

Original Research Article

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Physical and Chemical Properties of Sandy Soil as Influenced by the Application of Hydrogel and Mulching in Maize (*Zea mays* L.)

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ABSTRACT

Keywords

Hydrogel, Rice straw mulch, Rice husk mulch, Coirpith compost mulch, Porosity, Bulk density and Available soil N, P₂O₅ and K₂O

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A field experiment was conducted at College of Agriculture, Padannakkad, Kerala Agricultural University, Thrissur, Kerala, India to study the effect of hydrogel (super absorbent polymer) and mulching on physical and chemical properties of sandy soil in maize (*Zea mays* L.). The experiment was conducted in factorial randomized block design having two factors with three levels each and one additional control. Different levels of hydrogel and types of mulches, their interactions and a control were analysed statistically on physical properties of soil like porosity and bulk density and chemical properties like available soil N, P₂O₅ and K₂O. Results revealed that main effects of hydrogel applied @ 3.75 kg ha⁻¹ and coirpith compost mulch @ 2.5 t ha⁻¹ recorded the maximum soil porosity. The residual nutrient status with respect to available soil N and K₂O recorded maximum with main and interaction effects of treatments contain hydrogel @ 1.25 kg ha⁻¹ and rice husk mulch @ 5 t ha⁻¹ and available soil P₂O₅ was recoded maximum with hydrogel @ 3.75 kg ha⁻¹ and rice husk mulch @ 5 t ha⁻¹. Control recorded the high available soil N, P₂O₅, K₂O content than the remaining treatments.

Introduction

Maize (*Zea mays* L.) is one of the most versatile crop having capacity to adapt under different agro-climatic conditions (Kogbe and Adediran, 2003), with altitudinal ranges of 0 to 3000 meters above the mean sea level. Generally, maize is known as “queen of cereals” because it has the highest genetic yield potential among the cereals. In India, maize is the third most important food crop after rice and wheat. In addition to staple food

for human being and quality feed for animals, maize serves as a basic raw material for thousands of industrial products like starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceuticals, cosmetics, film, textile, gum, package and paper industries etc.

According to Wallace (2000), presently 80 per cent of water resources are available in the world for supporting irrigated agriculture. As resources of water decreases, water saving agriculture is required for the sustainable growth of human societies. Besides, due to

climate changes droughts are predicted to increase. So it is the need of the hour to adopt different practices to improve the crop production under water scares condition (Gornall *et al.*, 2010). In present experiment a new technology which is hydrogel and an old technology which is mulching with different organic mulches were used for conservation of moisture in the soil.

Less moisture retaining capability, less fertility and high percolation losses of soil moisture caused the less crop productivity in sandy soils and finally reduced moisture and nutrient use efficiency (Rigas *et al.*, 1999; Sivapalan, 2006). Hydrogel absorbs 20 times more water than its own weight. Because of the improvement of a more cross-linked polymer having more water holding capacity (400 to 2000 times than its weight) and its less cost has revived interest on the utilization of hydrogel in Agriculture. Several studies have been focused on the efficacy of hydrogel uses in sandy soils and in soils of desert areas. Hydrogel prolongs the plant nutrient and water uptake by releasing the water slowly over a longer period. It decreases the water usage and improves the physical properties of the soil. Moreover, this may be providing accurate entry to essential nutrients for plant growth and thus the biomass production was noticeably improved (Gunes *et al.*, 2016).

Hydrogel improved the physical condition of soils like porosity, bulk density, water holding capacity, soil permeability, infiltration rate, etc. Improvement of porosity causes the enhancement in seed germination, seedling emergence rate, root growth. It also improved biological/microbial activities in the soil, that enhanced the air accessibility in root zone of plants (Dar *et al.*, 2017).

According to Mbagwu (1989), organic wastes application decreases soil apparent specific gravity and enhances total porosity of soil.

