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RESEARCH ARTICLE

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Productivity and Profitability of Green Gram [*Vigna radiata* (L.) Wilczek] under System of Crop Intensification

K. Sowmya[1], J.S. Bindhu[2], P. Shalini Pillai[1], D. Jacob[3], R. Gladis[4]

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ABSTRACT

Background: Green gram is one of the important pulse crop and also a drought resistant crop, suitable for summer fallows in Kerala. Though it has multifarious advantages, productivity of green gram is declining year by year due to various reasons. Adoption of low-cost production technologies like system of crop intensification (SCI) practices in green Gram may enhance the productivity and reduce the gap between per capita availability and consumption and enhance the resource use efficiency of the farming system.

Methods: A field experiment was laid out in split plot design with four replications during 2022. Main plot treatments were spacings of 25 cm × 15 cm and 25 cm × 25 cm each maintained with single and double seedling per hill. The sub plot treatments include foliar application with urea @2%, DAP @2%, KNO_3 @ 0.5% and DAP @ 2% + KNO_3 @ 0.5% at 15 and 30 DAS.

Result: The experiment results revealed that spacing of 25 cm × 25 cm or 25 cm × 15 cm with single seedling per hill along with foliar application of KNO_3 @ 0.5% or DAP @ 2% + KNO_3 @ 0.5% at 15 and 30 DAS recorded higher growth attributes, yield attributes and economics of green gram *viz.,* plant height, number of branches per plant, leaf area, number of pods per plant, seeds per pod, 100 seed weight, net income and benefit cost ratio.

Key words: Green gram, Intensification, Pulses, Sustainability, System.

INTRODUCTION

Pulses, endowed with unique ability of nitrogen fixation constitute an important component of crop diversification and resource conservation in farming systems. Green gram [*Vigna radiata* (L.) Wilczek] is one of the thirteen food legumes grown in India and the third most important pulse crop after chickpea and pigeon pea.

Large areas are left fallow after the harvest of rice in India. These summer fallows can be effectively utilised for crop intensification and diversification. Integrating the two core principles of system of crop intensification (SCI) *i.e.,* spacing and foliar nutrition, pulse crops can be raised effectively with minimum resources because of their uniqueness of nitrogen fixation, deep extensive root system, low crop water requirement and ability to withstand drought. SCI has emerged as a next generation agro-ecological innovation. SCI principles and practices build upon the productive potentials that derive from plants having larger, more efficient, longer-lived root systems and from their symbiotic relationships with a more abundant, diverse and active soil biota. System of crop intensification practices enable the crop to grow and develop potentially which provides enhanced production in sustainable and eco-friendly manner (Sowmya *et al*., 2022).

Planting pattern is an important factor determining individual crop plant performance. Spatial arrangement has been quantified as the mean rectangularity, or the ratio of distance between rows to the distance between plants within a row. The influence of rectangularity has been quantified by measuring mean population yield rather than individual plant yield within the population (Fanish and Raghavan, 2020). Many experimental findings proved that foliar application of nutrients increased the growth, better utilization of nutrients, yield attributes and yield in different pulse crops (Yeshwanth, 2020).

Considering the inadequate adoption of production technology that led to low productivity of pulses, various alternatives were considered over the conventional cultivation practices. In pursuit of extending the beneficial effects of SCI, a field study was proposed under system of crop intensification in green gram.

MATERIALS AND METHODS

Field experiment was conducted during summer season in farmer's field at Southern coastal plain (AEUI), Thiruvananthapuram district, Kerala (8°43′11″N and 76 45′ 50″ °E longitude; 52 m above mean sea level) during 2021-

[1]Department of Agronomy, College of Agriculture, Vellayani, Thiruvananthapuram-695 522, Kerala, India.
[2]AICRP-IFS, Integrated Farming System Research Station, Karamana-695 002, Thiruvananthapuram, Kerala, India.
[3]On Farm Research Centre, Kayamkulam-690 502, Kerala, India.
[4]Agricultural Research Station, Thiruvalla-689 107, Kerala, India.

