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Impact of varying irrigation levels on yield and quality of summer green gram (*Vigna radiata* L.) in south Gujarat condition

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Abstract
The field investigation was conducted at College Farm, Navsari Agricultural University, Navsari, to assess the impact of land configuration on summer green gram (*Vigna radiata* L.) under South Gujarat conditions during the summer seasons of 2022 and 2023. The experiment utilized a split plot design with 24 treatment combinations, comprising four irrigation levels: irrigation at 30 and 45 DAS (I_1), irrigation at 30, 45, and 60 DAS (I_2), irrigation at 30 and 60 DAS (I_3), and irrigation at 45 and 60 DAS (I_4) as main plots. Two bio compost treatments were included in sub plots: without bio compost (B_0) and with bio compost at 5 t/ha (B_1), replicated four times. The experimental soil was clayey, low in organic carbon and available nitrogen, medium in available P_2O_5, and high in available K_2O, with a slightly alkaline pH and normal electrical conductivity. Results from both years indicated that the highest irrigation level (I_2) significantly improved plant height at 60 DAS and harvest, increased the number of branches and root nodules per plant at 40 and 60 DAS, and enhanced dry matter accumulation and crop growth rate compared to I_4. However, treatments I_2 required more days to reach 50% flowering and maturity. Furthermore, I_2 also resulted in a higher number of pods per plant, greater grain weight per plant, and increased grain and stover yields. In terms of nutritional content, I_2 showed the maximum protein content, protein yield, and higher N, P, and K levels in the grain compared to I_4. Notably, irrigation levels did not significantly affect initial or harvest plant population, pod length, 100-grain weight, grains per pod, harvest index, soil pH, electrical conductivity, organic carbon content, or nutrient status post-harvest. The highest field water use efficiency was observed with two irrigations (I_1), as opposed to the three irrigations in I_2. Overall, the highest consumptive water use and significant improvement in N, P, and K uptake were recorded under the I_2 treatment.

Keywords: Green gram, growth habit, physical condition of soil, irrigation levels, economic yield, protein content and yield, etc.

Introduction
Pulse production in India has been persistently low, failing to keep pace with the growing population. This stagnation has resulted in a significant decline in per capita availability, dropping from 70.3 g/day in 1956 to 30.0 g/day by 2001. Although there was a rebound to 41.9 g/day in 2014 (Anon., 2015) [1], the per capita availability reached about 53 grams in the financial year 2022. This figure still falls short by 66% of the World Health Organization's recommended minimum of 80 g/capita/day. Consequently, enhancing pulse production remains a critical focus area for improving food security and nutritional standards in the country.

In Gujarat, pulses are cultivated over 240,000 hectares, yielding 128,000 tones, with a productivity of 525 kg/ha (Anon., 2012) [2]. However, approximately 1.69 million hectares in the state are impacted by salinity, sodicity, or both (Minhas *et al*., 1998) [15]. The high clay content in South Gujarat's soils, coupled with elevated levels of exchangeable sodium, results in poor physical conditions such as low permeability, surface crusting, and hardening upon drying. These conditions restrict air and water movement, leading to poor root growth. The severity of soil sodicity's effects is influenced by soil texture.

Additionally, the escalating issues of soil salinity and waterlogging are critical concerns, particularly in coastal salt-affected areas where rice predominates during the kharif season, as they significantly impact agricultural productivity and sustainability.

So far, there is a need to find out scientific approaches for sustainable and profitable production of green gram on salt affected soils to meet the increasing demand. The germination, penetration, development and proliferation of root in the soil are dependent on the physical conditions of soil *viz*., looseness, friability, infiltration rate, soil crusting *etc*. moreover pulse crops are very sensitive to water logging. Therefore, different irrigation levels can play an important role for easy and uniform germination as well as for better growth and development of plant.

