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Land Configuration and Nutrient Management on Yield and Nutrient Uptake of Green Gram under Sodic Soil

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ABSTRACT

Background: Pulses, endowed with unique ability of nitrogen fixation constitute an important component of crop diversification and resource conservation in farming systems. Green gram [*Vigna radiate*], a drought resistant crop, is one of the thirteen food legumes grown in India and the third most important pulse crop after chickpea and pigeon pea It is a protein rich staple food which contains about 25 percent protein and plays a crucial role in enhancing soil fertility through biological nitrogen fixation. Sodic soils typically exhibit poor nutrient availability as essential cations are displaced by sodium ions. They significantly influence green gram productivity, posing challenges to its sustainability, with the potential for sodification extending into subsoil layers, impeding plant root development and requiring remedial action. Appropriate land configuration and nutrient management could mitigating the challenges posed by sodic soils for pulse crops. Understanding the effects of land configuration and nutrient management on its growth, yield andeconomic viability is vital for sustainable agriculture. Keeping this in view, the field experiment was conducted to study the effect of different land configuration and nutrient management for their impact on plant height, dry matter production, grain yield, haulm yield, net income andBenefit Cost ratio with nutrient uptake under sodic condition.

Methods: The land configuration factor consists of the three treatments *viz.,* flat bed, ridges and furrows and broad bed furrow system. The second factor nutrient management comprising of five treatments like 100% RDF + 1% DAP, 100% RDF + 1% MAP, 75% RDF + 2% MAP, 100% RDF + 1% MKP, 75% RDF + 2% MKP. The RDF for green gram was 25 kg N + 50 kg P2O5 + 25 kg K2O per hectare.

Result: Higher plant height, dry matter production, grain and haulm yield, protein yield, economic and nutrient uptake was recorded in broad bed furrow over farmer's practice of flatbed method. N_4 - 100% RDF + 1% MKP foliar spray twice at (plant height, dry matter production, grain and haulm yield, protein yield, economic and nutrient uptake) were observed than farmer's practice. Hence, Broad bed furrow and nutrient management practice of 100% RDF + 1% MKP has the potential to enhance the productivity green gram under sodic condition.

Key words: Broad bed furrow, Grain yield, Green gram, Nutrient uptake, Protein yield.

INTRODUCTION

Green gram [*Vigna radiata* (L), one of the important pulses in India, has 4.5 million hectares area under cultivation, with a total production of 2.5 million tonnes and productivity of 548 kg/ha, contributing 10% to the total production (Anon., 2021). Green gram has significant amount of protein and is easier to digest than other pulses. Though pulse crops are nutritionally richer than cereals, they have comparatively lower productivity. In order to increase productivity, various crop management practices need to be optimized.

The problem of water logging in sodic soil, even for a short period, proves detrimental to the green gram, particularly during the early growth period (Karikalan *et al.,* 2020). The high levels of sodium in sodic soil negatively impact soil structure and nutrient availability. Sodic soils typically exhibit the presence of excess exchangeable sodium which adversely affect the physical and nutritional properties of the soil (Bahadhur *et al*., 2012). Land configuration plays a crucial role in influencing the root and nodule growth in green gram (Sweta Rath *et al.,* 2023). The cultivation of greengram faces many problems like water logging and inadequate aeration, which affect the growth and yield in flatbed conditions adversely. Further the major causes of poor productivity and soil fertility are imbalanced application of nutrients (Porpavai and Nagarajan, 2022). Water is a critical input for sustained crop production and is becoming limited day by day. Hence, the need of the hour is to evaluate effective resource

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conservation practices, such as land configurations and scientific scheduling of irrigation to achieve higher productivity, profitability and resource use efficiency (Aakash Meher *et al*., 2024). Appropriate land configuration and nutrient management could mitigate the challenges posed by sodic soils for pulse crops. For example, the adoption of raised beds or broad bed furrows (BBF) improves soil structure, enhances water drainage, aids in root development andallows better aeration in sodic soils (Dhimmar, 2003 and Akbar *et al.,* 2007). Optimum nutrient management involves adjusting external nutrient application to address sodicity-induced deficiencies, ensuring pulse crops access essential nutrients adequately. The application of essential plant nutrients through foliar spray in sodic soil prevents the interaction of applied nutrients with soil sodium, thereby enhancing nutrient use efficiency and facilitating the rapid correction of nutrient deficiencies in crop plants (Vijayakumar *et al.,* 2022). Given the aforementioned facts, a study was conducted with the aim of identifying appropriate land configuration and nutrient management practices for green gram under sodic soil during the rainy season.

