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ENHANCING THE GROWTH AND PRODUCTIVITY OF WHEAT (*TRITICUM AESTIVUM* L.) USING PUSA HYDRO GEL AND FARM YARD MANURE

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ABSTRACT

A field experiment was carried out in the adopted villages of KVK in the Katra Block of Reasi district, Jammu region, during the winter (*rabi*) season of 2022–2023. Chak Bhagta and Kotli Bajalian Reasi SKUAST-Jammu, India to investigate the impact of farm yard manure and Pusa hydrogel on wheat (*Triticum aestivum* L.) growth and productivity. Three irrigation levels, viz., I1 [at crown-root initiation (CRI) stage], I2 (at CRI, booting and milking) and I3 (at CRI, late tillering, late jointing, flowering and milking stage), and 4 moisture-conservation practices, viz. application of Pusa hydrogel @ 5 kg/ha, farm yard manure @ 2.5 t/ha, Pusa hydrogel @ 5 kg/ha + farm yard manure @ 2.5 t/ha and no application, were tested in split-plot design, with 3 replications. Results revealed that, the growth parameters, viz. of plant height (103.8 cm), tillers/m, dry-matter accumulation (195.0 g/m), leaf-area index (3.15 and 3.23) and harvest index, of wheat were significantly higher under 5 irrigation levels than 3 and 1, being the lowest under 1 irrigation. The yielding wheat received 3 and 1 irrigations by 8.1 and 69.4%, respectively, whereas the wheat received 5 irrigations. Similarly, the straw yield of wheat cultivated with three and five irrigations was 5.84 q/ha and 26.65 q/ha higher, respectively. In the research trial, applying Pusa hydrogel at a rate of 5 kg along with 2.5 t of farm yard manure per hectare instead of applying none at harvesting produced 31.0% more dry matter production per hectare and 38.4% greater grain yield per hectare, respectively.

***Keywords*:** Irrigation, Nutrient content, Pusa hydrogel, Vermicompost, Yield, Yield attributes

Introduction

The domestic production of agricultural goods should rise in order to raise the contribution of agriculture in GDP and to ensure that the food system has access to a timely, dependable, and nutritionally appropriate supply of food.Since the population of India increased from 1.22 billion in 2013 to 1.34 billion in 2017 (till September 30), the per capita availability of land decreased from 0.34% to 0.12% (1961 to 2014). As a result, we can boost productivity by utilizing all of the land that is available to each individual. Despite India's 329 million hectares (about) of land, only about 143 million of those are used for cultivation. Of these 143, arid lands with low output make up more than 64%.The majority of the fertile land in our nation roughly 67% of the net planted area remains rainfed despite the agricultural sector's rapid development. Approximately 40% of the agricultural area still requires irrigation, even after the nation's maximum irrigation potential was reached through different government initiatives including the "Pradhan Mantri Krishi Sinchayi Yojna" and "Har Khet Ko Pani." As a result, the monsoon provides the primary source of livelihood security for much of the agricultural area throughout the nation. These rainfed areas are under significant pressure due to their growing population and rising food consumption. They do not have reliable irrigation for their crops and are running out of water for everyday household needs. To feed the growing population, the current productivity of rainfed regions must be increased from 1 t ha^{-1} to 2 t ha^{-1}. Natural resources are now severely burdened, which has resulted in overuse and low living standards in many regions. India is placed 41st out of 181 countries in terms of water stress, with 82% of its rural population living in rain-fed areas. The population that receives rainfed circumstances is particularly susceptible to the unpredictable nature of climate change, monsoon failure, and increased rainfall unpredictability. It has a negative effect on the rainfed region's cattle, crops, and human population, pushing people into extreme poverty on the whole. Given that agriculture uses the most water (85%) compared to industry (10%) and the home sector (5%), the effects of water shortage on agriculture are particularly noticeable in the context of climate change. A number of initiatives are being developed and planned to increase agriculture's water-use efficiency. Farmers are using a variety of techniques to manage the limited water supply, including mulching, ridge furrow methods, compartmental bunding, drip irrigation, mechanical measures of water harvesting, and alternate micro-irrigation methods like sprinklers and drip systems. Using hydrogel and anti-transpirants are two further techniques used to increase the water-use efficiency of agricultural systems. Hydrogel is a synthetic polymer used is soil amendment. Since hydrogel is insoluble, it can improve the availability of water for crop establishment and has significant potential in locations with limited irrigation opportunities. According to Johnson and Veltkamp (1985), hydrogel, also known as super absorbent polymer, is an amorphous polymer that is cross-linked, hydrophilic, biodegradable, and capable of retaining water at least 400–1500 times its original weight. It also makes at least 95% of the stored water available for crop absorption. The polymer functions as a slow release source of water in soil because it hydrates to form an amorphous gelatinous mass and can absorb and desorb over an extended period of time. The hydrogel particles in the soil can be thought of as "miniature water reservoirs," from which water is drawn out when roots require it due to an osmotic pressure differential. According to Johnson (1984), using hydrogel increases the quantity of moisture that is available in the root zone, suggesting that watering intervals should be prolonged. If hydrogel is allowed to dry up, it will lose its effectiveness; hence, irrigation is crucial to the hydrogel's durability. Applying hydrogel to the soil can be done by spraying it on or mixing it in. Pesticides and micronutrients can be combined with hydrogels while utilizing the spray approach. Improves the moisture content of the soil is humic acid. Both seed respiration and germination rate are increased by it. It also increases the respiration of leaves and roots as well as the amount of chlorophyll in leaves. It encourages the production of phenolic chemicals including flavonoids and anthocyanins, which may enhance plant quality and serve as a pest and disease deterrent. The final byproduct of pulverized bituminous coal (lignite) in thermal plant furnaces, fly ash is made up of partially burned coal's mineral components. Because fly ash is so effective at modifying soil health and crop performance, it has a lot of potential applications in agriculture. According to Pandey *et al*. (1994), fly ash-treated sunflower plants grew more rapidly.

