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Effect of different *Vapsa* regimes and mulching on growth and yield of summer green gram under natural farming conditions

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Abstract

A field experiment was conducted at College Farm, College of Natural Farming, Gujarat Natural Farming Science University, Halol (Gujarat) India during summer season of the year 2024 to study the “Effect of different VAPSA regimes and mulching on growth and yield of summer green gram under natural farming conditions”. The experiment was laid out in a Split Plot Design with different VAPSA regimes as main plot and mulching as a sub plot treatment. The main plot treatments included were V₁ (Flatbed method), V₂ (Raised bed method), V₃ (Alternate furrow method) and sub plot treatments were M₀ (Control), M₂ (Rice straw mulch 5,000 kg/ha), M₃ (Rice straw mulch 10,000 kg/ha). Green gram (variety GM 8) was sown at a spacing of 45 cm between rows.

The raised bed method (V₂) emerged as the most effective VAPSA regime, significantly enhancing plant height, number of branches, root nodule weight, number of pods per plant, pod length, grain yield, stover yield and green gram equivalent yield. Likewise, application of rice straw mulch at 10,000 kg/ha (M₂) significantly improved growth and yield parameters, including plant height, dry weight of root nodules, pods per plant and grain yield. The interaction effect of raised bed method with rice straw mulch @ 10,000 kg/ha (V₂M₂) was statistically significant for grain yield and green gram equivalent yield.

Keywords: VAPSA, mulching, summer green gram, growth, yield, natural farming

Introduction

Pulses are an extraordinary gift from nature, serving as a gateway to sustainable agriculture through their exceptional nutritional value. Legumes, an integral component of the Indian diet, have historically provided essential proteins and amino acids. Green gram (*Vigna radiata* L.) commonly known as “mung” or “mung bean” is one of the most important and extensively cultivated pulse crops of the Indian subcontinent. Including it into the rotation maintains the soil's vitality and productivity. Green gram can be grown in rabi, summer and kharif seasons because it is not sensitive to light or temperature. It matures in 65 to 70 days. Because there are less biotic and abiotic stressors on summer green gram than on kharif crop, the yield level is higher ^[3]%. Inadequate irrigation management and inefficient water use are among the primary causes of low green gram productivity during summer. Notably, mungbean ranks second only to soybean in drought resistance ^[1]. Agronomic intervention such as mulching proves to be a practical solution to maintain optimal soil temperature and moisture conditions ^[19] and finally achieve higher yields ^[37].

Methodology

An experiment was conducted during the summer season of 2024 at College Farm, College of Natural Farming, Gujarat Natural Farming Science University, Halol (Gujarat) on a green gram crop. Geographically, Halol is located at 22° 42' N latitude, 73° 54' E longitude at an altitude of about 104 meters above the mean sea level. The climate of Halol region is semi-arid and sub-tropical with hot in summer and cool in winter. The soil of the experimental site was clayey in texture (Coarse sand 0.56%, Fine sand 82.10%, Silt 10.06% and Clay 7.16%) with a pH of 7.22. The experiment was laid out in a Split Plot Design with different VAPSA regimes as main plot

and mulching as a sub plot treatment. A Main Plot treatment VAPSA Regime (V) Flatbed method (V_1), Raised bed method (V_2), Alternate furrow method (V_3) and Sub Plot treatment Mulching (M) as a Control (M_0), Rice Straw 5,000 kg/ha (M_1), Rice Straw 10,000 kg/ha (M_2). *Beejamrut* was applied @ 100 ml/ kg seed as a seed treatment, *Jeevamrut* was applied @ 1000 liter/ha at pre-sowing irrigation, *Jeevamrut* was applied @ 500 liter/ha as a foliar spray at 15 days interval up to maturity of the crop, *Ghanjeevamrut* was applied @ 1000 kg/ha before one week of sowing, Cowpea, Okra, Guar and Bajri crops were grown as mixed cropping @ 30-40% of main crops and first irrigation was applied as common to all treatments. The treatments were replicated four times and assigned randomly to each plot in each replication. The gross and net plot sizes were 4.5 m x 6.0 m and 3.6 m x 5.0 m, The experiment encompassed 9 treatments consisting of different VAPSA regimes and applications with mulching.

