<u>*Original Research Article*</u>

Potential effect of Hydrogel on Physical Properties and Nutrient content in Soil

Abstract

This experiment was performed at the Rajiv Gandhi South Campus, Barkachha (BHU) Mirzapur, as a pot culture study, during November to March 2019-20.This experiment in completely randomized design taking three replications with six treatments i.e. T_1: Control, T_2: 5 g kg^{-1} Hydrogel, T_3: 10 g kg^{-1} Hydrogel, T_4:15 g kg^{-1} Hydrogel, T_5:20 g kg^{-1} Hydrogel, T_6: 25 g kg^{-1} Hydrogel. Soil was incubated with different doses of hydrogel for 120 days duration. The samples were collected after incubation processed in laboratory and analyzed for physical and chemical properties of soil. the result showed that the application of hydrogel had a significant influence on the various soil properties, especially water holding capacity and bulk density of soil. Other soil properties which were significantly influenced were particle density, porosity, electrical conductivity, soil available nitrogen, phosphorus, potassium, calcium, magnesium and sulphur. However application of hydrogel did not influenced the pH of soil and organic carbon content in soil. The application of hydrogel at the rate of 25 g kg^{-1} showed the highest values of available N, P, K and S content in soil as well as the water holding capacity. In some soil properties the treatment containing 25 g kg^{-1} hydrogel was found statistically at par to that containing 20 g kg^{-1} hydrogel.

Key word: *Hydrogel, Polymer, Organic Carbon, Available nitrogen etc.*

1. Introduction

India is an agricultural country where in most of field rain fed agriculture is followed India is first among rain fed countries of the world in term of area. While in term of yield, it counts the lowest which is around 1 ton ha^{-1}. Though maximum cultivated area is under rain fed condition. More than 45% of cereals, 66% of oilseeds, and 75% of pulses are grown under rain fed conditions (Kalhapure et al. 2016).

The stress crunch of inefficient use of rainwater and irrigation water by rain fed crops is the countable problem in arid and semiarid regions. The water holding soil conditioners are mostly helpful where there is reduced water availability. Hydrogel is drilled in the soil before sowing the crop, it is well known that hydrogel can hold large quantities of water and help in checking of nutrients losses, which are free as and when expected by the plant and it might be that plant growth could be improved under scarce water and nutrient supply (Gehring and Lewis, 1980). Application of water-saving hydrogel (SAP) i.e. super absorbent polymer into the soil could be an effective way to increases nutrient use efficiency and both water in crops.

Hydrogel of water absorb water and support crop growth ensuring a higher productivity potential from the land. Significant production response could be expected by use of high-yielding varieties, irrigation and fertilizer application in combination of hydrogels (Kukal et al. 2014).Superabsorbent polymer are also called as slush powder, they can absorb and retain very large quantity of a liquid relative to its own mass. Its ability to absorb and retain water depends on the aqueous solutions ionic concentration. In distilled or deionized water, a hydrogel may absorb about 300 times its weight which is about 30 - 60 times of its own volume and it can become liquid up to 99.9%. But when it is put into a 0.9% saline solution, its absorption capacity drops to approximately 50 times of its weight(Horieet*al.,*2004).

Water scarcity has become a global concern because of increasing demands from industries, agriculture, urban inhabitation and increasing population. Also, because of ever changing climatic conditions these problems are further aggravating. The paucity of water and desertification in many arid and semiarid regions in India is increasing, this problem may be solved by use of hydrogels (Vundavallia, Ramesh, 2015).

Water stress is one of the key factors limiting crop growth and productivity, also in several areas environmental. This Hydrophilic polymers have greater ability in reclamation and restoration projects where post planting irrigation facility is limited and protecting plant. Indian soils are poor in terms of soil depth, fertility and organic carbon content in surface soils. Availability of soil moisture in off season or non-rainy month is a major concern. Although the soils are productive but because of scarcity of soil moisture we are unable to grow food year round. Application of hydrogel technology could supplement the water availability to crop.

2. MATERIAL AND METHOD

2.1 Experimental area and pot experiment

This experiment conducted as a pot culture study, during November to March 2019-20, after that laboratory analysis of the collected soil samples in the soil and water conservation Laboratory, Department of Soil Science and Agricultural Chemistry, Rajiv Gandhi South Campus, Barkachha, Banaras Hindu University, Mirzapur. The district stretches out between the centre Gangetic plain basin in the north and the Vindhyan range in the south. The southern bumpy parcels of eastern Uttar Pradesh, covering Mirzapur structures an unmistakable geological district called Vindhyachal level.

The pot experiment was performed to see the effects of Hydrogel on soil nutrients release in the rabi season and different doses of Hydrogel were applied in pot along with soil and it was incubated for four months. However the bulk of soil was obtained from the agricultural farm of, RGSC, Barkachha, Banaras Hindu University, Mirzapur.

