Effect of tillage and weed management practices on growth and yield of green gram [*Vigna radiata* (L.) Wilczek]

.

ABSTRACT

A field experiment was conducted during 2023 at Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, to find out the effect of different tillage management [Minimum tillage (primary tillage only) and Conventional tillage (primary and secondary tillage)] and five weed control treatments [(PE Pendimethalin @ 1.0 kg ha^{-1}, PE Pendimethalin + Imazethapyr (pre-mix) - Valor 32% EC 1.0 kg ha^{-1}, Hand weeding on 15 and 30 DAS, Weed free plot and Un weeded control (weedy check)] on weeds and productivity of green gram (*Vigna radiata* (L.) Wilczek) during the winter (Rabi). Conventional tillage generally led to taller plants and higher leaf counts compared to minimum tillage, while effective weed management practices, particularly the combination of Pendimethalin and Imazethapyr, resulted in superior growth indices. Additionally, conventional tillage and weed-free conditions significantly enhanced dry matter production and yield parameters of green gram.

Keywords: Tillage, Weed management, Green gram, Yield

1. INTRODUCTION

Pulses or legumes, are a crop of particular significance in the shift to more sustainable food systems, produced for their edible seeds and harvested when mature. Many plant families are the source of plant-based proteins, however legumes contain the majority of them [1]. Pulses are also useful break crops in crop rotations that mostly consist of cereals because they increase soil structure and decrease weeds, pests, and illnesses. [2]. A substantial amount of the world’s land use, water, and greenhouse gas emission are caused by the production of foods derived from animals [3]. According to the Organization for Economic Cooperation and Development over the next ten years, meat consumption is expected to rise by 12% (OECD/FAO, 2020) whereas pulses plays a significant role in sustainability of the diet as they minimize the consumption of animal-based products and greenhouse gas emission [4]. The area under pulses has grown from 64.14 Mha (1970) to 93.54 Mha (2019) globally, and as a result, the production has increased from 42.1 Mt to 92.13 Mt. And during the same time period, pulse productivity increased from 664 kg ha^{-1} to 994 kg ha^{-1} [5]. Asia is the producer of almost 45% of the world’s pulse supply. The highest production is found in Europe, while Asia produces the maximum pulses (29.07 Mt). India is the leading producer of pulses, making up 25% of global production [6].Of the thirteen food legumes cultivated in India, greengram (*Vigna radiata* (L.) Wilczek) is the third most important crop afterpigeonpea and chickpea [7] which is a widely cultivated crop in the parts of arid and semi-arid regions [8]. On a dry weight basis, greengram grains include roughly 25–28% protein, 1.02-1.05% oil, 3.5–4.5% fiber, 4.5–5.5% ash, and 60–65% carbohydrates [9]. The grains also include vitamin-A ((94mg), Vitamin-C (8mg), iron (7.3 mg), calcium (124 mg), magnesium (189 mg), phosphorus (367 mg), potassium (1246 mg), zinc (3 mg), and foliate (549 mg) [10]. India has an annual production of 2.01 million tonnes on 4.26 million hectares, with a productivity of 472 kg ha-1. In Tamil Nadu, there are 1.86 lakh hectares under greengram cultivation, and the state produces 0.86 lakh tonnes of greengram annually, with an average productivity that is 457 kg ha-1 less than the national average [7].

Pulses are exposed to a variety of biotic and abiotic stressors. Comparatively weeds are the main biotic stressor that seriously reduces pulse yields among the other stresses. Of all the pulses, soybeans had the largest loss (1.5 b$), followed by green grams (0.16 b$) [11]. A modification in the tillage and crop establishment techniques affects the species composition of the soil by either directly eliminating weeds or dispersing their seeds at varying soil depths. Additionally, the soil environment is altered, which impacts the emergence and germination of weed seeds [12]. The practice of conservation agriculture (CA), which involves farming in a way that minimizes environmental harm, is widely supported globally. Crop management strategies based on conservation agriculture (CA) have the potential to enhance agricultural and water yield while protecting and maintaining natural resources [13]. Compared to minimum tillage and conventional tillage, no-till may offer superior ecosystem services. [14] have reported that in reduced tillage-based cropping systems, rice grown with reduced tillage following the wet season yields a higher pulse yield than rice grown with conventional tillage. When crop residues are retained, both minimum tillage and no-till can minimize soil crusting, lower soil water evaporation, and enhance the hydro physical characteristics of the soil [15]. Among various production practices, establishment techniques, weed management practices and conservation tillage have vast potential to enhance yield of greengram.

