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RESEARCH ARTICLE

PRODUCTION POTENTIAL AND ECONOMICS OF SUMMER GROUNDNUT UNDER DIFFERENT HYDROGEL LEVELS AT VARYING IRRIGATION SCHEDULING IN SOUTH SAURASHTRA AGRO-CLIMATIC ZONE

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Abstract: A field experiment was conducted during the summer season of 2019–20 on medium black soils at the Instructional Farm, Junagadh Agricultural University to study the Production potential and economics of summer groundnut (*Arachis hypogaea* L.) under different hydrogel levels at varying irrigation scheduling in south saurashtra agro-climatic zone. The field experiment was conducted in a split-plot design, comprising of 3 irrigation schedules, *viz*., irrigation water (IW): cumulative pan evaporation (CPE) ratio 0.60, 0.80 and 1.00 in main plots and 3 hydrogel levels, *viz*.,Control, 2.5and 5.0 kgha^{-1} in subplots, combined having 9 treatment combinations, which were replicated 4 times. The results revealed that an application of irrigation at IW:CPE ratio of 1.00 had significant effect on yield attributes and yield, *viz*., number of pods per plant (15.12), weight of pods per plant (9.93 g), seed index (48.15), pod yield (3286kg ha^{-1}) and haulm yield (4021kg ha^{-1}) and these ratio significantly improved the yield over IW:CPE ratio of 0.60 and 0.80.IW:CPE ratio 1.00 fetched highest net returns of 73,155`ha^{-1}, with benefit: cost ratio 2.04. Application of 5 kgha^{-1} hydrogel resulted in the highest number of pods per plant (14.40), weight of pods per plant (9.53 g), seed index (46.53), pod yield (3171 kg ha^{-1}) and haulm yield (3926 kg ha^{-1}) and these level significantly enhanced summer groundnut yield over application of 2.5 kgha^{-1} hydrogel and the control. Application of hydrogel at 5.0 kgha^{-1} significantly enhanced net returns (68,971 ₹ha^{-1}) and benefit: cost ratio (1.99) as compared to application of 2.5 kgha^{-1} hydrogel and the control.

Keywords: Summer Groundnut, Hydrogel, Irrigation Scheduling, Economics, Yield

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed and edible legume plant in the world's tropical and subtropical areas. It is the world's fourth most important source of edible oils and the third most important source of quality food, minerals and carbohydrates. Groundnut is an important oilseed crop in India and has always been the backbone of the agricultural industry. Being the most important agricultural sector, India exported 5.04 million tonnes of groundnut in 2017-18, earning foreign exchange worth ₹ 3.389 billion (Anonymous, 2020).

In recent years, due to the increase in productivity and profitability and the availability of irrigation facilities, the areas suitable for summer peanut cultivation have increased. Among the many limitations of summer groundnut production *viz*., low temperature and water management during germination are crucial.

In arid and semi-arid areas, a rising number of people and livestock necessitate irrigated agriculture in order to increase food production while conserving water and avoiding adverse environmental effects. Irrigation planning is important for effective water management and reduction of water stress in summer groundnut. It increases the moisture content of the soil during growth, promoting germination, pod formation and yield. Correct water planning is essential for summer cultivation where water resources are limited (Prihar *et al*. 1974).

Pusa hydrogel, an indigenously developed superabsorbent polymer, is used to conserve water, enhance crop productivity, and improve water-use efficiency in agriculture. When hydrogel is used, it absorbs 350 compounded by its water content and slowly releases it to the plant, thus increasing water availability in the roots and shortening irrigation intervals, thus delaying irrigation times. In addition to improving morphological characteristics, increasing the concentration of superabsorbent polymers in soil can reduce crop water requirements by up to 33%. Superabsorbent polymers improve water storage and soil conservation by providing adequate moisture throughout the growing season (Radwan *et al*. 2016). It works like a sponge,

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absorbing water and slowly releasing it into the crop to keep it moist (Shikha *et al*. 2019).