2.2 Experimental Details

The experimental design for analysis the data CRBD (Completely Randomized Design) with 3 replication and 6 treatments each treatment required soil for pot experiment was 10 gram, this are following treatment denoted as T_1 Control (not application), T_2 (5 g kg^{-1} Hydrogel), T_3 (10 g kg^{-1} Hydrogel Hydrogel), T_4 (15 g kg^{-1} Hydrogel),T_5 (20 g kg^{-1} Hydrogel) and T_6 (25 g kg^{-1} Hydrogel).

2.3 Analyses of soil samples

The soil samples are analysis of different soil physical and chemical properties available in soil i.e. Bulk density and particle density, Water holding capacity, Porosity, Soil pH and EC as well as Organic Carbon, Available Nitrogen, phosphorus and potassium with micronutrients Sulphur, Calcium and magnesium through following scientifically applicable formula

2.4 Bulk density and particle density:

The bulk density was analyzed by

Bulk density (Mg m^{-3}) = Weight of soil (y - x)/$_{\text{Volume of solid and pores (z)}}$

Whereas,

Weight of pycnometer = x (g), Weight of pycnometer + soil = y (g), Volume of pycnometer = z (mL)

The particle density was calculated as per the procedure outlined by Black *et al.*, 1965

2.5 Water holding capacity

$$\text{Water holding capacity (\%)} = \frac{\text{Weight of water held by a soil}}{\text{Weight of oven dry soil}} \times 100$$

2.6 Porosity

$$\text{Porosity (\%)} = (1 - \text{Bulk density / Particle density}) \times 100$$

2.7 Soil pH and EC

The pH of soil was measured by pH meter (Chopra and Kanwar, 1982). The electrode of the conductivity meter was inserted in clear part of the suspension and the EC(Electrical conductivity) of the soil was measured and presented in unit dS m^{-1} (Sparks, 1996).

Organic Carbon

2.8**Organic carbon** content in soil was estimated by chromic acid wet digestion method (Walkley and Black, 1934)

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$$\text{\% Organic 'C' in soil} = \frac{\text{(B-S) x 0.003 x 10 x 1 x 100}}{\text{B x wt. of soil}}$$

Where,

B = Volume of 0.5 *N* FAS consumed for blank titration

S = Volume of 0.5 *N* FAS consumed for sample titration

2.9 Available Nitrogen, phosphorus and potassium

The available nitrogen content in the soil was estimated as per procedure outlined by Subbiah and Asija (1956). Available phosphorus content of soil was determined by Olsen's method (Olsen *et al*., 1954). The available potassium content in the incubated soil samples was estimated using neutral normal ammonium acetate as an extractant (Jackson*et al*, 1973) this formula are:-

$$\text{Available N (kg ha}^{-1}) = \frac{(S-V) \times 0.02 \times 14 \times 10^{6} \times 2.24}{1000 \times 5}$$

Whereas, S -Sample titration reading V -Blank titration reading

Available P (kg ha^{-1}) = (Absorbance x dilution factor x 2.24)/ Slope of the standard curve

Available K (kg ha^{-1}) = C x dilution factor x 2.24

2.10 Available calcium and magnesium

The available Ca^{+2} and Mg^{+2} was determined by complex metric titration method (Cheng and Bray 1951).

Ca or Ca + Mg (mgkg^{-1})= (R x Normality of EDTA x1000) / Aliquot (mL)

Where, R = volume (mL) of standard EDTA used in titration

2.11 Available Sulphur

Available sulphur content in soil was determined by Turbidity method (Chesin and Yein, 1951).

Available S (ppm) in soil = $\frac{\text{absorbance}}{\text{Slope of std curve}}$ x dilution factor

3. RESULT AND DISCUSSION

The bulk density of soil at different level of hydrogel ranged between 1.22 to 1.38 Mg m^{-3}. The maximum bulk density (1.38 Mg m^{-3}) was recorded in soils of control. While, the minimum bulk density (1.22 Mg m^{-3}) was recorded with application of 25 g kg^{-1} Hydrogel. From the data it is also clear that the bulk density decreased with the increased application of hydrogel. The bulk density obtained in treatment T_5 (20 g kg^{-1} Hydrogel) and T_6 (25 g kg^{-1} Hydrogel) was statistically at par similar studies The bulk density decreased in the present study with increasing the levels of hydrogel, this might be attributed to the storage of water due to hydrogel application and replacement of mineral matter with organic copolymer. Decrease in bulk density was also reported by Shiva Kumar, *et al*. (2018). The particle density of soil as affected by different level of hydrogel ranged between 2.52 to 2.64 Mg m^{-3}. The maximum particle density (2.64 Mg m^{-3}) was recorded in soils of control. However, the minimum particle density (2.52 Mg m^{-3}) was recorded in application of 25 g kg^{-1} Hydrogel. From the data it is also clear that the particle density decreased with the increased application of hydrogel it was presented by table 1.

