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# CHARACTERIZATION OF SWELLING BEHAVIOUR OF NANOCLAY COMPOSITE

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**Abstract**: Water sorption capacity is an important characteristic for nano clay composite (NCC) super absorbents especially when used under rainfed condition. The Zn coated nano clay composite cross-linked polyacrylamides polymers were synthesized by polymerization reaction with 10% acrylic acid, acrylamide, 0.9% ammonium persulphate as initiator, 0.12% N, $N^{/}$ methyl biscrylate as cross linker loaded with 8% benitonite clay and 10 % Zn citrate at $65^{0}$C reaction temperature. The water absorbency of product had 165.7 g/g in tap water, 183.0 g/g in distilled water and 74.3 g/g in 1% NaCl solution. Water-holding capacity of the soil with NCC was 8.5% more as compared to original soil.

**Keywords**: nanoclay composite, water absorbency, swelling, retention, superabsorbent

## I. INTRODUCTION

Nanotechnology has many applications in the field of agriculture. In dryland areas, variation in amount and distribution of rainfall mainly influence the crop production. Out of 143 million hectare of total cultivated area in the country, 101 million ha (*i.e*. nearly 70 percent) are rainfed. The dryland areas of the country contribute about 42 percent of the total food grain production. Soil moisture is the most critical factor for the failure of second crop after rice under rainfed condition. Moisture stress is a restrictive factor for crop production in arid and semi-arid regions because of low and uncertain rainfall (Hayat and Ali 2004). Super absorbent materials (SAMs) are hydrophilic polymer complexes that have potential to absorb large volumes of aqueous fluids within a short time and under stress conditions can desorbs the absorbed water. Super absorbent polymer can hold 400-1500 g of water per dry gram of hydrogel (Bowman and Evans, 1991; Woodhouse and Johnson, 1991). All type of hydrogel when use correctly and in ideal situation will have at least 95% of their stored water available for plant absorption (Johnson and Veltkamo, 1985). Woodhouse and Johnson (1991) classified polymers into 3 groups: starch-polyacrylonitrile graft polymers (starch co-polymers), vinyl alcohol-acrylic acid co-polymers (polyvinylalcohols) and acrylamide sodium acrylate co-polymers (cross-linked polyacrylamides). Loosely described as super absorbents, these substances can hold up to a thousand times their own weight of water (James and Richards, 1986). When mixed with the soil, they form an amorphous gelatinous mass on hydration and are capable of cyclical absorption and desorption over long periods of time, hence acting as a slow-release source of water and dissolved nutrients in the soil. Under rain fed conditions they may be expected to increase the survival of seedlings by increasing the time to wilting between rainfall events. Under certain conditions this may lead to increased yields. The application of super absorbent polymer has a significant impact in reducing drought stress effects and to improve plants yield and stability in agriculture production (Khadem *et al*., 2010).

On the basis of the above background the present study focused on the water holding capacity, water absorbency and water retention capacity of a Zn coated nano clay composite cross-linked polyacrylamides polymers developed for promotion of rainfed rice crop.

## II. MATERIAL AND METHODS

The Zn coated nano clay composite cross-linked polyacrylamides polymers were developed in the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during 2012-13. Nano-clay–composites (NCC) super absorbent were synthesized by polymerization reaction with 10% acrylic acid, acrylamide, 0.9% ammonium persulphate as initiator, 0.12% N, $N^{/}$ methyl biscrylate as cross linker loaded with 8% benitonite clay at $65^{0}$C reaction temperature in presence of nitrogen gas. Just before polymerization reaction 10 % of zinc citrate was added which leads to the synthesis of Zn –coated NCC. The dried polymerized sample was

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further crushed in a heavy wooden mortar and pastel into a fine powder. This product was tested for water sorption properties in order to explore its usefulness in rainfed rice crop.