Materials and Methods

The field experiment titled "Effect of Land Configuration, Irrigation, and Bio Compost on Summer Green Gram (*Vigna radiata* L.) under South Gujarat Conditions" was conducted at the College Farm, N. M. College of Agriculture, NAU, Navsari, during the summer seasons of 2022 and 2023. Agro-climatically, the College Farm is situated in South Gujarat's heavy rainfall zone-I (Agro-ecological situation-3), receiving an average rainfall of approximately 1,633 mm over the past decade. The region experiences a humid and warm climate characterized by heavy monsoon rains, moderate cold winters, and fairly hot summers.

The experimental field's soil, locally referred to as "Clay Soil," is classified under the order Inceptisols, specifically the fine montmorillonitic, isohyperthermic family of Vertic Ustrochrepts, with the soil series being Jalalpur. The field features flat topography and is characterized by medium to poor drainage, along with good water-holding capacity. Soil samples were analyzed for initial physico-chemical properties during both years of the study, revealing a clayey texture with medium organic carbon and varying levels of available nitrogen, phosphorus, and potassium.

The experiment comprised 24 treatment combinations, including three levels of land configuration and four levels of irrigation as main plots, along with two bio compost treatments in sub plots. The layout was designed in a Split Plot Design (SPD) with four replications. Throughout the experiment, the water table remained more than three meters below the surface, indicating no groundwater contribution to the green gram crop. The seeds of the GM 6 cultivar were used for the investigation.

Field preparation occurred in February 2022 and 2023, utilizing a tractor-drawn cultivator followed by harrowing to achieve fine tilth. The layout of the experiment was established manually according to the research plan, preparing flatbed/conventional beds, ridges and furrows, and raised beds as per the treatments. Biometric observations were recorded at various growth stages and at harvest on five randomly tagged plants from each plot. Upon physiological maturity, these plants were harvested for biometric data, and their produce was added to the respective net plot yield.

After a two-day sun drying period, the harvested produce was weighed prior to threshing to record biological yield. Threshing was performed manually using a wooden stick, and the seeds were cleaned manually before recording the grain weight for each plot. Following the determination of test weight, the grains were further analyzed for quality parameters.

Statistical analysis of the data was conducted using the analysis of variance technique for the split plot design, as outlined by Panse and Sukhatme (1967). Significant differences were assessed using the F-test at a 5% significance level. The standard error of the mean was calculated for all parameters, with critical differences computed when treatment differences were significant. The coefficient of variation (CV %) was also determined for all studied characters.

Results and Discussion

The experiment was conducted in a split plot design over two consecutive years to assess the consistent effects of various treatments. Green gram cv. GM 6 was sown on March 4, 2022, and harvested on May 18, 2022, while the second year saw sowing on March 2, 2023, and harvesting on May 17, 2023. Different irrigation treatments were applied as per the designated levels, along with the recommended dose of inorganic fertilizers at sowing.

The various irrigation levels did not significantly affect plant stand at 20 DAS or at harvest. However, irrigation at 30, 45, and 60 DAS (I_2) resulted in taller plants throughout the growth period, except at 30 DAS, where it was statistically comparable to treatment I_1 (irrigation at 30 and 45 DAS). Treatment I_2 also yielded a significantly higher number of branches per plant, while treatment I_4 (irrigation at 45 and 60 DAS) had the lowest branch count. Additionally, I_2 significantly enhanced dry matter accumulation at 60 DAS and at harvest compared to I_4. The highest crop growth rate was observed under treatment I_2, while the lowest occurred with the lesser irrigation treatment I_4.

Days to 50% flowering and maturity were significantly influenced by the irrigation treatments. Treatment I_4 required the fewest days to 50% flowering, whereas treatment I_1 had the shortest duration to maturity. Notably, the highest number of root nodules per plant at 40 and 60 DAS was recorded under treatment I_2, while treatment I_4 showed the least.

Yields and yield-attributing characters, such as pods per plant, grain yield, and stover yield, were significantly affected by irrigation levels. Although pod length, 100-grain weight, and grains per pod did not show significant variation, treatment I_2 had numerically higher values. Treatment I_2 also produced the highest number of pods and grain weight per plant, while treatment I_4 had the lowest. Grain and stover yields were significantly greater under treatment I_2, with the lowest recorded for I_4. However, irrigation levels did not significantly affect the harvest index.

