



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
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NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(3): 471-477
Received: 02-12-2025
Accepted: 09-01-2026

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Efficacy of *Fasal Amrit* hydrogel on growth, yield and economics of Green Gram (*Vigna radiata* L.) under South Gujarat Conditions, India

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i3g.5299>

Abstract

Water scarcity is a primary constraint on crop productivity, with moisture stress during key growth stages causing yield losses of 30–40%. Sustaining yields requires enhancing soil water retention and irrigation efficiency through improved water-saving technologies and agronomic strategies.

A field experiment was conducted during the summer season of 2024 and 2025 at Krishi Vigyan Kendra, BAIF Campus, Chaswad, Bharuch district in Gujarat to study the efficacy of *Fasal Amrit* (EF Polymer) on crop productivity, plant nutrient uptake, soil nutrient status and water savings in green gram (*Vigna radiata* L.). The study involved field experiments incorporating two levels of *Fasal Amrit* (EF Polymer) at 15 and 20 kg ha⁻¹, along with RDF levels of 100, 90, 85 and 80%, to assess their impact on various agronomic parameters and water regimes. The pooled results indicated that among the treatments, *Fasal Amrit* @ 20 kg ha⁻¹ + 100% RDF (T₃) recorded the highest plant height (53.20 cm), number of leaves (36.57), branches per plant (9.69), pods per plant (18.30), grains per pod (8.37), and test weight (4.15 g). This treatment also produced the maximum grain yield (1556.42 kg ha⁻¹) and straw yield (3559.03 kg ha⁻¹), showing a 53.7% yield increase over RDF alone (1012.78 kg ha⁻¹). Economic analysis revealed that T₃ resulted in the highest gross return (₹1,29,141 ha⁻¹), net return (₹71,358 ha⁻¹) and benefit–cost ratio (2.23). Nutrient uptake analysis showed increased nitrogen and crude protein contents in grain and straw under *Fasal Amrit* treatments. Soil analysis after harvest indicated improvements in organic carbon and nutrient contents. Additionally, this treatment saved 0.97 million liters of water per hectare. The study concludes that *Fasal Amrit* can be a viable strategy for improving the resilience of summer green gram cultivation under water-limited conditions.

Keywords: Hydrogel, *Fasal Amrit* (EF Polymer), green gram, yield, economics, water savings

Introduction

India is the largest producer, consumer and importer of pulses, which serve as a major source of protein for a large section of the population. Among different dietary protein sources, pulses are consumed more frequently, highlighting their vital role in daily food habits. Pulses contribute about 11% to the total protein intake in India (Reddy, 2010) [16].

Green gram (*Vigna radiata*) is one of the most important pulse crops, accounting for nearly 40% of total pulse production. It is consumed in multiple forms—whole grain, sprouts and split dal—making it an integral part of Indian diets. India is the leading global producer of green gram, predominantly grown in arid and semi-arid regions where water scarcity is a major challenge, contributing around 10% of the country's total pulse output. During 2020–21, green gram was cultivated on approximately 5.13 million hectares with a production of 3.08 million tonnes and an average productivity of 601 kg ha⁻¹ (DES, 2021). In Gujarat, it covered 0.15 million hectares, yielding 0.11 million tonnes with an average productivity of 712 kg ha⁻¹. The major producing states include Rajasthan, Karnataka, Madhya Pradesh, Haryana, and Gujarat. Specifically, in Bharuch district, green gram cultivation covered 4,985 hectares with an average productivity of 987 kg ha⁻¹ (DAO, Bharuch, 2023).

Despite its significance, a considerable yield gap has been reported in Bharuch, primarily due to technological and extension limitations (Patil *et al.*, 2015) [13]. Moreover, yellow vein mosaic

disease poses a major challenge, often becoming more severe under water stress conditions. In this context, water management technologies assume critical importance.

Hydrogels—superabsorbent polymers capable of holding several times their weight in water—have emerged as a promising option to improve soil moisture availability and reduce irrigation frequency (Allahdadi *et al.*, 2005, El-Hady and Camilia, 2006) [4, 8]. By absorbing and releasing water gradually, hydrogels help mitigate the effects of drought stress, thereby enhancing crop growth and yield (Dass *et al.*, 2013; Rehman *et al.*, 2011) [5, 17]. Considering the recurring water scarcity in summer cultivation, the present study was undertaken to evaluate the effectiveness of hydrogel *Fasal Amrit* in improving the growth, productivity, and water-use efficiency of summer green gram. *Fasal Amrit* is an organic superabsorbent polymer made from bio-waste by EF Polymer Pvt. Ltd., Rajasthan, India.