MATERIALS AND METHODS

The field experiment was conducted at Anbil Dharmalingam Agriculture College and Research Institute, Trichy during *kharif* season of 2020 and 2021.The experimental field featured a sandy clay loam soil texture with an alkaline (pH = 8.1; EC = 4.6 dSm) reaction. The study was designed using Factorial Randomised Block Design with three replications. Fifteen treatment combinations were tested, including three levels of land configuration (factor A) *viz.,* L_1 - flat bed, L_2 - ridges and furrows and L_3 - broad bed furrow system (BBF) and five levels of nutrient management (factor B), namely N_1 - farmer's practice of 100% recommended dose of fertilizer (RDF) + 2 % Diammonium phosphate (DAP), N_2 - 100% RDF + 1 % Monoammonium Phosphate (MAP), N_3 - 75% RDF + 2% MAP, N_4 - 100% RDF + 1% Monopotassium Phosphate (MKP), N_5 - 75% RDF + 2% MKP. The RDF for greengram was 25 kg N + 50 kg P_2O_5 + 25 kg K_2O per hectare and applied as 55 kg of urea, 315 kg of single super phosphate and 42.5 kg of murate of potash. The selected green gram variety for the study was VBN (Gg) 2.

The spray solutions of DAP, MKP and MAP were prepared by dissolving 10 g and 20 g of fertilizers in one litre of water to achieve 1% and 2% concentration, respectively. MKP and MAP fertilizers are highly water-soluble salts that completely dissolve in water, but DAP granules were dissolved in a small quantity of water and allowed to settle overnight. The supernatant solution was taken for spraying after dilution with remaining quantity of water. The plant height and dry matter production were recorded for five plants at the harvesting stage andthe averages were reported. Data on growth, yield attributes and yield were recorded plot-wise from each replication.

Representative samples of seed were taken from each treatment and dried in oven at 65°C temperature for 24 hours and powdered by mechanical grinder. Then the nitrogen content of seed was determined by micro Kjheldahl's method. The protein content in seed was calculated by multiplying nitrogen content of seed (%) with the conversion factor of 6.25 (Bhuiya and Chowdhary 1974). The protein yield in seed was calculated by using the following formula:

$$\text{Protein yield}\left(\frac{\text{kg}}{\text{ha}}\right) = \frac{\text{Protein content in seed (\%)} \times \text{Seed yield (kg/ha)}}{100}$$

Statistical analysis

The pooled data was subjected to statistical scrutiny by Panse and Sukhatme (1985). The ANOVA and critical difference at five per cent level of significance were calculated.

RESULTS AND DISCUSSION

Land configuration

Among the land configuration methods tested, Broad Bed Furrow (BBF) system recorded the highest plant height (49.9 cm) andit remained on par with the ridges and furrow method (48.1 cm) at harvest stage. On contrary, the lowest plant height (43.3 cm) was recorded in flat bed method. The plant height under BBF was 15 times (6.6 cm) higher than that of the flat method (Table 1). This might be attributed to the effective maintenance of suitable moisture regimes and the adequate availability of plant nutrients, thereby contributing to the improved growth and development of the plant under both methods. Similar positive effect of broad bed method of sowing on growth has registered by Dhimmar (2003), Sangakkara (2004) and Kumar and Singh, (2014). Correspondingly, dry matter production exhibited a significant increase with the BBF method (2874 kg ha^{-1}), followed by ridges and furrows method (2616 kg ha^{-1}) at harvest stages. Similar to plant height, the lowest dry matter production (1986 kg ha^{-1}) was recorded in flat bed method. Under BBF method, the dry matter production increased by 59.8% over the flat bed method. This heightened dry matter production in BBF is attributed to the overall increased growth of plant in terms of plant height and number of branches per plant. similar findings have also been reported by Lewade (2017) and Sodavadiya (2017). Consistent with our study results, Singh *et al.* (2020) reported higher plant height and dry matter production under the BBF and the ridges and furrow method compared to the flat bed method. Similar report was given by Sainath *et al*. (2023).

The seed yield (854.6 kg ha^{1}) and haulm yield (1952.8 kg ha^{-1}) of green gram under BBF increased by 58.2% and 36.5%, respectively over flatbed method Fig 1. Additionally, this method also resulted in a higher net return of ^{1} 29,955 ha^{-1} and a BCR value of 2.0 (Table 1). Following closely, the ridge and furrow method yielded 40% higher grain yield and 25.4% higher haulm yield than flatbed method.