Summer cultivation of groundnuts faces problems due to lack of water and bad weather conditions, affecting crops and economic outcomes. Solving these problems requires good understanding, and we investigated the response of summer groundnut (*Arachis hypogaea* L.) to hydrogel levels under varying irrigation schedules.

METHODOLOGY

Site characterization

Field trials were conducted in medium black clay soil under irrigated conditions at the Instructional farm of the Junagadh Agricultural University, in summer 2019. Site was located in a semi-arid region with mean annual rainfall of 844 mm. In this region the onset of monsoon rains occurs in the third week of June but can start as late as the first week of August. The average maximum temperature from April to June is very high with a mean of 41 °C. In January, temperature falls to a minimum of 12 °C. It reaches a maximum in May. The soil is classified as Vertic Ustochrept, medium black, clayey, shallow (15-20 cm depth) and highly calcareous in nature (pH 7.9). The soil contains moderate available nitrogen (285 $kgha^{-1}$), low available phosphorus (18 $kgha^{-1}$) and high in available potassium (316 $kgha^{-1}$), EC 0.33 dSm^{-1}, high P fixation capacity (75-95%) and contains an appreciable amount of $CaCO_3$.

Field experiment

This experiment included nine treatment combinations, including a three-levelsof irrigation and three-levels of hydrogels (*i.e.*, irrigation at IW:CPE ratios of 0.6, 0.8, and 1.0 and hydrogels of 0, 2.5, and 5 $kgha^{-1}$). It was used in four replications. The ground (*cv.* TG-37A) crop was planted on February 22th, 2020 with a planting geometry of 30 x 10 cm and two common irrigations was given *i.e.* first irrigation immediately after sowing, second at 5-6 days after sowing. Apply the recommended amount of fertilizer based on the area of the field. All nine treatments, along with irrigation and hydrogel levels, were used to compare different yield attributes, yield and economics.

Data analysis

Standard analysis of variance was used to do the statistical analysis of the data (Gomez and Gomez, 1984). The F-test was used to assess the treatment effects' significance. Using the least significant difference (LSD) at the 5% probability level, the significance of the difference between the means of the two treatments was examined.

Economic analysis

The yield and cost-effectiveness of hydrogel and irrigation scheduling were evaluated to determine whether to add more groundnut production. Utilizing crop yield and produce market price, net realization return and benefit cost ratio were computed to compare the economics.

RESULTS AND DISCUSSION

Effect of irrigation schedules on yield and economics

Scheduling of irrigation through IW: CPE ratio brought about significant variation in number of pods per plant, weight of pods per plant, seed index, pod yield and haulm yield (Table 1). Summer groundnut crop irrigated at IW: CPE ratio of 1.00 recorded highest yield attributes and yield. *viz*, number of pods per plant (Fig. A), weight of pods per plant (Fig. B), seed index (Fig. C), pod yield (Fig. D) and haulm yield (Fig. E) which was found significantly increased number of pods per plant, weight of pods per plant, seed index, pod yield and haulm yield over irrigation at IW: CPE ratios of 0.60 and 0.80. Successive increase in irrigation regime up to IW: CPE ratio of 1.00 significantly increased the net returns as compared to irrigation at IW: CPE ratio of 0.60 and 0.80. The crop irrigated at IW: CPE ratio of 1.00 fetched the highest net returns of ₹ 73,155 ha^{-1} (Fig. F) with benefit: cost ratio 2.04 (Fig. G).

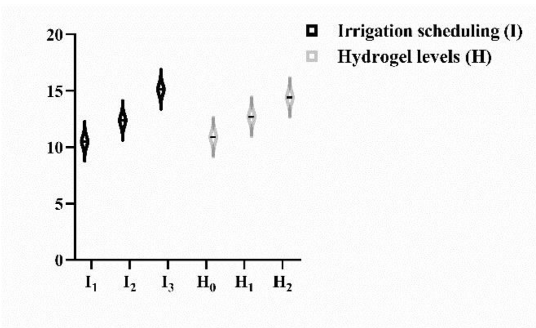

Fig. A: Number of pods per plant
This figure shows trends of increasing irrigation scheduling and hydrogel increase pods number per plant.

