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# Effect of hydrogel on growth and yield of summer groundnut (*Arachis hypogaea* L.) under middle Gujarat condition

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**Abstract**
In India, especially those in arid and semi-arid regions, are battling serious problems with agricultural productivity brought on by soil degradation and finite water supplies. The use of soil additives, particularly in dry and semi-arid regions, to enhance soil qualities and water consumption productivity has drawn the most interest. This study's objective was to evaluate the impact of hydrogel on plant growth metrics. A field experiment on "Effect of hydrogel and irrigation on growth and yield of summer groundnut (*Arachis hypogaea* L.) under middle Gujarat condition" was carried out at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during summer season of the year 2020. The experiment was laid out in split plot design. Twelve treatment combinations comprising of three levels of irrigation schedules based on IW/CPE ratio as main plot treatments as well as four hydrogel treatments taken in the sub plot treatments, with three replications. The results revealed that all the growth parameters *viz.,* plant population, plant height and dry biomass, yield parameters *viz.,* number of pods per plants, seed index, pod yield, kernel yield, haulm yield and quality parameters *viz.,* protein content were significantly increased by irrigation scheduling at 0.8 IW/CEP ratio along with application of hydrogel @ 6 kg $ha^{-1}$.

**Keywords:** Hydrogel, irrigation, groundnut, growth, yield, WUE, IW/CPE ratio

## 1. Introduction

Groundnut (*Arachis hypogaea* L.) is an essential edible oil and food crop of the world; it is known to be a unique and important legume cum oilseed crop of India. Groundnut comes under the family leguminaceae and it is native to Brazil. It is grown mainly in the tropical and sub-tropical regions of the world. India ranks second in groundnut production with a share of about 20% of world production, total cultivated area is 6 m ha with an annual production of 10.24 mt and productivity of 1703 kg $ha^{-1}$. Gujarat is the largest producer of groundnut, contributing 39.79% of the total production. (Anonymous, 2022) [1].

Water is the basic input for increasing the crop production, which is accomplished by irrigation. Irrigation optimization is a very important practice used in crop management, which could reduce irrigation water losses and maintain high yield. With increasing costs associated with irrigation, there is a need to ensure the maximum return from each unit of input applied.

The need of crop for water is related to moisture sensitive periods. If moisture sensitive periods could be identified for groundnut crop under field conditions, it would have important implications for irrigation practice. Irrigation frequency is the decision of when and how much of water should be supplied to a field. Its purpose is to maximize irrigation efficiencies by applying the exact amount of water needed to maintain the soil moisture to the desired level. Scheduling irrigation to crop is mostly based on physiological growth stage and latest approach of scheduling irrigation through cumulative pan evaporation (IW/CPE ratio).

Soil conditioners have been reported to be effective tools in increasing the water holding capacity, reducing infiltration rate and cumulative evaporation and improving water conservation in coarse textured to medium textured soils. Hydrogel is a network of polymer chain. A three-dimensional solid result from the hydrophilic polymer chains being held together by cross-links. Because of these inherent cross-links, the structural integrity of the hydrogel network does not dissolve from the high concentration of water. When water comes into contact with one of these chains, it is drawn into the molecule by osmosis. Water rapidly migrates into the interior of the polymer network and turns to water gel. As this water gels absorption ability is bigger than soil but less than roots of plants, the absorbed water by SAP will be released to plants when it is dry.

## 2. Material and Methods

### 2.1 Description of the experimental field

Field experiment entitled was conducted during summer season of the year 2020 at Anand Agricultural University, Anand, (Gujarat). Anand district is part of Agro-climatic zone 13, which is Gujarat plains and hills zone (Planning commission, 1989). The climate of Anand is semi-arid and sub-tropical. The soil of the experimental field was loamy sand in texture, low in organic carbon and low in available nitrogen, available phosphorus with an alkaline (pH 8.44) in reaction.

### 2.2 Experimental details

Twelve treatment combinations involving three levels of irrigation and four levels of hydrogel were incorporated in the study. Three irrigation treatments *viz*., Irrigation at critical growth stage i.e., at branching, flowering, pegging and pod development ($I_1$), 0.6 IW/CPE ratio ($I_2$) and 0.8 IW/CPE ratio ($I_3$) were allotted to main plot while four treatments of hydrogel *viz*., No hydrogel ($H_0$), Hydrogel @ 3.0 kg ha$^{-1}$ ($H_1$), Hydrogel @ 4.5 kg ha$^{-1}$ ($H_2$) and Hydrogel @ 6.0 kg ha$^{-1}$ ($H_3$) were allotted to sub plot in split plot design with three replications.