2. MATERIAL AND METHODS

A field experiments involving green gram (December-march) was conducted during 2023on the instructional farm (North), Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu. The geographical details of experimental site are 10◦56’N latitude, 76◦44’E longitude and altitude 474 m above sea level. (10056’ N latitude and 76044’E longitude; altitude of 474 m above mean sea level).During thegrowth period, a total rainfall of 58.2 mm wasreceived in 91 rainy days during *rabi*2023-2024. The soil (0–15 cm) at the experimental site was clay loam in texture, having pH 8.42, and EC 0.52 dS m^{-1}, organic carbon 1.78%, available N, P and K 305.2, 16.9 and 42.56 kg ha^{-1}, respectively. The place under study falls in the Western agro- climatic zone of Tamil Nadu. The climate is tropical semi-arid slightly temperate with altitude. The experiment was carried out in a split plot design with three replications with individual plots measured 4.5 m x 3.5 m. Main plot Treatments (T1 and T2) were based on tillage [minimum tillage (primary tillage only)] and subplot treatments (W1-W5) were based on weed management practices [PE Pendimethalin @ 1.0 kg ha^{-1}, PE Pendimethalin + Imazethapyr (pre-mix) - Valor 32% EC 1.0 kg ha-1, Hand weeding on 15 and 30 DAS, Weed free plot and Un weeded control (weedy check)] in green gram.

Crops were either direct seeded with minimum tillage involving primary tillage operations alone or with conventional tillage, completing both primary and secondary tillage practices. Conventional tillage was done twice using a field cultivator and once with a disc harrow to prepare a fine seed bed prior to sowing. The field was ploughed once during minimum tillage, and the soil disturbance during the seed bed preparation was minimal. Well decomposed farmyard manure (FYM) @ 12.5 t ha^{-1} was uniformly applied over the experimental plot along with the final ploughing. Basal application of NPK in the ratio of 25:50:25 kg ha^{-1} was done before sowing. The Nitrogen (N), Phosphorus (P), and Potassium (K) fertilizers were applied in the form of urea (46% N), Single super phosphate (16% P2O5), and Muriate of potassium (60% K2O) respectively. Sowing was done on 20th December 2023 at a seed rate of 20 kg ha^{-1}. Good viable seeds were selected and treated with carbendazim at the rate of 2 g kg^{-1}. Seeds were sown maintaining a uniform population density and spacing of 45 x 10 cm for all the treatments. Seeds were dibbled at the rate of two seed $hill^{-1}$. On 3rd day after sowing pendimethalin 30% E.C. @ 1.0 kg ha^{-1} and Pendimethalin + Imazethapyr (pre-mix) - Valor 32% EC 1.0 kg ha^{-1} as a pre-emergence herbicide was sprayed using knapsack sprayer fitted with flat fan nozzle using 500 litres of water for spraying one ha to the sub plot treatments W1 and W2 respectively for both the main plot treatments. On 15th and 30th day after sowing hand weeding was done to sub plot treatment W3 in respect with both the main plot treatments. Sub plot treatment W4 for both the main plot treatments were kept free of weeds whereas in Sub plot treatment W5 for both the main plot treatments no weeding was done.Gap filling was done after two weeks of planting to maintain the plant population.

3. RESULTS AND DISCUSSION

3.1 Effect of tillage and weed management practices on growth parameters of green gram: Significant improvements in the growth and development of green gram, compared to weedy control, were observed across all weed control treatments under various tillage practices (Table 1). Conventional tillage (T2) resulted in slightly taller plants (29.25 cm) compared to minimum tillage (T1) (27.60 cm). According to Ram *et al.*[16], all the growth indices (plant population, plant height, dry matter accumulation at harvest, pod length, seeds pod^{-1}, and 100 seed weight) indicated a little increase with conventional tillage when compared to minimum tillage.Among weed management measures, plot W2 (PE Pendimethalin + Imazethapyr) produced the tallest plants, closely followed by the weed-free plot (W4). [17] discovered that the weed-free treatment produced higher growth indices, such as plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, and root biomass. This was statistically equivalent to shaking (propaquizafop + imezathyper) as post-emergence at 20 DAS and pendimethalin as pre-emergence followed by manual weeding once at 20 DAS.