Crop residue mulch application @ 4 and 6 t ha⁻¹ improved chemical and physical properties of the soil and finally increased grain yield of the crop (Bhatt *et al.*, 2004; Khurshid *et al.*, 2006). Mulching offers an improved soil environment, controls soil temperature, enhances soil porosity and water infiltration rate at severe rain and maintains runoff and erosion besides it suppress weeds development (Anikwe *et al.*, 2007; Glab and Kulig, 2008). Besides preserving water and preventing erosion, mulching also enhanced the soil flora and fauna, suppress weeds growth and maintains maximum crop productivity (Essien *et al.*, 2009). The other findings proved that rice husk upgraded soil physical properties and which improves the corn grain yield. Porosity significantly changes moisture circulation and air exchange in soil (Uguru *et al.*, 2015).

Materials and Methods

The experiment was conducted at College of Agriculture, Padannakkad, Kerala Agricultural University, Thrissur, Kerala, India. Soil of experimental field is sandy. The experiment was laid out in factorial randomized block design having two factors with three levels each and one additional control. Hydrogel and mulch were the two factors. Three levels of hydrogel H₁ – 1.25 kg ha⁻¹, H₂ – 2.5 kg ha⁻¹, H₃ – 3.75 kg ha⁻¹ and three types of mulch M₁ – rice straw mulch, M₂ – rice husk mulch, M₃ – Coir pith compost mulch were tested in the study. Straw mulch and rice husk mulch was applied @ 5 t ha⁻¹ and coir pith compost mulch was applied @ 2.5 t ha⁻¹. The treatment combinations were T₁ - 1.25 kg ha⁻¹ hydrogel + rice straw mulch, T₂ - 1.25 kg ha⁻¹ hydrogel + rice husk mulch, T₃ - 1.25 kg ha⁻¹ hydrogel + Coir pith compostmulch, T₄ - 2.5 kg ha⁻¹ hydrogel + rice strawmulch, T₅ - 2.5 kg ha⁻¹ hydrogel + rice huskmulch, T₆ - 2.5 kg ha⁻¹ hydrogel + coir pith compostmulch, T₇ - 3.75 kg ha⁻¹ hydrogel + rice strawmulch, T₈ - 3.75

kg ha⁻¹ hydrogel + rice huskmulch, T₉ - 3.75 kg ha⁻¹ hydrogel + coir pith compostmulch, T₁₀ - control (without hydrogel and mulch). Before the start of experiment to all the treatments an equal amount of FYM was applied @ 25 t ha⁻¹. Fertilizers were applied @ 135:65:15N, P₂O₅, K₂O kg ha⁻¹ respectively. Nitrogen was applied in three equal doses, first as basal, second at knee high stage and third at tasseling stage. Full dose of P₂O₅ and half dose of potassium was applied as basal and the remaining half dose of K₂O was applied at tasseling stage along with N. The observations were recorded at harvest stage on soil physical properties like bulk density and porosity and the chemical properties like available soil N, P₂O₅ and K₂O. The methods adopted for estimation of physical and chemical properties of soil are presented in the Table 1.

Results and Discussion

Bulk density

The data on bulk density of soil at harvest stage of maize crop (Table 2 and 3), indicated that there was no significant difference among the levels of hydrogel, types of mulches, their interactions and between control and other treatments.

Porosity

The data on porosity of soil at harvest of the crop are presented in Table 2 and 3. The results showed that porosity of soil was significantly influenced by levels of hydrogel and types of mulch and no significant difference was observed between interactions of levels of hydrogel and types of mulch and control versus other treatments.

Among the levels of hydrogel, maximum porosity was observed in hydrogel applied @ 3.75 kg ha⁻¹ (43.64 %) which was significantly