### 2.3 Sowing, application of fertilizers and hydrogel

Seeds of GG 34 variety of groundnut was sown at the rate of 120 kg ha$^{-1}$ followed by covering of the furrows with soil manually. RDF (25:50:0 NPK kg ha$^{-1}$) were applied to each plot. Urea and Single Super Phosphate were used as sources of N and P respectively. Required quantity of hydrogel as per the treatments was weighed and applied to the farrows by mixing with soil of experimental field (1:10) at a depth of 5 cm before sowing of the seeds.

### 2.4 Irrigation scheduling

Two common irrigations were given for germination and better establishment of crop. After that, irrigations were given based on cumulative pan evaporation. With the help of USWB class 'A' open pan evaporimeter. Cumulative pan evaporation values were calculated from daily pan evaporation values. The quantity of irrigation water was measured by Parshall flume, a fixed depth of 50 mm irrigation water was given to each irrigation treatment ($I_1$, $I_2$ and $I_3$) based on growth stages and IW:CPE ratios of 0.6 and 0.8 when there were CPE of 83.3 mm and 62.5 mm evaporation, respectively. The detailed information regarding dates of the irrigation for each treatment along with number of irrigation and total quantity of water applied are given in table 1.

### 2.5 Statistical analysis

The experimental data obtained were subjected to statistical analysis adopting Fisher's method of analysis of variance (Cochran and Cox, 1957) by computer system at Computer Centre, Department of Agricultural Statistics, BACA, Anand Agricultural University, Anand. The level of significance used in the F test was at 5 per cent. The values of S.Em.± and C.V. % were also calculated.

## 3. Results and Discussion

Below is a summary of the experimental findings and data collected during the study.

### Effect on growth attribute

The data regarding plant growth parameters like plant population, plant height and dry matter were taken at different growth stages are presented in Table 1.

Plant population was not significantly affected by irrigation schedule based on a 0.8 IW/CPE ratio ($I_3$), however there were significant variations between the treatments in terms of plant height at 60 DAS (18.86 cm) and at harvest (52.39 cm), as well as plant dry biomass at 40 DAS (3.85 g plant$^{-1}$). The increased plant height and dry biomass under 0.8 IW/CPE ratio might be owing to more soil moisture being available when the plant required it for growth. As a result, soil moisture kept within a readily available range may have offered favourable conditions for good cell division and cell elongation, resulting in plant height development and more plant dry biomass. The present findings are in close agreement with Patel (2011) [3] and Behera *et al*. (2015) [4].

Among different doses of hydrogel, soil application of hydrogel @ 6 kg ha$^{-1}$ showed significant difference on plant population at harvest (4.47) comparing with other treatments. The plant height at 60 DAS (18.38 cm), at harvest (52.55 cm) as well as dry biomass at 40 DAS (3.66 g plant$^{-1}$) were also indicated significant differences by the application of hydrogel @ 6 kg ha$^{-1}$. This might be due to increase in the availability of water, also hydrogel increase the availability of macro and micronutrients to the roots of the crop which intern helps in increasing the photosynthetic activity of plants that later enhances the vegetative growth thus plant population, plant height and plant dry biomass (Sharma *et al*., 2014 and Sureshrao *et al*., 2016) [5, 6]. 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 leaves, number of branches, plant dry biomass and root growth. The findings are in close conformity with the results of Al-Harbi *et al*. (1999) [7] in cucumber Nazarli *et al*. (2010) [8].

### Effect on yield parameters and yield

The data regarding yield parameters like pods per plant, pod yield, kernel yield, haulm yield, shelling, seed index and harvest index were taken at different growth stages are presented in Table 2.

Irrigation scheduling at 0.8 IW/CPE ratio recorded higher number of pods plant$^{-1}$ (25.97), pod yield (3069 kg ha$^{-1}$), kernel yield (1944 kg ha$^{-1}$), haulm yield (3875 kg ha$^{-1}$), shelling (62.62 %), seed index (47.39 g) and harvest index (41.81 %) comparing with treatment $I_1$that is irrigation scheduling at critical growth stages.

Positive effect on yield attributes and yield is due to treatment $I_3$ (0.8 IW/CPE ratio) might be due to maximum number of irrigations applied at shorter intervals and total consumptive use of water. These situations avoid soil moisture stress which provided favourable conditions for nutrients availability, further increasing number of pods per plant might be due to frequent water supply that resulted in increasing uptake of water and provided the longest reproductive phase with larger photosynthetic green surface and reproductive storage capacity, ultimately that results in increasing the yield. (Chaudhary *et al*., 2015, Behera *et al*., 2015 and Patel *et al*., 2008) [9, 10, 4].