Results and Discussion

1. Effect on Growth Parameters

1.1 Plant height

A perusal of data presented in Table 1 indicated that height of plant at 20 DAS did not affect significantly due to different VAPSA regimes. While, cultivation of green gram on treatment raised bed method (V_2) recorded significantly the highest plant height (45.59 cm). While significantly, lower plant height (40.07 cm) was recorded due to V_1 . At harvest, higher plant height (57.22 cm) was obtained with V_2 which was significantly higher than V_3 . While significantly, lower 53.11cm was noted with V_1 . The plant height increased linearly up to 40 DAS and continued to increase until maturity at a diminishing rate. These results are in agreement with the findings of [23, 30, 16, 38].

The data on plant height measured at 20 DAS under different mulching treatments were found non-significant, while 40 DAS and at harvest, plant height was found significant (Table 1). The improved plant height in green gram with mulching over control might be due to optimum availability of nutrients and moisture [33, 6 and 41].

1.2 Dry weight of root nodules

The perusal of data in Table 1 indicated that VAPSA regimes significantly influenced dry weight of root nodules accumulation per plant recorded at 40 DAS. Raised bed method (V_2) recorded significantly higher dry weight of root nodules per plant at 40 DAS (43.49 mg) which was statistically at par with V_3 . Nodulation in the various VAPSA regimes is governed by soil structure associated with micro climatic conditions of soil in which plant grow. The various VAPSA regimes with V_1 registered significantly the lowest dry weight of root nodules accumulation per plant (39.68 mg) at 40 DAS. This might be due to maintaining of optimum moisture supply in the effective root zone which improved physico-chemical and biological properties of soil resulting in better nodulation under V_2 sowing. Almost similar results were also reported by (5, 15, 21 and 42).

A perusal of data in Table 1.0 elucidated that dry weight of root nodules per plant was affected significantly due to different sub plot treatments at 40 DAS. The highest dry weight of root nodules per plant at 40 DAS (43.00 mg) was recorded under an application of M_2 . Whereas significantly, lower dry weight of root nodules per plant at 30 DAS (40.66 mg) was recorded under treatment M_0 . which was statistically at par with rice straw mulch @ 5000 kg/ha application (M_1). These results are in agreement with that reported by [13]. They claimed that plants cultivated with organic mulch treatments had the highest root

length, number of secondary roots and lateral roots, root weight with nodules and root weight without nodules.

1.3 Number of branches

The effect of VAPSA regimes on number of branches per plant registered at harvest in green gram was observed significant. As indicated in Table 1, significantly the highest number of branches per plant (5.77) at harvest was recorded under V_2 . Whereas, lower number of branches per plant (4.44) were recorded when green gram was irrigated using the V_1 . The difference in performance of different VAPSA regimes concerning the number of branches per plant might be due to improved growth characteristics, viz., number of branches, which could be attributed to optimum availability of nutrients and moisture. These results are in accordance with the findings of [32, 24].

Number of branches per plant at harvest was affected significantly due to different sub plot treatments are presented in Table 1 Treatment of M_2 recorded significantly the highest number of branches per plant (5.43). While significantly lower number of branches per plant (4.71) was observed under M_0 treatment. Using various mulching materials can modify the soil microclimate, which in turn promotes an increase in number of branches per plant, leaf area and total dry matter accumulation. These results align with the findings of [40, 20, 4, 8, 10].

2. Effect on Yield Attributes and Yield

2.1 Number of pods per plant

An appraisal of data presented in Table 1 revealed that VAPSA regimes produce significantly higher number of pods per plant recorded at harvest. However, significantly higher number of pods per plant (27.61) and significantly lower number of pods per plant (23.71) were noted under V_2 and V_1 treatments, respectively. Significantly higher number of pods per plant was recorded under V_2 sowing. This might be due to better growth of plant in terms of dry matter accumulation under raised bed sowing which might have adequately supplied more photosynthates for development of sink. The present findings were in accordance with those of [15] in groundnut, [38] in chickpea.