Materials and Methods

The experiment was conducted at Krishi Vigyan Kendra, BAIF Campus, Chaswad, Bharuch district in south Gujarat (21°34'31.44 N latitude, 73° 34'31.44 E longitude, and an elevation of 135 m above mean sea level) during summer 2024 and 2025. The climate of the region is semi-arid with hot summers and mild winters. The mean annual rainfall received at Chaswad is 1000 mm. Nearly, 95% of the total precipitation is received during the southwest monsoon season (June to September) and the remaining period of the year is generally dry. During the summer months (April, May and June), temperatures rise to 40 °C. The soil is a fine textured clay loam. The initial soil sample was collected before laid out of the research trial. The initial status of soil is given in Table 1.

Table 1: Initial fertility status of soils of experimental plot

Parameter	Value	Rating
pH	6.16	Acidic
EC (dSm ⁻¹)	0.32	Normal
OC (%)	0.55	Medium
Available N (kg ha ⁻¹)	235.83	Low
Available P ₂ O ₅ (kg ha ⁻¹)	30.20	Medium
Available K ₂ O (kg ha ⁻¹)	140.78	Low
DTPA-Fe (ppm)	2.23	Low
DTPA-Mn (ppm)	6.82	Medium
DTPA-Zn (ppm)	0.43	Low
DTPA-Cu (ppm)	1.08	High

The landscape is characterized by mild slopes (<1%). The surface soil has a low water holding capacity; it is highly permeable and readily drains. The soil pH is neutral to slightly acidic. Green gram variety GM-6 (Gujarat Mungbean-6) was sown during 2nd week of February. The experiment was laid in a randomized block design (RBD) with three replications and eight treatments. The treatments included different levels of hydrogel mixed into the soil with sowing the green gram seeds. The treatments details were as follows

Treatment Details

T₁: RDF 20:40:40 NPK (kg/ha)
 T₂: *Fasal Amrit* 15 kg/ha + 100% RDF
 T₃: *Fasal Amrit* 20 kg/ha + 100% RDF
 T₄: *Fasal Amrit* 15 kg/ha + RDF 90%
 T₅: *Fasal Amrit* 20 kg/ha + RDF 90%
 T₆: *Fasal Amrit* 15 kg/ha + RDF 85%
 T₇: *Fasal Amrit* 20 kg/ha + RDF 85%
 T₈: *Fasal Amrit* 15 kg/ha + RDF 80%

T₉: *Fasal Amrit* 20 kg/ha + RDF 80%

Data were collected on soil, plant growth and yield parameters. These parameters were compared across the different treatment groups and the control. 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 green gram. Net returns (R_{sha}⁻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.

The soil moisture was measured at seven-days interval with the help of a soil moisture indicator (at 0-15 cm depth). The quantity of irrigation water consumed by crop was measured by using “V-notch weir” device. The soil samples were collected from each treatment after harvest of crop and analysed for fertility parameters. The samples of grain and stalk of green gram were digested with the help of sulphuric salicylic acid for analysis of N and diacid (HClO₄ + HNO₃) for analysis of P and K. Total nitrogen content was estimated by Kjeldahl method while, phosphorus and potash were determined using a spectrophotometer and flame photometer, respectively.

Statistical Analysis

Data on plant growth and yield were analysed by two-way analysis of variance (ANOVA) as per the model suggested by Panse and Sukhatme (2000). The data recorded was analysed using SPSS 16.0 package software as per design of the experiment.

Results and Discussion

The growth and yield of green gram was assessed to understand the effect of *Fasal Amrit* at two levels and varying doses of RDF. The details are described in the following sub-sections.

