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To study the effect of different salt solution on swelling behaviour of Nano clay polymer composite superabsorbent

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Abstract
The benefits of superabsorbent composite application in agricultural or forest areas with dry weather to improve water resource ‘ management efficiency’ were studied using a novel superabsorbent composite (NCPC) with high swelling properties was synthesized by polymerization reaction with 10% acrylic acid, acrylamide, 0.9% ammonium per sulphate as initiator, 0.12% N,N’- methylene bis acrylamide as cross linker loaded with 10% Pure, FYM modified and CTAB modified Montmorillonite clay at 65^0C reaction temperature in presence of nitrogen gas. Modified clay imparts slow release property and enhances the water holding capacity of soil. The Superabsorbent prepare were characterized by swelling behaviors of the superabsorbent were also investigated. Results showed that the proper amount incorporation of FYM modified montmorillonite could form a loose, porous surface and improve the water absorbency, swelling rate, salt resistant property and water retention capacity. The found maximum water absorbency for T4 (179.09g/g) Hot water FYM extract modified Montmorillonite clay was higher than T3 (141.61g/g) Pure Montmorillonite clay in distilled water. The present study focus on the water absorbency decreased with increasing the concentration of NaCl, CaCl2 and FeCl3 salt solution from 0.01M to 1M for all the samples. The swelling behaviour of the superabsorbent was depends on % loaded of P concentration in NCPC. When added of superabsorbent composites in soil exhibited good water retention ability i.e. for extra 16 day compare than no application of superabsorbent. According to the performance eco-friendly NCPC as a superabsorbent, it can be use as a promising candidate for application in various fields like rainfed and drought condition.

Keywords: superabsorbent, swelling behaviour, salt sensitivity and water retention

Introduction
Superabsorbent polymers are three-dimensional cross-linked hydrophilic materials that can absorb and retain large amounts of water, salt solution and other liquid up to thousand times their own weight even under some pressure compare to general absorbents. Therefore, superabsorbent have great advantages over traditional water absorbing materials and their exhibited potential application in many fields such as agriculture Chu *et al*., (2006) [5] Pouci *et al*., (2008) [31] Raju and Raju, (2001) [33], Horticulture Swain *et al*., (2013) [37], waste-water treatment Li and Wang (2005) [17] Wang *et al*., (2008) [38] and Kasgoz *et al*., (2008) [13], hygienic products Kamat and Malkani, (2003)[12] and Kosemund *et al*., (2009) [15] and drug delivery Omidian *et al*., (2005) [27] and Sadeghi and Hosseinzadeh, (2008) [35] etc. When hydrogel add to soil which help speed absorption, more retention of water and improve the fertilizer retention capacity, which promotes the germination of seed and plant growth Kazanskii and Dubrovskii (1992) [14] and Mohana and Padmanabha, (2001) [24]. Introducing of clay minerals into polymer composites has been long interesting subject of scientific research and industrial application because the incorporation of clay minerals can reduce production cost, improve the strength, stiffness properties of superabsorbent and improve the performance of material Ray and Okamoto, (2003) [34] Liu, (2007) [21] and Bergaya *et al*., (2006) [3]. Because of its low cost and unique properties such as good water adsorption, high swelling and cation exchange capacity montmorillonite as inorganic layered clay is the interested of researchers Pavlidou and Papaspyrides, (2008) [28] and Marandi *et al*., (2011) [23]. But Montmorillonite lack affinity with organic polymer because of their hydrophilic nature. To obtain good interfacial adhesion, mechanical and other properties, the hydrophilic clay needs to be modified prior to its introduction in polymer matrices which are hydrophilic Garcia-Lope *et al*., (2003) [8]. The absorption capacity of superabsorbent hydrogel can be significantly affected by several factors

in external solution such as salts concentration and its valence. Recently, the studies of organic and inorganic superabsorbent nano composites have become a very important field because of their excellent properties like, relatively cheap coat, enhanced salt resistance, swelling capacity, absorbency rate and retention of water Wu *et al*., (2003) [40] and Li *et al*., (2007) [18]. Superabsorbents have more water absorbing abilities and the slow releasing properties may make them useful in agricultural applications especially in the area of water management Li *et al*., (2007) [19]. Superabsorbent composites with 10 wt-% organo-montmorillonite clay exhibit better water absorbency and gel strength than composites without organo-montmorillonite clay Zhang *et al*., (2016) [45]. The effect of modified Montmorillonite on the water absorbency ability in distilled water was discussed. Furthermore factors, Swelling behaviors of the nano clay polymers composite as a superabsorbent in water absorbency, and retention capacity were examined. Finally effect of various cationic salt solution and loaded of P on water absorbency were also systematically evaluated.