A scrutiny of data (Table 1.0) revealed that different sub plot treatments significantly affected the number of pods per plant at harvest. Among the different treatments, application of M_2 produced significantly higher number of pods per plant (27.02), which was at par with application of M_1 . Whereas significantly, the lowest number of pods per plant (23.31) was recorded under M_0 treatment. The difference in number of pods per plant might be due to experiencing drought stress by different treatments during its reproductive stages. Drought stress greatly reduces the grain yield which is dependent on the level of defoliation due to water stress during early reproductive growth [29].

2.2 Length of pod

The data presented in Table 1.0 revealed that pod length was significantly affected due to VAPSA regimes treatments. Among different treatments, VAPSA regimes at V_2 produced significantly the highest pod length (8.92 cm). Whereas, significantly lower pod length (7.86 cm) was recorded under VAPSA regimes at V_1 . Similar results were also reported by [17]. The concerned data (Table 1.0) showed that different sub plot treatments significantly affected the pod length. Among the various treatments, significantly the highest pod length (8.57 cm) was recorded under the application of M_2 . Whereas, significantly lower pod length (8.06 cm) was recorded under M_0 .

Similar results were also reported by [7, 13].

2.3 Grain weight per plant

The data presented in Table 1.0 revealed that grain weight (g) per plant at harvest was significantly affected due to VAPSA regimes treatments. Among the different treatments, VAPSA regimes treatment at V_2 produced significantly the highest grain weight per plant at harvest (13.50 g). Whereas, significantly lower grain weight per plant at harvest was recorded (9.62 g) due to VAPSA regimes at V_1 . These results are in accordance with the findings of [17, 39].

Concerned data (Table 1.0) showed that different sub plot treatments affected significantly on grain weight per plant. Among the various treatments, significantly the highest grain weight per plant at harvest (12.66 g) was recorded under an application of M_2 . Whereas, significantly lower grain weight per plant at harvest (10.46 g) was recorded under M_1 . Similar results were also reported by [17] in green gram.

The data on interaction effect presented in Table 2.0 revealed that the combination of VAPSA regimes at raised bed method and application of V_2M_2 recorded significantly the highest grain weight per plant (16.69 g) as compared to rest of combinations at harvest. Whereas significantly, the lowest grain weight per plant at harvest (7.62 g) was recorded under the treatment combination V_1M_0 .

2.4 Grain yield

The results of the experiment depicted in Table 1.0 revealed that cultivation of summer green gram on V_2 resulted in significantly the highest grain yield. Between the different VAPSA regimes the highest grain yield of (1075 kg/ha) was recorded under the V_2 , while the lowest grain yield (736 kg/ha) was observed under V_1 . The V_2 resulted in a (46.01%) increase in grain yield compared to the V_1 . V_3 recorded a grain yield (900 kg/ha), showing an 22.88% increase over V_1 , but it was (19.44%) lower than V_2 treatment. This might be due to the cumulative effect exerted from better improvement in drainage, soil environment, aeration, root development, rhizobium bacteria fixing nitrogen inside root nodules using the nitrogenase enzyme. This process requires ATP and anaerobic conditions (protected from oxygen by leghemoglobin in nodules). It is a mutualistic relationship, where both plant and bacteria benefit. Optimum moisture-air equilibrium throughout the crop growth besides supply of available nutrients to the crop resulting in better growth and development ultimately reflected in better grain yields. These findings corroborated the results of [22, 9, 12] with respect to grain yield; [15, 38, 11] in cowpea with respect to grain and stover yields.

Data pertaining to grain yield (kg/ha) revealed that different sub plot treatments caused their significant influence on grain yield presented in Table 1.0. Significantly the highest grain yield (1083 kg/ha) was recorded under an application of M_2 to a 48.96% increase in grain yield compared to M_0 . While significantly the lowest grain yield (727 kg/ha) was recorded under M_0 Treatment. Mulching conserves soil moisture by reducing evaporation, regulates soil temperature, and suppresses weed growth; ensuring crops have better access to resources. It also improves soil structure and fertility by adding organic matter as it decomposes, enhances microbial activity, and reduces soil erosion and compaction. These combined benefits create optimal growing conditions, leading to significantly higher yields compared to untreated control plots, as evidenced by studies such as [26, 33, 28].