FYM is the decomposing combination of farm animal feces and dung, litter, and leftover roughage or fodder that is fed to cattle. FYM has a composition of 0.5% N, 0.2% P2O5, and 0.5% K2O. Actinomycetes and bacteria are actively involved in decomposition. In the early stages, it has 60–70% moisture, while the decomposed manure has 30–40% moisture. In India, FYM is the most widely utilized organic manure.

Numerous studies have indicated the positive effects of hydrogel on soil characteristics and crop growth. In an alluvial sandy loam soil, hydrogel applied at a rate of 5 kg ha^{-1} in conjunction with farm yard manure (FYM) had a significant impact on the soil's hydrological parameters, including its relative field capacity, saturated hydraulic conductivity, field capacity, and plant accessible water content. Rice is grown in soggy conditions, and any form of water stress reduces rice output negatively. When rice was grown in an aerobic environment, the use of hydrogel increased both the overall yield and specific yield components. When hydrogel was treated at a rate of 5 kg ha^{-1} on a sandy loam soil, winter wheat's grain yield, nitrogen uptake, and water-use efficiency improved.

By using hydrogel as a conditioner, crop yields might be raised and water efficiency could be enhanced. When applied, the amount of irrigation needed for the best crop growth in the wheat-growing regions of India's northwest, central, and peninsular zones can be decreased without sacrificing grain production.

The majority of farmers in Reasi engage in rain-fed, low-input subsistence farming. Even though the area receives about 1100 mm of rain annually, the steep terrain, light soil (mostly sandy loam with 25–30% coarse pieces), and high penetration rates lessen the amount of rainwater that is stored in the soil profile. Water thus emerges as the primary constraint restricting crop productivity in this area. Winter rains are essential for crop growth throughout Rabi season; any deviation could result in crop failure as a whole. This context motivated the current investigation, which aims to determine how hydrogel application under field conditions affects Rabi wheat productivity and yield. In this agro-ecological zone, hydrogel as a soil conditioner was first presented, and it is a novel idea among the local farming community.

Hydrogel may prove to be beneficial in the Jammu region, which is located in the Reasi district beneath the Shivalik foothills and has delicate microclimatic conditions. Just 9% of the hill population's agricultural land is connected to irrigation systems, and most of their cultivation is subsistence-based. Water scarcity is therefore a big issue for farmers in the mountainous area. Hydrogel can be an excellent technological choice to boost agricultural production in the steep rainfed terrains, as the government is primarily focused on raising the water productivity of crops. In this study, farmers in the Katra block in the Reasi area of Jammu and Kashmir assessed the effects of hydrogel on wheat output and productivity.

