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Kumar Naik AH
Assistant Professor (Agronomy), AICRP on Groundnut, ZAHRS, Hiriyur, Karnataka, India

Chaithra GM
Zonal Agricultural and Horticultural Research Station, Hiriyur, Karnataka, India

Kiran Kumar N
COH, Zonal Agricultural and Horticultural Research Station, Hiriyur, Karnataka, India

Madhu G
Zonal Agricultural and Horticultural Research Station, Hiriyur, Karnataka, India

Nataraja M
Zonal Agricultural and Horticultural Research Station, Hiriyur, Karnataka, India

Umesha S
Zonal Agricultural and Horticultural Research Station, Hiriyur, Karnataka, India

Madhu BM
Zonal Agricultural and Horticultural Research Station, Hiriyur, Karnataka, India

Corresponding Author:
Kumar Naik AH
Assistant Professor (Agronomy), AICRP on Groundnut, ZAHRS, Hiriyur, Karnataka, India

Effect of hydrogel on growth, yield and Economics of rainfed castor

Kumar Naik AH, Chaithra GM, Kiran Kumar N, Madhu G, Nataraja M, Umesha S and Madhu BM

Abstract
A field experiment was conducted during *kharif* 2016-17 to test the impact of hydrogel application on growth, yield and economics of rainfed castor at Zonal Agricultural and Horticultural Research Station, Babbur Farm, Hiriyur, Karnataka. The superabsorbent polymer as pusa Hydrogel at 50% RDH, 100% RDH and 150% RDH and control were set as treatments. The results of study indicated that soil application of pusa hydrogel @ 100% RDH resulted in significant improvement on plant height and number of capsules/spike which reflected in higher seed yield (1776 kg/ha) followed by 50% RDH (1652 kg/ha) as compared to Control (1242 kg/ha). However, application of 50% and 100% RDH recorded similar B:C ratio (2.0). Hydrogel application beyond 100% RDH reduced the seed yield of castor by 11% and brought down the B:C ratio drastically (1.6). Next best treatment is found to be soil application of pusa hydrogel @ 50% RDH. From the above results, it can be inferred that soil application of hydrogel may be a significant practice to increase the yield of castor under rainfed conditions.

Keywords: Hydrogel, yield, economics, rainfed castor

Introduction
Castor is one of the ancient and important non-edible oilseeds grown in 30 countries across the globe in tropical and subtropical regions. Castor oil and its' by products have multifarious uses -[63 in agricultural, industrial, medicinal and ornamental fields (Ramanjaneyulu *et al.*, 2017) [18]. Globally castor is cultivated in an area of 12.5 lakh ha with a production of 17.7 lakh tonnes and a productivity of 1414 kg ha^{-1} (www.fao.org). India is the global leader with 66% area (8.23 lakh ha), 80% production (14.21 lakh tonnes) and highest productivity (1713 kg ha^{-1}) in castor. In India, the crop is grown in more than 1.0 lakh ha area purely under rainfed conditions characterized by low and erratic distribution of rainfall leading to occurrence of mid-season or terminal dry spell finally leading to reduced yields (Kumar Naik *et al.*, 2015) [13]. In view of global climate change, frequency of dry spells or drought may still aggravate the problem of soil moisture availability leading to significant reduction in crop yields. Further, castor is raised by resource poor farmers in arid and semiarid regions, mostly on marginal and sub marginal lands having shallow depth, low water holding capacity, less clay and organic matter (Abdelfattah, 2013) [1] besides the problems like vulnerability to soil erosion and poor native fertility (Falkenmark and Rockstrom, 2004) [7]. No doubt, castor being drought hardy plant is well adapted to low moisture conditions with its deep root system and reflective bloom on stems and leaves to reduce heat load and thrive under conserved moisture. However, yields -are greatly reduced under limited moisture supply conditions. Low cost moisture conservation practice such as ridge and furrow has been proved to enhance castor seed yield by 6.5-12% over dead furrow and flatbed method of land configuration (Krishna and Ramanjaneyulu, 2012) [12]. Hence, new strategies have to be adopted to mitigate the ill effects of drought. One such novel approach is thought to be use of hydrogels in Agriculture.Hydrogels are superabsorbent polymers (SAPs) which on an average, hold 332-465 times water of its weight and release it slowly in drought stress conditions in light soils (Dehkordi, 2016) [5]. Due to their three-dimensional cross linked hydrophilic polymer networks, hydrogels are subjected to swelling and retain large amount of water or de swelling to loose its moisture. Thus, they act as 'miniature reservoirs'. They undergo volume transition in response to physical and chemical stimuli depending on the environmental conditions (Ahmed, 2015) [2]. The hydrogel gradually releases up to 95% of its stored water when its surroundings begin to dry out. But, when comes in contact with water again, it gets replenished.