Materials and Methods

Experimental

Preparation of Nano clay polymer composite (NCPC)

According to Liang and Liu (2007) [20] standard procedure preparation of NCPC is as follow: The P coated nano clay polymers composite were developed in the soil physics lab, Department of soil science & agricultural chemistry, Institute of agricultural sciences, BHU, Varanasi during 2014-2015. Nano clay polymer composite (NCPC) super absorbent were synthesized by polymerization reaction with 10% acrylic acid, acrylamide, 0.9% ammonium per sulphate as initiator, 0.12% N,N'- methylene bis acrylamide as cross linker loaded with 10% Pure Montmorillonite clay, 10% Hot water FYM extract modified Montmorillonite clay and10% CTAB modified Montmorillonite clay at 65 ^{0}C reaction temperature in presence of nitrogen gas. Just before polymerization reaction 10%, 15% and 20% potassium dihydrogen phosphate (KH_2PO_4) was added which lead to synthesis of P coated nano clay polymer composite. The dried at 100^{0}C temperature to a constant weight. Finally, drying, grinding and screening of samples were done. This sample product was tested for swelling properties and retention capacity of NCPC.

Fig 1: Swelling of superabsorbent composite (NCPC)

Table 1: Treatment details

T_1	Pure Montmorillonite clay + NCPC with P @ 10%
T_2	Pure Montmorillonite clay + NCPC with P @ 15%
T_3	Pure Montmorillonite clay + NCPC with P @ 20%
T_4	Hot water FYM extract modified Montmorillonite clay + NCPC with P @ 10%
T_5	Hot water FYM extract modified Montmorillonite clay + NCPC with P @ 15%
T_6	Hot water FYM extract modified Montmorillonite clay + NCPC with P @ 20%
T_7	CTAB modified Montmorillonite clay + NCPC with P @ 10%
T_8	CTAB modified Montmorillonite clay + NCPC with P @ 15%
T_9	CTAB modified Montmorillonite clay + NCPC with P @ 20%

Measurement of water absorbency of NCPC

Measurements of equilibrium water absorbency were performed at room temperature according to a conventional filtration method Irani *et al*., (2014) [10] series of small tea bag containing an accurate dry weight of finely powdered NCBPC samples (0.1g) were immersed in distilled water, at room temperature. Swollen samples were weighted at different time interval up to it reached a constant Weight. The Swollen samples separated from water at different time by filtering and hung up for 15 min. until no liquid was dropped off from the sample. The water absorbency, Q of sample was calculated according to following equation;

$$Q = \frac{M_2 - M_1}{M_1}$$

Where, M1 and M2 are the weight of dry sample and swollen sample, respectively. Q was calculated as grams of water per gram dry hydrogel (g/g).

Measurement of water absorbency of NCPC in various saline solutions

Accurately weighed 0.1 g sample was immersed in 250 mL of various saline (NaCl, $CaCl_2$ and $FeCl_3$) solutions with different concentrations for 30 and 60 minutes to maintain equilibrium. The swollen samples were filtered through a 100-mesh screen and weighed. The water absorbency in various saline solutions could then be calculated using eqn. (1).

Measurement of Water Retention in soil

The determination of the water retention was carried out according to the following procedure Qi *et al*., (2007) [32] for measurement of water retention percent we take a pot which was perforated at the base and filled it with 50gm soil and add 0.1gm NCPC. After then put it in a water tub so the soil reached at saturation. Then remove the pot from water tub. After then weight it. Now we take weight of this soil every day up to it reach their initial. Then using the following formula we calculated the water retention percent of it. Formula is:

$$WR\% = \frac{W_t - W_i}{W_{eq} - W_i} \times 100$$

Where, WR% = percent water retain.
Wt. = weight at different time.
Wi = initial weight.
Weq.= equilibrium weight.

Statistical analysis

The data were subjected to one way analysis of variance (ANOVA) using SPSS version 23 software. Duncan's multiple range test (DMRT) was performed to test the significance of difference between the treatments. In the summery tables of the results, the standard error of mean (Sem ±) and the value of critical difference (CD) to compare the difference between the means have been provided. The data were calculated opstat software.