Corresponding Author: J.S. Bindhu, AICRP-IFS, Integrated Farming System Research Station, Karamana-695 002, Thiruvananthapuram, Kerala, India. Email: bindu.js@kau.in

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2022. The experimental soils were clay loamy in nature. The pH of the soils was 5.5, EC was 0.18 dS m^{-1}, organic carbon was 1.32% and available N, P and K were 328, 71.2 and 188 kg ha^{-1}, respectively. The experiment was laid out in a split plot design with four replications. The main plot treatments were S_1-spacing of 25 cm × 15 cm with single seedling per hill, S_2-spacing of 25 cm × 15 cm with double seedling per hill, S_3-spacing of 25 cm × 25 cm with single seedling per hill and S_4- spacing of 25 cm × 25 cm with double seedling per hill; Sub-plot treatments were F_1-Urea at 2%, F_2 -DAP at 2%, F_3-KNO_3 at 0.5% and F_4-DAP at 2% + KNO_3 at 0.5%. The green gram variety, CO 8 was used for the experiment. Foliar nutrition was given at 15 and 30 DAS. All other recommended package of practices was followed to raise the crop as per package of practices (KAU, 2016).

Five plants were selected randomly from each treatment and observations were made on growth and yield parameters. The yield parameters were recorded at the time of harvest in each treatment. The data were subjected to statistical analysis by applying the techniques of analysis of variance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth attributes

The SCI practices had significant effect on all the growth attributes like plant height, number of branches per plant and total leaf area per plant at flowering and at harvest (Table 1).

At harvest, taller plants were recorded with a spacing of 25 cm × 15 cm with one seedling per hill (S_1) and the shortest plants were observed in S_2. The increase in plant height was due to increased cell division and cell elongation at higher level of nitrogen. This may be due to the competition between the inter and intra plants for sun-light, water and nutrients at closer spacing encouraged the vertical growth rather than horizontal growth (Sathiyavani *et al.,* 2016). At flowering and harvest, KNO_3 @ 0.5 % (F_3) recorded taller (46.44 and 54.25 cm, respectively) plants.

Branching is basically a genetic character but environmental conditions may also influence the number of branches per plant which play an important role in enhancing seed yield of green gram. A spacing of 25 cm × 25 cm with single seedling per hill (S_3) recorded more number of branches (5.18 and 6.56, respectively) at flowering and at harvest which was on par with S_1. The results clearly indicated that optimum spacing with reduced plant density might have provided more room for the plant to produce a greater number of branches. Lowest number of branches were recorded with double seedling per hill, this might be due to absence of horizontal space for the plant to expand its canopy due to high plant density. Foliar nutrition with KNO_3 @ 0.5% (F_3) recorded higher number of branches at both the stages. This would be due to the foliar application of higher concentration of multi nutrients at critical growth stages increased the growth and yield parameters (Neethu and Kaleeswari, 2018). These findings are corroborated with Jagtap *et al*. (2021).

Total leaf area per plant was significant with spacing and foliar nutrition at flowering only. S_1 recorded the highest leaf area (1110.26 cm^2) and the lower leaf area (798.26 cm^2) was recorded in S_4. Abid *et al*. (2018) also reported that better branching results in higher leaf area. Among the foliar nutrition treatments, DAP @2% + KNO_3 @ 0.5% (F_4) recorded the highest leaf area (995.29 cm^2) and the lowest was recorded in F_2. Dey *et al*. (2017) also reported the increased availability of nutrients to plants leading to maximum plant growth in terms of plant height and leaf area.

Yield attributes and yield

A perusal of data revealed that the yield attributes and the yield were significantly influenced by crop intensification practices (Table 2).

The spacing of 25 cm × 25 cm with single seedling per hill (S_3) recorded higher number of pods and number of

Table 1: Effect of spacing and foliar nutrition on plant height, number of branches per plant and total leaf area per plant under SCI.