Irrigation at 30, 45, and 60 DAS (I_2) resulted in the highest protein, nitrogen, phosphorus, and potassium content in grains compared to I_4. The highest consumptive water use was observed under treatment I_2, while maximum field water use efficiency was noted with two irrigations (I_1) compared to three irrigations (I_2). Furthermore, irrigation at I_2 significantly improved the uptake of nitrogen, phosphorus, and potassium.

No significant variations were observed in soil pH, electrical conductivity, or organic carbon content after harvest across the different irrigation treatments, although the lowest values for these physico-chemical properties were noted with treatment I_4. The available nitrogen, phosphorus, and potassium status in the soil after harvest did not show significant differences due to the various irrigation levels.

Table 1: Yield (Grain and stover yield) of green gram as influenced by different treatments.

Treatments	Grain yield kg/ha		
	2022	**2023**	**Pooled**
Irrigation levels (I)			
I_1 - Irrigation at 30 and 45 DAS	1080	1069	1074
I_2 - Irrigation at 30, 45 and 60 DAS	1115	1099	1107
I_3- Irrigation at 30 and 60 DAS	1055	1039	1047
I_4- Irrigation at 45 and 60 DAS	997	982	989
SEm± (L)	19.10	20.12	11.95
CD (P=0.05) (L)	54.95	57.90	34.39
CV (%)	8.81	9.42	7.85
Treatments	Stover yield kg/ha		
	2022	2023	Pooled
Irrigation levels (I)			
I_1 - Irrigation at 30 and 45 DAS	2348	2317	2333
I_2 - Irrigation at 30, 45 and 60 DAS	2410	2395	2403
I_3- Irrigation at 30 and 60 DAS	2294	2251	2273
I_4- Irrigation at 45 and 60 DAS	2237	2186	2212
SEm±	39.60	49.25	26.29
CD (P=0.05)	113.93	141.71	75.64
CV (%)	8.35	10.55	7.90

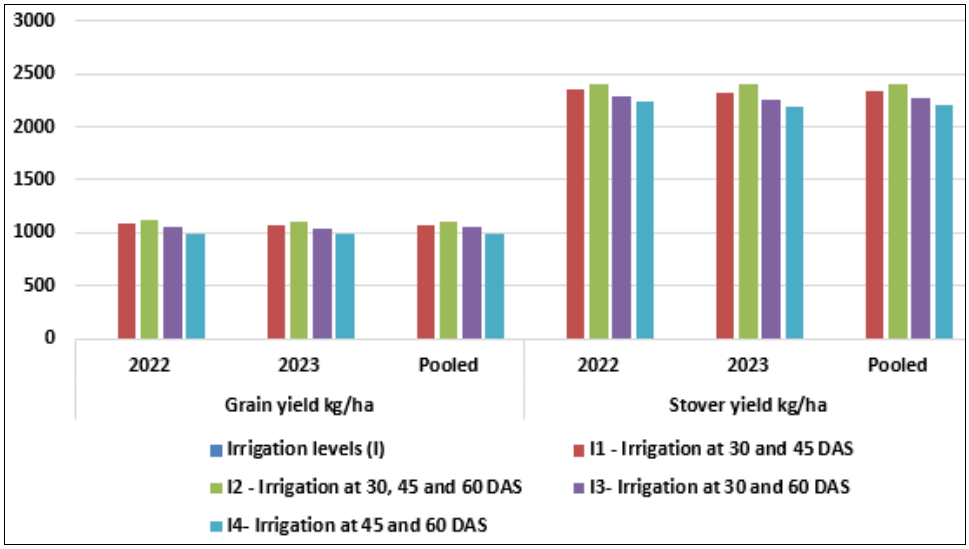
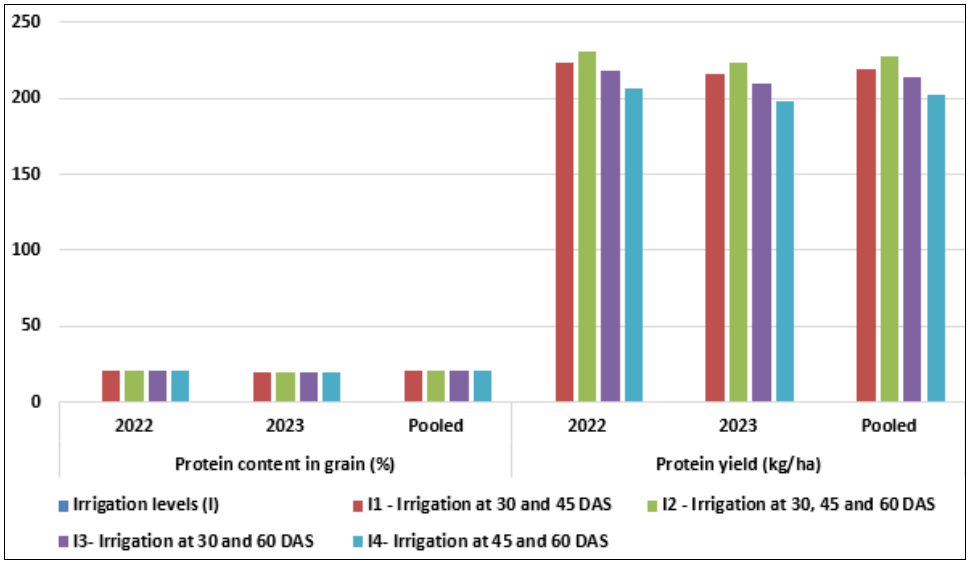