Furthermore, T2 showed a slightly higher number of leaves compared to T1. Similarly, the combination of Pendimethalin and Imazethapyr (W2) resulted in the highest leaf count per plant (Table 1). Although the number of branches did not significantly vary across different weed management practices, conventional tillage (T2) led to a higher leaf area per plant compared to minimum tillage (T1). Notably, the combination of Pendimethalin and Imazethapyr (W2) exhibited the highest leaf area per plant, followed by the weed-free plot (W4). Applying 125 g ha^{-1} of imazethapyr and hand weeding produced at par plant height, number of branches $plant^{-1}$, and harvest index of green gram [18]. Overall, these findings underscore the positive impact of both conventional tillage and specific weed management practices, particularly the combination of Pendimethalin and Imazethapyr, on enhancing the growth parameters of green gram.

3.2 Effect of tillage and weed management practices on yield parameters of green gram:

3.2.1 Dry matter production: At 15 days after sowing (DAS), both tillage methods resulted in similar dry matter production, with T1 at 0.062 g $plant^{-1}$ and T2 at 0.064 g $plant^{-1}$ (Figure 1). At 30 DAS, dry matter production was slightly higher in T1 (0.381 g $plant^{-1}$) compared to T2 (0.354 g $plant^{-1}$). At harvest, T2 (0.849 g $plant^{-1}$) showed higher dry matter production compared to T1 (0.731 g plant^{-1}). Dry matter production varied across different weed management measures. W4 (Weed-free plot) consistently exhibited the highest dry matter production at all stages (15 DAS, 30 DAS, and at harvest), indicating the importance of weed control in maximizing dry matter accumulation in green gram plants. W2 (PE Pendimethalin + Imazethapyr) also showed high dry matter production, particularly at harvest, suggesting effective weed suppression and enhanced plant growth (Figure 1). W5 (Unweeded control plot) consistently showed the lowest dry matter production, emphasizing the negative impact of weed competition on plant growth and dry matter accumulation. This might be due to reduction of weed competition in the early stages of crop growth with the simultaneous increase in the uptake of nutrients by the crop which favoured taller plants, increased leaf area of assimilation surface which enhanced the crop DMP [19]. Overall, the results suggest that both conventional tillage and certain weed management practices, particularly the use of effective herbicides such as Pendimethalin and Imazethapyr, contribute to higher dry matter production in green gram cultivation. Additionally, maintaining weed-free conditions significantly enhances dry matter accumulation in green gram plants, leading to improved productivity.

3.2.2 Yield of green gram: Conventional tillage (T2) resulted in significantly higher seed yield (751.82 kg/ha) compared to minimum tillage (T1) with a seed yield of 503.02 kg/ha (Table 2). Similarly, T2 exhibited a higher biological yield (2023.34 kg/ha) compared to T1 (1479.61 kg/ha). T2 also had a slightly higher harvest index (0.36) compared to T1 (0.33), indicating a better partitioning of biomass into seed yield. Chaudhari *et al.* [20] recorded that conventional tillage has produced the highest seed cotton yield (2.52 t ha-1), whereas zero tillage produced the lowest seed cotton yield (1.88 t ha-1) in cotton-green gram cropping system.