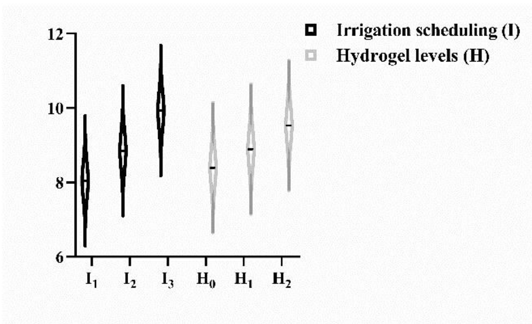

Fig. B: Weight of pods per plant (g)
This figure illustrations drift of increasing irrigation scheduling and hydrogel increase pods weight per plant.

Scheduling of irrigation through IW:CPE ratio brought about significant variation in number of pods per plant, weight of pods per plant, seed index, pod yield and haulm yield(Table 1). Summer groundnut crop irrigated at IW:CPE ratio of 1.00 recorded highest yield attributes and yield. *viz*,number of pods per plant (Fig. A), weight of pods per plant (Fig. B), seed index (Fig. C), pod yield (Fig.D) and haulm yield (Fig. E) which was found significantly increased number of pods per plant, weight of pods per plant, seed index, pod yield and haulm yield over irrigation at IW:CPE ratios of 0.60 and 0.80. Successive increase in irrigation regime up to IW:CPE ratio of 1.00 significantly increased the net returns as compared to irrigation at IW:CPE ratio of 0.60 and 0.80. The crop irrigated at IW:CPE ratio of 1.00 fetched the highest net returns of ₹ 73,155 ha^{-1}(Fig. F) with benefit: cost ratio 2.04 (Fig. G).

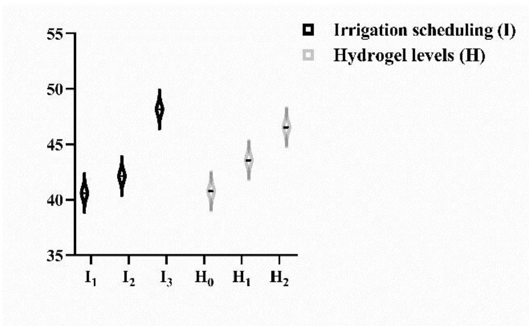

Fig. C: Seed index (g)

This figure instances show how the hydrogel slightly raises the seed index and how irrigation schedule wanders upward.

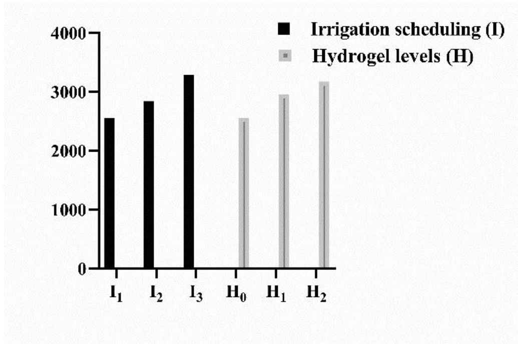

Fig. D: Pod yield (kg ha^{-1})

The trends in increase irrigation schedule and hydrogel-induced pod yield increase are portrayed in these figures.

The main benefits of water treatment appointments are reflected in the efficiency results. As irrigation provides sufficient water, it can accelerate photosynthesis and therefore increase carbohydrate supply, resulting in increased growth. The superiority of these treatments can be explained by the fact that better growth and greater nutrition in these treatments will lead to a greater distribution of photosynthates and assimilates, thus improving the yield. Photosynthesis and the existence of assimilates (sources) and organs (sinks) play an important role in the complex equilibrium process (Michael and Beringer, 1980). This procedure is not solely dependent on the nutrient source and photosynthetic capacity of the plant, but also hormonal structure plays an important role in the production of products (Michael and Beringer, 1980). Therefore, providing more water through more channels can help maintain higher activity of the roots, thus providing the best nutrients/water for the development of the plant structure.