The data on interaction effect presented in Table 2.0 revealed that different of VAPSA regimes at raised bed method and

application of V_2M_2 recorded significantly higher grain yield per (1289 kg/ha) but it was at par with V_3M_2 treatment combination. Whereas significantly lower grain yield (635 kg/ha) was recorded under treatment combination of V_3M_0 . Mulching significantly enhances soil moisture retention by reducing surface evaporation, ensuring prolonged water availability in the root zone. It also regulates soil temperature, improving root growth and nutrient uptake. Furthermore, mulching suppresses weed growth, minimizing competition for resources, and improves soil structure and organic matter content, enhancing water infiltration and nutrient availability. These benefits, coupled with VAPSA conditions that maintain optimal moisture levels for plant growth, create a synergistic effect that boosts overall crop productivity. Which also provided nutrient to long period of crop life which reflected in better growth and development of plant and ultimately resulted in increased grain yield. The results were supported by the findings of [35, 14, 27].

2.5 Stover yield

The perusal of data in Table 1.0 indicated that VAPSA regimes significantly influenced stover yield. Raised bed method (V_2) recorded significantly the highest stover yield (1498 kg/ha). However, VAPSA regimes with flatbed method (V_1) registered significantly the lowest stover yield (1039 kg/ha). The raised bed system provides improved soil aeration, better drainage, and reduced soil compaction, creating an optimal environment for root development and nutrient uptake. Enhanced soil physical properties in raised beds allow for greater root exploration volume and improved water-holding capacity in the active root zone. These findings were corroborated the results of [15, 38, 11] with respect to stover yields.

Among mulching treatments (Table 1.0) significantly the highest stover yield (1467 kg/ha) was recorded under treatment M_2 . While significantly, the lowest stover yield (1065 kg/ha) was recorded under M_0 treatment. These results are in accordance with the findings of [34, 31].

2.6 Green gram equivalent yield

The study (Table 1.0) revealed that different VAPSA regimes significantly influenced green gram equivalent yield. Among V_2 recorded the highest GEY (1567 kg/ha), representing a 49.81% increase over the V_1 which produced significantly the lowest GEY (1046 kg/ha). Cultivation methods like raised beds and alternate furrows influence soil structure, aeration and moisture, which directly affect nutrient availability. Raised beds improve drainage and root growth, enhancing nutrient uptake. Better soil conditions also support microbial activity, which aids nutrient cycling through processes like nitrogen fixation and mineral solubilization. These practices can influence soil pH, where suitable levels improve nutrient availability and microbial function. Thus, VAPSA regimes impact both crop performance and long-term soil fertility.

The data related to green gram equivalent yield as presented in Table 1.0 indicated that different sub-plot treatments had a significant influence on yield. Among the various treatments, an application of M_2 resulted in the highest green gram equivalent yield, reaching 1579 kg/ha. This yield represented a 52.56% increase compared to the M_0 , highlighting the positive impact of mulching on crop productivity. On the other hand, the lowest green gram equivalent yield, recorded of 1035kg/ha was observed under the M_0 treatment. Significantly the lowest yield in the absence of mulch underscores the crucial role of mulching in improving soil moisture retention, suppressing weed growth and enhancing nutrient availability, which collectively

contribute to higher crop yields. These findings are consistent with research conducted by [25], which demonstrated that straw significantly improves water retention and crop yields in green gram by reducing evaporation and weed competition. Similarly [34] found that higher rates of straw mulch application led to improve growth parameters and yields in green gram due to better soil moisture conservation and nutrient availability.

The data on interaction effect presented in Table 2.0 revealed that combination of VAPSA regimes at raised bed method and application of V₂M₂ recorded significantly higher green gram equivalent yield (1865 kg/ha), however it was statistically, at par with treatments of V₃M₂ indicating that similar benefits could be achieved under slightly different VAPSA regime and mulching conditions. On the contrary, lower green gram equivalent yield (898 kg/ha) was recorded under V₁M₀ treatment which involved the flat bed method without any mulch application (control). Significantly reduced yield in this treatment highlights the negative impact of inadequate soil moisture conservation and the absence of mulch, which likely led to higher evaporation, poor nutrient retention, and increased weed competition.