Effect of *Fasal Amrit* on growth parameters of green gram

The data on vegetative growth parameters, namely plant height, number of leaves, and number of branches, revealed significant improvement with the integration of *Fasal Amrit* and RDF compared to RDF alone (Table 2). Plant height at 20 and 40 DAS remained statistically non-significant across treatments and years, indicating uniform early growth. However, at harvest, treatments differed significantly, with T₃ (*Fasal Amrit* 20 kg ha⁻¹ +100% RDF) recording the maximum height (53.20 cm), which was markedly higher to RDF alone (40.08 cm) and T₈ (43.13 cm). Other *Fasal Amrit* treatments showed intermediate plant heights (47.57–48.55 cm) and remained statistically at par. The year and Y × T interaction was non-significant, reflecting stable performance across seasons. For number of leaves per plant, T₃ consistently produced the maximum number of leaves (9.97 at 20 DAS; 24.21 at 40 DAS; 36.57 at harvest), followed by *Fasal Amrit* treatments at reduced RDF levels, all of which were significantly superior to RDF alone (8.55, 18.96, and 24.27 leaves at respective stages). A significant year effect was recorded at 40 DAS and harvest, with higher leaf counts in 2024 and 2025, possibly due to favourable climatic conditions, while the Y × T interaction remained non-significant. Number of branches per plant also exhibited a similar trend (Table 3). At 40 DAS, significant differences were noted in 2024 and pooled data. T₃ recorded the highest pooled branches (7.20), which was significantly superior to RDF alone (6.07). At harvest, T₃ again dominated (9.69 branches), significantly exceeding T₁ (7.36),

while other *Fasal Amrit* treatments (8.43–8.57) remained statistically at par. Reduction in RDF levels up to 20% (T₄–T₉) did not significantly reduce plant height, leaf number, or branching, highlighting the potential of nutrient saving without compromising growth. The improvement in these traits may be attributed to enhanced moisture retention and nutrient use efficiency, supporting cell division, elongation, and leaf expansion. These findings corroborate earlier reports by Al-Harbi *et al.* (1999) [3] and Akhter *et al.* (2004), who emphasized the role of hydrogel polymers and integrated nutrient

management in sustaining higher vegetative growth and branching ability under field conditions.

Kunjir *et al.* 2022 also stated that, the application of SPG 1818 hydrogel @20 kg along with 2 kg of vermicompost was recorded significantly higher growth and yield parameters such as plant height (97.2cm), branches per plant (2.5), pods per plant (2.29), leaves per plant (18.3), total pods per plot (540.3), root length (30.4 cm), root weight (41.5g), and shoot weight (142.1g) as compared to other treatments.

Table 2: Effect of *Fasal Amrit* on growth parameters of green gram at different stages

Treatment	Plant Height (cm)									Number of Leaves per Plant								
	20 DAS			40 DAS			At Harvest			20 DAS			40 DAS			At Harvest		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
T ₁	6.80	7.03	6.91	13.93	14.17	14.05	40.27	39.89	40.08	8.24	8.87	8.55	18.47	19.45	18.96	22.20	26.33	24.27
T ₂	7.50	7.81	7.66	15.00	15.32	15.16	47.73	48.05	47.89	8.35	9.53	8.94	18.87	19.83	19.35	27.53	30.53	29.03
T ₃	7.20	7.47	7.33	15.33	15.93	15.63	53.07	53.33	53.20	9.47	10.47	9.97	23.80	24.62	24.21	33.60	39.53	36.57
T ₄	7.67	7.86	7.76	15.33	15.52	15.43	48.33	48.52	48.43	8.25	9.20	8.72	18.60	19.13	18.87	27.67	30.20	28.93
T ₅	7.76	7.90	7.83	15.53	15.67	15.60	47.93	48.07	48.00	8.28	9.00	8.64	18.93	19.65	19.29	28.47	32.20	30.33
T ₆	7.10	7.39	7.25	14.20	14.49	14.35	48.40	48.69	48.55	8.25	8.93	8.59	18.47	19.55	19.01	26.53	30.40	28.47
T ₇	7.37	7.67	7.52	14.73	15.17	14.95	47.93	48.23	48.08	8.36	9.00	8.68	18.60	19.74	19.17	26.33	30.44	28.39
T ₈	7.37	7.59	7.48	14.73	15.09	14.91	41.27	44.99	43.13	8.30	8.93	8.62	18.60	19.29	18.94	27.27	29.00	28.13
T ₉	7.13	7.41	7.27	14.93	15.21	15.07	48.13	47.01	47.57	8.27	9.00	8.63	18.73	19.47	19.10	27.07	28.60	27.83
S.Em.±	0.44	0.36	0.28	1.00	0.85	0.65	2.41	1.88	1.53	0.36	0.28	0.23	0.66	0.69	0.48	1.79	1.59	1.20
C.D. at 5%	NS	NS	NS	NS	NS	NS	7.23	5.63	4.41	NS	0.85	0.66	1.97	2.08	1.38	5.37	4.78	3.45
Year																		
S.Em.±			0.13			0.31			0.72			0.11			0.23			0.56
C.D. at 5%			NS			NS			NS			0.31			0.65			1.63
Y x T																		
S.Em.±			0.40			0.93			2.16			0.32			0.68			1.69
C.D. at 5%			NS			NS			NS			NS			NS			NS

