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Sequential studies on soil physical properties by application of hydrogel in groundnut (ArachishypogaeaL.) under Central dry zone of Karnataka

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Abstract— A field study was conducted at Zonal Agricultural and Horticultural Research Station (ZAHRS), Babbur farm, Hiriyur to study "Effect of hydrogel on soil properties in groundnut (ArachishypogaeaL.) in Central dry zone of Karnataka" with an objective to study the effect of hydrogel on soil physical properties. The results revealed that the treatment with an application of RDF + hydrogel @ 4 kg ha^{-1}and FYM @ 10 t ha^{-1}recorded the higher soil porosity (48.64 %), MWHC (25.27 %), higher field capacity of the soil (15.56 %), lowest PWP (2.13 %) and higher available water content (13.43 %). The treatment with RDF + 3.0 kg hydrogel ha^{-1} + 10 tons FYM ha^{-1} and RDF + 2.0 kg hydrogel ha^{-1} + 10 tons FYM ha^{-1} were found on par with the above said treatment. Thus, the moisture stress, which is limiting the yield in groundnut production, could be overcome by the combined application of RDF, FYM @ 10 t ha^{-1}and hydrogel @ 4.0 kg ha^{-1}.

Keywords : Hydrogel, Field capacity, Groundnut, Physical properties

INTRODUCTION

Groundnut (*Arachishypogaea*L.) is an essential edible oil and food crop of the world. It is an annual and highly self-pollinated crop belongs to the family*leguminaceae* and subfamily *Papilionaceae*. In India, groundnut is cultivated in an area of 5.31 m. ha with an annual production of 7.57 mt and productivity of 1424 kg ha^{-1} and India ranks second in groundnut production and shares 22 per cent of world production (Anon., 2017). In Karnataka groundnut occupies an area of 8.48 lakh hectares with an annual production of 7.42 lakh tones with productivity of 921 kg ha^{-1} (Anon., 2017).It

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is a unique crop with attributes of both oilseed and proteins, consisting of 44 to 50 per cent of edible oil and 25 per cent of high-quality protein.

In recent years, it has been shown that the area under groundnut in dry lands is decreasing gradually, due to erratic rainfall and low moisture availability at critical stages. Under these circumstances, we have to raise a crop by utilizing less amount ofwater and should produce maximum yields in turn. So, the combined use of hydrogel and nutrient management appears to be the best alternative to get higher pod yields with enhanced seed quality. In arid and semiarid regions with limited soil-water availability, hydrogel polymers are the materials for enhancing water and nutrient use efficiency (Nazarli*et al*., 2010).

Indian Agricultural Research Institute (IARI), New Delhi has developed a hydrogel, which are cross-linked polyacrylamide polymers (PMA). These are semisyntheticsuperabsorbent and biodegradable polymers which absorb water and release it to the soil when moisture drops. They are made up of water-insoluble acrylate and potassium acryl amide. The hydrogel was a long parallel chain of molecules and when cross-linked, they can form a network of polymeric chains. Water is brought into the network by process of osmosis and quickly moves into the plant system and it is reserved. When the hydrogel acts absorb water appears as a gel, amazingly hydrogel can absorb up to 300 to 500 times more water than its weight and when surroundings begin to dry out, the hydrogel gradually dispenses up to 95 per cent of their stored water. When they are exposed to water again, they will rehydrate and repeat the process of storing water. This process can last up to several years when the biodegradable hydrogels decompose. The hydrogel attaches itself to the roots and sheds water under water deficit conditions and nourishes the crop. Due to its sticky nature, hydrogel binds to fertilizers and reduces fertilizer leaching. The polymerichydrogel is a boon for the dryland ecosystems subjected to various moisture stresses.

For an increased crop production in dry land condition, a greater percentage of the precipitation must be stored in the soil. The stored moisture must be used more efficiently. Additions of water retaining materials are known to improve moisture holding capacity of the soil and help to overcome the moisture stress during the crop growth period. Keeping these things in view, an investigation was carried out at

Zonal Agricultural and Horticultural Research Station (ZAHRS), Babbur farm, Hiriyur to study "Effect of hydrogel on soil properties in groundnut (*Arachishypogaea*L.) in central dry zone of Karnataka" with an objective to study the effect of hydrogel on soil physical properties.

Material and Methods

The experiment was conducted continuously two years during 2018-2018 at Zonal Agricultural and Horticultural Research Station (ZAHRS), Babbur farm, Hiriyur. It falls under the region X and agro-climatic zone IV (Central dry zone) of Karnataka. Geographically an experimental site was located at 13° 94' 38" North latitude and 76° 61'61" East longitude, with an altitude of the 630 meters above mean sea level.