Results and discussion

Water absorbency and equilibrium water absorbency of NCPC in distilled water

Clay play an important part in influencing properties of superabsorbent NCPC because reaction between the clay and the monomer that form the superabsorbent composite polymeric network. Three type of clay were introduced into polymer network to investigate the effect of clay type on the Water absorbency and equilibrium water absorbency as influenced by different treatment were presented in the figure 2 and 3. The absorbency found maximum was T4 (179.09 g /g). Followed by T5 (175.31 g /g) and the minimum found was T3 (141.61g /g). It also found that initially the rate of water absorbency was very fast than it decline. It will known that the swelling rate of superabsorbent composites was significantly influenced by the chemical composition, the swelling ability, the particle size, the surface area as well as and the density of the superabsorbent (Pourjavadi and Salimi, 2008 [30] and Buchanan *et al*., 1986) [4]. But according to Flory's theory (1953) [7] the water absorbency of gel depends on ionic osmotic pressure, cross linking density and affinity of the gel for water. During the initial 50 min, the swelling rate was higher than that of later swelling process. As the swelling process continuing, the swelling rate was reduced, and the curves of the swelling rate became flatter and swelling equilibrium could be finished within 60 minutes then after decline. Within 50 min T4 swell 83.60% and all other treatments also show same trend. The incorporation of modified montmorillonite can improve the surface structure and increasing the surface area of superabsorbent and this make water more easily diffuse into the polymeric network and lead to the increase swelling rate of superabsorbent. The swelling capability of the superabsorbent can be obtain in follow order; FYM modified montmorillonite >CTAB modified montmorillonite> pure montmorillonite. So we concluded that due to modification of clay and add of modified of clay into polymer it increase the water absorbency of NCPC. Zhang *et al*., (2016) [45] similar results found Superabsorbent composites with 10 wt-% organo montmorillonite clay exhibit better water absorbency and gel strength than composites without organo montmorillonite clay. Lee *et al.,* (2004) [16] reported that add of small amount of montmorillonite into copolymeric gel to increase water absorbency. Guo *et al.,* (2005) [9] Sarkar *et al.,* (2013) [26] and Jatav *et al.,* (2013) [11]. Are reported that the high water absorbency with time is probably due to additional polymeric network and hydrophilic interaction between clay and polymer increase the network to hold a large amount of water. This suggested that the changes in polymeric structure and surface area resulting from the introduction of modification of clay can not only improve swelling rate but also enhancing the water absorbency of NCPC.

Effect of salt solution on water absorbency of the NCPC

The effect of saline on the water absorbency of the superabsorbent is especially significant for its practical application as a water-manageable material and agricultural applications. Salinity has a well-known influence on the swelling properties of superabsorbent polymer. In this paper, the effect of the concentration of the chloride saline solutions on the swelling behavior of the superabsorbent polymer was investigated. We found the maximum water absorbency with salt concentration 1M in NaCl, CaCl2 and FeCl3 was in T4 (118.82 g/g), T4 (111.45 g/g) and T4 (102.39g/g) respectively and minimum was T3 (67.53), T3 (55.03) and T3 (37.92g/g), respectively. With decrease salt concentration increase the absorbency and at the salt concentration 0.01 M the maximum water absorbency in NaCl, CaCl2 and FeCl3 was T4 (148.95 g/g), T4 (141.19 g/g) and T4 (135.25g/g) respectively, and minimum found was T3 (92.65), T3 (82.55) and T3 (73.89g/g), respectively in both case in after 30 and 60 minutes time interval. Table 2, 3 and 4 illustrate the influence of NaCl, CaCl2, and FeCl3 aqueous solutions on the water absorbency of the superabsorbent nano clay polymer composites incorporated with 10 wt% pure, FYM modified and CTAB modified montmorillonite, respectively. The result indicated that the water absorbency decreased with increasing the salt solution for all the samples. Zhang *et al*., (2016) [45] obtain similar result the experimental results indicated that the water absorbencies decreased with increasing the concentration of the salt solutions for all the samples. Ma *et al*., (2015) [22] Obtain similar result the swelling capacity at equilibrium decreased as the concentration of the external saline solution increased. The reason may be that the increasing saline concentration led to the reduction of the osmotic swelling pressure difference between the polymer matrix and the external solution, which prevented water molecules from penetrating inside the hydrogel Zhou *et al.,* (2013) [47]. A screening effect of the additional cations from the salt solutions caused a non-efficient anion-anion electrostatic repulsion. This led to the reduction of the osmotic pressure difference between the hydrogel network and external solution Pourjavadi and Soleyman (2010) [29] and Flory (1953) [7].