A. *Water holding capacity of soil*

Finely grind 0.5 g of synthesized nanoclay composite (NCC) was mixed with 50 g of dry 2 mm sieved soil in a keen's box and weighted ($W_1$). The box was kept over a petri dish added with water. The assembly was kept for 24 hours and weights the box again when there was no water seeping out at bottom. The control experiment *viz.*, with no NCC only soil and soil with FYM, was also carried out. The water holding capacity of the soil was calculated using following equation:

$$W\ \% = 100 \times (W_2 - W_1) / (W_2 - W_1 + 50)$$

B. *Water absorbency measurement*

A series of tea bags containing an accurately weighed dry finely powdered Zn coated NCC sample (1 g) were immersed in distilled water, tap water and 1% NaCl solution at room temperature for 24 hours. Swollen samples were then separated from unabsorbed water by filtering and hung up for 15 min until no liquid was dropped off from the sample. The water absorbency, Q of samples was calculated according to following equation:

$$Q = (m_2 - m_1) / m_1$$

Where $m_1$ and $m_2$ are the weights of dry sample and swollen sample, respectively. Q was calculated as grams of water per gram dry hydrogel (g/g).

C. *Water-retention in soil*

A finely powdered 0.5 g sample of nanoclay composite (NCC) was mixed with 50 g of dry soil (below 2 mm in diameter) and kept in a beaker and then 50 mL of tap water was slowly added into the beaker and weighed ($W_1$). A controlled experiment, i.e., without NCC only finely grinds dry soil sample and another treatment, soil with FYM was also carried out. The beakers were maintained at room temperature and were weighed every 5 days (Wi) interval over a period of 30 days. The water evaporation ratio (W %) of soil was calculated using the following equation:

$$W\ \% = 100 \text{ X } (W_1 - W_i) / 200$$

## III. RESULT AND DISCUSSION

*A. WATER-HOLDING CAPACITY OF THE SOIL*

The experiment results indicated that the water-holding ratio of the soil with NCC and soil with FYM was 8.5% and 3.5% higher respectively, when compared to original soil. This showed that the NCC had excellent water absorbency in soil, could obviously improve the water holding capacity and water use efficiency of the soil. The NCC could efficiently store rainwater or irrigation water resources to 160 to 180 times of its weight. This was one of the significant advantages over the conventional coated slow-release fertilizers.

*B. WATER ABSORBENCY*

The water absorbency rate of NCC was observed higher in distilled and tap water compared to 1% NaCl solution (Fig. 1). The swelling and shrinkage behavior of the developed NCC superabsorbent was greatly influenced by the characteristics of external solution such as charge valencies and salt concentration. The osmotic pressure difference was the most important factor. The increasing osmotic pressure of the external solution with the increasing concentration of the NaCl solution led to the reduction of the osmotic pressure difference between internal and external of superabsorbent, which lowered the swelling rate and reduced the swelling capacity.

*C. WATER-RETENTION BEHAVIOR OF NCC IN SOIL*

The water desorption rate of soil with NCC was lower compared to the soil without it and soil with FYM. The water release ratio of soil without NCC reached 62.3 and 90.2 wt% on the 15th and 30th days, respectively and soil with FYM reached 59.6 and 82.6 wt% on the 15th and 30th days, while that of the soil with NCC was 55.7 and 78.6 wt%, respectively (Fig. 2). The time needed for 50.0 wt% water evaporation was 12.2 and 13.5 days for the soil without NCC and with FYM respectively, while it was 14.6 days for the soil with NCC. The soil moisture desorption curve indicated that after 20 days, the volumetric water content of the soil without application of NCC was 9.8 % and with FYM was 11.4 %, while that of the soil with NCC was 21.4 %. Thus, NCC had good water-retention capacity in soil, and that with NCC use water can be saved and managed so that they can be effectively used for the growth of plants. These results showed that the NCC had excellent water absorbency, water-retention, and moisture preservation capacity. The reason was that the superabsorbent polymer NCC could absorb and store a large quantity of the water in soil, and allow

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the water absorbed in it to be slowly released with the decrease of the soil moisture. The swollen NCC was just like an additional nutrient reservoir for the plant-soil system. Consequently, it prolonged irrigation cycles, reduced irrigation frequencies, and strengthened the ability of plants to tolerate drought stress.