This process can last up to 2-5 years, by which time biodegradable hydrogel decomposes to CO_2, water and ammonia and potassium ions, without any residue, thus, environment friendly (Trenkel, 1997) [23]. Further, they acts as soil conditioners and improve the physical properties of soils *viz*., porosity, bulk density, water holding capacity, soil permeability and infiltration rate. They improve the crop growth by increasing water holding capacity in soil and delay the wilting point in drought stress (Boatright *et al*., 1997) [4]. Many authors have reported positive (Rehman *et al*., 2011; Singh, 2012; Langaroodi *et al*., 2013) [19, 21, 15] and negative (Mandal *et al*., 2015) [16] results in terms of moisture conservation and yield improvement in several crops with an exception of economic feasibility. However, so far very few research activities were carried out in rainfed castor. Hence, we have evaluated agronomically and economically the impact of hydrogel in rainfed castor.

Material and Methods

A field experiment was conducted at Zonal Agricultural and Horticultural Research Station, Babbur Farm, Hiriyur, Karnataka state, India during *kharif* season of 2016 under rainfed conditions to find out the effect of hydrogel addition on growth, yield and economics of rainfed castor. The station is situated at 13^0 94’ 38” North latitude and 76^0 61’ 61” East longitudes, with an altitude of 630 meters above means sea level. It comes under Agro-Climatic Region-10 and Central Dry Zone (Zone-IV) of Karnataka. The soil of the experimental site is medium black, slightly alkaline in pH (8.05), low in organic carbon (0.15%) and medium available nitrogen (273 kg ha^{-1}), low in available P_2O_5 (42 kg ha^{-1}) and high available K_2O (315 kg ha^{-1}). The total rainfall received during 2016 was 312.2 mm with 31 rainy days. The meteorological data during the course of crop growth (July-October) as well as normal data were obtained from Agro Met Observatory (Gramina Krushi Mausam Sewa), Department of Agronomy, Hiriyur. The weekly rainfall data was used for calculation of rainfall deviation by using Microsoft Excel. Further, the rainfall was classified based on IMD (Indian Meteorological Department) specifications as detailed below.

Rainfall	% Departure
Excess	+20% and above the normal
Normal	+19.0 to -19.9% of the normal
Deficit	-20.0 to -59.9% of the normal
Scarcity	≤ 60.0% of the normal

The experiment consisted of 4 treatments *viz*., Control (No hydrogel), 50% RDH (2.5 kg ha^{-1}), 100% RDH (5 kg ha^{-1}) and 150% RDH (7.5 kg ha^{-1}), each replicated three times. The experiment was conducted in a randomized complete block design (RCBD). The plot size of 7.2 m × 4.8 m was used. Compound fertilizer [NPK (12:32:16)] at a rate of 20 kg nitrogen, 40 kg of phosphorus and 20 kg potassium as basal dose followed by top dressing with an additional 20 kg N/ha each at 35-40 and 65-70 days after sowing applied. The required quantity of hydrogel was applied to the rows at a depth of 8-10 cm before sowing and mixed with soil. The ‘DCH- 177’ variety of castor was sown using two castor seeds per hill on ridges by hand dibbling at recommended spacing of 90 cm (between rows) x 60 cm (plant to plant) with a depth of 8-10 cm. At two weeks after sowing, the seedlings of castor crop were thinned to 1 plant per hill. Acephate at the rate of 1.25 kg/ha was applied with a hand operated knapsack sprayer to semilooper (*Achoeajanata* L.) control.

The crop harvested in three pickings manually based on the physiology maturity of the capsule, five representative plants were collected randomly to assess the parameters *viz*., plant height, number of branches, number of primary spikes, spike length and seed yield were collected at harvest. The data was analyzed statistically in randomised block design using OPSTAT. The significance of the treatment effect was determined using the F-test. Least significant differences were calculated at the 5% probability level to determine the significance of the difference between two treatments (Gomez and Gomez, 1984).