And then, the decreasing swelling driving force induced a decrease in the water absorbency. The effect of the ionic strength of the external solution on the swelling had been determined Aalaie *et al.,* (2008) [1]. The water absorbency of superabsorbent composite depends on the ionic strength of external solution. An increase in the ionic strength of external solution will reduce the water absorbency. The absorbency of the composites in various salt solutions was measured to determine the resistance to salts. Figures 5 and 6 show that for a given concentration of saline solution, the water absorbency in NaCl solution was far higher than that in CaCl2 and FeCl3 solutions. This dramatic decrease of water absorbency in multivalent cationic solutions could be due to the fact that Ca^{2+} and Fe^{3+} ions could form complexes with carboxylate groups in hydrogels, leading to deswelling or contraction, whereas Na+ ions were not able to form any complexes and showed normal swelling capacity. We found the effect of vacancy on absorbency in the following order $Na^{+}< Ca^{2+}<Fe^{3+}$. Similar result was found the following order $Na^{+}< Ca^{2+}< Fe^{3+}$ Ma *et al.,* (2015) [22] and Zhang *et al.,* (2006) [42]. Zhang *et al*., (2005) [43] reported that this result may due to the ability of carboxylate groups in the hydrogels to form complexes with the cations from the salt solutions. Based on their formation constants with ethylene diamine tetra acetic acid, the ability of the hydrogel carboxylate group to complex with the three studied cations should be in the order Na+<Ca2

+ <Al^{3+} and this order is in good agreement with the absorption results. So with increase the valance decrease the water absorbency. Zhang *et al*., (2014) [44] this was because, for ionic hydrogels, the additional cations causing an anion−anion electrostatic repulsion, leading to a reduced osmotic pressure difference between the external solution and the polymer network, resulted in decreased swelling. The addition of FYM modified montmorillonite compare than pure montmorillonite and CTAB modified montmorillonite also increase the absorbency of polymer in salt solution but at high concentration of salt we found the decrease in water absorbency because CTAB modified montmorillonite long alkyl chains of ammonium salt ion attached on the surface of MMT micro particles not only improved the polymeric network by forming tiny hydrophobic regions, but also weakened the hydrogen bond interaction between hydrophilic groups (such as COOH, COO^-, $CONH_2$, and OH), which prevented the expansion of the polymeric network. The hydrophilicity of the polymeric network decreased, thereby decreasing the water absorbency of the corresponding superabsorbent composites Zhang *et al.,* (2006) [42] Elliott *et al.,* (2004) [6] and Wang and Wang, (2016) [39]. These results obtained indicate that the introduction of FYM modified montmorillonite compare than CTAB modified and pure montmorillonite can improve the salt resistant property of the corresponding nano clay polymer superabsorbent composites.

Effect of P solution on water absorbency of the NCPC

To load Phosphorus, the nano clay polymer composite (10 wt% pure, hot water FYM extract modified and CTAB modified montmorillonite) was swollen in aqueous solutions of Phosphorus with the concentrations of 10%, 15% and 20% respectively. As shown in Figure 4, the swelling capacity of the superabsorbent composite is dependent on the concentration of the Phosphorus. We found the water absorbency increases with the concentration of Phosphorus solution 10% in pure, hot water FYM extract modified and CTAB modified montmorillonite but slightly decreases when this concentration further increase from 10% to 20% in hot water FYM extract modified and CTAB modified montmorillonite and sharply decrease in pure montmorillonite. Zhang *et al.,* (2016) [45]. Similar results obtain the swelling capacity of the hydrogel composite is dependent on the concentration of the urea solution. The swelling absorbency increases with the concentration of urea solution increasing from 0.02 to 0.04 $mol.L^{-1}$, but slightly decreases when this concentration further increases from 0.04 to 0.12 $mol.\ L^{-1}$. A possible reason for the behavior might be as follows. When the concentration of the Phosphorus solution was10%, Phosphorus does not affect the electrostatic repulsion force of $-COO-$ on the polymer chain and has hydrophilic sites, such as $-NH_2$, which may improve the interaction between water and the polymer network. Therefore, with the concentration of the phosphorus solution increasing, the water absorbency of the superabsorbent composite increases. When concentration of the phosphorus solution is greater than 10% the existence of the excessive phosphorus leads to osmotic pressure differentials in the superabsorbent hydrogel composite, which may facilitate water molecules to move in the direction of the electrolyte dilution concentration Zhang *et al.,* (2014) [44]. Thus, a decrease in the water absorbency with increasing the concentration of the phosphorus solution was observed.