Similarly, the highest net return and B: C ratio was recorded in BBF, followed by ridges and furrow, while the lowest was recorded in the flat bed method. BBF recorded a net return of ₹ 23,244 ha^{-1} with a BCR of 1.8. The net return and B: C ratio recorded in the BBF method were 139% and 33.3% higher than the flat bed method, respectively.

The interaction between land configuration and nutrient management had a significant impact. The findings indicate that the combination of L3N4 positively enhances greengram grain yield performance by improving growth parameters.

Regarding protein yield (Table 2), once again, BBF recorded a higher protein yield (184.89 kg ha^{-1}), which is 12.5% and 62.5% higher than the ridges and furrow and flat bed methods, respectively. Due to its higher seed yield and protein content, BBF significantly outperformed both the ridge and furrow method and the flat bed method in protein yield. The results obtained were consistent with those reported by Subbulakshmi *et al.* (2024), who observed higher grain yield, net return anda better benefit-to-cost ratio (B:C ratio) in the best bet fertilization (BBF) treatment under conditions of moisture stress. These results were supported with the findings of Shete *et al.* (2010) in green gram.

With respect to nutrient uptake (Table 2), significantly higher NPK uptake (52.2, 11.1, 39.0 kg N, P, K/ha) was observed under the BBF method, which was comparable to that of the ridges and furrow at harvest. Conversely, lower NPK uptake (49.1, 10.4, 37.1 kg N, P, K/ha) was recorded with flatbed method. This discrepancy may be attributed to the deeper penetration of root and suitable soil environment provided by BBF method over the flat bed method. Additionally, the better aeration, microbial activity, optimum moisture and nutrients for crop growth under sodic condition likely contributed to high nutrient recovery by seed and haulm in the BBF method of sowing, reflecting in the overall higher uptake of nutrients. These results are in close conformity with Muralidaran and Solaimalai (2010).

Table 1: Effect of land configuration and nutrient management on growth, yield and economics of green gram.

Treatment	Plant height (cm)	Dry matter Production (kg ha^{-1})	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Net income (Rs.)	B:C Ratio
Land configuration						
L_1 _ Flat Bed	43.32	1986	540.2	1430.2	12511	1.5
L_2 - Ridges and Furrows	48.12	2616	761.3	1794.4	23244	1.8
L_3 - Broad Bed Furrow	49.91	2874	854.6	1952.8	29955	2.0
SEd	1.11	74	20.31	63.54	-	-
C.D (P=0.05)	2.27	153	41.61	130.16	-	-
Nutrient management						
N_1 - 100%RDF + 2 % DAP	47.73	2493	730.1	1721.89	22944	1.8
N_2 - 100%RDF +1 % MAP	49.35	2764	792.3	1912.56	26110	1.9
N_3 - 75 %RDF + 2 % MAP	42.92	2086	600.8	1438.33	15207	1.6
N_4 - 100%RDF +1 % MKP	49.80	2860	801.4	1996.22	26794	2.1
N_5 - 75 %RDF + 2 % MKP	45.81	2257	651.7	1560.00	18460	1.7
SEd	1.43	96	26.22	82.03	-	-
C.D (P=0.05)	2.29	197	53.72	168.04	-	-
Interaction between L × N						
L1N1	43.22	2123	590.2	1510.4	15544	1.6
L1N1	44.85	2312	610.3	1612.6	17582	1.7
L1N1	41.82	1943	540.1	1380.1	12001	1.4
L1N1	45.31	2456	620.5	1650.2	18312	1.7
L1N1	42.87	2096	550.4	1465.8	13018	1.5
L2N2	48.34	2545	750.3	1805.9	24211	1.9
L2N2	49.93	2820	780.1	1935.8	26515	2
L2N3	45.23	2180	690.2	1510.2	17250	1.7
L2N4	50.85	2903	810.6	2011.8	27831	2.2
L2N5	46.78	2368	710.2	1632.4	19162	1.8
L3N1	49.63	2810	850.2	1950.4	29177	2.1
L3N2	53.28	3160	910.5	2290.2	34232	2.3
L3N3	46.72	2135	672.2	1506.7	16370	1.8
L3N4	53.24	3222	850.1	2326.7	34239	2.4
L3N5	48.78	2311	695.7	1581.8	18599	1.9
SEd	1.43	96	26.2	82	-	-
CD (P=0.05)	2.29	197	53.7	168	-	-