superior to other levels of hydrogel @ 2.5 kg ha⁻¹ and 1.25 kg ha⁻¹. Generally sandy soil has less porosity than the fine textured soils though it contains large pores. Increased porosity of soil with increase in the hydrogel dose might be due to occupying of large sandy soil pores with hydrogel. Increased porosity of soil due to hydrogel application was also observed by Uz *et al.*, (2008). Among the types of mulch, maximum porosity was observed with coirpith compost mulch @ 2.5 t ha⁻¹ (43.56 %) which was significantly superior to rice straw and rice husk mulch. The maximum porosity was observed in case of coirpith compost mulch than other two types of mulch might be due to fine texture of coir pith compost and was mixed well with sandy soil than the other two types of mulches viz. rice straw mulch and rice husk mulch. The microbial decomposition products of organic mulches such as polysaccharides and bacterial gums are known to act as soil particle binding agents. These binding agents improve soil aggregation and hence increase the porosity (Bhatia and Shukla, 1982). Increase in the porosity of soil due to mulching was observed by Uguru *et al.*, (2015). Porosity of soil revealed no significant difference among the interaction effects of levels of hydrogel and types of mulches and when comparing the control with rest of treatments.

Available soil N

Available soil N content was significantly influenced by the levels of hydrogel, types of mulch, their interactions and control versus other treatments (Table 2 and 3). Among the levels of hydrogel, hydrogel applied @ 1.25 kg ha⁻¹ (238.34 kg ha⁻¹) recorded higher available soil N content than other two levels of hydrogel @ 2.5 kg ha⁻¹ and 3.75 kg ha⁻¹. Among types of mulch, rice husk mulch @ 5 t ha⁻¹ (236.94 kg ha⁻¹) recorded higher available soil N content followed by coirpith compost @ 2.5 t ha⁻¹ which was on par and superior to

rice straw mulch. Among the interactions, hydrogel applied @ 1.25 kg ha⁻¹ with rice husk mulch @ 5 t ha⁻¹ (246.70 kg ha⁻¹) recorded maximum available soil N content and was on par with hydrogel applied @ 2.5

kg ha⁻¹ with coirpith compost mulch @ 2.5 t ha⁻¹ and superior to other interactions. When control was compared with other treatments, control recorded higher soil nitrogen content of soil than the other treatments.

Table.1 The methods adopted for estimation of physical and chemical properties of soil

S. No.	Parameters	Method used	Refernce
1.	Bulk density (g cc ⁻¹)	Undisturbed core sample method	Black <i>et al.</i> , (1965)
2.	Particle density (g cc ⁻¹)	Pycnometer method	Black <i>et al.</i> , (1965)
3.	Available N (kg ha ⁻¹)	Alkaline permanganate method	Subbiah and Asija, (1956)
4.	Available P ₂ O ₅ (kg ha ⁻¹)	Bray extraction and photoelectric colorimetry	Jackson, (1958)
5.	Available K ₂ O (kg ha ⁻¹)	Ammonium acetate method	Jackson, (1973)

Table.2 Main effect of hydrogel and mulching in bulk density (g cc⁻¹), porosity (%) and nutrient content of soil (kg ha⁻¹)

Treatment Level of hydrogel	Bulk density of soil (g cc ⁻¹)	Porosity of soil (%)	Available nutrient content of soil (kg ha ⁻¹)		
			N	P ₂ O ₅	K ₂ O
H ₁	1.43	42.93	238.34	64.63	276.12
H ₂	1.42	43.20	232.76	62.47	230.27
H ₃	1.42	43.64	204.89	68.02	202.44
SEm (±)	0.013	0.159	1.958	1.197	9.167
CD (0.05)	NS	0.334	4.114	2.515	19.260
Types of mulch					
M ₁	1.42	43.07	204.89	55.91	200.55
M ₂	1.42	43.16	236.94	76.97	268.29
M ₃	1.41	43.56	234.15	62.24	239.98
SEm (±)	0.013	0.159	1.958	1.197	9.167
CD (0.05)	NS	0.334	4.114	2.515	19.260

Table.3 Interaction effect of hydrogel and mulching in bulk density (g cc⁻¹), porosity (%) and nutrient content of soil (kg ha⁻¹)