Water Retention Capacity of NCPC with Alluvial Soil

It is important to investigate the water-retention capacity of a superabsorbent in view practical application. The practical water retention in alluvial soil of a superabsorbent as a water-manageable material is essential to its applications in agriculture and water stress condition such as rainfed ecosystem. Table 5 and Figure 5 showed the results, of the water-retention capacity test of swollen superabsorbent and the content of water remaining in alluvial soil decreases with the time increasing. Ma *et al.,* (2015) [22] reported that the results indicate that the water retention ability had a decreasing tendency with prolonging time. In alluvial soil found highest water retention in T4 which retain water up to 16 days, (92.3% after 1day to 0.1% after 16 day) respectively followed by T5 (88.1% after 1day to 0.1% after 16 day). The minimum water retention found in T3 (79.8% after 1 day to 0.0% after 15 day) respectively. we conclude that the water-retention capacity increased of alluvial soil by adding a hot water FYM extract modified montmorillonite compare than CTAB modified montmorillonite and pure montmorillonite in NCPC as a superabsorbent. But all treatments show better performance than T3 (Pure montmorillonite NCPC with P @ 20%). All treatments could hold absorbed water more than 75% after 1 day. Zhang *et al.,* (2014) [44] similar results obtain It was apparent that the water-retention capacity increased by adding a small amount of OMMT, and poly(AA–AM/OMMT #2) series were slightly higher than poly(AA–AM/OMMT #1) series. Both of them could hold absorbed water more than 60% after 12 h. But the water retention ability of two types of superabsorbent i.e. FYM modified montmorillonite and CTAB modified montmorillonite + NCPC was very close, and it was more than 83% after 1 day. Ma *et al.,* (2015) [22] similar results obtain the water retention ability of two types NaAlg-g-PAA/organo-loess and NaAlg-g-PAA/loess of superabsorbents was very close, and it was more than 69% after 12 h at 40^0C and 100^0C, and could also hold the capacity for approximately 8 h, respectively. Superabsorbent polymeric materials in combination with clay minerals play a significant role in improving the water-holding capacity Mortland *et al.,* (1970) [25]. Currently, reinforcing polymer with small amounts of smectite clays has attracted increasing interest because these materials exhibit high stability Basak *et al*., (2012) [2]. The experimental results have shown that the water content of the soil with SRFSMP is obviously higher than that of the soil without SRFSMP; the water content of the soil without SRFSMP was only 3% on the 30th day, while that of the soil with SRFSMP was 14.5%, about 12% higher than the former Guo *et al.,* (2005) [9]. An experiment conducted on the water retention of SAPSRPF, showed that the water evaporation rate decreased after the addition of SAPSRPF to the soil Zhan *et al.,* (2004) [41]. The use of FYM modified montmorillonite +NCPC as a superabsorbent in alluvial soil obviously improves its water-holding capability. This indicates that the superabsorbent composites have excellent water retention ability and are expected to have great potential application for agricultural and horticultural applications, especially for saving water in dry, desert regions and rainfed ecosystem.

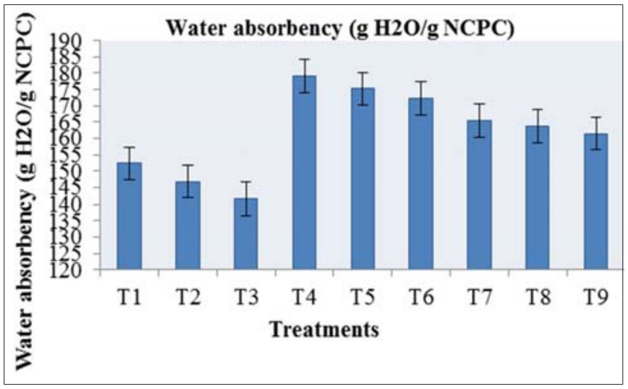

Fig 2: Water Absorbency (g H_2O/g NCPC)

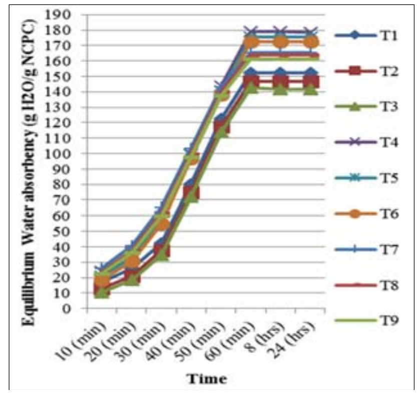

Fig 3: Equilibrium Water Absorbency (g H_2O/g NCPC)

Table 2: Effect of NaCl salt on Water Absorbency (g H_2O/g NCPC) (mean of 3 replicates ± SE)