Table 3: Effect of *Fasal Amrit* on Number of Branches per Plant of Green gram at different stages

Treatment	Number of Branches per Plant					
	40 DAS			At Harvest		
	2024	2025	Pooled	2024	2025	Pooled
T ₁	5.20	6.93	6.07	6.93	7.78	7.36
T ₂	6.29	7.53	6.91	8.47	8.38	8.43
T ₃	6.27	8.13	7.20	10.40	8.98	9.69
T ₄	6.20	7.40	6.80	8.73	8.25	8.49
T ₅	6.31	7.27	6.79	9.00	8.12	8.56
T ₆	6.16	7.51	6.83	8.69	8.36	8.53
T ₇	6.20	7.47	6.83	8.76	8.32	8.54
T ₈	6.20	7.22	6.71	8.93	8.07	8.50
T ₉	6.24	7.38	6.81	8.91	8.23	8.57
S.Em.±	0.22	0.27	0.17	0.54	0.27	0.30
C.D. at 5%	0.65	NS	0.50	1.62	NS	0.87
Year						
S.Em.±			0.08			0.14
C.D. at 5%			0.23			0.41
Y X T						
S.Em.±			0.24			0.43
C.D. at 5%			NS			NS

Effect of *Fasal Amrit* on yield parameters and yield of green gram

Application of *Fasal Amrit* in combination with RDF levels significantly influenced yield attributes of the crop (Table 4). The number of pods per plant was markedly higher under *Fasal Amrit* treatments compared with RDF alone. Among the treatments, *Fasal Amrit* @ 20 kg ha⁻¹ + 100% RDF (T₃) recorded the maximum number of pods per plant (18.30, pooled) followed by T₅ (15.60), whereas the minimum was observed under RDF alone (10.37). A similar trend was evident for the

number of grains per pod, where T₃ produced significantly more grains (8.37) compared with RDF (6.17). Pod length was also enhanced due to *Fasal Amrit* application, with the longest pods (6.05 cm) recorded in T₃, while RDF alone resulted in the shortest pods (5.21 cm). Test weight showed significant improvement with the application of *Fasal Amrit*, the highest being recorded under T₃ (4.15 g), which was statistically superior to RDF (3.76 g).

Year effect was found to be significant only for test weight, suggesting some influence of seasonal variation on grain filling,

whereas year $\times$ treatment interaction remained non-significant across all traits, indicating consistency of treatment performance over the years. These results clearly demonstrate that the application of *Fasal Amrit*, particularly at 20 kg ha⁻¹ along with RDF, substantially improved reproductive parameters such as pods per plant, grains per pod, pod length and test weight.

Table 4: Effect of *Fasal Amrit* on yield parameters at different stages

Treatment	Number of Pods per Plant			Number of Grains per Pod		
	2024	2025	Pooled	2024	2025	Pooled
T ₁	10.27	10.47	10.37	6.20	6.13	6.17
T ₂	13.27	14.60	13.93	7.33	7.40	7.37
T ₃	17.60	19.00	18.30	8.33	8.40	8.37
T ₄	13.53	14.53	14.03	7.33	7.27	7.30
T ₅	15.67	15.53	15.60	7.27	7.33	7.30
T ₆	13.07	14.00	13.53	7.27	7.20	7.23
T ₇	12.80	13.60	13.20	7.27	7.27	7.27
T ₈	10.67	11.87	11.27	6.20	6.20	6.20
T ₉	10.60	11.33	10.97	6.33	6.33	6.33
S.Em.±	1.01	0.87	0.67	0.39	0.38	0.27
C.D. at 5%	3.02	2.61	1.92	1.16	1.14	0.78
Year						
S.Em.±			0.31			0.13
C.D. at 5%			NS			NS
Y X T						
S.Em.±			0.94			0.38
C.D. at 5%			NS			NS

Table 4: continues....