Table 2: Quality attributes (Protein content in per cent and protein yield in kg/ha) of green gram as influenced by different treatments.

Treatments	Protein content in grain (%)		
	2022	**2023**	**Pooled**
Irrigation levels (I)			
I_1 - Irrigation at 30 and 45 DAS	20.68	20.23	20.45
I_2 - Irrigation at 30, 45 and 60 DAS	20.70	20.29	20.50
I_3- Irrigation at 30 and 60 DAS	20.68	20.22	20.45
I_4- Irrigation at 45 and 60 DAS	20.63	20.17	20.40
SEm± (L)	0.42	0.39	0.28
CD (P=0.05) (L)	NS	NS	NS
CV (%)	9.86	9.41	9.64
Treatments	Protein yield (kg/ha)		
	2022	2023	Pooled
Irrigation levels (I)			
I_1 - Irrigation at 30 and 45 DAS	223.21	215.73	219.47
I_2 - Irrigation at 30, 45 and 60 DAS	231.15	223.01	227.08
I_3- Irrigation at 30 and 60 DAS	218.45	210.05	214.25
I_4- Irrigation at 45 and 60 DAS	206.48	198.03	202.25
SEm± (L)	6.17	4.80	3.60
CD (P=0.05) (L)	NS	13.80	10.35
CV (%)	13.75	11.10	11.55



Conclusion

From the above experiment, it can be concluded that the sustainable and economical yield and quality of summer green gram will be obtained with application of three irrigations at 30, 45 and 60 DAS addition to two common irrigations at initial under South Gujarat condition.

Future line of work

Based on the findings of the above investigation on the effect of different irrigation levels on summer green gram (*Vigna radiata* L.) under South Gujarat conditions, several future lines of work can be proposed to further enhance the yield and quality of green gram cultivation.

- More studies are require to assess the sustained effects different irrigation levels on soil health, crop growth, yield, and quality over multiple growing seasons.
- Conduct comprehensive soil health assessments before and after the experiment to evaluate changes in microbial activity, organic matter content, and nutrient cycling resulting from different irrigation levels.
- Analyze the water use efficiency of summer green gram under varying soil and climatic conditions and with different water-saving technologies.

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