As per the treatment, the required quantity of hydrogel was applied to the seed rows by mixing with fine sand (1:10) at a depth of 10 cm before sowing and mixed with soil.

The physical properties of soil were determined in the laboratory by using standard analytical procedures *viz.,* soil texture by International Pipette method, bulk density (Mg m^{-3}) by core sampler method, maximum water holding capacity (%) (MWHC) by Keen Raczkowski Cup method (1966) and Total soil porosity (%) by Keen Raczkowski Cup method as recommended by Piper (1966). The parameters like field capacity and permanent wilting point (%) and available water content (%) by Pressure plate apparatus method as described by Page *et al.* 1982.

Experimental details

Experimental Design : Randomized complete block design (RCBD)
No. of Treatments : Ten
No. of Replications : Three
Test crop : Groundnut
Variety : G2-52
Spacing : 30 cm × 10 cm
Gross plot size : 5 m × 4.5 m
Season : *Kharif* 2018
Date of sowing : 14-07-2018 and 11-07-2019
Date of harvesting : 03-12-2018 and 30-11-2019

Treatment details

T_1: RDF (Control)
T_2: RDF + 1.0 kg hydrogel ha^{-1}
T_3: RDF + 2.0 kg hydrogel ha^{-1}
T_4: RDF + 3.0 kg hydrogel ha^{-1}
T_5: RDF + 4.0 kg hydrogel ha^{-1}
T_6: T_2+ 10 tons of FYM ha^{-1}
T_7: T_3+ 10 tons of FYM ha^{-1}
T_8: T_4+ 10 tons of FYM ha^{-1}
T_9: T_5+ 10 tons of FYM ha^{-1}
T_{10}: RDF + Mulching

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- RDF: Recommended dose of Fertilizers- 50 per cent N + 100 per cent P and K as basal dose and 25 per cent N each at 25 and 40 DAS.
- RDF = $N:P_2O_5:K_2O$= 25:50:25 kg ha^{-1} (rainfed)

Table 1. Initial soil physico-chemical properties of the experimental plot.

Parameters		Values
Particle size distribution	Sand (%)	61.42
	Silt (%)	13.12
	Clay (%)	25.46
	Texture	Sandy Clay Loam
BD (Mg m^{-3})		1.50
MWHC (%)		42.87
FC (%)		9.56
PWP (%)		4.80
AWC (%)		4.76

Results and Discussion

The data about the physical properties of soil as influenced by hydrogel are presented in Table 2 and 3.

Bulk density and total soil porosity did not differ significantly due to the application of hydrogel. However, the higher bulk density (1.60Mg m^{-3}) was recorded in treatment (T_1) with application RDF alone. Whereas the treatment (T_9) application of RDF + hydrogel @4 kg $ha^{-1}$and FYM @ 10 t ha^{-1}recorded the lowest bulk density (1.31Mg m^{-3}).The treatment (T_9) with an application of RDF + hydrogel @4 kg $ha^{-1}$and FYM @ 10 t ha^{-1}recorded the higher soil porosity (48.64 %). The treatment (T_1) which received RDF alone recorded the lower soil porosity (46.73 %).

Maximum water holding capacity (MWHC) and field capacity was differed significantly due tohydrogel application. However, higher MWHC (25.27 %) was recorded in the treatment (T_9) with an application of RDF + hydrogel @ 4 kg $ha^{-1}$and FYM @10 t ha^{-1}, which was on par with T_8, T_7 and T_6 (24.58, 24.26 and 23.30 %),respectively. Whereas the treatment (T_1) with an application of RDF alone obtained significantly lower MWHC (20.83 %), followed by T_2 (20.87 %).Treatment (T_9)with an application of RDF + hydrogel @ 4 kg $ha^{-1}$and FYM @ 10 t ha^{-1}wasrecorded significantly higher field capacity of the soil (15.56 %), it was on par withT_8, T_7 and T_6 (15.28, 14.71 and 14.53 %), respectively. The significantly lower fieldcapacity of the soil (9.28 %) was recorded in the treatment (T_1) with an application ofRDF alone, followed by T_2 (10.59 %).