Treatment	Pod Length (cm)			Test Weight (g)		
	2024	2025	Pooled	2024	2025	Pooled
T ₁	5.21	5.20	5.21	3.80	3.72	3.76
T ₂	5.60	5.73	5.67	3.92	3.91	3.91
T ₃	6.07	6.03	6.05	4.13	4.18	4.15
T ₄	5.53	5.83	5.68	3.82	3.84	3.83
T ₅	5.88	5.87	5.88	3.80	3.81	3.80
T ₆	5.51	5.47	5.49	3.86	3.77	3.81
T ₇	5.74	5.70	5.72	4.10	3.72	3.91
T ₈	5.27	5.27	5.27	3.98	3.60	3.79
T ₉	5.13	5.33	5.23	3.82	3.57	3.69
S.Em.±	0.19	0.16	0.12	0.03	0.05	0.09
C.D. at 5%	0.57	0.47	0.36	0.08	0.14	0.28
Year						
S.Em.±			0.06			0.04
C.D. at 5%			NS			0.13
Y X T						
S.Em.±			0.17			0.04
C.D. at 5%			NS			0.11

The application of *Fasal Amrit* in combination with RDF significantly enhanced grain and straw yields compared to RDF alone (Table 5). Pooled grain yield data revealed that the maximum yield (1556.42 kg ha⁻¹) was obtained with *Fasal Amrit* @ 20 kg ha⁻¹ + 100% RDF (T₃), which was significantly superior to RDF (1012.78 kg ha⁻¹) and other reduced RDF treatments. The lowest yield was recorded in RDF alone. Similarly, pooled straw yield was highest in T₃ (3559.03 kg ha⁻¹), followed by T₂ (3327.92 kg ha⁻¹) and T₄ (3208.89 kg ha⁻¹). RDF alone recorded the lowest straw yield (2583.28 kg ha⁻¹). The improvement in straw yield with *Fasal Amrit*, application could be attributed to better vegetative growth and higher biomass accumulation, which also translated into enhanced grain yield. The year effect was significant for both grain and straw yields, while the year $\times$ treatment interaction was non-significant, indicating consistent treatment response across

years. Overall, the results indicated that *Fasal Amrit* @ 20 kg ha⁻¹ + RDF (T₃) was the most effective treatment in enhancing both grain and straw yields. Importantly, treatments with reduced RDF (85–90%) in combination with *Fasal Amrit* also produced yields significantly higher than RDF alone, suggesting the potential of *Fasal Amrit* to partially substitute chemical fertilizers without compromising productivity. Super absorbent polymers enhanced yield attributes by improving cell membrane development, chlorophyll, protein content, and CO₂ fixation through prolonged stomatal opening, consistent with findings in mustard (Rathore *et al.*, 2019) [15]. Similar findings reported were consistent with the results obtained by Roy *et al.* (2019) [18] in wheat.

Effect of *Fasal Amrit* on economics of green gram cultivation

The economic analysis of different treatments (Table 6) revealed considerable variation in gross returns, net returns, and benefit–cost ratio (BCR) across the two years as well as in pooled results. Among the treatments, *Fasal Amrit* @ 20 kg/ha + RDF (T₃) recorded the highest gross returns (₹1,29,141/ha pooled), net returns (₹71,358/ha pooled), and BCR (2.23), followed closely by *Fasal Amrit* @ 15 kg/ha + RDF (T₂) with pooled gross returns of ₹1,18,304/ha, net returns of ₹65,220/ha, and BCR of 2.23. The treatment *Fasal Amrit* @ 15 kg/ha + RDF 90% (T₄) also performed well, showing a BCR of 2.17 in pooled data. In contrast, the lowest returns were obtained under *Fasal Amrit* @ 20 kg/ha + RDF 80% (T₉), which recorded pooled gross returns of ₹97,778/ha, net returns of ₹40,912/ha, and a BCR of 1.72. Statistical analysis indicated that the differences in gross and net returns were significant at the 5% level during both years and in pooled data, whereas BCR showed significance only in the second year and pooled results. Overall, the study demonstrates that the application of *Fasal Amrit* particularly at 20 kg/ha, in combination with 100% RDF, offers the most favourable economic returns without compromising input efficiency. On the other hand, reducing RDF below 90% led to reduced profitability, implying that partial substitution of fertilizers with *Fasal Amrit* is feasible only up to a limited extent. The results are in agreement with the findings of Li and Zhang 2010 [11] and Singh *et al.* (2018) [19].

