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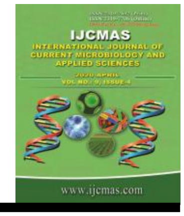

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Improvement in Growth Parameters, Yield Attributes and Economics of Groundnut (*Arachis hypogaea* L.) through Graded Levels of Hydrogel Application

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A B S T R A C T

A field experiment was conducted during *Kharif* 2018 at Zonal Agricultural and Horticultural Research Station, Hiriyur, University of Agricultural and Horticultural Sciences, Shivamoggato study the effect of various levels of hydrogel, farm yard manure (FYM) and mulching on growth parameters, yield attributes and economics of groundnut cultivation under the rainfed condition. Results revealed that, treatment with the application of recommended dose of fertilizers (RDF) along with hydrogel @ 4 kg ha^{-1} and FYM @ 10 t ha^{-1} was recorded significantly higher plant height (6.45, 17.83 and 30.14 cm) and number of branches (4.91, 7.52 and 9.27) at 30, 60 and 90 DAS, respectively and also yield attributes *viz.*, number of pods per plant (25), pod yield per plant (4.57 g), shelling percentage (67.41%), dry pod yield (1470 kg ha^{-1}), kernel yield (991 kg ha^{-1}) and haulm yield (3114 kg ha^{-1}) at harvest with higher gross returns (Rs.62, 560 ha^{-1}), net returns (Rs.25, 760 ha^{-1}) and benefit-cost (B: C) ratio (1.70). Significantly lower growth and yield attributes were noticed in treatment with no hydrogel and manure application.

Introduction

Groundnut (*Arachis hypogaea* 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*. Groundnut is native to Brazil and it is grown mainly in the tropical and sub-tropical regions of the world. It was introduced to India during the 18th century. It is a unique crop with attributes of both oil and proteins, consisting of 44 to 50 per cent of edible oil and 25 per cent of high-quality protein. Since groundnut is an energy-rich crop and it needs fertile and well-aerated soils. 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 of water 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. When the root zone of the plant dries up, the hydrogel is able to retain water, plant nutrients and release it to the plant. Nowadays soil moisture conservation is considered one of the significant challenges for countries in arid and semi-arid regions. By 2030, global water demand is probable to be 50 per cent higher than today, resulting in water scarcity, at the same time the agricultural sector uses over 70 percent of freshwater in most regions of the world.

A hydrogel is a biodegradable superabsorbent polymer which can hold 400 to 500 g of water per gram of dry hydrogel. It has greater potential in storing water available for plant growth and production. Hydrogel, when used properly in an ideal situation, 95 per cent of its stored water willbe available for plant absorption (Nazarli *et al*., 2010).

Indian Agricultural Research Institute (IARI), New Delhi has developed the hydrogel, which are cross-linked polyacrylamide polymers (PMA). These are semi-synthetic superabsorbent 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 acrylamide. 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 absorbs water, it 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 polymeric hydrogel is a boon for the dryland ecosystems subjected to various moisture stresses.

Materials and Methods

A field experiment was conducted during *Kharif* 2018 at the Zonal Agricultural and Horticultural Research Station, Babbur farm, Hiriyur, Karnataka. The experiment consisted of ten treatments and three replications, treatments involving hydrogel (Fig. 2) application with four doses of the hydrogel, *i.e.*, 1.0, 2.0, 3.0, 4.0 kg ha^{-1} and FYM 10 t ha^{-1}, mulching with pongamia green leaf at 4.0 t ha^{-1}. RCBD design was used in a test crop groundnut (G-2-52 variety) with spacing 30cm ×10cm. During the investigation, various biochemical properties of groundnut were analysed at different growth stages.

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
Date of harvesting	:	03-12-2018

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

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 = 25:50:25 kgN:P_2O_5:K_2Oha^{-1} (Rainfed)

Growth parameters

The plant height was recorded at 30, 60, 90 DAS and at harvest from the surface of the soil to the tip of plant of the five randomly selected plants in all the treatments. The average plant height was computed and expressed in centimetre.