Treatment Interactions	Bulk density of soil (g cc ⁻¹)	Porosity of soil (%)	Available nutrient content of soil (kg ha ⁻¹)		
			N	P ₂ O ₅	K ₂ O
H ₁ M ₁	1.43	42.80	234.15	58.56	223.10
H ₁ M ₂	1.43	42.80	246.70	72.50	319.42
H ₁ M ₃	1.42	43.20	234.15	62.84	285.82
H ₂ M ₁	1.43	42.80	217.43	48.65	192.64
H ₂ M ₂	1.41	43.47	238.34	72.58	246.40
H ₂ M ₃	1.42	43.33	242.52	66.17	251.78
H ₃ M ₁	1.41	43.60	163.07	60.53	185.92
H ₃ M ₂	1.42	43.20	225.79	85.84	239.05
H ₃ M ₃	1.40	44.13	225.79	57.71	182.34
SEm (±)	0.022	0.275	3.391	2.073	15.878
CD (0.05)	NS	NS	7.125	4.356	33.359
Control vs other treatments					
control	1.41	43.47	250.88	85.94	323.71
SEm (±)	0.016	0.205	2.528	1.545	11.835
CD (0.05)	NS	NS	5.311	3.247	24.864

Available soil P₂O₅

Available soil P₂O₅ content was significantly influenced by the levels of hydrogel, types of mulch, their interactions and control versus other treatments (Table 2 and 3). Among the levels of hydrogel, maximum available soil P₂O₅ content was observed with hydrogel level @ 3.75 kg ha⁻¹ (68.02 kg ha⁻¹) which was significantly superior to other two levels of hydrogel @ 2.5 kg ha⁻¹ and 3.75 kg ha⁻¹. Among the types of mulch, maximum available soil P₂O₅ content was observed with rice husk mulch @ 5 t ha⁻¹ (76.97 kg ha⁻¹) which was significantly superior to rice straw and coirpith compost mulch. With respect to interactions, hydrogel applied @ 3.75 kg ha⁻¹ with rice husk mulch @ 5 t ha⁻¹ (85.84 kg

ha⁻¹) recorded maximum available soil P₂O₅ content and was significantly superior to other combinations. When compared the control with other treatments, control recorded higher available soil P₂O₅ content of than the other treatments.

Available soil K₂O

The effect of hydrogel and mulching on available soil K₂O content (Table 2 and 3) indicated that potassium content was significantly influenced by the levels of hydrogel, types of mulch, their interactions and control versus other treatments. Among the levels of hydrogel, maximum available soil K₂O content was observed in hydrogel @ 1.25 kg ha⁻¹ (276.12 kg ha⁻¹) which was

significantly superior to other two levels of hydrogel. Among the types of mulch maximum available soil K₂O content was recorded by rice husk mulch @ 5 t ha⁻¹ (268.29 kg ha⁻¹) and was significantly superior to other two types of mulch. With respect to interactions, hydrogel applied @ 1.25 kg ha⁻¹ with rice husk mulch @ 5 t ha⁻¹ (319.42 kg ha⁻¹) recorded maximum available soil K₂O content which was on par with hydrogel applied @ 1.25 kg ha⁻¹ with coirpith compost mulch @ 5 t ha⁻¹ and superior to other combinations.

When control was compared with other treatments, control recorded higher available soil K₂O content than the other treatments.

From the above results on available soil N, P₂O₅, K₂O, among the types of mulch, rice husk mulch @ 5 t ha⁻¹ showed high content of available soil N, P₂O₅, K₂O than other types of mulch. Though rice husk is applied as a mulch, it will take more time to degrade due to wide C: N ratio and high silica content. Part of the applied nutrients and the nutrients available from the soil may be utilized for decomposition of rice husk and might be retained in the soil.

High available soil N and K₂O content was recorded when hydrogel was applied @ 1.25 kg ha⁻¹ and high available P₂O₅ recorded when hydrogel was applied @ 3.75 kg ha⁻¹ it might be due to hydrogels usually contain micro pores that allow small molecules such as NH₄ to diffuse through the hydrogel. The subsequent release of nutrient is then based on the diffusive properties of the polymer, its decomposition rate, and the nature of the nutrient salt (Johnson and Veltkamp, 1985). Control recorded high available soil N, P₂O₅, K₂O content than the remaining treatments because less uptake of these nutrients in control plot due to poor growth of the plant.

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