Material and Methods

The current study was carried out in November 2022 in villages that KVK Reasi had adopted in the Katra Block of the Reasi district, in the Jammu region of Jammu and Kashmir. The hamlets of Kotli Bajalian and Chak Bhagta were chosen for this experiment. Kotli Bajalian (N320 58.902 E 74-54.69 with elevation of 2591m), (N320 57.78 E 74-57.45 with elevation of 2465m) Subtropical weather prevails, with hot, dry summers and chilly, dry winters. The area is in Jammu, India's maize-wheat crop zone, which is part of the "Shivalik Foot Hills" agroclimatic zone. Nearly 1358 mm of rain falls on average each year, mostly between mid-June and mid-September, with July and August seeing the highest concentration. In the remaining months of the year, there is sporadic minimal rain (less than 70 mm). During the summer, the typical relative humidity (RH) is 15%, whereas during the rainy season, it is 90%. In the area, the minimum temperature drops to 1°C during the winter, when there may be sporadic frost. The maximum temperature climbs to 44.3°C in May and June. The soil was sandy clay loam in texture, neutral in reaction (pH 7.2) with low organic carbon (0.44 g/kg) and available nitrogen (228 kg/ha) and medium in available phosphorus (16.2 kg/ha) and potassium (297 kg/ha). The electrical conductivity of the soil (0.34 d/Sm) was normal. The experiment was conducted in the farmer's field with two treatments: (a) wheat grown with hydrogel applied at the rate of 5 kg ha^{-1} (WH), (b) wheat grown without hydrogel (WHO). For each treatment ten demonstrations were established (each demonstration was a replication). The selection of the farmers was completely based on their interest to use hydrogel as a soil conditioner. Observations related to yield and productivity were taken from unit area (1 m^2) from each plot to maintain uniformity in observations. Soil samples were collected from surface (0–15 cm) of the study area.

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Pusa hydrogel, also known as Varidhar G1, is a polymer gel with a carboxymethyl cellulose basis that is produced by M/s Earth Internationals. The physical shape of hydrogel is a light yellowish-colored, loose, granular, powdery structure. The hydrogel attempts to form clumps and loses its ability to flow freely when it comes into touch with air moisture. As a result, all necessary measures were done to prevent any type of moisture contamination when applying hydrogel. Depending on the soil texture, the hydrogel dose recommended in the literature ranges from 2.5 to 5 kg ha^{-1}. For clayey soil that can store more moisture, a lower dose is advised; for sandy soil that can hold less moisture, a greater dose is advised. Due of the sandy loam nature of the experimental soil, a greater dose 5 kg ha^{-1} was utilized in this investigation. The farmer's field was treated with hydrogel using the broadcasting approach because, typically, they did not follow the line sowing procedure for crops. For uniform dispersion in the field, hydrogel was applied by mixing it at a ratio of one to ten with dry soil. Following application, it was blended with soil during the latter stages of site preparation to ensure even mixing in the top 15 cm of soil. Gel made of carboxymethyl cellulose degrades naturally over a period of two to five years in the soil.

The treatments comprised 12 combinations of the 2 factors, i.e. irrigation levels (3) as main plot factor, viz. 1 irrigation at [crown-root initiation (CRI) stage], 3 irrigations (at CRI, booting and milking stage) and 5 irrigations (at CRI, late tillering, late jointing, flowering and milking stage), and moisture-conservation practices (4) as subplot factor (control, Pusa hydrogel @ 5 kg/ha, FYM @ 2.5 t/ha and Pusa hydrogel @ 5 kg/ha + FYM @ 2.5 t/ha), were tested in split-plot design with 3 replications. Hydrogel is a synthetic polymer, insoluble, hydrophilic and can absorb large quantity of water. It has great potential in areas where opportunity for irrigation is limited and can increase the water availability during crop establishment. The capacity of the hydrogel to absorb and retain water is as much as 80- 180 times its original volume and releases absorbed water slowly. The hydrogels can also modify various physical properties of soil like infiltration rates, density, soil structure and compaction, etc. Pusa hydrogel was mixed with soil (1 : 10 W/W) and applied at the time of sowing in bands of the seed line with respective treatments @ 5 kg/ a. The well-rotten FYM (0.5% N, 0.6% P_2O_5 and 0.45% K_2O on dry-weight basis) collected from the University Instructional Livestock Farm was applied as per the treatments. The FYM (2.5 t/ha) was mixed with soil and applied 10 days before sowing during both the years. The experimental crop was grown with standard recommended package of practices for wheat during both the years. Wheat var. 'HD3043 was sown in rows, 20 cm apart at a depth of 5 cm using a seed rate of 100 kg/ha on 1st fortnight of November during 2017, respectively. Leaf-area index was measured by using leaf-area meter (LA-3100). The produce excluding root, of each net plot was allowed to sun-dry after harvesting and weighed to record the biological yield (grains + straw), plot-wise, and then converted into q/ha. After harvesting, threshing, cleaning and drying, the grain yield of wheat was estimated at 14% moisture content. The harvest index (HI) was computed as:

$$\text{Harvest index} = \frac{\text{Economic Yield (kg/ha)}}{\text{Biological Yield (kg/ha)}} \times 100$$

Thus, in our study, hydrogel was applied once during Rabi season of 2022 just before the sowing of wheat during final field preparation following the same methodology as described above. This requires a comparative study on relative performance of organic manure and hydrophilic polymer hydrogel on sunflower production under rainfed condition.

Soil-available nutrients and organic carbon content were estimated by using standard procedures as suggested by Prasad *et al.* (2006). The data were subjected to computer based statistical tools using OPSTAT program for split-plot design.

Results and Discussion

Growth parameters

Plant height, the number of tillers, and the yield of dry matter at crop harvesting were significantly impacted by irrigation levels and moisture conservation techniques in both years (Table 1). No matter the year, the irrigation that was applied five times showed itself to be better to irrigations that were applied three times and once in terms of tallest plants and largest number of tillers. In addition, a crop that had five irrigations had taller plants and 22.9% more tillers than a crop that received just one irrigation. When harvested, wheat with five irrigations had the highest mean dry matter (195.0 g/m row length) in the first and second years, respectively, compared to wheat with three irrigations. Similar outcomes were also noted by Sharma et al. (2020). In contrast, wheat that had just one irrigation at harvest time had the lowest mean dry matter accumulation (121.0 and 120.7 g/m, respectively) in the first and second years. Regardless of the year, the crop fertilized with Pusa hydrogel at 5 kg/ha + FYM at 2.5 t/ha had a noticeably higher maximum plant height than the other treatments. Nonetheless, during both years, the application of FYM at 2.5 t/ha outperformed the control at every stage, matching Pusa hydrogel at 5 kg/ha. Furthermore, at the harvesting stage, the increase in plant height under Pusa hydrogel at 5 kg/ha and FYM at 2.5 t/ha was 32.0% greater than the control. Similar findings were also noted by Joshi et al. (2013) in wheat.

Table 1 : Effect of irrigation levels and moisture-conservation practices on growth-parameters of wheat

Treatments	Plant height (cm) at harvesting	Tillers/m row length at harvesting	Dry-matter accumulation (g/m) at harvesting	Leaf-area index 90 DAS
Irrigation levels				
1 Irrigation at CRI stage	81.3	70.7	120.7	2.58
3 Irrigations at CRI, booting and milking	98.5	79.6	161.0	2.92
5 Irrigations at CRI, late tillering, late jointing, flowering and milking stage	103.8	91.2	195.0	3.23
SEm±	0,8	0.3	4.9	0.01
CD (P=0.05)	2.8	1.4	19.3	0.04
Moisture-conservation practices				
Control	78.8	78.2	151.2	2.65
Pusa hydrogel @ 5 kg/ha	97.3	80.6	180.5	3.03
FYM @ 2.5 t/ha	99.6	83.4	165.8	2.93
Pusa hydrogel @ 5 kg/ha +FYM 2.5 @ t/ha	103.5	85.2	198.5	3.05
SEm±	1.1	0.4	1.7	0.01
CD (P=0.05)	3.4	1.2	5.2	0.02

Leaf-area index

The data showed that the crop receiving five irrigations had the highest leaf-area index at 90 DAS (3.15 and 3.23), which was comparable to the crop receiving three irrigations. The leaf-area index was higher with FYM application at 2.5 t/ha than with the control, while it was lower with Pusa hydrogel application at 5 kg/ha. Additionally, at 90 DAS stage, the leaf-area index under Pusa hydrogel gel @ 5 kg/ha and FYM @ 2.5 t/ha was 3.05. Our findings closely match those of Jahangir and colleagues (2008).