The total number of branches per plant was counted at 30, 60, 90 DAS and at harvest from five labelled plants in the respective treatment.

Yield and yield attributing parameters

After separating and drying the pods from randomly selected five plants, the number of pods per plant was recorded and weight of pods per plant was recorded and expressed in grams. The pod yield per hectare was calculated using pod yield per plot.

Harvest index was calculated by using the formula.

$$\text{Harvest index(HI)} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

The known weight of dried pods from each treatment was shelled manually and the weight of the kernel was recorded. The shelling percentage was calculated as follows:

$$\text{Shelling (\%)} = \frac{\text{Weight of kernels obtained (g)}}{\text{Weight of pods used for shelling (g)}} \times 100$$

Hundred seeds were counted manually from a sample drawn from each treatment in four replications and weighed as per the procedure given by ISTA (2012). The kernel yield and haulm yield per hectare were calculated using kernel yield and haulm yield per plot, respectively.

Economics

The cost of cultivation per hectare was calculated for the individual treatment based on inputs used and the prevailing market price of the produce. Gross monetary returns were estimated by multiplying economic yield with the current market price of groundnut pods.Net returns (Rs. ha^{-1}) were calculated by deducting the cost of cultivation from gross monetary returns for each treatment. Benefit-cost (B:C) ratio was calculated by dividing gross returns with the cost of cultivation.

$$\text{Benefit: cost (ratio)} = \frac{\text{Gross returns } (Rs.ha^{-1})}{\text{Cost of cultivation } (Rs.ha^{-1})}$$

Statistical analysis

The experimental data obtained were subjected to statistical analysis by adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984). The level of significance used in the 'F' test was at 5 per cent.

Results and Discussion

Growth parameters

The plant height fairly gives the idea of photosynthetic capacity due to the application of hydrogel combined with RDF and FYM. The increase in plant height (Table 1) was mainly due to the good moisture and nutrient supply along with fair weather condition at critical growth stages. As the water content of the plant increases, it leads to the increased cell swelling and turgor pressure against cell walls.

Therefore, application of RDF, hydrogel and FYM increase the turgor pressure inside the cells by maintaining sufficient amount of water as per plant need and thus causing an increase in plant height. Similar results were also reported by Al-Harbi *et al.*, (1999).

The treatment (T_1) with the application of only recommended dose of NPK was recorded lower plant height. This is because of early response of the treatment to water deficit condition. As the water content of the plant decreases, there will be cell shrinkage and turgor pressure against cell walls will be relaxed. This lowered cell volume resulting from the lower turgor pressure subsequently accumulates solutes in cells (Otitoloju, 2014).

Number of branches per plant was the indication of overall utilization of resources and better light interception. It increased significantly with the application of RDF, hydrogel @ 4 kg ha^{-1} along with FYM application @ 10 t ha^{-1}. Increased number of branches per plant (Table 1) was due to the higher synthesis in carbohydrates, proteins, total amino acids and other biochemical and physiological parameters, especially in the presence of hydrogel polymer with the supply of sufficient moisture for plant growth during the moisture stress conditions.

Similarly, a significant increase in the number of branches and other growth parameters were due to the application of hydrogel polymer with RDF and FYM application was reported by Silberbush *et al.*, (1993) in peanut, Akhter *et al.*, (2004) in barley and wheat. Increased concentration of hydrogel showed increased number of branches per plant and also resulted in more retention of moisture and indirectly the availability of nutrients. It might help to increase the activity of cell division, expansion, elongation and ultimately leading to the increased number of branches per plant.

Yield attributes

Treatment (T_9) with the application of recommended dose of NPK along with hydrogel (4.0 kg ha^{-1}) and FYM (10 t ha^{-1}) differed significantly in yield attributes *viz.*, number of pods and pod yield per plant, test weight, shelling percentage, pod yield, kernel yield and haulm yield (Sahana, 2016) (Table 2 and Fig. 1).