The maximum water holding capacity (257 %) was found with the application of 25 g kg^{-1} Hydrogel as compared to 5 g kg^{-1} (243.8%), 10 g kg^{-1} (197.4), 15 g kg^{-1} (218.4%) and 20 g kg^{-1} (243.8%) hydrogel level. Analyzed data clearly revealed that the water holding capacity was increased significantly with the increasing levels of hydrogel. The results of present investigation strongly corroborate with the work done by Akhter *et al*. (2004) and Increase in water holding capacity of soil due to application of hydrogel was also reported by Pattanaik*et al*. (2015) and (Montesano *et al*., 2015).Analyzed data clearly revealed that the soil porosity was increased significantly and linearly with the increasing levels of hydrogel, Shiva Kumar *et al*., 2012) also reported higher porosity with higher doses of hydrogel in the soil it was showed by table 1.

The data clearly revealed that the maximum soil pH (6.78) was found with the application of 25 g kg^{-1} Hydrogel as compared to 5 g kg^{-1} (6.52), 10 g kg^{-1} (6.65), 15 g kg^{-1} (6.69) and 20 g kg^{-1} (6.75) Hydrogel. Analyzed data clearly revealed that the soil pH was increased non significantly with the increasing levels of hydrogel and soil Electrical conductivity was increased significantly with the increasing levels of hydrogel The basic cations mostly dissolved from minerals and organic matter substances might increase the soil electrical conductivity it was presented by table 1.

The maximum organic carbon (0.51 %) was found with the application of 25 g kg^{-1} Hydrogel as compared to as compared to 5 g kg^{-1} (0.36%), 10 g kg^{-1} (0.40%), 15 g kg^{-1} (0.45%) and 20 g kg^{-1} (0.51%) Hydrogel. Analyzed data clearly showed that the soil organic carbon was increased with the increasing levels of hydrogel as possible the data similar found by (Agaba, *et al*., 2010) it was displayed by table 2.

Available nitrogen (kg ha^{-1}) in soil was increased with increasing levels of hydrogel among different treatments. The maximum available nitrogen (152.7 kg ha^{-1}) was recorded with the application of 25 g kg^{-1}which was found to be statistically at par to (142.3 kg ha^{-1}) with the application of 20 g kg^{-1} Hydrogel this results analogues findings in Hydrogel application to soil minimizes macro and micronutrients from washing out to ground water tables and increases the water consumption efficiency; they may also reduce the quantity of nutrient fertilization, since the nutrient leaching in soil is limited by decreasing the runoff. The nutrients are released through soil nitrification (El-Hady, 1981)The maximum available phosphorus content (10.92 kg ha^{-1}) was recorded with the application of 25 g kg^{-1} Hydrogel as compared to 5 g kg^{-1} (8.23 kg ha^{-1}), 10 g kg^{-1} (9.09 kg ha^{-1}), 15 g kg^{-1} (10.3 kg ha^{-1}) and 20 g kg^{-1} (10.7 kg ha^{-1}) Hydrogel. Hydrogel application provides favorable condition for its solubilization and release from complex compound to soil solution.Available potassium content (kg ha^{-1})in soil is increased with increasing levels of hydrogel among different treatments. The maximum available potassium content (179.2 kg ha^{-1}) was recorded with the application of 25 g kg^{-1} Hydrogel which was found to be statistically at par to (160.5 kg ha^{-1}) with the application of 20 g kg^{-1} Hydrogel, Hydrogel provides favorable conditions for release of potassium from inter layer spaces, as well as its exchange from the clay colloids and increases its availability in soil. As there was not crop taken in the present investigation, there was no uptake of nutrient elements. Hence whatever released nutrients were there it remained in soil solution due to moist condition of soil. This might be a probable reason for the release of potassium from the soil and its increased availability in soil it was exposed by table 2.

Soil is increased with increasing levels of hydrogel among different treatments. The maximum available calcium content (11.8 mg kg^{-1}) was recorded with the application of 25 g kg^{-1} Hydrogel followed by (10.8 mg kg^{-1}) with the application of 20 g kg^{-1} Several researchers has reported that hydrogel-treated plants generally require 20% less fertilizer than untreated plants (Repac, *et al*., 2013), (Chen *et al*. 2012).Available magnesium content (mg kg^{-1})in soil is increased with increasing levels of hydrogel among different treatments. The maximum available magnesium content (10.7 mg kg^{-1}) was recorded with the application of 25 g kg^{-1} Hydrogel some researches the banding of polymer in the furrow had indicated that the total nutrient requirements for particular crop could be reduced, as the superabsorbent polymer tend to increase the reserve pool of nutrients in the rhizosphere soil and increase the uptake efficiency of the nutrient elements in the plant (Orzolek, 1991).AvailableSulphur content (mg kg^{-1})in soil is increased with increasing levels of hydrogel among different treatments. The maximum available sulphur content (10.7 mg kg^{-1}) was recorded with the application of 25 g kg^{-1} Hydrogel also reported Hydrogel forms a flexible envelope in soil, it mimics the effects of mucilages which are naturally exuded by roots of plants in order to maintain water and ion exchange processes in between the rhizosphere and the root system. Hydrogel application influences the growth of soil microorganisms and therefore may increase the availability of various organic and inorganic nutrients in soil (Landis and Haase, 2012) it was introduced by table 2.