A significant difference was noticed in permanent wilting point of the soil and available water content with different levels of hydrogel application. The higher PWP (4.89 %) was observed in the treatment (T_1) with application RDF alone, which was on par with T_2, T_3 and T_4(4.65, 4.51 and 4.11 %), respectively. The treatment (T_9) with application of RDF +hydrogel @ 4 kg ha^{-1}and FYM @ 10 t ha^{-1}was recorded the lowest PWP(2.13 %), followed by T_8 (2.51 %).The treatment (T_9) with an application of RDF + hydrogel @ 4 kg ha^{-1}and FYM @ 10 t ha^{-1}was recorded the significantly higher available water content (13.43 %) and it was on par with T_8 andT_7 (12.77 and 11.76 %), respectively. Lower available water content (4.39 %) was observed in the treatment (T_1) with the application of RDF alone. The data about the moisture content of the soil at different critical growth stages during groundnut cultivation with an application of different doses of soil moisture retaining material like hydrogel are presented in Table 3.

Treatment (T_9) with an application of recommended dose of NPK along withhydrogel (4.0 kg ha^{-1}) and FYM (10 t ha^{-1}) during groundnut cultivation was shown significant differences in soil physical properties like maximum water holding capacity, field capacity, permanent wilting point and available water content(Table 4). This is mainly due to the application of the hydrogel along with FYM improves the soil structure, soil porosity, soil water holding capacity and other hydraulic properties (Shivakumar*et al.*, 2018). The application of manure helped in greater soil aggregation with more root biomass, decreased bulk density and other physical properties by interaction between clay and humus (Parashuram Chandravanshi*et al.*, 1999). Application of hydrogel increases its volume by 400 to500 times and retaining the moisture for a longer time, which corroborates the results of Gales *et al*. 2016.

The treatment (T_1) with an application of an only recommended dose of fertilizers recorded the higher bulk density, PWP and lower MWHC, FC and AWC; this is because application of fertilizers alone destroys the soil structure and also evaporates the early soil moisture leading to the destruction of soil physical properties. Similar results were recorded by Verma and Sharma, 2008.

Treatment (T_9) with an application of RDF along with hydrogel (4.0 kg ha^{-1}) and FYM (10 t ha^{-1}) during groundnut cultivation was showed significant higher soil moisture content at different growth stages (Table 5). This is mainly due to hydrogel application which absorbed more water during rainfall and retains for a longer time and was beneficial for plant uptake at critical moisture stages (Pooran*et al*., 2018).

The application of manure to the soil improved the soil moisture content by increasing the soil porosity. The treatment (T_1) with an application of an only recommended dose of fertilizers recorded significantly lower soil moisture content at all the critical growth stages of groundnut (except germination stage); this is mainly due to soil moisture losses by evaporation and seepage with less moisture retention and conservation. Similar results were recorded by Bai*et al*. 2010.

Conclusion

- The hydrogel is moisture-retaining polymer, which releases moisture specifically during stress condition.
- The moisture stress, which is limiting the yield in groundnut production, could be overcome by the combined application of RDF, FYM @ 10 t ha^{-1} and hydrogel @ 4.0 kg ha^{-1}.

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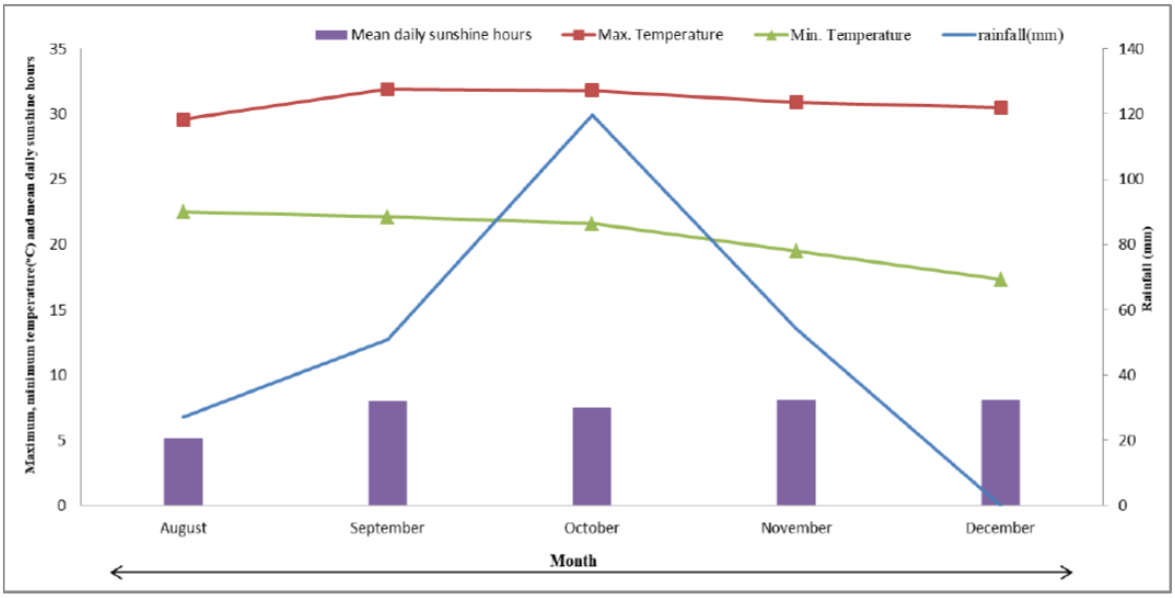