Yield

With each increase in irrigation level, wheat yields/ha (grain, straw, and biological; Table 2) grew significantly. The crop getting five irrigations shown its superiority to record the largest grain yield when compared to three irrigations and one irrigation. Compared to one irrigation, there was a 69.4% increase in grain yield/ha under five irrigations. Even still, the wheat that only got one irrigation yielded the lowest grain yield of all the others. The next in line was three-time irrigation, which demonstrated noticeably higher yield than one-time watering at CRI, tillering, and jointing. However, wheat irrigated five times produced 15.8 q/ha more straw than wheat irrigated three times. Similar outcomes were also noted by Dhaliwal et al. (2020).

Regardless of the year, the combination of FYM @ 2.5 t/ha and Pusa hydrogel at 5 kg/ha produced the maximum grain production compared to each component alone. 38.4% was the rate of increase over the control. While the grain yield from the application of Pusa hydrogel at 5 kg/ha was much higher than that of the control, it was lower than that of FYM at 2.5 t/ha in both years. Similar findings in wheat were also reported by Tyagi et al. (2015). The straw yield of the crop fertilized with Pusa hydrogel at 5 kg/ha and FYM at 2.5 t/ha was 64.09 q/ha, which was significantly greater than the yield of the other crops, with the exception of FYM at 2.5 t/ha in both years. Despite the Pusa hydrogel's inclusion at 5 kg/ha. was at par with FYM @ 2.5 t/ha, while significantly superior to the control in recording the maximum straw yields.

Table 2 : Effect of irrigation levels and moisture-conservation practices on grain, straw and biological yields and harvest index of wheat

Treatments	Grain q/ha	Straw q/ha	Biological q/ha	Harvest index %
Irrigation levels				
1 Irrigation at CRI stage	26.58	50.37	76.95	38.48
3 Irrigations at CRI, booting and milking	41.63	56.21	97.84	42.55
5 Irrigations at CRI, late tillering, late jointing, flowering and milking stage	45.02	72.02	117.03	44.44
SEm±	0.47	0.68	1.12	0.18
CD (P=0.05)	1.82	2.67	4.58	0.71

Moisture-conservation practices				
Control	28.12	55.01	83.13	41.43
Pusa hydrogel @ 5 kg/ha	41.42	58.35	99.77	41.51
FYM @ 2.5 t/ha	43.17	60.68	103.85	41.56
Pusa hydrogel @ 5 kg/ha + FYM @ 2.5 t/ha	45.62	64.09	109.71	41.57
SEm±	0.68	1.52	2.52	0.08
CD (P=0.05)	3.00	4.50	7.60	NS

Furthermore, in both years, the control performed worse than the rest of its contemporaries. Our findings in wheat support the conclusions made by Singh et al. (2017). On the other hand, a significant increase in biological yield/ha was seen with increasing irrigation frequency. While applying five times as much irrigation to wheat produced a much higher maximum biological output (117.03 q/ha), the crop that had only one irrigation had the lowest biological yield (76.95 q/ha) when compared to the other irrigation levels. The highest biological yield was obtained when Pusa hydrogel at 5 kg/ha and FYM at 2.5 t/ha were applied together. This was in comparison to the control and Pusa hydrogel at 5 kg/ha. Even with the addition of FYM at a rate of 2.5 t/ha, the grain production was noticeably higher than with Pusa hydrogel at a rate of 5 kg/ha. Due to the addition of irrigation, the harvest index in wheat increased from 1 to 3. The beneficial effects of organic manures on grain, straw, biological yields, and yield-attributing characteristics may result from their direct provision of plant nutrients to plants following appropriate decomposition and mineralization, as well as their ability to solubilize fixed forms of nutrients in soil. These treatments' superior yield performance may be explained by increased moisture conservation or less competition, which will allow the treatments' yield qualities to manifest themselves more fully.

This may be related to the manures' crop-specific selectivity and moisture-saving properties, as previously documented by Ramasamy and Suresh (2011). According to Kalhapure *et al*. (2016), the application of hydrogel can preserve two irrigations in wheat without lowering grain production. While moisture conservation measures did not significantly alter the harvest index over the course of the year, the maximum and minimum harvest indices were, respectively, under combined application of Pusa hydrogel at 5 kg/ha coupled with FYM at 2.5 t/ha and control.

Therefore, the preliminary results suggest that the best option for increasing wheat crop yields and growth parameters is to apply three to five irrigations along with Pusa hydrogel at five kg/ha and farm yard manure at two and a half tons per hectare. However, more long-term research is required to provide a thorough and trustworthy recommendation.

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