In addition, better root activity, especially during pod development, is thought to be important for cytokinin production and their transport into the kernel. Therefore, the improvement in the sink relationship seems to result in higher crop yields as a result of using water with an IW:CPE ratio of 1.00. The additional behavior of low water, for example, the IW:CPE ratio of 0.60, indicates a low groundnut capacity with a good balance regarding the greater usability of the sink. Although the crops in the above irrigation show improvements in terms of various yield attributes and yields, these increases do not reach significant levels. The observed crop performance under higher irrigation levels is in conformity with finding ofRanjitha *et al.* (2018), Maurya, A.C. *et al.* (2019), Bhargavi *et. al.* (2022) and Karthik & Singh (2023) who reported that groundnut crop under irrigation IW:CPE ratio of 1.00 recorded significantly higher yield attributes and yield.

Effect of hydrogel levels on yield and economics

Increasing levels of hydrogel application up to 5.0 kg ha^{-1} significantly enhanced number of pods per plant (Fig. A), weight of pods per plant (Fig. B), seed index (Fig. C), pod yield (Fig. D) and haulm yield (Fig. E) over application of 2.5 kg hydrogel ha^{-1} and control (Table 1). Application of hydrogel at 5.0 kg ha^{-1} significantly enhanced the net returns (Fig. F) and benefit: cost ratio (Fig. G) as compared to application of 2.5 kg hydrogel ha^{-1} and control (Table 1).

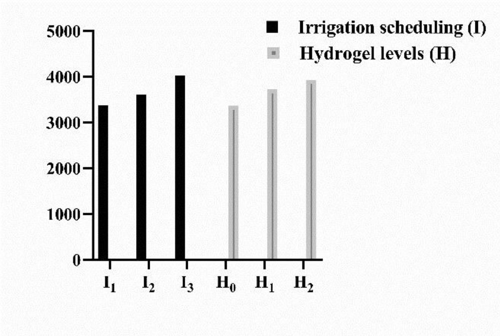

Fig. E: Haulm yield (kg ha^{-1})
The increase hydrogel and decrease irrigation interval boost haulm yield observed in these figure depictions.

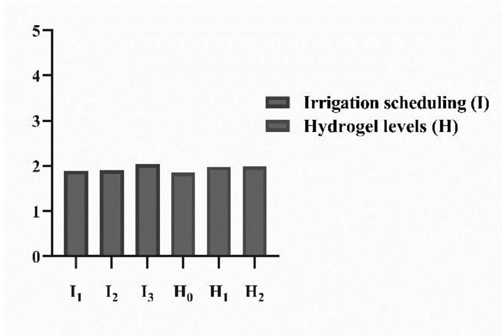

Fig. F: Net realization (₹ ha^{-1})
This figure representations illustrate how the irrigation schedule and hydrogel levels impact on net realization.

Hydrogel has an additive impact on soil because it creates an optimal environment for nutrient absorption, which increases biomass and the number of leaves and branches in the plant. Hydrogel has been shown to enhance the physical and chemical characteristics of soil, which in turn promotes improved root growth, enhanced nutrient uptake, and increased water holding capacity. These factors ultimately result in larger pod yields, improved pod quality, and a greater quantity and weight of pods per plant. Furthermore, the use of hydrogel enhanced the porous soils' capacity to store water and delayed the beginning of the permanent withering percentage under high evaporation. These similar results are in conformity with the results of those reported by Jain *et al*. (2017) in groundnut, Shashidhar *et al*. (2020) in lentil and Varamin *et al*. (2019) in sesame.In fact, the hydrogel improves cell membrane development by balancing nutrients and increasing carbon dioxide fixation by opening stomata for energy efficiency. Additionally, the hydrogel penetrates against leaching and provides water storage in the root zone of the soil through a deep percolation layer (Sow *et al*. 1997). A greater amount of biomass at each stage indicates that the plant has sufficient amounts of metabolites/nutrient sources in the hydrogel strength to meet the needs of the growth pattern. Therefore, improved seed nutrition with larger assimilation surface and high level of hydrogel during growth seems to provide a suitable environment for grain growth due to adequate supply of metabolites and nutrients (Tyagi *et al*. 2015).