Figure 1. Meteorological observations during crop growth period

Table 2: Effect of hydrogel application on soil physical properties after harvest of groundnut crop.

Treatment	Bulk density ($Mg\ m^{-3}$)			Porosity (%)			Maximum water holding capacity (%)		
	2018	**2019**	**Pooled**	**2018**	**2019**	**Pooled**	**2018**	**2019**	**Pooled**
T_1 :Control (RDF)	1.59	1.61	1.6	46.23	47.22	46.73	20.15	21.5	20.83
T_2 : RDF + 1.0 kg hydrogel ha^{-1}	1.58	1.6	1.59	46.24	46.84	46.54	20.68	21.06	20.87
T_3 : RDF + 2.0 kg hydrogel ha^{-1}	1.56	1.57	1.57	46.26	46.52	46.39	21.93	21.93	21.93
T_4 : RDF + 3.0 kg hydrogel ha^{-1}	1.56	1.49	1.53	46.28	47.25	46.77	22.16	23.07	22.62
T_5: RDF + 4.0 kg hydrogel ha^{-1}	1.55	1.51	1.53	46.31	47.32	46.82	22.39	22.85	22.62
T_6 :T_2 + 10 tons FYM ha^{-1}	1.34	1.36	1.35	47.51	48.25	47.88	23.15	23.45	23.3
T_7 : T_3 + 10 tons FYM ha^{-1}	1.34	1.34	1.34	47.54	48.74	48.14	23.94	24.58	24.26
T_8 :T_4 + 10 tons FYM ha^{-1}	1.33	1.33	1.33	47.64	47.64	47.64	24.58	24.58	24.58
T_9 :T_5 + 10 tons FYM ha^{-1}	1.31	1.31	1.31	47.82	49.45	48.64	25.12	25.23	25.27
T_{10} : RDF + Mulching	1.51	1.53	1.52	46.32	44.36	45.34	25.55	24.98	25.18
S. Em (±)	**0.17**	**0.19**	**0.17**	**0.85**	**0.91**	**0.85**	**0.66**	**0.7**	**0.65**
C.D. at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**2.02**	**2.04**	**1.98**

Table 3: Effect of hydrogel application on soil moisture constant properties after harvest of groundnut crop

Treatment	Field capacity (%)			Permanent wilting point (%)			Available water capacity (%)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T_1 :Control (RDF)	9.32	9.23	9.28	4.82	4.95	4.89	4.5	4.28	4.39
T_2 : RDF + 1.0 kg hydrogel ha^{-1}	10.51	10.66	10.59	4.61	4.68	4.65	5.9	5.98	5.94
T_3 : RDF + 2.0 kg hydrogel ha^{-1}	11.08	11.12	11.10	4.48	4.54	4.51	6.6	6.58	6.59
T_4 : RDF + 3.0 kg hydrogel ha^{-1}	13.58	13.25	13.42	4.08	4.13	4.11	9.5	9.12	9.31
T_5: RDF + 4.0 kg hydrogel ha^{-1}	13.95	13.87	13.91	3.92	3.95	3.94	10.03	9.92	9.98
T_6 :T_2 + 10 tons FYM ha^{-1}	14.07	14.98	14.53	3.17	3.28	3.23	10.9	11.7	11.30
T_7 : T_3 + 10 tons FYM ha^{-1}	14.4	15.02	14.71	2.98	2.92	2.95	11.42	12.1	11.76
T_8 :T_4 + 10 tons FYM ha^{-1}	15.28	15.28	15.28	2.45	2.57	2.51	12.83	12.71	12.77
T_9 :T_5 + 10 tons FYM ha^{-1}	15.46	15.65	15.56	2.14	2.12	2.13	13.32	13.53	13.43
T_{10} : RDF + Mulching	13.46	13.52	13.49	3.46	3.41	3.44	10	10.11	10.06
S. Em (±)	**0.47**	**0.23**	**0.35**	**0.62**	**0.62**	**0.61**	**0.82**	**0.63**	**0.72**
C.D. at 5%	**1.41**	**0.68**	**1.05**	**1.83**	**1.85**	**1.82**	**2.43**	**1.86**	**2.13**