Effect of *Fasal Amrit* on the uptake of nutrients by green gram

The data presented in Table 7 shown the mean effect of different treatments of *Fasal Amrit* on the moisture content, crude protein and nutrient composition of both grain and straw during 2024 and 2025. The results revealed considerable variation among the treatments for all measured parameters.

Moisture content in grain ranged from 3.27% (T₆) to 5.94% (T₂), while in straw it varied from 6.72% (T₉) to 9.62% (T₄). The crude protein content in grain was observed to be highest with *Fasal Amrit* 20 kg/ha + 100% RDF (24.07%), followed by T₇ (23.94%). In straw, the crude protein content ranged from 6.26% (T₃) to 8.38% (T₂), indicating a moderate response of straw protein accumulation to different treatments. The nitrogen concentration in grain varied between 3.53% (T₁) and 3.85% (T₃), while in straw it ranged from 1.01% to 1.34%. This can be attributed to the enhanced microbial activity and nutrient mobilization facilitated by *Fasal Amrit*, which likely improved nitrogen uptake and assimilation into protein in the grain. Phosphorus content in grain was highest in T₁ (1.87%), closely followed by T₂ (1.95%). In straw, the phosphorus content varied from 0.53% (T₃) to 0.66% (T₁). Similarly, potassium content in grain was highest under T₁ (1.18%) and lowest under T₈

(0.63%), whereas in straw, potassium ranged from 0.37% (T₆) to 0.47% (T₁). Phosphorus and potassium content in grain and straw also showed positive responses under *Fasal Amrit* treatments. The microbial consortia and nutrient-solubilizing

components of the formulation may have enhanced P and K availability in the rhizosphere, facilitating greater translocation to grain. The results are consistent with the findings of Mandal *et al.* (2015) ^[12] and Rathore *et al.* (2020) ^[14].

Table 5: Effect of *Fasal Amrit* on yield parameters of green gram

Treatment	Grain Yield (kg/ha ⁻¹)			Straw Yield (kg/ha ⁻¹)		
	2024	2025	Pooled	2024	2025	Pooled
T ₁ : RDF 20:40:40 NPK (Kg/ha)	880.56	1145.00	1012.78	2638.89	2527.67	2583.28
T ₂ : Fasal Amrit 15 kg/ha + RDF	1246.47	1603.33	1424.90	3465.83	3190.00	3327.92
T ₃ : Fasal Amrit 20 kg/ha + RDF	1404.83	1708.00	1556.42	3780.06	3338.00	3559.03
T ₄ : Fasal Amrit 15 kg/ha + RDF 90%	1231.44	1512.00	1371.72	3356.11	3061.67	3208.89
T ₅ : Fasal Amrit 20 kg/ha + RDF 90%	1269.39	1381.00	1325.19	3294.72	3025.67	3160.19
T ₆ : Fasal Amrit 15 kg/ha + RDF 85%	1211.72	1422.00	1316.86	3277.36	2802.33	3039.85
T ₇ : Fasal Amrit 20 kg/ha + RDF 85%	1173.25	1483.33	1328.29	3229.44	2910.33	3069.89
T ₈ : Fasal Amrit 15 kg/ha + RDF 80%	1120.50	1242.67	1181.58	3270.28	2717.00	2993.64
T ₉ : Fasal Amrit 20 kg/ha + RDF 80%	1089.67	1245.33	1167.50	3242.14	2751.33	2996.74
S.E.m.±	53.48	53.20	37.72	74.69	140.52	79.57
C.D. at 5%	160.34	159.50	108.71	223.92	421.31	229.33
Year						
S.E.m.±			17.78			37.51
C.D. at 5%			51.24			108.11
Year x Treatment						
S.E.m.±			53.34			112.53
C.D. at 5%			NS			NS