Application of hydrogel at different levels showed different effects on yield attributing characters. The number of pods plant$^{-1}$ (25.41), pod yield (3081 Kg ha$^{-1}$), kernel yield (2087 kg ha$^{-1}$) haulm yield (4044 Kg ha$^{-1}$), and seed index (45.10 g) were increased by the application of hydrogel @ 6 kg ha$^{-1}$. It may be attributed with super absorbing properties of 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) [12] and Kumari *et al*., (2017) [14] in maize crop.

**Effect on quality parameters**

The data pertaining to the effect of irrigation schedules and hydrogel on protein content are presented in Table 1.

Protein content was significantly higher in treatment $I_3$ (0.8 IW/CPE ratio) that is 22.18% and the lowest protein content (19.15%) was in $I_1$ (irrigation at critical growth stages). The higher protein content in $I_3$ (0.8 IW/CPE ratio) might be due to more number of irrigations which increased available water content in soil. Since nitrogen uptake by plants is majorly through the mass flow were the water plays major role results in higher uptake of nitrogen which ultimately converted in higher protein content. Patel *et al*. (2008) [10].

The results reveal that effect of hydrogel were significantly higher protein content (21.95%) was observed in $H_3$ (Hydrogel at 6 kg ha$^{-1}$). The lowest protein content (19.29%) was observed in $H_0$ (Control). Due to the higher uptake of nitrogen by kernel higher protein content in kernel was observed in the treatment $H_3$ (Hydrogel at 6 kg ha$^{-1}$). Same results were observed by Fried *et al*. (2014) in potato and Jain *et al*. (2017) [15] in groundnut.

But effect of irrigation schedules and soil application of hydrogel on oil content of the groundnut kernel was non-significant.

**Table 1:** Date of irrigation, number of irrigation and total quantity of irrigation water applied

| Irrigation numbers | Treatments | | |
|---|---|---|---|
| | I1 (Critical growth stages) | I2 (0.6 IW: CPE) | I3 (0.8 IW: CPE) |
| Common | 10-02-20 | 10-02-20 | 10-02-20 |
| Common | 25-02-20 | 25-02-20 | 25-02-20 |
| 1 | 09-03-20 | 11-03-20 | 07-03-20 |
| 2 | 20-03-20 | 24-03-20 | 17-03-20 |
| 3 | 21-04-20 | 06-04-20 | 28-03-20 |
| 4 | 12-05-20 | 17-04-20 | 06-04-20 |
| 5 | - | 30-04-20 | 15-04-20 |
| 6 | - | 11-05-20 | 20-04-20 |
| 7 | - | 20-05-20 | 27-04-20 |
| 8 | - | 27-05-20 | 02-05-20 |
| 9 | - | 06-05-20 | 09-05-20 |
| 10 | - | 20-05-20 | 16-05-20 |
| 11 | - | 01-06-20 | 22-05-20 |
| 12 | - | 08-06-20 | 28-05-20 |
| 13 | - | - | 03-06-20 |
| 14 | - | - | 12-06-20 |
| Total no. of irrigation applied | 06 (2+4) | 14(2+12) | 16 (2+14) |
| Total quantity of Water applied (mm) | 300 mm | 700 mm | 800 mm |