The weed-free plot (W4) exhibited the highest seed yield (918.70 kg/ha), followed by W2 (676.61 kg/ha) and W3 (653.34 kg/ha). W5 (Unweeded control plot) had the lowest seed yield (341.44 kg/ha). Similar trends were observed in biological yield, with W4 showing the highest biological yield (2237.04 kg/ha), followed by W3 and W2 (Table 2). W5 had the lowest biological yield. W4 also had the highest harvest index (0.41), indicating efficient biomass allocation towards seed production. W3 had the second-highest harvest index (0.37), followed by W2. W5 had the lowest harvest index (0.27), indicating poor biomass partitioning towards seed yield. According to Kataria *et al.* [21], the weed-free treatment was the most successful in terms of yield (1252 kg ha^{-1}), yield attributes, quality,and net profit (50102 ha^{-1}). It also had the highest B:C ratio (3.05). Similar observation was recorded by Chaudhari *et al.* [8] who examined the effects of weed management on summer green gram (*Vigna radiata* L.), weeds, growth, and yield. They found that, upon harvest, the weed-free treatment had a notably higher number of branches plant^{-1} (8.88), yield, and yield-related characteristics, such as number of pods plant^{-1} (20.73). The study conducted by Kaur *et al*. [22] indicated that the combination of herbicide and crop residue mulch, specifically pendimethalin (pre-emergence) + 2t ha^{-1} residue followed by imazethapyr (post-emergence), resulted in higher pod yield. Singh *et al*. (2015) observed that a high dose of imazethapyr (75 g ha^{-1}) increased the grain production of green gram as a post emergence herbicide. Sequential application of pendimethalin fb imazethapyr produced greater weed suppression and increased green gram growth, yields, and net income compared to ready-mix Na-acifluorfen + clodinafop-propargyl [23]. Applying pendimethalin 30 EC + imazethapyr 2EC (ready mix) @ 1.0 kg a.i. ha^{-1} as pre-emergence and then manually weeding at 25-30 days post-sowing resulted in a considerably greater yield of green gram seeds (655.5 kg ha^{-1}) and stover yield (1078 kg ha^{-1}) [24]. Overall, the results suggest that both conventional tillage and effective weed management practices significantly impact the yield characters of green gram. Conventional tillage and weed management practices that promote weed suppression and efficient resource utilization contribute to higher seed yield, biological yield, and harvest index, ultimately enhancing the overall productivity of green gram cultivation.

Table 1. Effect of tillage methods and weed management practices on growth parameters of green gram at harvest

Treatments	Plant height (cm)	No. of leaves	No. of branches	Leaf area per plant (cm^2)
Tillage methods (T)				
T1- Minimum tillage	27.60	17.60	4.63	186.88
T2- Conventional tillage	29.25	19.25	4.52	247.80
SEm (±)	0.154	0.154	0.068	5.97
CD (0.05)	0.935	0.935	NS	36.37
Weed management measures (W)				
W1- PE Pendimethalin @ 1.0 kg ha^{-1}	28.97	18.97	4.50	233.92
W2- PE Pendimethalin + Imazethapyr (premix) @ 1.0 kg ha^{-1}	30.94	19.31	4.58	271.56
W3- Hand weeding on 15 and 30 DAS	27.95	17.95	4.66	200.44
W4- Weed free plot	29.36	21.00	4.90	259.98
W5- Un weeded control plot	24.89	14.89	4.25	120.82
SEm (±)	0.870	0.870	0.254	23.74
CD (0.05)	2.60	2.60	NS	71.18

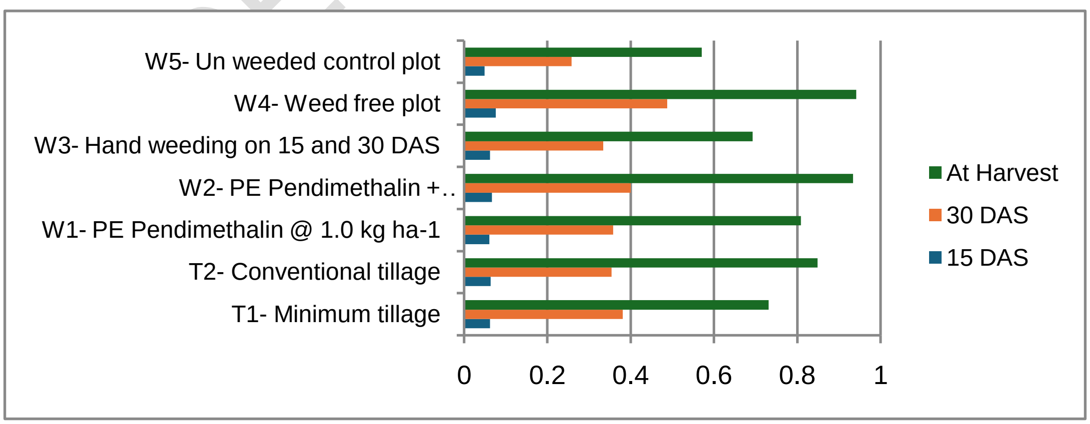

Figure 1. Influence of tillage and weed management measures on dry matter production of green gram (g plant^{-1})