Nutrient management

The significantly highest plant height (49.8 cm) and plant dry matter (2860 kg ha^{-1}) at harvest were recorded with 100% RDF + 1% MKP at harvest, which remained on par with 100% RDF + 1% MAP, followed by the farmer's practices of 100% RDF + 2% DAP (Table 1). This result could be attributed to the application of full recommended fertilizer dose at basal, along with an additional application of K as MKP through foliar spray which might aid in the better uptake of nutrients by lowering the concentration of Na^{+} salts in plants, particularly under sodic condition. Similar results was observed by Mohammadi *et al.* (2008), Pessarakli and Kopec (2009) and Tsegay and Gebreslassie (2014).

The application of 100% RDF + 1% MKP produced significantly higher seed yield (797 kg ha^{-1}) and haulm yield (1996 kg ha^{-1}) (Fig 1.), which remained on par with 100% RDF + 1% MAP and 100% RDF + 2% DAP. This might be due to optimum supply of P and K, enabling the green gram crop to increase the absorption of other essential nutrients and assimilate adequate photosynthetic products under sodic conditions. This cumulative effect resulted in the plants producing more pods with a greater number of seeds, higher test weight and ultimately maximum seed and haulm yield. This results are supported by Gawai and Pawar (2007) in chickpea and Geetha and Velayutham, (2009).

In terms of economics, the highest net return of ₹ 26794 ha^{-1} and a BCR of 2.1 were obtained under the treatment 100% RDF + 1% MKP, followed by 100% RDF + 1% MAP with net return of ₹ 26110 ha^{-1} and BCR of 1.9 (Table 1). This is due to higher seed and haulm yields of green gram in these treatment in comparison to the farmer's practice. The result corroborates with the findings of Gupta *et al* (2011) and Kulkarni *et al.* (2016). Treatment 100% RDF +

Table 2: Effect of land configuration and nutrient management on quality and nutrient uptake of greengram.

Treatment	Protein yield (kg ha^{-1})	Nutrient uptake (kg ha^{-1})		
		N	P	K
Land configuration				
L_1 – Flat Bed	113.72	49.13	10.40	37.11
L_2 - Ridges and Furrows	164.32	51.43	10.91	38.81
L_3 - Broad Bed Furrow	184.89	52.23	11.07	38.97
SEd	6.03	1.03	0.16	0.72
C.D (P=0.05)	12.36	2.11	0.33	1.48
Nutrient management				
N_1 - 100%RDF + 2 % DAP	156.21	51.20	10.98	38.74
N_2 - 100%RDF +1 % MAP	178.23	52.50	11.71	39.77
N_3 - 75 %RDF + 2 % MAP	121.87	48.23	9.68	36.08
N_4 - 100%RDF +1 % MKP	182.43	52.93	11.78	40.08
N_5 - 75 %RDF + 2 % MKP	132.81	49.80	9.97	36.81
SEd	7.79	1.32	0.21	0.93
C.D (P=0.05)	15.95	2.71	0.42	1.91
Interaction between L × N				
L1N1	127.42	49.60	10.80	37.62
L1N1	143.32	50.88	11.24	38.12
L1N1	98.61	47.21	9.53	35.42
L1N1	148.18	50.94	11.32	38.34
L1N1	110.08	48.12	9.73	36.05
L2N2	168.41	51.61	10.97	38.89
L2N2	192.68	52.91	11.72	39.90
L2N3	137.83	49.24	9.75	36.19
L2N4	199.84	53.40	11.81	40.42
L2N5	145.85	50.01	9.94	37.02
L3N1	172.81	52.38	11.16	39.71
L3N2	198.69	53.71	12.18	41.29
L3N3	129.18	48.25	9.77	36.64
L3N4	199.26	54.45	12.22	41.47
L3N5	142.51	51.26	10.25	37.37
SEd	7.79	1.32	0.21	0.93
CD (P=0.05)	15.95	2.71	0.42	1.91

N, Nitrogen; P, Phosphorus; K, Potassium.