Table 1: Normal and Actual Rainfall Distribution at ZAHRS, Hiriyur

Months	Normal rainfall	Rainfall(mm)		Rainy days	
		2018	2019	2018	2019
Jan	3.35	0.0	4.8	0.0	1
Feb	3.93	1.2	0.2	0.0	0
Mar	6.23	34.2	0.0	02	0
Apr	26.8	16.2	0.0	01	0
May	79.8	131.2	51.6	09	6
Jun	54.8	30.4	45.6	03	3
Jul	46.2	25.2	24.6	03	3
Aug	57.8	27.0	76.4	05	9
Sep	134	51.0	224.0	04	5
Oct	116	119.8	296.4	06	14
Nov	33.3	54.2	20.6	02	3
Dec	7.58	0.0	44.2	0.0	1
Total	**569.9**	**490.4**	**788.4**	**35**	**45**

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During the year 2018 and 2019 higher Rainfall of **490.4** mm and 788.4 mm, respectively was received as against Normal Rainfall of 569.70 mm with uneven distribution. During the Pre-Monsoon period Rainfall was good in the month of May 2018 (131.2 mm) which enables to take up land preparation and during Monsoon period (June to September) the Rainfall was 30.4 mm, 25.2, 27.0 and 51.0 mm, respectively with unevenly distributed. During the year 2019 the higher rainfall was received during cropping period and well distributed from June to September *viz.,* 45.6, 24.6, 76.4 and 224.0, respectively. The total number of rainy days during the year 2018 and 2019 were (35 and 45, respectively).

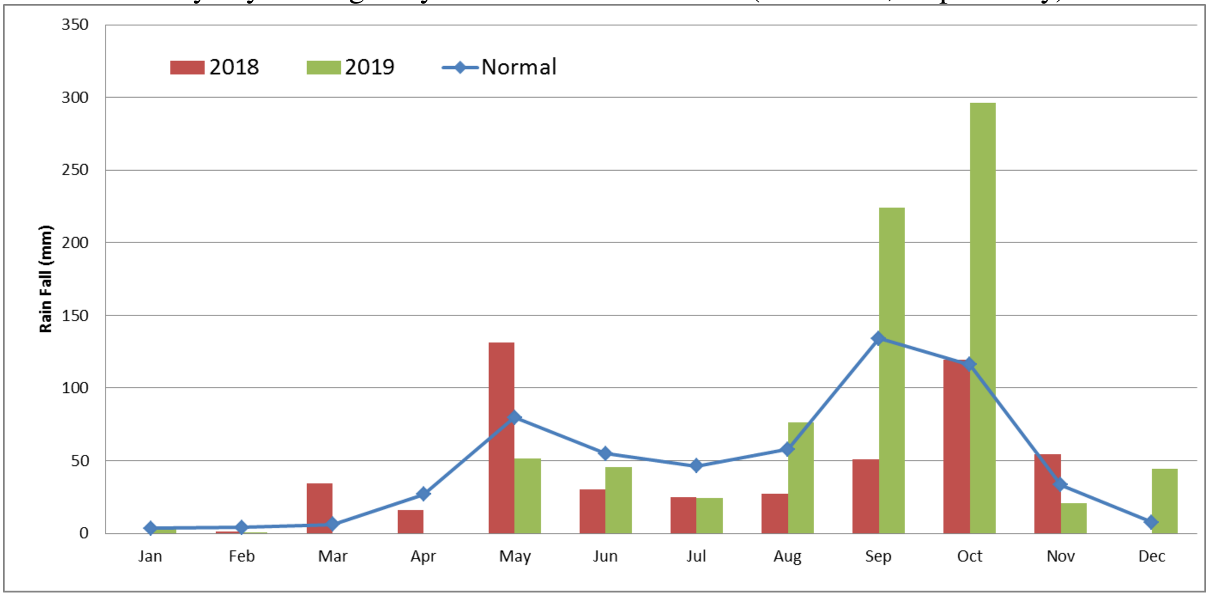

Fig: 2 Normal and Actual Rainfall (2018 and 2019) Distributions at ZAHRS, Hiriyur