Results and Discussion

The data presented in Table 1 indicated that growth and yield traits and seed yield of castor were higher in treatment receiving soil application of 100% RDH (1776 kg ha^{-1}). The probable reasons were, though less amount of rainfall (268.80 mm) was received during crop growth period in 2016, its’ distribution was better. High intensity rainfall of 46.4 mm received on 28-08-16 (35^{th} week) has helped to get better yield from primary raceme, good amount of rainfall received during early crop growth might have helped to build up soil moisture thus plants might have extracted moisture from soil which was absorbed by hydrogel granules and produce better yield from different order racemes.

Effect on growth attributes

The growth attributes like plant height and number of branches $plant^{-1}$ was taken at maximum growth stage at 90 DAS and the data is presented in Table 1. The data revealed that, among different doses of hydrogel application, treatment receiving soil application of 100% RDH recorded significantly higher plant height (106 cm) and number of branches (3.4) than the other treatments. Hydrogel increase availability of nutrients like macro (N, P, K) as well as micronutrient (Mo, Zn and Mn) to the roots of crop which helps in turns to increase in photosynthetic activity of plants that later enhances the vegetative growth thus the number of leaves per plant, number of branches, plant height and root length (Sharma *et al*., 2014 and Sureshrao *et al*., 2016) [20, 22]. Hydrogel have been reported to increase the activity of cell division, cell expansion and cell elongation, ultimately leading to an increased plant height, number of branches, leaf area index, plant biomass and root growth. Similar results have been reported by AlHarbi *et al*. (1996) in cucumber.

Effect on yield parameters and Yield

The data (Table 1) showed that different doses of hydrogel has shown significant variation on yield parameters and seed yield (kg ha^{-1}) and data reveals that soil application of 100% RDH (1776 $kgha^{-1}$) recorded significantly higher seed yield which was significantly higher over rest of the treatments. The lowest grain yield was recorded under control (1242 $kgha^{-1}$) which was 30 per cent lower than the best treatment. An increase in yield and yield related attributes could be because of sufficient availability of water and indirectly nutrients supplied by the SAP to the plants under water stress condition, which in turn lead to better translocation of water, nutrients and photosynthates and finally better plant stand and yield (El Hardy *et al*., 2009) [6]. It may be attributed with super absorbing properties of the hydrogel which absorbs the water and releases it slowly to the growing plants as per the crop needs. The positive effect of superabsorbent polymers in increasing the yields was reported by Khadem *et al.*, (2010) [11], Gunes *et al.*, (2016) [9] and kumar *et al.*, (2017) [14] in maize crop.

Effect on economics

In the current study, economics data (Table 1) showed that castor crop grown without hydrogel addition has accrued lower net returns (Rs.19,255 ha^{-1}) and B:C ratio (1.6). Further, addition of hydrogel has increased the net returns and B:C ratio to Rs. 56,538 ha^{-1}, 1.8 (150% RDH); Rs. 59,472 ha^{-1}, 2.0 (50% RDH) and Rs. 63,936 ha^{-1}, 2.0 (50% RDH) respectively. It was mainly due to significant improvement in seed yield. A minimum increase in seed yield by 200 kg ha^{-1} is required to compensate the increased cost due to hydrogel addition. Further, an increase in seed yield by 400-500 kg ha^{-1} is required to achieve higher net returns and B:C ratio. Such results were also reported by Islam *et al.*, (2011) [10] who concluded that optimum dose of super absorbent polymer for maize cultivation was 30 kg ha^{-1} and lower (10-20 kg ha^{-1}) or higher ($\geq$ 40 kg ha^{-1}) would neither be sufficient nor economical.