Table 6: Economics of green gram cultivation with *Fasal Amrit* application

Treatment	Gross Returns			Net Returns			BCR		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
T ₁ : RDF 20:40:40 NPK (Kg/ha)	77042	92195	84618	37658	52811	45235	1.96	2.34	2.15
T ₂ : Fasal Amrit 15 kg/ha + RDF	108382	128225	118304	55299	75142	65220	2.04	2.42	2.23
T ₃ : Fasal Amrit 20 kg/ha + RDF	121837	136445	129141	64054	78662	71358	2.11	2.36	2.23
T ₄ : Fasal Amrit 15 kg/ha + RDF 90%	106906	121054	113980	54281	68429	61355	2.03	2.30	2.17
T ₅ : Fasal Amrit 20 kg/ha + RDF 90%	109788	111139	110464	52463	53815	53139	1.92	1.94	1.93
T ₆ : Fasal Amrit 15 kg/ha + RDF 85%	105131	113656	109393	52735	61260	56998	2.01	2.17	2.09
T ₇ : Fasal Amrit 20 kg/ha + RDF 85%	101934	118525	113979	44838	68929	56884	1.79	2.08	1.93
T ₈ : Fasal Amrit 15 kg/ha + RDF 80%	97816	99993	98904	45649	47826	46738	1.88	1.92	1.90
T ₉ : Fasal Amrit 20 kg/ha + RDF 80%	95279	100278	97778	38412	43412	40912	1.68	1.76	1.72
S.E.m.±	4368	4083	2989	4368	4082	2989	0.09	0.07	0.06
C.D. at 5%	13096	12240	8616	13096	12240	8616	NS	0.22	0.17
Year									
S.E.m.±			1409			1409			0.03
C.D. at 5%			4062			4407			0.08
Year x Treatment									
S.E.m.±			4228			4228			0.08
C.D. at 5%			NS			NS			NS

Effect of *Fasal Amrit* on soil properties

The application of *Fasal Amrit* hydrogel combined with RDF levels led to improvements in soil nutrient availability, particularly nitrogen, phosphorus and potassium. The mean soil data in Table 8 revealed that soil pH remained stable, ranging from 6.16 to 6.39, while EC varied slightly (0.16-0.23 dSm⁻¹), indicating salinity remained within safe limits. The organic carbon content (OC) increased in most treatments, peaking at 0.65% in T₃ and T₄. The soil organic matter (SOM) content increased significantly with increasing *Fasal Amrit* rates, as it is derived from organic materials. Available N improved with the highest level in T₇ (378.83 kg/ha⁻¹), and available P content ranged from 35.46 kg/ha (T₇) to 49.9 kg/ha (T₉). The potassium availability improved, especially in T₃ (184.65 kg/ha⁻¹). Micronutrient levels also improved modestly, contributing to overall better soil fertility.

Effect of *Fasal Amrit* on irrigation water requirement in green gram

Table 9 presents an overview of the irrigation water management across different treatments and their efficiency in water conservation. Treatment T₁, the RDF (20:40:40 kg/ha⁻¹), followed the standard practice and required five irrigations. All other treatments (T₂ through T₉) involved four irrigations. This is, indicating that by application of *Fasal Amrit*, helps to reduce one irrigation without affecting the crop yield. The total irrigation water applied varies across treatments, the control treatment (T₁) required highest irrigation water (45.17 acre-inch), among all treatments. The other treatments, which have the *Fasal Amrit* saved one irrigation, water applied between 35.94 to 36.93 acre-inch of irrigation water, showing a clear reduction in water use compared to the control. Among the *Fasal Amrit* application treatments, T₃ (*Fasal Amrit* @20 kg/ha

+ 100% RDF) required only 35.94acre-inch water, representing the most efficient water use among the all treatments. Kalhapure *et al.* (2016) ^[10] opined that two irrigations in wheat can be saved by the application of hydrogel without compromising the grain yield.