Table 2. Effect of tillage methods and weed management practices on yield characters of green gram

Treatments	Seed yield (kg/ha)	Biological yield (kg/ha)	Harvest Index (HI)
Tillage methods (T)			
T1- Minimum tillage	503.02	1479.61	0.33
T2- Conventional tillage	751.82	2023.34	0.36
SEm (±)	48.27	78.85	0.005
CD (0.05)	NS	479.83	0.015
Weed management measures (W)			
W1- PE Pendimethalin @ 1.0 kg ha^{-1}	547.00	1689.70	0.32
W2- PE Pendimethalin + Imazethapyr (premix) @ 1.0 kg ha^{-1}	676.61	1847.72	0.36
W3- Hand weeding on 15 and 30 DAS	653.34	1735.94	0.37
W4- Weed free plot	918.70	2237.04	0.41
W5- Un weeded control plot	341.44	1247.00	0.27
SEm (±)	46.02	66.62	0.017
CD (0.05)	137.98	199.75	0.050

4. CONCLUSION

The study highlights the significant impact of tillage methods and weed management practices on both the growth parameters and yield characteristics of green gram. Across various tillage practices, significant improvements in plant growth were observed compared to weedy control conditions, particularly under conventional tillage. The combination of Pendimethalin and Imazethapyr resulted in the tallest plants and highest leaf count per plant, emphasizing its effectiveness in enhancing growth parameters. Dry matter production varied across weed management measures, with the weed-free plot consistently exhibiting the highest production, underscoring the importance of effective weed control in maximizing productivity. Additionally, conventional tillage led to significantly higher seed yield and biological yield compared to minimum tillage, further emphasizing its role in optimizing yield parameters. These findings highlight the importance of tailored agronomic practices in maximizing green gram yields and promoting sustainable cultivation methods.

REFERENCES

[1] AyerdiGotor, A., and Marraccini, E. Innovative pulses for Western European temperate regions: A review. Agronomy, 2022, 12(1), 170.

[2] Tidåker, P., Potter, H. K., Carlsson, G., and Röös, E. Towards sustainable consumption of legumes: How origin, processing and transport affect the environmental impact of pulses. Sustainable production and consumption, 2020, 27, 496-508.

[3] Henchion, M., Hayes, M., Mullen, A. M., Fenelon, M., and Tiwari, B. Future protein supply and demand: strategies and factors influencing a sustainable equilibrium. Foods, 2017, 6(7), 53.

[4] Hall, C., Hillen, C., and Garden Robinson, J. Composition, nutritional value, and health benefits of pulses. Cereal Chemistry, 2017, 94(1), 11-31.

[5] Bhat, S., Aditya, K. S., Kumari, B., Acharya, K. K., and Sendhil, R. (2022). Pulses production, trade and policy imperatives: A global perspective. In Advances in legumes for sustainable intensification (pp. 639-656). Academic Press.

[6] Mishra, P., Yonar, A., Yonar, H., Kumari, B., Abotaleb, M., Das, S. S., and Patil, S. G. State of the art in total pulse production in major states of India using ARIMA techniques. Current Research in Food Science, 2021, 4, 800-806.

[7] DPD [Directorate of Pulses Development]. Annual Report. Vindhyachal Bhavan, Kanpur, Government of India,2017, pp. 112.

