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STUDY THE EFFECT OF HYDROGEL SUPERABSORBENT TECHNOLOGY ON YIELD OF AEROBIC RICE AND SOIL CHARACTERISTICS

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ABSTRACT

Due to limited availability of irrigation water in India it is important to increase irrigation efficiency and water productivity of crop and to exploit the existing water potential by reducing the losses of water and also ensuring better living condition for crop growth. The use of soil conditioner like super absorbent polymer (Hydrogel) has great potential to exploit the existing water in the soil for agricultural crops by increasing their production. It was developed for improving in water use efficiency of agricultural and horticultural crops under limited irrigation and rainfed conditions. Hydrogel can absorb and retain water 350 - 400 times of its original weight and make at least 95% of stored water available for crop absorption. It acts as a slow release source of water in the soil. Under rainfed condition, crops can better withstand drought condition without moisture stress. This will help to ensure uniform and healthy crop stand as well as achieve high crop yield. Taking the above fact in mind The Krishi Vigyan Kendra, Hazaribag has been conducted field experiments on hydrogel with paddy as a crop. The performance of hydrogel on production was carried out on paddy crop and effect on soil health during 2014 and 2015. The soil samples for soil fertility status were analyzed at initial and final stage of the crop with other technological observations. The three treatments as were: $T_{1:}$ is direct seeding @ 100 kg ha^{-1} seed + NPK (kg ha^{-1}) 80:40:20 with rainfed conditions, T_2: is direct seeding @ 100 kg ha^{-1} seed + NPK (kg ha^{-1}) 80:40:20 & use of hydrogel @ 2.5 kg ha^{-1} with rainfed conditions and T_3: direct seeding @ 100 kg ha^{-1} + NPK (kg ha^{-1}) 80:40:20 with irrigated conditions. As per the finding hydrogel 2.5 kg ha^{-1} with standard doses of fertilizers gave maximum yield, net profit and soil available nitrogen as compared to other treatments. The rain spell is irregular and rainfed farming is popular, the use of hydrogel may be better option to conserve the moisture in field and provide to crop respectively. Hydrogel application increases the productivity in the paddy crop in term of crop yield with environmental sustainability.

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INTRODUCTION

In India, Rainfed agro-ecologies contribute 60% of the net sown area, 66 % of the livestock. About 84-87% of pulses and minor millets, 80% of horticulture, 77% of oil seeds, 66% of cotton and 50% of cereals are cultivated under this region (Rainfed Authority 2014). The area comes under dry land farming condition is 85 m.ha (60% of total cultivated area), which receives average annual rainfall less than 1150 mm. Also more than 30 per cent of total geographical area of the country comes under low rainfall (less than 750 mm). About 84 districts in India fall in the category of low rainfall area. Average annual per capita availability of water in India was 1816 m^3 $year^{-1}$ in 2001 and it will be 1140 m^3 $year^{-1}$ in 2025 *(UNICEF 2013)*

A per capita availability of water less than 1700 m^3 is termed as a water-stressed condition while per capita availability below 1000 m^3 is termed as a water scarcity condition. It indicates that India is headed towards as becoming a country with water scarcity condition.

Hence, there is an urgent need for efficient water resource management through enhanced water use efficiency. As the water utilization is less in industrial (15%) and domestic (5%) sector as compared to agriculture (85%), and there are no further chances to reduce quantity of water in these sectors, the focus should be on agriculture sector for water saving without compromising crop production. India ranks 41st among the countries of the world with regard to water stress. More than 60% area is under dryland condition out of the net cultivated area. More than 30% area faces the problem of insufficient rainfall (Ground water year book 2010-11 and Times of India, 2013). Hydrogel may prove as practically convenient and economically feasible option to achieve the goal of agricultural productivity under water scarcity conditions. It can easily be applied directly in the soil at the time of sowing of field crops and in growth medium for nursery plantation. The low application rate of hydrogel is effective for almost all the crops in relation to soil type and climate of India (Sivapalan, 2006). The improvement in growth and yield attributing characters and yield of different field, ornamental and vegetable crops has been reported with the application of hydrogel (Islam *et al.,* 2011). Agricultural, hydrogel is not only option as water saving technology for irrigation, but it also have tremendous potential to improve physio - chemical and biological properties of the soil (El-Amir *et al.*, 1993). Bulk density, porosity and water holding capacity of the soil are improved with the application of hydrogel (Narjary *et al.*, 2013). Agricultural hydrogels are eco friendly, because they are naturally degraded over a period of time, without leaving any toxic residue in the soil and crop products *(Mikkelsen, 1994).* Hence application of hydrogel will be a fruitful option for increasing agricultural production with sustainability in water stressed environment.

