*Rabi)* crops for re-drying the seed back to near to initial moisture content.

(ii) Make the hydro-primed dry seed sticky by treatment with homemade adhesive of 200 gram jiggery *(Gur)* plus 100 gram Gum Acacia(B*abbol/ Kikar*) in one litre of boiling water, cool it down before use which is sufficient to make 100 kg seed sticky for coating of dry hydrogel.

(iii) Then, pour dry hydrogel powder on the sticky hydro-primed seed and mix it well with hand *or* rotating drum for large quantity of seed followed by air drying for 6-12 hours in shade before use for sowing with the seed drill or broadcasting or any other methods.

(iv) The 10% or 100 g hydrogel powder per kg seed is needed for seed coating with cost of ₹300 - 1000 / ha depending on seed rate of the crop which can also be fortifies by mixing dry powders of plant nutrients, bio-fertilizers, fungicides to hydrogel powder before seed coating.

Hydrogel coated seed (Fig. 1a) were evaluated at room temperature under laboratory conditions in the trays filled with water saturated sand for tolerance against moisture stress at seed germination and seedling stages. The results showed that herbal hydrogel *Katira* gel coated hydro-primed seed delayed the initiation of seedlings wilting and mortality in rice (paddy) and wheat for about two

Figure 1a: Hydrogel Coated Seed

Figure 1b: Seed germination affected by excessive Hydrogel Coating

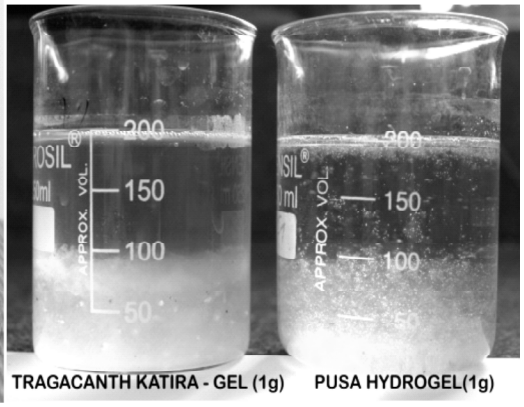

Figure 1c: Water absorption capacity of Katira-Gel & Pusa Hydrogel

Fig-2 : Performance of Rice(Paddy) seedlings of seed coated with HHG (Herbal Hydrogel Gum *Tragacanth-Katira*), Pusa Hydrogel and Seed Priming treatments.

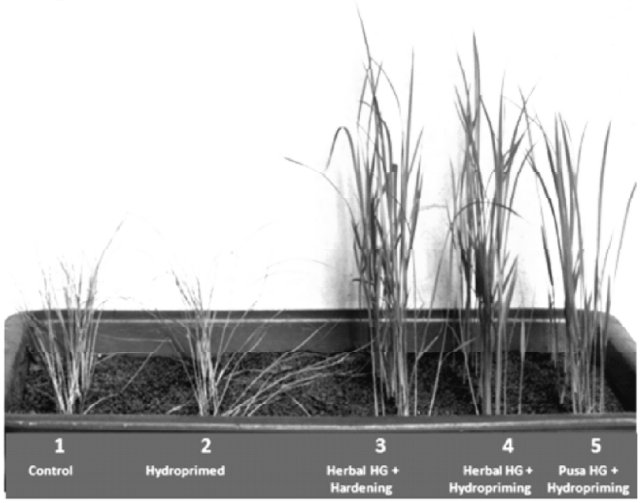

Fig-3 : Performance of Wheat seedling of seed coated with HH (Herbal Hydrogel Gum *Tragacanth-Katira*), Pusa Hydrogel and Seed Priming treatments

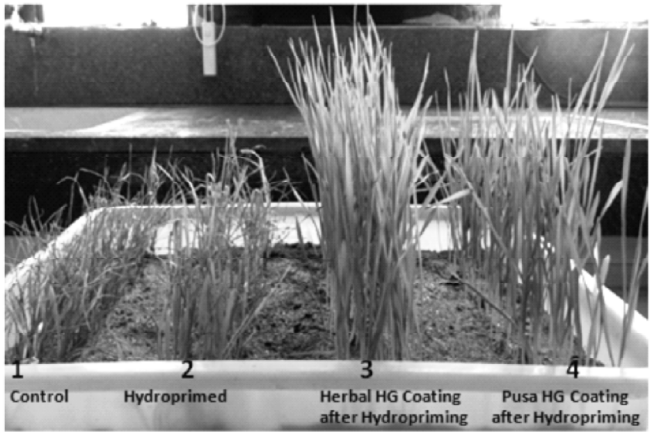

Table 1
Performance of Novel herbal hydrogel *'Tragacanth-Katira gel '* for tolerance against suboptimal moisture stress at seedling stages in Rice (Paddy) and Wheat crop under laboratory conditions.