Water Absorbency (g H_2O/g NCPC)				
	30 min		60 min	
Treatment	**1 M**	**0.01M**	**1 M**	**0.01M**
T1	17.12 ± 0.574^{bc}	33.12 ± 1.714^{bc}	77.46 ± 0.632^{c}	102.44 ± 1.221^{c}
T2	15.31 ± 0.635^{ab}	29.53 ± 1.853^{ab}	71.81 ± 0.544^{b}	96.73 ± 1.148^{b}
T3	14.18 ± 0.558^{a}	27.41 ± 1.160^{a}	67.53 ± 0.563^{a}	92.65 ± 0.548^{a}
T4	23.81 ± 1.247^{e}	53.27 ± 2.419^{g}	118.82 ± 1.181^{h}	148.95 ± 1.177^{g}
T5	23.02 ± 1.148^{e}	46.53 ± 1.657^{f}	114.57 ± 1.210^{g}	144.73 ± 1.178^{f}
T6	22.91 ± 0.617^{e}	45.25 ± 1.199^{ef}	111.36 ± 0.568^{f}	141.81 ± 0.589^{f}
T7	22.31 ± 1.216^{e}	40.51 ± 2.424^{de}	95.4 ± 0.458^{e}	123.8 ± 1.042^{e}
T8	21.06 ± 0.580^{de}	39.68 ± 1.798^{d}	93.32 ± 0.568^{de}	121.71 ± 1.146^{de}
T9	19.23 ± 0.532^{cd}	37.09 ± 1.137^{cd}	91.22 ± 0.589^{d}	119.39 ± 1.183^{d}
SE(m) ±	0.843	1.769	0.751	1.056
CD (0.05)	2.526	5.297	2.249	3.162

Table 3: Effect of $CaCl_2$ salt on Water Absorbency (g H_2O/g NCPC) (mean of 3 replicates ± SE)

Water Absorbency (g H_2O/g NCPC)				
	30 min		60 min	
Treatment	**1 M**	**0.01M**	**1 M**	**0.01M**
T1	12.92 ± 0.566^{abc}	29.43 ± 0.554^{c}	65.21 ± 0.643^{c}	92.57 ± 0.560^{c}
T2	11.82 ± 0.545^{ab}	25.87 ± 0.595^{b}	59.81 ± 0.502^{b}	86.34 ± 0.548^{b}
T3	11.36 ± 0.583^{a}	22.58 ± 0.548^{a}	55.03 ± 0.571^{a}	82.55 ± 0.560^{a}
T4	17.61 ± 0.692^{g}	44.02 ± 0.574^{f}	111.45 ± 1.639^{h}	141.19 ± 1.795^{h}
T5	16.47 ± 0.568^{fg}	39.29 ± 0.592^{e}	107.48 ± 0.904^{g}	137.28 ± 1.166^{g}
T6	15.73 ± 0.592^{ef}	37.07 ± 0.565^{de}	104.26 ± 0.465^{f}	134.22 ± 0.626^{f}
T7	14.89 ± 0.558^{def}	35.43 ± 0.606^{d}	85.34 ± 1.113^{e}	115.86 ± 1.186^{e}
T8	14.15 ± 0.554^{cde}	35.02 ± 1.734^{d}	83.56 ± 0.893^{de}	113.49 ± 1.169^{de}
T9	13.32 ± 0.611^{bcd}	30.19 ± 1.146^{c}	81.35 ± 0.484^{d}	111.72 ± 0.563^{d}
SE(m) ±	0.587	0.860	0.881	1.000
CD (0.05)	1.759	2.575	2.639	2.994

Table 4: Effect of $FeCl_3$ salt on Water Absorbency (g H_2O/g NCPC) (mean of 3 replicates ± SE)

Water Absorbency (g H_2O/g NCPC)				
	30 min		60 min	
Treatment	**1 M**	**0.01M**	**1 M**	**0.01M**
T1	6.66±0.650^{abc}	26.52±0.563^{c}	47.97±0.565^{c}	83.03±1.148^{c}
T2	5.85±0.560^{ab}	22.67±0.514^{b}	41.66±0.688^{b}	77.83±0.548^{b}
T3	5.41±0.762^{a}	20.55±0.995^{a}	37.92±0.606^{a}	73.89±0.571^{a}
T4	9.75±0.573^{d}	36.25±0.560^{h}	102.39±1.245^{h}	135.25±1.712^{h}
T5	8.55±0.704^{cd}	32.25±0.536^{g}	98.78±1.200^{g}	131.25±1.131^{g}
T6	7.92±0.536^{cd}	31.02±0.580^{fg}	95.19±0.640^{f}	128.21±0.592^{f}
T7	7.75±0.453^{bc}	30.33±0.548^{ef}	73.69±1.169^{e}	107.38±1.137^{e}
T8	7.08±0.560^{abc}	29.15±0.595^{de}	71.06±0.592^{d}	105.15±1.120^{de}
T9	6.63±0.647^{abc}	28.06±0.571^{cd}	69.37±0.601^{d}	103.61±0.586^{d}
SE(m) ±	0.612	0.564	0.859	1.022
CD (0.05)	1.832	1.687	2.573	3.061