Hydrogel can absorb more than 400 times its weight of water by this mode. When its surroundings begin to dry out, the hydrogel gradually dispenses up to 95% of its stored water (Wang and Gregg, 1990). When exposed to water again, it will rehydrate and repeat the process of storing water. This process can last up to 2-5 years, by which time biodegradable hydrogel decomposes. It increase in seed germination and the rate of seedling emergence, root growth and density and reduced soil erosion due to the reduction in soil compaction. They also increase biological/ microbial activities in the soil which increases the oxygen/ air availability in the root zone of plant (EI-Rehirn *et al*., 2004). Hydrogels help plants to withstand extended moisture stress by delaying onset of permanent wilting point and reduces irrigation requirements of crops due to the reduced water loss through evaporation. The water hold in root zone of crop, leaching of nutrients in the soil is also reduced.

Hydrogel is environmental friendly

The hydrogel are more biodegradable and therefore kinder to the environment (Nnadi and Brave, 2011).

It contains labile bonds either in the polymer backbone or in the cross- links used to prepare the hydrogel. The labile bonds can be broken under physiological conditions either enzymatically or chemically over a period of time. End products after degradation: CO2, water and Ammonia (Mikkelsen, 1994., L.O. *et al*., 2011). Irrigation water is becoming scarce and the world is looking for water-efficient agriculture. Increasing food demand and declining water resources are challenges for food security (Kreye *et al*., 2009). With decreasing water availability, rice production is needed to be switched towards water saving production systems. In the system of aerobic rice, especially adapted aerobic rice cultivars are grown under non-flooded or aerobic soils with supplemen-tary irrigation (Bouman, 2001; Bouman *et al*. 2005). Although aerobic rice has a great potential for saving water but all this is at the cost of severe reduction in yield. A less water availability at reproductive stage is found to be a reason for low yield of aerobic rice (Bouman *et al*., 2002). It is, therefore, obligatory to develop appropriate management strategies in order to make water available to maximize the income on sustainable basis. Aerobic rice is emerging water saving rice production system in which rice is grown like wheat or maize. Hydrogel acts as a reservoir to store and release a steady stream of water and nutrients which plants need to grow. Plant roots are able to absorb water from the crystal bead of hydrogel. Several previous studies showed that these are very useful under limited water conditions to cope with plant water needs (Henderson and Hensley, *1985;* Ingram and Yeager, 1987; Wang and Gregg, 1990). Application of hydrogel decreases the irrigation requirements of several crops by improving water holding capacity resulting in delay and onset of permanent wilting percent-ages under intense evaporation. An increase in water holding capacity due to hydrogel amendment significantly reduced the irrigation requirement of many plants (Taylor and Halfacre, 1986). The present study was done with the hypothesis that application of hydrogel in different rice sowing techniques will increase the yield and soil fertility status. The objective of the study was to determine the effect of hydrogel and chemical fertilizers on yield and yield components of aerobic rice with the best sowing technique. Declining water is a great concern in production of rice, because rice is more sensitive to water deficiency which restricts normal rice growth resulting in enormous economic loss. A field experiment was conducted to study the effect of hydrogel in different treatments. Application of hydrogel improved soil moisture contents in the treatment as compared to soil without hydrogel. More soil moisture contents met the crop water needs and increased the number of germinated seeds. As a conse-quence of more emergence and better stand establishment, the yield components were also improved increasing the yield of rice in hydrogel amended soil. However, sowing of rice with hydrogel amendment was found the most effective; it not only improved the performance of aerobic rice but also enhanced growth and yield of aerobic rice more than other treatments.

MATERIALS AND METHODS

Field experiments were carried out in the research demonstration farm area of the Krishi Vigyan Kendra, Hazaribag (Longitude 82°25′, Latitude 23°53′ and Altitude 614 m) on paddy (var Abhishek) under aerobic conditions with three treatments and three replications in kharif (summer mansoon) seasons of 2014 and 2015. The experimental soil is sandy loam, gently sloppy, acidic in nature with pH 5.8 to 6.0, poor in organic matter (less than 0.5%) poor in available nitrogen, poor in available/exchangeable phosphorus and medium to high in available/ exchangeable potassium. Agro climatic zone is central and North Eastern plateau region, agro ecological situation is rainfed. The average annual rainfall is 1200 mm, maximum temperature is 40.5°C, minimum temperature is 5.6°C and average relative humidity is 71%.