Treatments	Plant height (cm)		Number of branches per plant		Total leaf area per plant (cm^2)	
Spacing (S)	Flowering	Harvest	Flowering	Harvest	Flowering	Harvest
S_1- Spacing of 25 cm × 15 cm with single seedling per hill	43.81	54.68	4.68	6.00	1110.26	447.51
S_2 - Spacing of 25 cm × 15 cm with double seedling per hill	40.25	48.93	3.06	5.00	816.31	423.37
S_3 - Spacing of 25 cm × 25 cm with single seedling per hill	42.94	52.06	5.18	6.56	1042.54	417.66
S_4- Spacing of 25 cm × 25 cm with double seedling per hill	44.69	50.12	3.43	4.75	798.26	360.54
SEm (±)	1.36	0.98	0.20	0.29	19.13	32.12
CD (P≤0.05)	NS	3.141	0.635	0.933	61.213	NS
Foliar nutrition (F)						
F_1- Urea at 2%	43.25	51.12	4.12	5.68	948.77	405.80
F_2- DAP at 2%	39.19	49.00	3.75	4.87	886.35	378.43
F_3- KNO_3 at 0.5%	46.44	54.25	4.62	6.43	936.96	449.88
F_4- DAP at 2% + KNO_3 at 0.5%	42.81	51.43	3.87	5.31	995.29	414.97
SEm (±)	1.11	1.07	0.29	0.33	11.38	26.40
CD (P≤0.05)	3.172	3.078	NS	0.956	32.646	NS

Significant at P≤0.05; NS- Non-significant at P>0.05.

seeds per pod (27.06 and 12.25, respectively). Lower number of pods were observed in double seedlings per hill treatments (S_2 and S_4). However, S_4 recorded the lowest number of seeds per pod. This might be due to better utilisation of applied nutrients and less competition due to wider spacing. Foliar application of KNO_3 @ 0.5% (F_3) recorded higher value for number of pods and number of seeds per pod. When nitrogen and potassium were administered to the foliage during crucial phases of the crop, they were efficiently absorbed and transferred to the growing pods, resulting in better-filled pods.

Grain and haulm yield were significantly influenced by spacing. Adopting a spacing of 25 cm × 25 cm with single seedling per hill (S_3) recorded higher grain yield (899.44 kg ha^{-1}) which was on par with the spacing of 25 cm × 15 cm with one seedling per hill (S_1) and significantly superior to the other two spacings. This may be due to effective utilization of the growth resources, particularly due to space and solar radiation. These treatments have more leaf area indicating higher photosynthetic efficiency. When plants suffered due to mutual shading in case of adjoining rows and more plants in double seedling treatments the yield were drastically reduced by 10.7 per cent and 38.2 per cent in S_2 and S_4, respectively over their single seedling treatments. Similar results were reported by Sathiyavani *et al.* (2016). The high grain yield can also be due to the absence of weed interference as reported by Strydhorst *et al*. (2008). The spacing of 25 cm × 25 cm with double seedling per hill (S_4) recorded the lowest (555.70 kg ha^{-1}) seed yield. This may be due to more competition for resources between plants for water and soil nutrients led to lesser yield.

Among the foliar nutrition application, KNO_3 @ 0.5% (F_3) recorded higher grain yield (880.85 kg ha^{-1}) and it was on par with DAP @ 2% + KNO_3 @ 0.5% (F_4). Lower seed yield (665.19 kg ha^{-1}) was observed in urea @ 2% (F_1) and it was on par with DAP @ 2% (F_2). This might be due to less competition and effective utilisation of translocated photosynthates from source to sink. Optimization of N and K nutrient interactions resulted in better yield attributes. The results clearly demonstrated that supplying legume plants with foliar application of major nutrients has positive impact on boosting growth and increasing seed output. This might be also due to the ability of potassium nitrate to tolerate the water stress and thus might have helped in retention of a greater number of flowers leading to more yield attributes and yield. Similar results were also reported by (Neethu and Kaleeswari (2018) and Jagtap *et al*. (2021).

The haulm yield was higher with the spacing of 25 cm × 15 cm with one seedling per hill (S_1) and it was on par with spacing of 25 cm × 25 cm with single seedling per hill (S_3), this is due to more amount of dry-matter produced by plant population per unit area. Even though more plant density was observed with the spacing of 25 cm × 15 cm with double seedling per hill (S_2), the amount of dry matter produced per plant was low due to heavy competition among the plants for growth resources that resulted in shorter plants. Foliar nutrition treatments followed same trend as of grain yield. The spraying of water-soluble nutrients increased uptake of nutrients and water, resulting in more photosynthesis and enhanced food accumulation thus resulting in higher dry matter production.