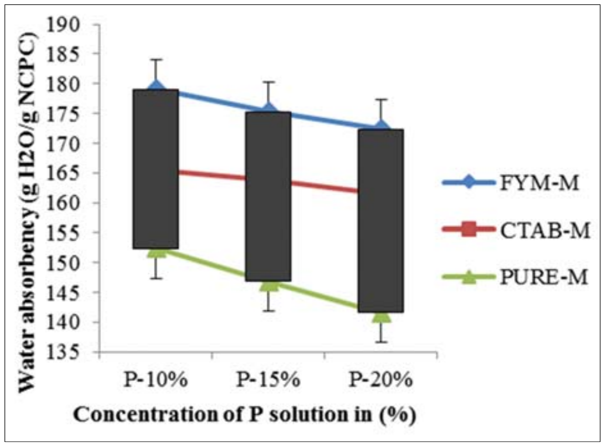

Fig 4: Effect of P solution on water absorbency of the NCPC

Table 5: Water Retention Capacity of Alluvial Soil with NCPC (mean of 3 replicates ± SE)

	Water Retention (%)															
Treatments	**1 day**	**2 day**	**3 day**	**4 day**	**5day**	**6 day**	**7 day**	**8 day**	**9 day**	**10 day**	**11 day**	**12 day**	**13 day**	**14 day**	**15 day**	**16 day**
T1	82.0± 1.154^{abc}	73.7± 1.553^{bc}	61.0± 1.732^{ab}	57.5± 1.824b	45.6± 1.847^{ab}	42.0± 2.081^{ab}	35.3± 2.369^{abc}	29.4± 2.778^{abc}	22.3± 2.227^{abc}	18± 2.645^{ab}	11.4± 1.928^{ab}	7.7± 1.616^{abc}	3.6± 1.234^{a}	1.0± 0.200^{a}	1.0± 1.000^{a}	0.0± 0.000^{a}
T2	81.5± 1.039^{bc}	71.5± 1.285^{b}	62.9± 2.081^{ab}	56.2± 1.792b	44.3± 2.309^{a}	41.2± 2.369^{ab}	33.3± 2.136^{bc}	28.6± 1.847^{bc}	20.7± 2.685^{ab}	15.6± 1/703^{ab}	10.7± 2.193^{a}	6.0± 1.732^{ab}	3.0± 1.154^{a}	0.5± 0.264^{a}	0.3± 0.173^{a}	0.0± 0.000^{a}
T3	79.8± 1.732^{a}	64.0± 2.309^{a}	54.1± 1.963^{a}	46.6± 1.824a	42.0± 1.732^{a}	35.1± 2.251^{a}	29.4± 2.205^{a}	25.3± 2.369^{a}	18.9± 2.645^{a}	14.4± 1.677^{a}	9.7± 2.003a	4.6± 1.401^{a}	2.6± 0.854^{a}	0.4± 0.173^{a}	0.0± 0.000^{a}	0.0± 0.000^{a}
T4	92.3± 1.216^{f}	82.2± 1.847^{e}	73.4± 2.759^{c}	65.8± 2.367c	58.8± 2.916^{e}	53.8± 3.292^{c}	47.4± 3.585^{d}	40.9± 3.214^{d}	32.2± 3.348^{d}	25.9± 2.309^{c}	18.5± 3.241^{b}	14.0± 2.645^{c}	7.0± 2.645^{a}	2.0± 2.081^{b}	1.4± 0.513^{a}	0.1± 0.033^{c}
T5	88.1± 1.184^{e}	79.3± 1.847^{cde}	66.4± 3.002^{c}	63.1± 1.732^{bc}	55.0± 1.732^{de}	48.8± 2.665^{bc}	42.9± 3.055^{cd}	37.6± 2.946^{cd}	29.6± 2.804^{cd}	22.6± 2.003^{bc}	17.0± 2.081^{ab}	11.7± 2.253^{bc}	6.0± 1.732^{a}	1.8± 0.923^{ab}	1.1± 0.305^{a}	0.1± 0.033^{bc}
T6	87.8± 1.159^{de}	77.1± 2.309^{bcde}	67.7± 1.652^{bc}	62.4± 2.579^{bc}	53.4± 1.628^{cde}	47.9± 2.886^{bc}	40.4± 3.328^{bcd}	35.4± 2.098^{bcd}	26.9± 2.081^{bcd}	21.5± 1.442^{bc}	14.4± 1.652^{ab}	10.2± 1.616^{abc}	5.9± 1.732^{a}	1.4± 0.692^{ab}	0.9± 0.185^{a}	0.0± 0.000^{ab}
T7	86.1± 1.527^{cde}	77.1± 2.309^{de}	69.0± 1.677^{bc}	62.1± 1.154^{bc}	51.4± 2.369^{bcd}	47.7± 2.714^{bc}	40.3± 2.535^{bcd}	34.2± 2.759^{bcd}	25.8± 0.000a^{bcd}	21.1± 2.251^{abc}	16.8± 2.281^{ab}	10.0± 2.516^{abc}	5.2± 1.942^{a}	1.6± 0.585^{ab}	0.8± 0.100^{a}	0.0± 0.000^{a}
T8	85.2± 1.270^{bcde}	76.8± 1.457^{cde}	67.9± 2.645^{bc}	61.1± 2.281^{bc}	48.6± 2.424^{abcd}	45.6± 2.946^{bc}	37.2± 1.442^{abc}	32.6± 2.627^{abcd}	23.8± 2.251^{abc}	19.4± 2.248^{abc}	15.2± 2.253^{ab}	9.3± 1.914^{abc}	4.8± 1.703^{a}	2.4± 0.173^{ab}	0.6± 0.088^{a}	0.0± 0.000^{a}
T9	83.8± 1.050^{abcd}	75.0± 1.732^{bcd}	62.0± 2.250^{bc}	58.0± 2.645^{b}	46.8± 1.734^{abc}	43.4± 2.707^{ab}	36.8± 1.734^{abc}	30.4± 2.338^{abc}	22.7± 1.732^{abc}	18.9± 2.309^{ab}	13.3± 2.475^{ab}	8.1± 2.645^{abc}	3.9± 1.527^{a}	0.9± 0.577^{a}	0.4± 0.088^{a}	0.0± 0.000^{a}
SE(m) ±	1.77	2.09	2.11	2.15	2.07	2.43	2.37	2.45	2.28	1.95	1.73	1.49	1.19	0.60	0.24	0.01
CD(0.05)	5.11	6.02	6.10	6.20	5.98	7.01	6.82	7.07	6.58	5.61	4.99	4.30	3.43	1.73	0.71	0.03