The three treatments were $T_{1:}$ is direct seeding @ 100 kg ha^{-1} seed + NPK (kg ha^{-1}) 80:40:20 with rainfed conditions, T_2: is direct seeding @ 100 kg ha^{-1} seed + NPK (kg ha^{-1}) 80:40:20 & use of hydrogel @ 2.5 kg ha^{-1} with rainfed conditions and T_3: direct seeding @ 100 kg ha^{-1}+NPK (kg ha^{-1}) 80:40:20 with irrigated conditions. The transplanting dates were 20th and 24th of July and harvested on 20th and 29th of November in 2014 and 2015 respectively.

Crop husbandry

Giving one deep ploughing with disc plough followed by cultivation and planking twice prepared the experimental field. Recommended dose of fertilizer (80-40-20 kg NPK ha^{-1}) was applied in the form of urea, die-ammonium phosphate and potassium chloride. All the P, K, and half of N were applied before sowing, and the second half of N was applied at panicle initiation stage, while 12 kg Zn ha^{-1} was applied in the form of zinc sulphate (Zn 35%) at the time of sowing.

The treatment 3 of the crop was irrigated as per the requirement to maintain moist field conditions. Irrigation was withheld about two weeks before harvesting when the signs of physiological maturity appeared. All other agronomic practices were kept normal and uniform for all the treatments. Harvesting was done manually in the second week of November, when panicles were fully ripened and threshing of crop from each plot was done separately.

Observations

Before the execution of experiment, the soil samples from 0-15 cm depth were collected for analyses of pH (Jackson, 1973), organic carbon percentage (Walkley and Black, 1934) available nitrogen (kg ha^{-1}) (Subbiah and Asija, 1956), available/exch. Phosphorus (kg ha^{-1}) (Olsen *et al*. 1954) and available potassium (kg ha^{-1}) (Hanway and Heidel, 1952). The experimental soil had initial (0-15 cm) pH 5.75, organic carbon

0.50%, available nitrogen 200 kg ha^{-1}, available/exch. Phosphorus 8.8 kg ha^{-1}, and available potassium 306.6 kg ha^{-1}. The phenological observations recorded were, no. of effective tillers hill^{-1} in treatment 1 is 10, in treatment 2 is 17 and in treatment 3 it is 16, effective tillers hill^{-1}. observed no. of spikelets panicle^{-1} were 255, 315 and 296 in the T_1, T_2 and T_3 respectively. The results have been supported by Harphool, 2012. The other recorded observation was test weight, yield q ha^{-1} and benefit and cost ratio. We got highest grain and test weight in the treatment 2 (application of hydrogel). The results were supported by Babaee *et al.*, 2013 All the data pertaining to the individual years were statistically analysed (Table 1&2).

Hydrogel application

Hydrogel was applied manually at the time of soil preparation at 2.5 kg ha^{-1}. Coarse rice variety abhishek was used as medium of trial with seed rate of 100 kg ha^{-1}. The rice crop was sown with a single row hand drill in lines at 22 cm spaced rows; seeds were planted on one side maintaining line to line distance 25 cm.

Soil Characteristics Studies

Soil samples collected from the plots at initial and after harvest of the crop were air dried and sieved from standard size sieves. These samples were analysed for pH, available N, P_2O_5 and K_2O as per the standard methods (Table 3 & 4) to determine the nutrient status of the initial and after completion of the experimentation.

Statistical analysis

The collected data were analyzed statistically using Fisher's analysis of variance technique and treatment means showing significant CD-values, SEM and CV at 5% probability level (Steel *et al.,* 1997).

RESULTS AND DISCUSSION

Yield and yield components

Application of hydrogel increases the no. of effective tillers hill^{-1}. It was highest in the hydrogel treatment (17) (Table 1). Similarly significant variation in no. of spikelet panicle^{-1} of rice was observed under different treatments. Maximum spikelet panicle^{-1} (312) of rice was measured in the treatment 2 in compared to the minimum spikelet of panicle^{-1} (255) in treatment 1. The results were supported by (Sendur *et al.*, 2001 and Yazdani *et al.,* 2007). Hydrogel application also improved test weight (1000 grain weight) of rice crop. Rice crop sown with hydrogel @ 2.5 kg ha^{-1} produced bold grains with highest test weight 23.18 g, while minimum (19.15 g) test weight was recorded in sowing with out hydrogel application in rainfed conditions (Table 2). Similar results were recorded by (Nazarali *et al.,* 2010 and Allahdadi *et al.,* 2005). As a consequence of improvement in all the yield contributors, hydrogel significantly increased the kernel yield of rice (5.50 t ha^{-1}) as compared to no hydrogel (4.0 t ha^{-1}). Water uptake is the first important event after sowing of seeds in the soil. A soil with optimum moisture contents is a good medium for seeds to germinate. Poor soil moisture level is often found the important reason causing destitution of crop establishment.