		Rice (Paddy)				*Wheat*			
SN	*Treatment*	*Seed Germination (DAS)*	*Seed Germination (%)*	*Seedling Height at 16 DAS (cm)*	*Initiation Seedling Wilting (DAS)*	*Seed Germination (DAS)*	*Seed Germination (%)*	*Seedling Height at 16 DAS (cm)*	*Initiation Seedling Wilting (DAS)*
1	Control (untreated)	3	92	10	8	5	92	8	11
2	Farmer's Practise/ Seed Hydro-priming	4	91	12	10	4	93	11	14
3	Herbal Hydrogel Coating after Seed Hardening	4	92	20	22	-	-	-	-
4	Hebal Hydrogel Coating after Seed Hydro-priming	4	92	19	22	5	92	18	26
5	Pusa Hydrogel coating after seed Hydro-priming	4	87	16	20	5	92	16	22
	CD	-	2.37	1.72	1.55	-	1.24	1.97	1.67
	CV(%)	NS	6.9	7.98	7.1	NS	7.7	9.5	7.5

Table 2
Performance of herbal hydrogel *Katira*- gel treatments in wheat crop during *rabi* 2014-15

Set –I: Normal Sown Variety : **HD- 2967**; DOS: **22.11.2014**

	Treatment	*Plant height (cm)*	*Tillers / meter²*	*Spike Length (cm)*	*Grain/ Spike*	*Test Wt. (g)*	*Seed yield (Kg/ha)*	*Biological Yield (kg/ha)*	*HI (%)*
T-1 (C)	No seed treatment with normal recommended irrigation schedules (21, 45, 65, 85, 105, 125 DAS)	65.75	310.724	10.88	53.42	4.32	5111.50	14489.0	34.90
T-2	No seed treatment with first irrigation at 35 DAS followed by normal recommended irrigation schedules.	63.75	308.714	11.01	52.00	4.30	4996.90*	14447.0	34.58
T-3	No seed treatment with first irrigation at 45 DAS followed by recommended irrigation schedules.	60.50	302.465	11.08	49.67	4.29	4882.30*	14220.0	34.34
T-4	Seed coated with Herbal Katira- gel with first irrigation at 35 DAS followed by recommended irrigation schedules.	59.75	298.706	11.34	54.47	4.42	5080.30	13612.0	37.32
T-5	Seed coated with Herbal Katira- gel with first irrigation at 45 DAS followed by recommended irrigation schedules.	59.75	298.717	11.54	57.30	4.40	5087.20	13890.0	36.62
CD(kg/ha)	*Significant at 5 % value						92.91		
CV (%)							14.35		

Set-II : Late Sown Variety : **WR- 544** ; DOS : **08.12.2014**

	Treatment	*Plant height (cm)*	*Tillers / meter²*	*Spike length (cm)*	*Grain/ Spike*	*Test Wt. (g)*	*Seed yield kg/ha)*	*Biological Yield (Kg/ha)*	*HI (%)*
T-1 (C)	No seed treatment with normal recommended irrigation schedules (21, 45, 65, 85, 105, 125 DAS)	85.33	272.47	9.79	46.40	4.36	3088.80	9479.90	32.58
T-2	No seed treatment with first irrigation at 35 DAS followed by normal recommended irrigation schedules.	82.20	264.968	9.98	46.43	4.28	2784.90*	9288.90	29.98
T-3	No seed treatment with first irrigation at 45 DAS followed by recommended irrigation schedules.	81.33	264.967	9.97	46.66	4.32	2673.80*	9202.10	29.05
T-4	Seed coated with Herbal Katira- gel with first irrigation at 35 DAS followed by recommended irrigation schedules.	82.33	271.227	10.19	49.86	4.36	3008.90	9445.20	31.86
T-5	Seed coated with Herbal Katira- gel with first irrigation at 45 DAS followed by recommended irrigation schedules.	81.66	268.722	10.26	49.03	4.38	3062.70	9479.90	32.30
CD(kg/ha)	*Significant at 5% value						102.20		
CV (%)							10.02		
Rainy days (2015)	2nd Jan.(6.4mm), 3rd Feb.(16.2 mm), 1st March(34.2 mm), 2nd March (62.8mm), 7th March(12.2MM), 8th -March (7.2mm), 29th Mach (4.4mm), 4th April (30mm), 7th April (12 mm), 16th April (8 mm).								

weeks against the control and farmer's practice of sole hydro-priming and comparable with Pusa hydrogel coated seed with additional benefit of efficient delivery system of hydrogel to the root zone which also remains attached to the roots throughout life cycle of the plant (Table 1). These results were further re-validated in large scale field experiments with plot size of 15m²/treatment at ICAR-IARI Regional Station, Karnal in the wheat crop during *rab*i season 2014-15 (Table 2). The result showed significant seed yield penalty if first irrigation delayed beyond 25 DAS in the treatments without hydrogel coated seed as compared to control (normal irrigation schedule) which may be due to CRI factor but no such seed yield penalty was observed in hydrogel coated seed treatments when first irrigation delayed up to 35 and 45 DAS for both cultivars (HD-2967 & WR-544) under both date of planting (normal & late sown conditions) which confirmed the potential benefits of 'Novel hydrogel *katira* gel' coupled with seed hydro-priming cum hydrogel coating technology for mitigation of sub-optimal moisture stresses and water saving in

high volume major crop wheat under moisture stress limited irrigation conditions. These results are only initial indicative findings as field experiment got regular heavy rains 100 DAS causing non-significant differences (NS) among the treatments for various characters under studies but showed promises of comparable wheat seed yield (50q/ha) under delayed and limited irrigations with *katira* gel coated seed as compared to control with recommended full schedule of six irrigations.

Therefore the cost effective (₹300/kg), novel herbal hydrogel *Katira* gel based seed priming-hydrogel coating technology has shown the promises of effective mitigation of suboptimal moisture stresses with improved seed germination, seedling survival, plant growth, water use efficiency and no seed yield penalty in delayed and limited irrigation condition in wheat and other crops which will save considerable amount of water and make agriculture sustainable and resilient to climatic variability. Now, its intended to further evaluate and popularize the novel herbal hydrogel *Katira* gel based farmer's friendly seed priming cum hydrogel coating technology at large scale on the experimental fields and on-farm trials for various sustainable cropping systems including DSR, wheat, pulses oilseeds and other crops with new combinations of seed priming and new sources of the hydrogels.

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