Table.1 Effect of hydrogel application on growth parameters in groundnut at different growth stages

Treatments	Plant height (cm)				No. of branches per plant			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1 : RDF(Control)	4.27	15.43	26.12	34.15	3.12	5.45	7.36	8.45
T_2 : RDF+ 1.0 kg hydrogel ha^{-1}	4.58	15.68	26.54	34.67	3.19	5.56	7.45	8.61
T_3 : RDF+ 2.0 kg hydrogel ha^{-1}	4.91	16.01	27.41	35.08	3.47	5.72	7.68	8.94
T_4 : RDF+ 3.0 kg hydrogel ha^{-1}	5.13	16.31	27.61	35.72	3.85	5.91	7.89	9.15
T_5 : RDF+ 4.0 kg hydrogel ha^{-1}	5.20	16.57	27.95	36.12	3.99	6.14	8.21	9.35
T_6 : T_2 + 10 tons of FYM ha^{-1}	6.05	17.08	28.14	37.54	4.21	6.54	8.46	9.81
T_7 : T_3 + 10 tons of FYM ha^{-1}	6.14	17.24	28.67	37.91	4.39	6.98	8.67	9.97
T_8 : T_4 + 10 tons of FYM ha^{-1}	6.31	17.45	29.54	38.48	4.62	7.35	9.03	10.24
T_9 : T_5 + 10 tons of FYM ha^{-1}	6.45	17.83	30.14	38.74	4.91	7.52	9.27	10.51
T_{10} :RDF+ Mulching	5.28	16.31	27.99	36.51	4.02	6.18	8.29	9.17
S. Em (±)	0.20	0.23	0.58	0.73	0.22	0.38	0.33	0.24
C.D. at 5%	0.59	0.67	1.71	2.18	0.61	1.12	1.00	0.69

Note: RDF: Recommended dose of fertilizers
DAS: Days after sowing
FYM: Farm yard manure

Table.2 Effect of hydrogel application on yield and yield attributes of groundnut

Treatments	Number of pod plant^{-1}	Pod yield plant^{-1} (g)	Test weight (g)	Harvest index	Shelling (%)	Dry pod yield (kg ha^{-1})	Kernel yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1: RDF(Control)	18	3.92	33.51	0.38	64.28	671	431	1270
T_2: RDF+ 1.0 kg hydrogel ha^{-1}	19	4.01	33.92	0.38	64.61	762	492	1412
T_3 : RDF+ 2.0 kg hydrogel ha^{-1}	19	4.07	34.38	0.38	64.95	835	543	1548
T_4: RDF+ 3.0 kg hydrogel ha^{-1}	20	4.17	34.65	0.39	65.17	916	597	1704
T_5 : RDF+ 4.0 kg hydrogel ha^{-1}	21	4.23	34.81	0.38	65.38	976	638	1965
T_6: T_2 + 10 tons of FYM ha^{-1}	22	4.29	35.15	0.4	66.12	1232	815	2443
T_7: T_3 + 10 tons of FYM ha^{-1}	23	4.34	35.37	0.39	66.49	1306	868	2677
T_8 : T_4 + 10 tons of FYM ha^{-1}	24	4.41	35.76	0.41	67.16	1373	922	2937
T_9: T_5 + 10 tons of FYM ha^{-1}	25	4.57	35.92	0.41	67.41	1470	991	3114
T_{10} :RDF+ Mulching	21	4.25	34.84	0.4	65.42	820	537	1817
S. Em (±)	0.63	0.12	0.71	0.04	0.71	81.1	59.6	228
C.D. at 5%	1.86	0.37	2.12	NS	1.89	239.1	178.0	677