Higher soil moisture content in soil with hydrogel was observed. The results of the present study strongly agree with the previ-ous work done by (Akhter *et al.,* 2004) that the hydrogel addition in soil was effective in improving soil moisture availability and thus increased plant establishment. It is well documented that the addi-tion of hydrogel has the potential to improve plant vegetative growth by retaining more moisture contents (Choudhary *et al.,* 1995, Al-Harbi *et al,.* 1999). The addition of gel-polymer to sandy soil could change the water-holding capacity to be comparable to that of silty clay or loam soils Johnson (1984) and Huttermann *et al.*, 1999. The findings of the study are supported by the earlier work done by (Woodhouse and Johnson, 1991) who also reported the improved emergence rate and percentage by soil treated with hydrogel.

The use of chemical fertilizer improve crop yield as well as influence phyco-chemical and biological properties of the soil (Nayak *et al.*, 2015). Application of hydrogel significantly improved all the yield components i.e. no. of effective tillers

Table 1: Phenological data of the paddy crop

Treatment	No. of effective tillers/hill			Mean	No. of spikelet/panicle			Mean
	R1	R2	R3		R1	R2	R3	
T1	12	10	8	10	278	253	235	255
T2	15	19	17	17	298	335	321	312
T3	17	17	14	16	308	311	269	296
C.D.	NS				48.105			
SE(m)	1.925				11.932			
C.V.	24.000				7.132			

Table 2: Yield data of the paddy crop

Treatment	Test weight (100 grain wt.)			Mean	Yield (q/ha)			Mean
	R1	R2	R3		R1	R2	R3	
T1	21.15	19.00	18.55	19.15	21.15	19.00	18.55	19.15
T2	21.94	24.44	23.18	23.18	21.94	24.44	23.18	23.18
T3	23.09	22.96	19.98	22	23.09	22.96	19.98	22
C.D.	NS				2.213			
SE(m)	0.842				0.549			
C.V.	6.755				1.913			

Table 3: Soil data of the experiment

Treatments	Initial soil status					Final soil status				
	pH	O.C%	Available N (kg ha^{-1})	Available P(kg ha^{-1})	Available K (kg ha^{-1})	pH	O.C%	Available N(kg ha^{-1})	Available P(kg ha^{-1})	Available (kg ha^{-1})
T1	5.75	0.50	200	8.8	306.6	5.78	0.50	213.27	13.96	225.0
T2	5.75	0.50	200	8.8	306.6	5.60	0.52	218.8	8.40	190.0
T3	5.75	0.50	200	8.8	306.6	5. 53	0.53	215.8	8.45	180.0
C.D.	NS	NS								
SE(m)	76.502					71.905				
C.V.	161.877					161.551				

$hill^{-1}$, no. of spikelet $panicle^{-1}$ and 1000 kernel weight (g) and as a result higher kernel yield was obtained. Our find-ings are in line with those reported by (Yezdani *et al.,* 2007) who obtained more yield of soybean by hydrogel application in drought-prone soils. (Bhardwaj *et al.*, 2007) used water absorbents in sandy soils from arid and semiarid regions and reported as an important tool in increasing water use efficiency and crop production. The results of present study match with the findings of (Hayat and Ali, 2004) who stated that absorption of wa-ter by synthetic polymer and its effect on yield parameters helps to increase the yield of crops. It was also confirmed by the work of (Madiwalar and Prabhakar,1998). The results of sowing methods confirm the earlier work done by Mobley and Albers (1993).

Changes in soil characteristics

Data pertaining to soil analyses as influenced in the hydrogel treatment are presented in Table 4. There were no significant changes in pH level and available potassium at harvest stage over initial states data. It was good improvement has been observed in available nitrogen and available phosphorus at harvest stage samples over initial stage. This may by application of NPK and Zn (NaiK, 2014) besides hydrogel. In the hydrogel treatment available nitrogen improvement was highest. It was because of reduced N leaching losses from soil column with hydrogel application as compared to N fertilizer (Mikkelsen *et al.,* 1993). The findings were supported by (Magalhaes *et al.*, 1987), who found a remarkable reduction in NH_4 leaching due to the presence of hydrogel. Hydrogel application with fertilizers increases the productivity and soil fertility status.

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