**Table 2:** Effect of irrigation scheduling and hydrogel on plant growth attribute

| Treatments | No. of plants per meter row length | | Plant height (cm) | | Dry biomass (g plant$^{-1}$) | Protein (%) | Oil (%) |
|---|---|---|---|---|---|---|---|
| | 20 DAS | At harvest | 60 DAS | At harvest | 40 DAS | | |
| **(A) Main plot treatment Irrigation scheduling (I)** | | | | | | | |
| $I_1$: Critical growth stages | 5.59 | 4.24 | 16.30 | 46.07 | 2.56 | 19.15 | 51.02 |
| $I_2$: 0.6 IW: CPE | 5.68 | 4.37 | 16.87 | 50.48 | 2.90 | 21.25 | 51.80 |
| $I_3$: 0.8 IW: CPE | 5.87 | 4.37 | 18.86 | 52.39 | 3.85 | 22.18 | 51.78 |
| S.Em.± | 0.09 | 0.07 | 0.46 | 1.15 | 0.09 | 0.16 | 0.50 |
| C.D. at 5% | NS | NS | 1.84 | 4.53 | 0.33 | 0.64 | NS |
| C.V.% | 5.9 | 5.9 | 9.4 | 8.1 | 9.50 | 2.7 | 3.4 |
| **(B) Sub plot treatment Hydrogel (H)** | | | | | | | |
| $H_0$: No Hydrogel | 5.54 | 4.14 | 16.33 | 47.21 | 2.57 | 19.29 | 51.62 |
| $H_1$: Hydrogel at 3.0 kg ha$^{-1}$ | 5.77 | 4.32 | 17.08 | 48.15 | 2.88 | 20.41 | 51.45 |
| $H_2$: Hydrogel at 4.5 kg ha$^{-1}$ | 5.77 | 4.38 | 17.60 | 50.68 | 3.29 | 21.79 | 51.81 |
| $H_3$: Hydrogel at 6.0 kg ha$^{-1}$ | 5.79 | 4.47 | 18.38 | 52.55 | 3.66 | 21.95 | 51.26 |
| S.Em.± | 0.09 | 0.06 | 0.46 | 1.25 | 0.14 | 0.27 | 0.39 |
| C.D. at 5% | NS | 0.19 | 1.39 | 3.71 | 0.43 | 0.821 | NS |
| C.V.% | 5.0 | 4.6 | 8.1 | 7.6 | 13.8 | 3.9 | 2.3 |
| (C) Interaction effect (I × H) | NS | NS | NS | NS | NS | NS | NS |

**Table 3:** Effect of irrigation scheduling and hydrogel on yield attributes and yield

| Treatments | No. of pods plant$^{-1}$ | Pod yield (Kg ha$^{-1}$) | Kernel yield (Kg ha$^{-1}$) | Haulm yield (Kg ha$^{-1}$) | Shelling (%) | Seed index (g) | Harvest index (%) |
|---|---|---|---|---|---|---|---|
| **(A) Main plot treatment Irrigation scheduling (I)** | | | | | | | |
| $I_1$: Critical growth stages | 21.33 | 2504 | 1556 | 3430 | 59.93 | 40.31 | 40.59 |
| $I_2$: 0.6 IW: CPE | 23.17 | 2874 | 1851 | 3731 | 61.65 | 42.21 | 40.85 |
| $I_3$: 0.8 IW: CPE | 25.97 | 3069 | 1944 | 3875 | 62.62 | 47.39 | 41.81 |
| S.Em.± | 0.71 | 89 | 38 | 83 | 1.82 | 1.33 | 0.530 |
| C.D. at 5% | 2.78 | 349 | 149 | 326 | NS | 5.24 | NS |
| C.V.% | 10.4 | 10.9 | 7.7 | 7.8 | 10.29 | 10.7 | 4.8 |
| **(B) Sub plot treatment Hydrogel (H)** | | | | | | | |
| $H_0$: No Hydrogel | 21.67 | 2529 | 1564 | 3224 | 61.69 | 42.02 | 41.00 |
| $H_1$: Hydrogel at 3.0 kg ha$^{-1}$ | 22.44 | 2697 | 1579 | 3491 | 60.23 | 42.36 | 40.41 |
| $H_2$: Hydrogel at 4.5 kg ha$^{-1}$ | 24.44 | 2956 | 1905 | 3954 | 61.48 | 43.73 | 40.86 |
| $H_3$: Hydrogel at 6.0 kg ha$^{-1}$ | 25.41 | 3081 | 2087 | 4044 | 62.20 | 45.10 | 42.08 |
| S.Em.± | 0.63 | 91 | 37 | 96 | 1.26 | 0.79 | 0.42 |
| C.D. at 5% | 1.86 | 270 | 111 | 284 | NS | 2.34 | NS |
| C.V.% | 8.0 | 9.7 | 6.3 | 7.8 | 6.2 | 5.5 | 3.1 |
| (C) Interaction effect (I × H) | Sig. | Sig. | Sig. | NS | NS | NS | NS |

## Conclusion

The study demonstrates that both irrigation scheduling at a 0.8 IW/CPE ratio ($I_3$) and hydrogel application at 6 kg ha$^{-1}$ ($H_3$) positively impacted plant growth, yield, and quality parameters. Irrigation scheduling significantly enhanced plant height, dry biomass, pod yield, kernel yield, and protein content due to better soil moisture availability. Similarly, hydrogel application improved plant population, height, biomass, and yields by increasing water and nutrient availability. These improvements are attributed to enhanced cell division and elongation, promoting better vegetative and reproductive growth. Protein content was notably higher with increased irrigation and hydrogel levels, linked to better nitrogen uptake facilitated by adequate soil moisture. However, oil content was not significantly affected by either factor. Overall, the combination of optimal irrigation and hydrogel application proved beneficial for enhancing plant growth, yield and protein content in groundnut.

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