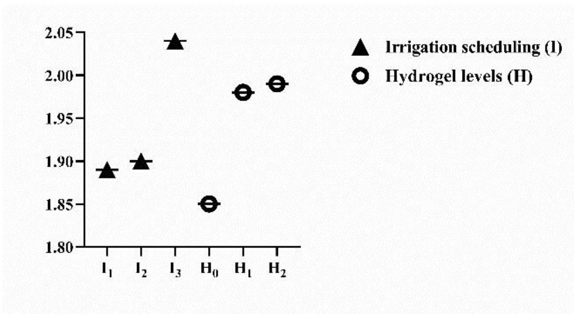

Fig. G: Benefit: cost ratio
This figure shows trends of different irrigation schedules and hydrogel levels affect the benefit: cost ratio during summer groundnut.

Table 1. Effect of irrigation scheduling and hydrogel levels on yield attributes and economics of summer groundnut (*Arachis Hypogaea* L.)

Treatments	Number of pods per plant	Weight of pods per plant (g)	Seed index (g)	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Net return (₹ ha^{-1})	Benefit: cost ratio
Irrigation scheduling (I)							
I_1 : 0.6 IW : CPE	10.50	8.04	40.59	2550	3377	52795	1.89
I_2 : 0.8 IW : CPE	12.36	8.85	42.12	2838	3610	58822	1.90
I_3 : 1.0 IW : CPE	15.12	9.93	48.15	3286	4021	73155	2.04
S.Em.±	0.59	0.34	1.91	116	137		
C.D. at 5%	1.44	0.84	4.67	285	334		
C.V %	11.40	9.40	10.71	9.86	9.12		
Hydrogel levels (H)							

H_0 : 0.0 kg ha^{-1}	10.89	8.39	40.76	2552	3365	51619	1.85
H_1 : 2.5 kg ha^{-1}	12.69	8.89	43.56	2950	3718	64183	1.98
H_2 : 5.0 kg ha^{-1}	14.40	9.53	46.53	3171	3926	68971	1.99
S.Em.±	0.44	0.26	1.36	95	110		
C.D. at 5%	0.92	0.54	2.85	201	230		
Interaction effect of I X H							
S.Em.±	0.76	0.45	2.35	165	190		
C.D. at 5%	1.60	0.94	4.94	347	NS		
C.V %	8.51	7.06	7.62	8.09	7.32		

Higher yields under treatment of hydrogel @ 5.0 kg ha^{-1} could ascribed to hydrogel at limited available water status improved the water storage in soil and helped the plant to resist against severe drought and on the other hand improved the N fixation through rhizobium which reflected through higher nodulation and nodule weight. Adequate water availability helps in efficient utilization of nutrients as well as better production and storage of photosynthetic products. These increase the growth and development characteristics of the plant and have a positive relationship with increased groundnut yield. Therefore, the importance of pod and haulm yield after hydrogel application appears to crop's ability to grow and develop. These results concur with earlier reports Patro and Ray (2016) and Jain *et al.* (2017) in summer groundnut, Singh *et al.* (2018) in Indian mustard, Singh *et al.* (2018) and Roy *et al.* (2019) in wheat, Shashidhar *et al.* (2020) in lentil and Ray*et al.* (2021) in pearl millet.