Water savings, calculated as the difference between the control treatment (T₁) and the treatments are ranged between 8.24-9.23 acre-inch compared to control and treatments with the

application of *Fasal Amrit*. This significant reduction in water use demonstrates the effectiveness of integrating *Fasal Amrit* and adjusted RDF levels in reducing the water requirement for crop growth. *Fasal Amrit* 20 kg/ha + 100% RDF (T₃) saved 9.23 acre-inch the maximum water savings across all treatments with maximum water saving of 20.44% compared to control (T₁) treatments.

Table 7: Effect of *Fasal Amrit* on moisture content, crude protein and nutrient content in grain (mean of 2024 and 2025)

Treatment	Moisture (%)		Crude Protein (%)		N (%)		P (%)		K (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T-1	4.87	7.54	22.02	7.90	3.53	1.25	1.87	0.66	1.18	0.47
T-2	5.94	8.50	14.64	8.38	3.83	1.25	1.95	0.58	1.11	0.41
T-3	3.93	8.38	24.07	6.26	3.85	1.01	1.95	0.53	1.03	0.39
T-4	5.85	9.62	22.42	7.18	3.59	1.15	1.79	0.60	0.87	0.39
T-5	5.93	7.89	22.28	8.13	3.56	1.30	1.82	0.64	0.79	0.45
T-6	3.27	7.51	22.67	6.90	3.63	1.10	1.85	0.54	0.88	0.37
T-7	3.73	7.91	23.94	6.74	3.83	1.08	1.88	0.58	0.96	0.38
T-8	4.27	7.31	22.19	8.00	3.55	1.26	1.76	0.65	0.63	0.44
T-9	3.73	6.72	23.07	8.37	3.74	1.34	1.76	0.63	0.79	0.40

Table 8: Changes in soil chemical properties (mean of two years)

Treatment	pH	EC (ds/m)	O.C. (%)	Available N (kg/ha ⁻¹)	Available P (kg/ha ⁻¹)	Available K (kg/ha ⁻¹)	DTPA Extractable (ppm)			
							Fe	Mn	Zn	Cu
Initial	6.16	0.32	0.55	235.80	30.20	140.78	2.23	6.82	0.43	1.08
T ₁	6.30	0.23	0.65	298.55	48.59	167.47	2.09	6.64	0.87	2.14
T ₂	6.37	0.20	0.63	269.07	43.33	156.15	2.15	5.32	0.89	2.03
T ₃	6.32	0.18	0.65	368.17	45.96	184.65	2.87	3.59	0.96	2.01
T ₄	6.38	0.19	0.65	371.30	42.02	174.94	2.15	4.54	0.85	1.84
T ₅	6.31	0.18	0.61	337.43	36.77	155.94	2.17	6.41	1.37	2.07
T ₆	6.32	0.19	0.66	318.62	43.33	141.24	2.23	5.83	1.28	2.12
T ₇	6.37	0.16	0.62	378.83	35.46	148.28	2.25	6.06	1.64	2.24
T ₈	6.35	0.18	0.65	319.87	47.27	138.49	2.15	4.96	0.97	1.79
T ₉	6.39	0.18	0.59	210.19	49.90	135.75	2.43	5.5	1.00	2.12

Table 9: Effect of *Fasal Amrit* on water requirements of green gram (mean of two years)

Treatment	No. of Irrigations	Irrigation water (acre-inch)	Water Saved (acre-inch)	Water Saved over control (%)
T ₁	5	45.17	8.90	0.00
T ₂	4	36.27	9.23	19.71
T ₃	4	35.94	8.57	20.44
T ₄	4	36.60	8.90	18.98
T ₅	4	36.27	8.24	19.71
T ₆	4	36.93	8.90	18.25
T ₇	4	36.27	8.24	19.71
T ₈	4	36.93	8.90	18.25
T ₉	4	36.27	8.90	19.71

Conclusion

The study demonstrated that the application of *Fasal Amrit* in the cultivation of summer green gram significantly enhance soil moisture retention, improve plant growth, and increase yield, making it a valuable input for sustainable agriculture in drought-prone areas. The data clearly demonstrated that applying *Fasal Amrit* at both 15 kg/ha⁻¹ and 20 kg/ha⁻¹, combined with either full or reduced RDF, is the most profitable treatment, providing the highest gross and net income along with the best benefit-cost ratio and substantial water savings in irrigated agriculture.

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