## IV. CONCLUSIONS

The experiment showed that synthesized Zn coated NCC product had a water absorbency of 165.7 in tap water, 183.0 g/g in distilled water and 74.3 g/g in 1 % NaCl solution. Water-holding capacity of the soil with NCC was 8.50% and 3.5 % higher than soil without NCC and soil with FYM, respectively. The results of experiment showed that the product has excellent water-retention capacity which could be especially useful in rainfed agriculture.

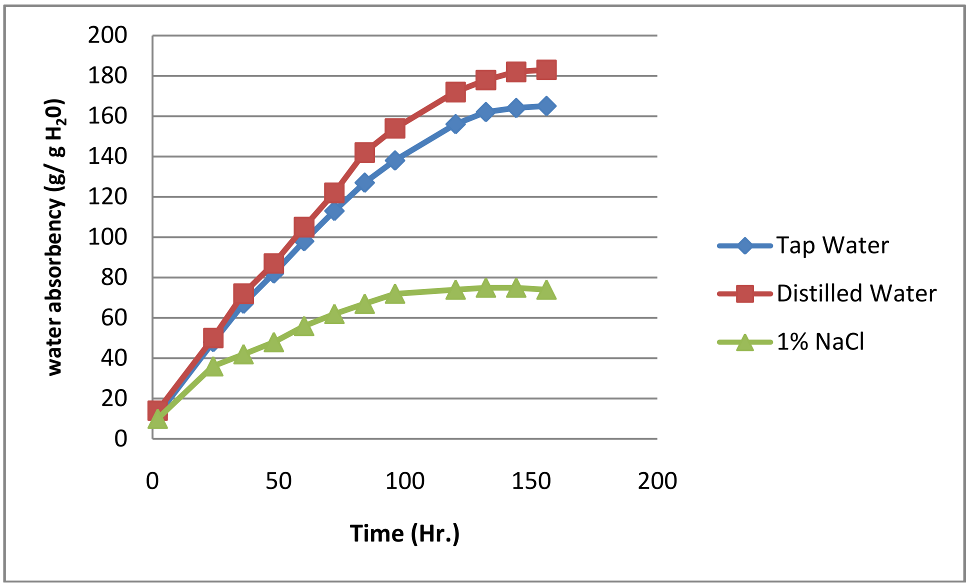


**FIGURE 1. Water absorbency of Zn coated nanoclay composite**

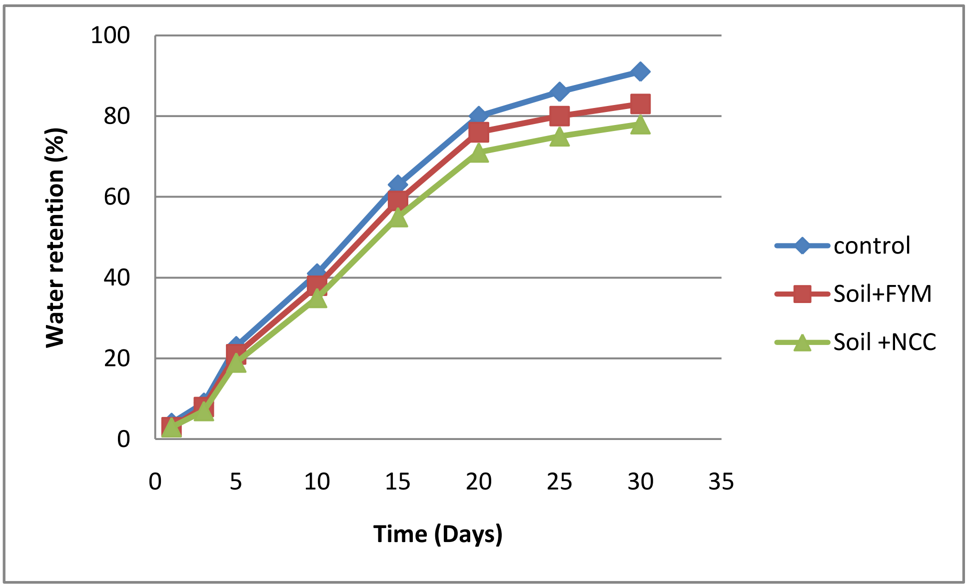


**FIGURE 2. WATER RETENTION OF ZN COATED NANOCLAY COMPOSITE**

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