Interaction effect of irrigation scheduling and hydrogel levels on yield and economics

Table 2. Treatment-wise yield attributes, yield and economics

Treatment combinations	Number of pods per plant	Weight of pods per plant (g)	100-kernel weight(g)	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Net realization (₹ ha^{-1})	Benefit: cost ratio
I_1H_0	8.14	7.91	38.98	2377	3007	49626	1.91
I_1H_1	11.56	8.09	41.06	2624	3496	56399	1.96
I_1H_2	11.79	8.11	41.72	2646	3630	53110	1.83
I_2H_0	11.25	7.96	36.85	2407	3196	44951	1.74
I_2H_1	12.09	9.15	40.70	2761	3641	55885	1.85
I_2H_2	13.74	9.43	48.81	3343	3993	75629	2.08
I_3H_0	13.28	9.29	46.45	2870	3891	60728	1.92
I_3H_1	14.41	9.44	48.93	3463	4017	80265	2.14
I_3H_2	17.67	11.05	49.06	3524	4156	78548	2.05

Treatment combination I_3H_2 recorded significantly higher pod and haulm yield (Table 2). Irrigating the crop at 1.0 IW: CPE ratio (I_3) and application of hydrogel @ 5.0 kg ha^{-1} (H_2) significantly increased yield which possibly because of treatment combination I_3H_2 have higher moisture content before irrigation from which frequent irrigation scheduling and hydrogel level under treatment might have created favorable moisture conditions as resulting from more soil nutrients' accessibility to plants, which improved soil conditions, the roots grow better, more nodules were produced and provides substrate for microbial growth and increased microbial activities, which resulted in improved vegetative growth and yield. Comparable outcomes were also reported by Tyagi *et al.* (2015) in wheat, Kumar *et al.* 2019in Indian musturd, Pradeep *et al.* (2017) in chick pea, Ali and Abdel-Aal (2021) in soybean, Jat *et al.* (2018) in mustard and Ray*et al.* (2021) in pearl millet.

Economic evaluation of different treatments showed that the benefit increased as irrigation interval time decrease and hydrogel level increased (Table 2). In the combined treatment I_3H_1 (irrigation and hydrogel at 1.0 IW: CPE @ 2.5 kg ha^{-1}), the maximum value achieved was 80,265 ha^{-1}, followed by I_3H_2 and I_2H_2, with a benefit: cost ratio of 2.14. This may be due to the higher yield obtained from these practices and also the higher summer groundnut yield.

In contrast, treatment combination I_1H_0(irrigation at 0.6 IW:CPE ratio and hydrogel @ 0.0 kg ha^{-1})recorded the lowest gross returns, net returnsand benefit: cost ratio, which might be due very low pod and haulm yields owing to lower moisture content. These findings results are in vicinity with those reported by Kumar *et al.* 2019.

CONCLUSION

From the above finding, it seems quite logical to concluded that under medium black calcareous soil of South Saurashtra agro-climatic zone for getting higher yield and net realization, groundnut (*Cv.* TG 37 - A) irrigated twenty times at an IW:CPE ratio of 1.0 including two common irrigations *i.e.* first irrigation immediately after sowing, second at 5-6 days after sowing and remaining eighteen irrigations should be given at based on pan evaporation and application of hydrogel @ 2.5 kgha^{-1} along with other recommended package of practices.

Under scarcity of irrigation water and for getting maximum benefit: cost ratio crop should be applying seventy irrigations at an IW:CPE ratio of 0.8 including two common irrigations i.e. first irrigation immediately after sowing, second at 5-6 days after sowing and remaining nine irrigations should be given at based on pan evaporation and application of hydrogel @ 5.0 kgha^{-1} along with other recommended package of practices.

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AUTHOR CONTRIBUTIONS

Data collection, analysis, and material preparation were handled by Dr. P. D. Vekariya, Dr. S. P. Kachhadiya and J. B. Gajera. J. B. Gajera wrote the original draft of the manuscript, while the other writers provided feedback on earlier drafts. The final manuscript was reviewed and approved by all writers. All project participants have received the proper credit.

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