3. Economics

Data presented in Table 3.0 indicated that maximum net realization of Rs. 1,17,149 per hectare and a BCR of 3.85 were achieved using V₂. This was followed by V₃, which was resulted in a net realization of Rs. 94,215 per hectare and a BCR of 3.39. Furthermore, the data presented in Table 3.0 showed that M₂ resulted in a net return of Rs. 1,13,787 per hectare and a BCR of 3.50. M₁ treatment demonstrated relatively favourable economic returns. This could be attributed due to maximum yield, stover

and green gram equivalent under existing conditions. These findings suggested that while the control may be a viable low-cost option, adopting improved methods can significantly enhance economic returns.

Among all the treatment combinations, V₂M₂ recorded the highest green gram equivalent yield (1865 kg/ha), stover yield (1739 kg/ha), gross realization (Rs. 1,88,239/ha) and net realization (Rs. 1,39,319/ha), along with the maximum BCR of 3.85. This clearly indicated that V₂M₂ treatment combination provided the most favourable environment for crop growth and yield attributes, leading to higher profitability.

The data on interaction effect presented in Table 4.0 revealed that, This was closely followed by V₃M₂, which also showed a high green gram equivalent yield (1698 kg/ha), high net return (Rs. 1,24,062/ha) and a BCR of 3.63, suggesting that even under slightly less favourable moisture conditions (V₃) and application of rice straw mulch @ 10,000 kg/ha can substantially improved economic returns. On the other hand, the lowest performance was recorded in V₃M₀ treatment combination, which resulted in lower green gram equivalent yield (926 kg/ha) and lower net realization (Rs. 54,273/ha) as well as the lowest BCR (2.38). This demonstrated that absence of mulching under less favourable moisture conditions significantly hampers productivity and profitability. Although V₁M₀ showed the lowest green gram equivalent yield (898 kg/ha), it was result in the lowest BCR (2.41) value because cost of the lowest cultivation of (Rs. 37,709/ha) V₁M₀ among all treatments combination. Even with lower production, the lower input cost resulted in a better net return per rupee invested, compared to V₃M₀ treatment combination.

Table 1: Effect of different treatments on growth, yield attributes, yield and dry weight of root nodules of green gram

Treatment	Plant height (cm)			Dry weight of root nodules per plant (mg)	Number of branches per plant	Number of pods per plant	Length of pod (cm)	Grain weight per plant	Test weight	Yield (kg/ha)		Green gram equivalent yield (kg/ha)
	20 DAS	40 DAS	Harvest	40 DAS	Harvest	Harvest		Harvest (g)		Grain	Stover	
A) Main Plot Factor: VAPSA Regimes (V)												
V ₁ : Flatbed method	12.97	40.07	53.11	39.68	4.44	23.71	7.86	9.62	34.92	736	1039	1046
V ₂ : Raised bed method	13.93	45.59	57.22	43.49	5.77	27.61	8.92	13.50	35.72	1075	1498	1567
V ₃ : Alternate furrow method	13.88	41.58	55.82	41.24	4.80	25.71	8.01	10.82	35.17	900	1294	1323
S. Em±	0.39	0.84	0.85	0.72	0.16	0.73	0.10	0.43	0.69	33	32	41
C.D. at 5%	NS	2.92	2.95	2.49	0.56	2.5	0.35	1.50	NS	114	112	143
C.V.%	9.91	6.88	5.34	6.02	11.19	9.9	4.18	13.26	6.77	12.63	8.81	10.89
B) Sub Plot Factor: Mulching (M)												
M ₀ : Control	12.91	40.24	51.39	40.66	4.71	23.31	8.06	10.46	35.61	727	1065	1035
M ₁ : Rice Straw 5000 kg/ha	13.78	42.64	56.23	40.75	4.88	26.69	8.17	10.82	35.14	901	1299	1323
M ₂ : Rice Straw 10,000 kg/ha	14.10	44.36	58.54	43.00	5.43	27.02	8.57	12.66	35.06	1083	1467	1579
S. Em±	0.36	0.70	0.81	0.62	0.15	0.58	0.08	0.36	0.62	29	29	38
C.D. at 5%	NS	2.08	2.39	1.83	0.44	1.7	0.25	1.07	NS	87	87	113
Interaction (V x M)	NS	NS	NS	NS	NS	NS	NS	Sig.	NS	Sig.	NS	Sig.
C.V.%	9.24	5.73	5.04	5.15	10.15	7.8	3.52	11.00	6.05	11.28	7.95	10.00