Table 1: Effect of hydrogel on Growth, Yield and Economics of rainfed castor

Treatments	Seed yield (kg/ha)	Plant height upto primary raceme(cm)	Number of branches/ plant	Number of spikes/ Plant	Primary spike length (cm)	Number of capsule per spike	Gross returns (Rs/ha)	Net Returns (Rs/ha)	B:C Ratio
Control (No hydrogel)	1242	83	3.0	4.0	43	44	44705	19255	1.6
50% RDH	1652	93	3.3	4.3	49	47	59472	30272	2.0
100% RDH	1776	106	3.4	4.5	50	49	63936	31486	2.0
150% RDH	1571	89	3.3	4.2	44	47	56538	20588	1.8
S.Em±	63.85	3.7	0.35	0.35	2.2	1.0			
CD (P=0.05)	196.7	11.5	1.09	1.07	6.75	3.1			

Note: RDH: Recommended dose of Hydrogel (5 kg/ha); Cost of Hydrogel Rs. 1400 kg/ha. In all the treatments recommended dose of fertilizers was applied

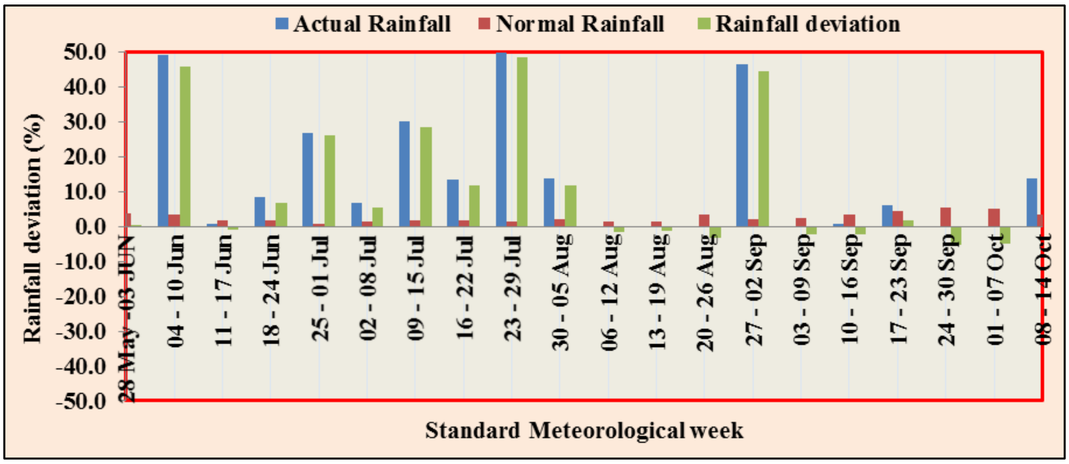

Fig 1: Weekly rainfall deviation (%) during 2016 at ZAHRS, Babbur Farm, Hiriyur

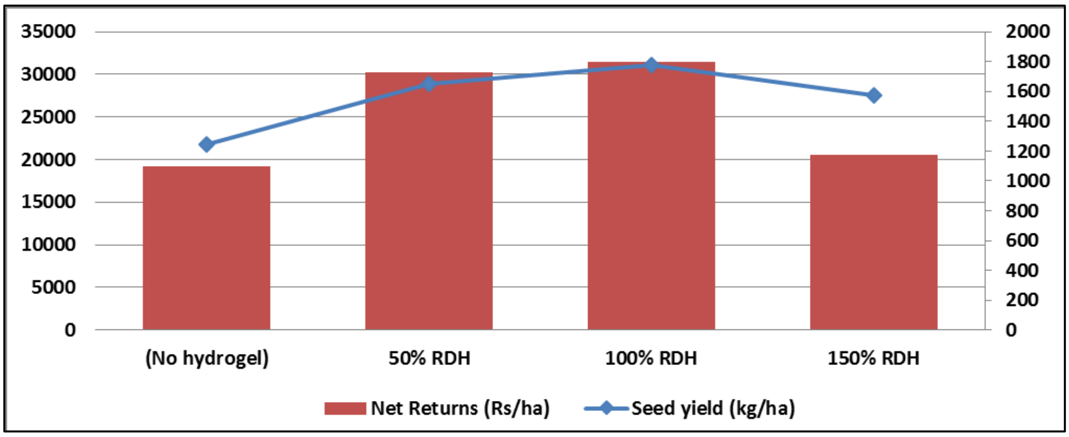

Fig 2: Seed yield and Net returns as influenced by different levels of hydrogel applications

Conclusion

The results of the experiment suggested that the soil application of hydrogel (50% RDH) should be used in castor production system to improve the soil fertility and crop productivity. Further, addition of hydrogel has increased the net returns and benefit per rupee invested. This treatment would reduce the farmer's initial cost of production and also help to sustain the soil ecosystem.

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