Economics

Adoption of cultivation practices depends on the economic feasibility. The perusal of data from the study indicated that economic analysis also had the same trend as that of seed yield of green-gram (Table 3a and 3b). The net income and benefit cost ratio varied with spacing and number of seedlings per hill. The spacing of 25 cm × 25 cm or 25 cm × 15 cm with single seedling per hill (S_3 and S_1) supplied with foliar nutrition of KNO_3 @ 0.5% (F_3) or DAP @ 2% + KNO_3 @ 0.5% (F_4) recorded the higher net returns and benefit cost ratio (Rs. 28524 ha^{-1} 1.49, respectively). These results

Table 2: Effect of spacing and foliar nutrition on yield attributes and yield of green gram under SCI.

Treatments	Number of pods per plant	Number of seeds per pod	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
Spacing (S)				
S_1-Spacing of 25 cm × 15 cm with single seedling per hill	19.81	11.69	865.07	1911.28
S_2 - Spacing of 25 cm × 15 cm with double seedling per hill	8.69	11.31	771.77	1606.82
S_3 -Spacing of 25 cm × 25 cm with single seedling per hill	27.06	12.25	899.44	1827.82
S_4- Spacing of 25 cm × 25 cm with double seedling per hill	9.13	10.63	555.70	1210.77
SEm (±)	0.27	0.30	26.62	70.21
CD (P≤0.05)	0.859	0.964	85.151	224.617
Foliar nutrition (F)				
F_1- Urea at 2%	15.13	11.00	665.19	1399.76
F_2- DAP at 2%	15.31	11.12	723.48	1542.33
F_3- KNO_3 at 0.5%	17.19	12.25	880.85	1854.29
F_4- DAP at 2% + KNO_3 at 0.5%	17.06	11.50	822.45	1760.31
SEm (±)	0.34	0.25	26.42	52.52
CD (P≤0.05)	0.974	0.721	75.782	150.640

Significant at P≤0.05; NS- Non-significant at P>0.05.

Table 3a: Economics of green gram cultivation under SCI.

Treatments	Net income (Rs ha^{-1})	BCR
Spacing (S)		
S_1- Spacing of 25 cm × 15 cm with single seedling per hill	25190	1.43
S_2 - Spacing of 25 cm × 15 cm with double seedling per hill	10370	1.16
S_3- Spacing of 25 cm × 25 cm with single seedling per hill	28524	1.49
S_4- Spacing of 25 cm × 25 cm with double seedling per hill	10589	0.84
SEm (±)	2581.80	0.04
CD (P0.05)	8259.64	0.135
Foliar nutrition (F)		
F_1- Urea at 2%	3214	1.06
F_2- DAP at 2%	8742	1.15
F_3- KNO_3 at 0.5%	23726	1.40
F_4- DAP at 2% + KNO_3 at 0.5%	17812	1.30
SEm (±)	2562.92	0.04
CD (P≤0.05)	7350.85	0.118

Table 3b: Interaction effect of spacing and foliar nutrition on economics of green gram under SCI.

Treatments	Net income (Rs ha^{-1})	BCR
S_1F_1	11266	1.19
S_1F_2	21114	1.36
S_1F_3	33981	1.58
S_1F_4	34398	1.58
S_2F_1	-3870	0.94
S_2F_2	15984	1.25
S_2F_3	17798	1.28
S_2F_4	11567	1.18
S_3F_1	20542	1.35
S_3F_2	17157	1.29
S_3F_3	43868	1.75
S_3F_4	32529	1.55
S_4F_1	-15083	0.77
S_4F_2	-19287	0.70
S_4F_3	-740	0.99
S_4F_4	-7245	0.89
SEm (±)	5125.83	0.082
CD (P≤0.05)	NS	NS

are supported with the findings of Sathiyavani *et al.* (2016) in green gram and Singh *et al.* (2009b) in black-gram. This might due to effective utilisation of both above and below ground resources effectively thus contributing to better growth and yield attributes.

CONCLUSION

Based on the above findings, it can be inferred that the yield of green gram is significantly influenced by plant population and foliar nutrition. In summer fallows, maintaining an optimum plant population with a spacing of 25 cm × 25 cm or 25 cm × 15 cm with single seedling per hill and foliar application of KNO_3 @ 0.5% or DAP @2% + KNO_3 @ 0.5% could fetch the most profitable returns.

Conflict of interest: None.

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