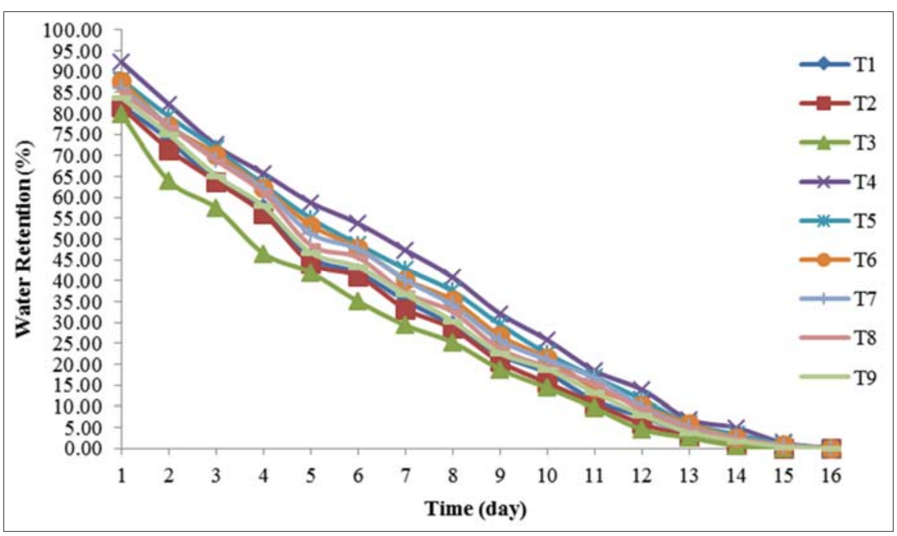

Fig. 5: Water Retention Capacity of Alluvial Soil with NCPC

Conclusion

A novel superabsorbent composite (NCPC) with high swelling properties was successfully synthesized by polymerization reaction by incorporating Pure Montmorillonite clay, Hot water FYM extract modified Montmorillonite clay and CTAB modified Montmorillonite clay into a NCPC polymer network. The superabsorbent composites (NCPC) exhibited excellent water absorbencies

(The maximum water absorbency for T4-179.09g/g) and water retention abilities. The water absorbency of the composite affected by saline solution and % loaded of phosphorus concentration. The impact of external saline solution on the swelling capacity has the following order: $Na^{+} < Ca^{2+} < Fe^{3+}$. Based on above mention description, we can concluded that incorporation suitable amount FYM modified Montmorillonite clay into a NCPC polymer network could not only enhance swelling capacity of the composites (NCPC) but improve salt resistant ability and water retention capacity of soil compare than pure Montmorillonite clay. This is an effective approach to improve the performance and application for agricultural and horticultural, especially for water saving in dry, desert regions and rainfed ecosystem.

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