4. CONCLUSION

Hydrogel or superabsorbent polymer is a very effective technology used in the dryland and rainfed agriculture. It can not only hold the water but provide it slowly and steadily. They help to increase the efficiency of irrigation, water productivity and water availability. The maximum bulk density (1.38 Mg m-3) was recorded in soils of control. Maximum water holding capacity (257%) was found with the application of 25 g kg-1 Hydrogel and soil porosity increased linearlywith the increasing hydrogel levels. The maximum soil pH (6.78) was found with the application of 25 g kg-1 Hydrogel. Electrical conductivity was increased significantly.

Available nitrogen (kg ha^{-1}) in soil was increased with increasing levels of hydrogel among different treatments. The maximum available phosphorus content (10.92 kg ha^{-1}) was recorded with the application of 25 g kg^{-1} Hydrogel as compared to 5 gkg^{-1} hydrogel. Hydrogel provides favorable conditions for release of potassium from inter layer spaces, as well as its exchange from the clay colloids and increases its availability in soil. The maximum available potassium content (179.2 kg ha^{-1}) was recorded with the application of 25 g kg^{-1} Hydrogel. The maximum available calcium content (11.8 mg kg^{-1}) was recorded with the application of 25 g Hydrogel followed by magnesium (10.7 mg kg $^{-1}$). The maximum available sulphur content in soil is increased with increasing levels of hydrogel among different treatments.Hydrogel forms a flexible envelope in soil, it mimics the effects of mucilages which are naturally exuded by roots of plants. It may increase the availability of various organic and inorganic nutrients in soil. Available Sulphur content (mg kg^{-1})in soil is increased with increasing levels of hydrogel.

5. REFERENCES

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Table 1 Effect of Hydrogel on soil Bulk Density, Particle Density, water holding capacity, Porosity, pH and electrical conductivity (EC)

Treatments	Bulk Density (Mgm^{-3})	Particle Density (Mgm^{-3})	WHC (%)	Porosity (%)	pH (1:2.5 Soil - Water)	EC (dS m^{-1})
T_1 - Control	1.38	2.64	38.3	47.7	6.47	0.065
T_2–5 g kg^{-1} Hydrogel	1.37	2.62	167.9	47.8	6.52	0.069
T_3 - 10 g kg^{-1} Hydrogel	1.35	2.60	197.4	48.0	6.65	0.087
T_4 - 15 g kg^{-1} Hydrogel	1.28	2.57	218.4	50.1	6.69	0.097
T_5 - 20 g kg^{-1} Hydrogel	1.24	2.55	243.8	51.4	6.75	0.099
T_6 - 25 g kg^{-1} Hydrogel	1.22	2.52	257.0	51.7	6.78	0.109
SEm±	0.007	0.008	1.664	0.35	0.040	0.004
CD (P=0.05)	0.022	0.024	5.184	1.08	NS	0.012

Table 2 Effect of Hydrogel on soil Organic carbon and available nitrogen, phosphorus, potassium, calcium, magnesiumand sulphurcontent in soil

Treatments	Organic carbon (%)	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Ca (mg kg^{-1})	Mg (mg kg^{-1})	S (mg kg^{-1})
T_1 - Control	0.33	113.7	6.07	93.3	8.1	8.5	2.20
T_2 - 5 g kg^{-1} Hydrogel	0.36	127.5	8.23	112.0	8.7	9.1	2.46
T_3 - 10 g kg^{-1} Hydrogel	0.40	135.8	9.09	123.2	9.7	9.6	2.59
T_4 - 15 g kg^{-1} Hydrogel	0.45	137.7	10.3	134.4	10.4	9.8	2.73
T_5 - 20 g kg^{-1} Hydrogel	0.46	142.3	10.7	160.5	10.8	10.5	3.92
T_6 - 25 g kg^{-1} Hydrogel	0.51	152.7	10.9	179.2	11.8	10.7	4.53
SEm±	0.041	0.855	0.51	0.871	0.175	0.420	0.377
CD (P=0.05)	NS	2.79	1.59	2.715	0.545	1.309	1.174