Table 2: Interaction effect of different VAPSA regimes and mulching on grain weight per plant, Grain yield (kg/ha) (at harvest) and green gram equivalent yield (kg/ha) under natural farming conditions

Factor Level	Grain weight per plant (g)			Grain yield (kg/ha)			Green gram equivalent yield (kg/ha)		
	M ₀	M ₁	M ₂	M ₀	M ₁	M ₂	M ₀	M ₁	M ₂
V ₁	7.62	10.17	11.07	647	747	812	898	1067	1172
V ₂	14.29	9.52	16.69	899	1037	1289	1282	1554	1865
V ₃	9.48	12.76	10.21	635	919	1147	926	1347	1698
S. Em±	0.62			51			66		
C.D. at 5%	1.85			151			195		
C.V.%	11.00			11.3			10.00		

Table 3: Economics as influenced by application of different VAPSA regimes and mulching of green gram under natural farming conditions

Sr. No	Treatments	Green gram equivalent yield (kg/ha)	Green gram of Stover Yield (kg/ha)	Total Cost of cultivation (₹/ha)	Gross realization (₹/ha)	Net realization (₹/ha)	BCR
A) Main Plot Factor: VAPSA Regimes (V)							
V ₁	Flatbed method	1046	1039	37709	105639	67930	2.80
V ₂	Raised bed method	1567	1498	41049	158198	117149	3.85
V ₃	Alternate furrow method	1323	1294	39379	133594	94215	3.39
B) Sub Plot Factor: Mulching (M)							
M ₀	Control	1035	1065	37709	104565	66856	2.77
M ₁	Rice straw 5000 kg/ha	1323	1299	41644	133599	91955	3.21
M ₂	Rice straw 10,000 kg/ha	1579	1467	45580	159367	113787	3.50

Note: Selling price of grain: 100 ₹ /kg and stover: 1.00 ₹/kg

Table 4: Interaction effect of different VAPSA regimes and mulching on economics of green gram under natural farming conditions

Factor Level	Green gram equivalent yield (kg/ha)	Green gram of stover yield (kg/ha)	Total cost of cultivation (₹/ha)	Gross realization (₹/ha)	Net realization (₹/ha)	BCR
V ₁ M ₀	898	914	37709	90714	53005	2.41
V ₁ M ₁	1067	1053	41644	107753	66108	2.59
V ₁ M ₂	1172	1150	45580	118350	72770	2.60
V ₂ M ₀	1282	1229	41048	129429	88381	3.15
V ₂ M ₁	1554	1526	44984	156926	111941	3.49
V ₂ M ₂	1865	1739	48920	188239	139319	3.85
V ₃ M ₀	926	1051	39379	93651	54273	2.38
V ₃ M ₁	1347	1319	43314	136019	92705	3.14
V ₃ M ₂	1698	1511	47249	171311	124062	3.63

Conclusion

The study demonstrates that the raised bed method (V₂) and rice straw mulch at 10,000 kg/ha (M₂) are the most effective treatments for optimizing growth, yield and economics status in summer green gram under natural farming conditions. Additionally, the raised bed method (V₂) with rice straw mulch at 10,000 kg/ha (M₂) significantly enhanced grain yield and nutrient uptake. From an economic perspective, the raised bed method (V₂) proved to be the most profitable practice, offering the highest BCR and net returns. These findings highlight the importance of selecting the appropriate VAPSA regimes and mulching strategies for profitable and sustainable in natural farming condition.

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