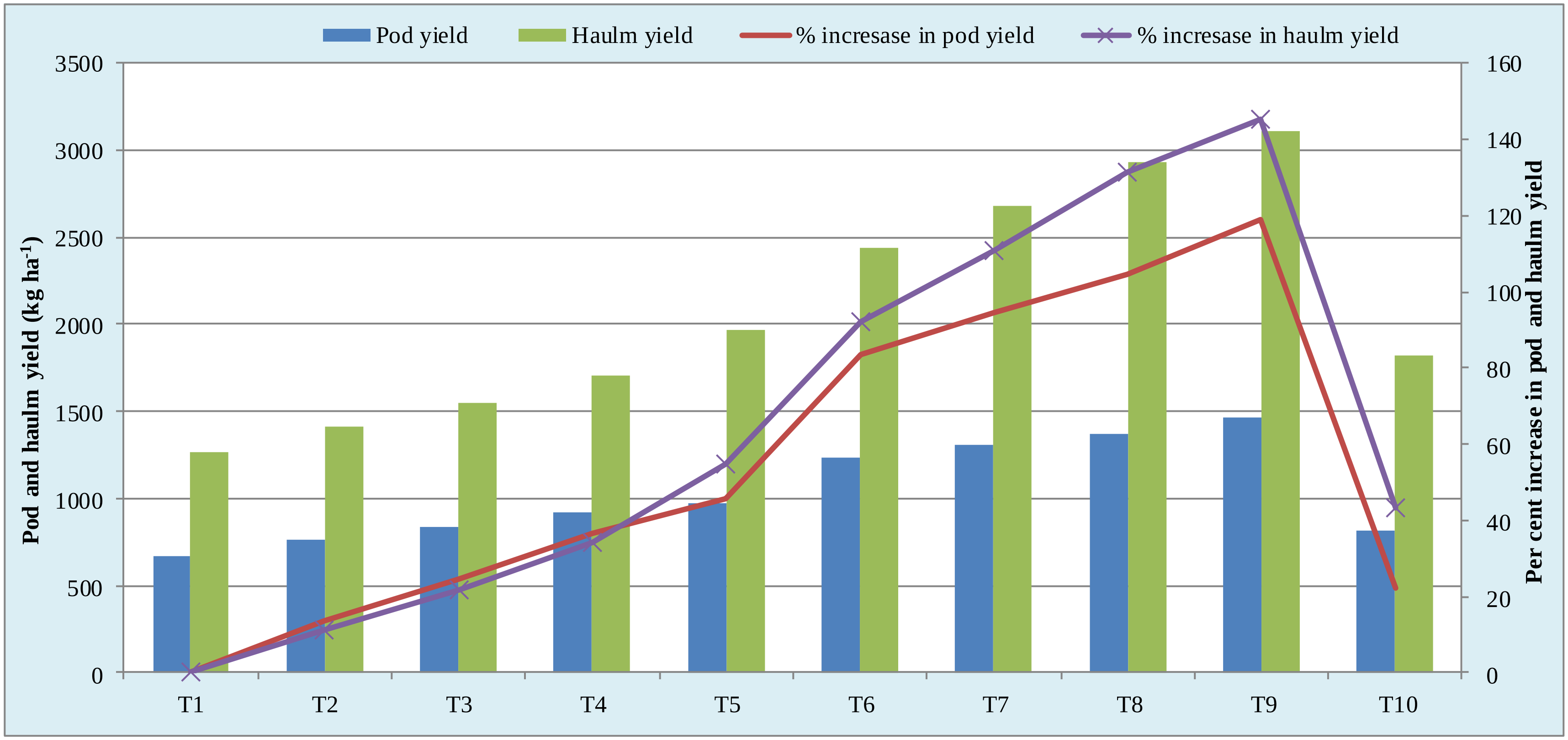
Note: RDF: Recommended dose of fertilizers
FYM: Farm yard manure

Table.3 Effect of hydrogel application on gross returns, net returns and benefit-cost (B: C) ratio of groundnut