[8] Chaudhari, V. D., Desai, L. J., Chaudhari, S. N., and Chaudhari, P. R. Effect of weed management on weeds, growth and yield of summer greengram (*Vigna radiata* L.). An International Quarterly Journal of Life Science, 2016, 11(1), 531-534

[9] United States Department of Agriculture. (2019). USDA food composition databases

[10] Udayasri, S., Lavanya, G. R., and Lal, G. M. (2022). Estimation of variability and genetic divergence in greengram [*Vigna radiata* (L.) Wilczek] for yield characters. International Journal of Plant Soil Science, 2022, 34(23), 49-56.

[11] Sinchana, J. K., and Raj, S. K. Weed management in pulses: a review. Legume Research-An International Journal, 2023, 46(5), 533-540.

[12] Sharma, P., Singh, M. K., Verma, K., and Prasad, S. K. Changes in the weed seed bank in long-term establishment methods trials under rice-wheat cropping system. Agronomy, 2020, 10(2), 292.

[13] Parihar, C. M., Yadav, M. R., Singh, A. K., Kumar, B., Pooniya, V., Pradhan, S., and Saharawat, Y. S. Long-term conservation agriculture and intensified cropping systems: Effects on growth, yield, water, and energy-use efficiency of maize in northwestern India. Pedosphere, 2018, 28(6), 952-963.

[14] Pratibha, G., Pillai, K. G., Satyanarayana, V., and Hussain, M. M. Tillage systems for production of blackgram (*Vigna mungo*) succeeding rice crop. Legume Research, 1996, 19(1), 23-28.

[15] Das, A., Layek, J., Ramkrushna, G. I., Rangappa, K., Lal, R., Ghosh, P. K., and Prakash, N. Effects of tillage and rice residue management practices on lentil root architecture, productivity and soil properties in India's Lower Himalayas. Soil and Tillage Research, 2019, 194, 104313.

[16] Ram, A., Dev, I., Kumar, D., Uthappa, A. R., Tewari, R. K., Singh, R., Sridhar, K. B., Mahendra, S., and Chaturvedi, O. P. Effect of tillage and residue management practices on blackgram and greengram under bael (*Aegle marmelos* L.) based agroforestry system. Indian Journal of Agroforestry, 2016, 18(1), 90-95.

[17] Singh, K., Ram, H., Kumar, R., Meena, R. K., and Kumar, R. Effect of weed management practices on weed dynamics, nutrient depletion, productivity and profitability of summer mungbean (*Vigna radiata*) under zero tillage condition. Legume Research-An International Journal, 2022, 45(6), 762-768.

[18] Singh, G., Kaur, H., Aggarwal, N., and Sharma, P. Effect of herbicides on weeds growth and yield of greengram. Indian Journal of Weed Science, 2015, 47(1), 38-42.

[19] Muthuram, T., Krishnan, R., and Baradhan, G. Productivity enhancement of irrigated greengram (*Vigna radiata* L.) through integrated weed management. Plant Archives, 2018, 18(1), 101-105.

[20] Chaudhari, D. D., Patel, V. J., Patel, H. K., Mishra, A., and Patel, B. D. Tillage and weed management influence on physico-chemical and biological characteristics of soil under cotton-greengram cropping system. Indian Journal of Weed Science, 2020, 52(1), 37-42.

[21] Kataria, K., Singh, S. P., and Yadav, R. S. Evaluation of post-emergence herbicides in greengram. Annals of Agricultural Research, 2018, 39(1).

[22] Kaur, R., Das, T. K., Banerjee, T., Raj, R., Singh, R., and Sen, S. Impacts of sequential herbicides and residue mulching on weeds and productivity and profitability of vegetable pea in North-western Indo-Gangetic Plains. Scientia Horticulturae, 2020, 270, 109456.

[23] Sen, S., Das, T. K., Dass, A., Kumar, D., Bhatia, A., Bhattacharyya, R., and Sharma, T. Tillage, residue, nitrogen and herbicides effects on weeds and greengram productivity and profitability in conservation agriculture-based maize-wheat-greengram system. Indian Journal of Weed Science, 2023, 55(4), 380-387.

[24] Banerjee, H., Das, T. K., Ray, K., Laha, A., Sarkar, S., and Pal, S. Herbicide ready-mixes effects on weed control efficacy, non-target and residual toxicities, productivity and profitability in sugarcane–green gram cropping system. International Journal of Pest Management, 2018, 64(3), 221-229.