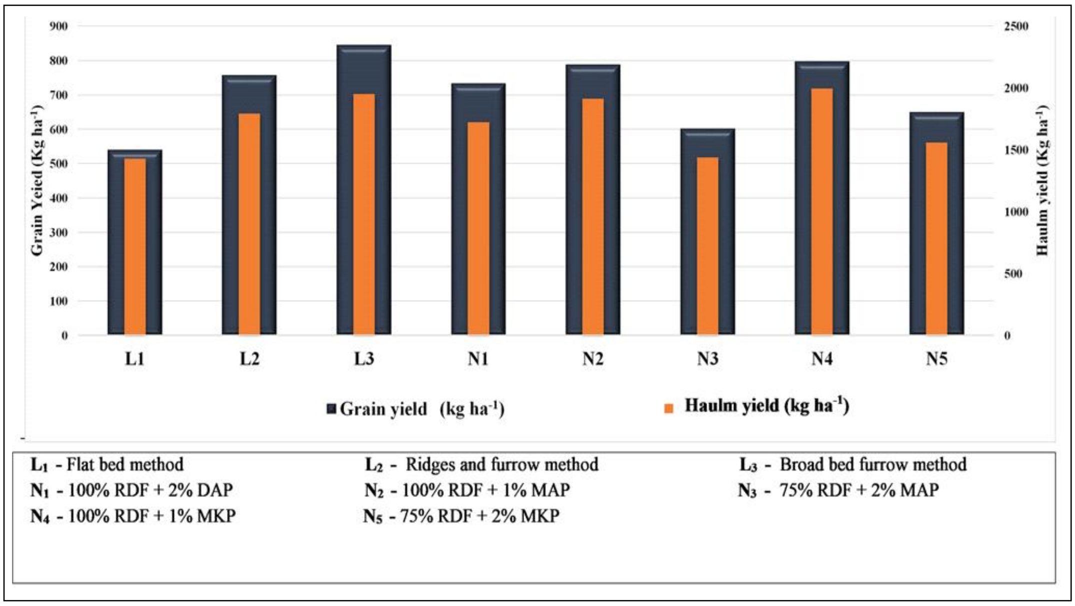

Fig 1: Effect of land configuration and nutrient management on grain yield and haulm yield.

1% MKP recorded a higher protein yield (182.43 kg ha^{-1}) andit remains on par with treatment 100% RDF + 1% MAP, followed by 100% RDF + 2% DAP. This might be due to fact that an adequate supply of P and K through foliar spray ensures optimum nitrogen supply by promoting root nodulation process and reducing Na^+ salt concentration in plants. This combined effect increased the nitrogen content in seed, leading to higher protein content. Nitrogen serves as a structural element of several co-enzymes which involved in protein synthesis. The higher protein content and seed yield ultimately result in increased protein yield under this treatment. Choudhary *et al.* (2013) with respect to protein yield of green gram.

Significantly maximum NPK uptake (52.9, 11.8, 40.1 kg N, P, K/ha) was observed with 100% RDF + 1% MKP and it remain on par with 100% RDF + 1% MAP and farmer's practice of 100% RDF + 2% DAP. This is due to proper nutrient management, more nodules formation, resulting in higher uptake of N, P and K in green gram compared with other treatment under sodic conditions. These results are in close conformity with of Veerabhadrappa and Yeledhalli (2010).

A significant difference was observed in the interaction between land configuration and nutrient management concerning protein yield and nutrient uptake. The combination of L3N4-BBF sowing with 100% RDF + 1% MKP-significantly recorded higher protein yield and nutrient uptake.

CONCLUSION

The results revealed that, among the land configuration methods, the broad bed furrow (BBF) method of sowing demonstrated a favourable impact on greengram, influencing factors such as plant population, growth and yield attributes, ultimately leading to a 12% increase in seed yield (854.6 kg ha^{-1}) and haulm yield (1952.8 kg ha^{-1}) along with significantly higher NPK uptake compared to the flat bed method. Among the nutrient management practices, the application of 100% RDF + 1% MKP produced significantly higher seed yield (797 kg ha^{-1}), haulm yield (1996 kg ha^{-1}) and higher protein yield (182.43 kg ha^{-1}). In terms of economics, the highest net return of ¹ 26794 ha^{-1} and a BCR of 2.1 were obtained under the treatment of 100% RDF + 1% MKP. Thus, the study highlights the potential of sowing green gram on Broad Bed Furrows (BBF) combined with the application of 100% RDF with 1% MKP foliar spray as effective strategies for maximizing productivity and profitability under sodic soil conditions, these practices could significantly contribute to sustainable agriculture by enhancing resource use efficiency and economic viability.

Conflict of interest

All authors declare that they have no conflicts of interest.

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