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross Returns (Rs. ha^{-1})	Net Returns (Rs. ha^{-1})	B:C ratio
T_1 : RDF(Control)	18100	27150	9050	1.50
T_2 : RDF+ 1.0 kg hydrogel ha^{-1}	20100	30954	10854	1.54
T_3 : RDF+ 2.0 kg hydrogel ha^{-1}	22000	34100	12100	1.55
T_4 : RDF+ 3.0 kg hydrogel ha^{-1}	23900	37523	13623	1.57
T_5 : RDF+ 4.0 kg hydrogel ha^{-1}	25800	40248	14448	1.56
T_6 : T_2 + 10 tons of FYM ha^{-1}	31100	51315	20215	1.65
T_7 : T_3 + 10 tons of FYM ha^{-1}	33000	54780	21780	1.66
T_8 : T_4 + 10 tons of FYM ha^{-1}	34900	58283	23383	1.67
T_9 : T_5 + 10 tons of FYM ha^{-1}	36800	62560	25760	1.70
T_{10} : RDF+ Mulching	21800	34008	12208	1.56

Note: RDF: Recommended dose of fertilizers
FYM: Farm yard manure

Figure.1 Per cent increase in pod and haulm yield of groundnut due to application of different levels of hydrogel



T_1: Control(RDF)
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 FYM ha^{-1}
T_7 :**T_3** + 10 tons FYM ha^{-1}
T_8: **T_4**+ 10 tons FYM ha^{-1}
T_9 : **T_5** + 10 tons FYM ha^{-1}
T_{10} : RDF + Mulching

Figure.2 Hydrogel (dry)

The pod yield of groundnut is influenced by dry matter accumulation in different parts, including reproductive parts. Although, the genetic composition of a crop cultivar is the primary determinant of its yield potential, the manifestation of morphological, physiological and biochemical parameters and weather parameters ultimately decide the productivity of crop in water stress condition. It mainly depends upon the production of carbohydrates, uptake of water and nutrients from the soil in addition to several environmental factors to which crop is exposed during the growing period (Sengupta *et al*., 2015). Application of hydrogel increases the yield and yield attributes by supplying sufficient moisture and nutrients at critical growth stages. Soil physical, chemical and microbiological properties enhance the plant growth in vegetative and reproductive phases by providing a better environment for plant growth.

Higher kernel yield was due to higher yield parameters *viz.*, pod yield per plant, number of pods per plant and hundred pod weights. However, higher pod yield facilitates the higher number of kernels, in turn, increases the yield with higher shelling percentage. This improvement in yield components was due to the improved growth parameters such as higher plant height, chlorophyll content and number of branches per plant.

While the treatment (T_1) which received RDF alone recorded lower yield attributes and yield compared to rest of the treatments because of insufficient soil moisture which extenuate the crop growth and ultimate reduction in yield attributes. It also might be due to without any moisture retaining materials, which in turn resulted in the reduction of photosynthetic activity and translocation of photosynthates to sink. Similar results were reported by Chaudhary *et al.*, (2015).

Economics

The treatment (T_9) with the application of RDF and hydrogel @ 4 kg ha^{-1} and 10 tons FYM ha^{-1} recordedhigher gross returns, net returns and benefit-cost ratio (Table 3). This is mainly due to the application of hydrogel which improved the soil physical, chemical and microbiological properties. This led to the higher growth parameters and yield attributes, hence higher gross and net returns from the treatment compared to other treatments. However, the highest B:C ratio (1.70) was recorded in the same treatment. The net returns and B:C ratio was not increased much due to the combined use of the hydrogel with RDF and FYM. This was mainly due to the higher cost of hydrogel which increases the input cost or cultivation cost under rainfed condition. Hence, hydrogel usage with FYM and RDF shows a high impact on rainfed groundnut productivity. Similar results were obtained by Ramanjaneyalu *et al.,* (2008).

The treatment with the application of RDF alone recorded the lower gross, net returns and benefit-cost ratio. It was mainly due to the lower physical, chemical and microbiological properties which lead to lower growth and yield due to moisture stress noticed at various grand growth stages.

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