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Comparative performance of intercultural tillage operations below the canopy spread on growth and yield of guava

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Abstract
The present study was conducted to evaluate the comparative performance of intercultural tillage operations below the canopy spread on the growth and yield of *Psidium guajava* L. cv. Lalith at the Regional Horticultural Research and Extension Centre (RHREC), University of Horticultural Sciences, GKVK Campus, Bengaluru. The experiment was laid out in a factorial randomized complete block design (RCBD) with five tillage treatments and eight replications to assess their influence on soil physical properties, vegetative growth, and fruit yield parameters. The treatments included: T_1 (control – no tillage), T_2 (tillage once with mini-tiller), T_3 (tillage twice with mini-tiller), T_4 (zero tillage + mulching), and T_5 (tillage once with mini-tiller + mulching). The recorded growth parameters comprised stem girth, plant height, and canopy spread in both north–south and east–west directions. Although statistical analysis indicated a non-significant effect of tillage practices on most growth traits, notable trends were observed. Plants under T_4 (zero tillage + mulching) showed the highest percent increase in stem girth, plant height, and canopy spread, followed by T_3 (tillage twice with mini-tiller). Similarly, yield parameters such as number of fruits per plant did not differ significantly among treatments. However, T_5 (tillage once with mini-tiller + mulching) consistently recorded higher fruit numbers compared to other treatments, indicating a potential synergistic effect of shallow tillage and organic mulching on fruit productivity. Overall, while the differences among treatments were statistically non-significant, the trends observed highlight the role of mulching in enhancing vegetative growth and fruit set in guava under semi-arid conditions. The study suggests that integrating mulching with tillage operations can create a more favourable soil environment, supporting better plant growth and fruit yield in guava under field conditions.

Keywords: Tillage operation, mulching, mini tiller, guava

Introduction

Guava (*Psidium guajava* L.) is an important fruit crop native to tropical America, which spread rapidly to tropical and subtropical regions of the world through Spanish and Portuguese explorers (Chandra and Govind, 1995) [1]. Today, it is extensively cultivated in South Asian countries, the Hawaiian Islands, Cuba, and India (Singh, 2007) [2]. In India, guava is grown on about 307 thousand hectares with an annual production of 4.52 million tonnes (NHB, 2021–22) [3]. The major guava-growing states include Madhya Pradesh, Uttar Pradesh, Bihar, Maharashtra, Andhra Pradesh, and Karnataka. Owing to its high productivity, wide adaptability, hardiness, and nutritional richness, guava has become one of the most popular fruit crops in India, ranking fourth in area and production after mango, banana, and citrus (Singh *et al*., 2012) [4]. Guava is often referred to as the "poor man's apple" due to its affordability and nutritional value, particularly its high vitamin C content, which surpasses many other commonly consumed fruits (Misra and Singh, 2009) [5]. Karnataka ranks second in guava productivity after Madhya Pradesh, with significant contributions to both fresh consumption and processing industries (NHB, 2021–22) [3]. The crop excels most other fruit trees with respect to productivity, hardiness, adaptability, and nutritional superiority (Samson, 1986; Yadava, 1996) [6,7]. Recent studies highlight that guava cultivation under sustainable practices, including organic inputs such as Jeevamrutha, can enhance yield and quality while improving soil health (Anand *et al*., 2025) [8]. Similarly, breeding efforts and genotype selection continue to play a vital role in enhancing yield, fruit quality, and nutrient content (Gupta *et al*., 2025) [9]. Soil management plays a crucial role in sustaining guava productivity. Among the various crop production factors, soil tillage is one of the most important, as it contributes up to 20% of crop yield (Ahmad *et al*., 1996) [11]. Tillage creates favourable soil physical conditions by improving soil aeration, root penetration, and water infiltration, thereby enhancing plant growth and productivity (Adamu *et al*., 2004; Nkakini *et al*., 2008) [12]. It is also one of the most effective ways to reduce soil compaction, which is a major constraint in perennial fruit orchards (Bowen, 1981) [13]. Furthermore, tillage practices influence the sustainable use of soil resources through their impact on soil structure, moisture dynamics, and nutrient availability (Hammel, 1989; Lal, 1993) [14, 15]. Recent work emphasizes that balanced tillage strategies are critical in orchard systems to minimize compaction and conserve soil health (Blevins *et al*., 1998; Swetha *et al*., 2024) [16, 17].

Despite extensive studies on tillage in annual crops, reports on the medium-term effects of tillage practices in perennial fruit crops like guava are limited. With increasing emphasis on soil conservation and sustainable orchard management, it becomes essential to evaluate different tillage operations and their impact on soil health and crop performance. Mini-tillers have recently gained importance as an efficient mechanization option for small and marginal orchards due to their manoeuvrability and cost-effectiveness (Kumar *et al*., 2011) [18]. It is hypothesized that different tillage operations below the canopy spread of guava trees will significantly influence soil physical properties, plant growth, and fruit yield. Specifically, intercultural tillage using a mini-tiller is expected to improve soil physical properties, facilitate better root growth and nutrient uptake, increase fruit yield and quality attributes and sustainable mechanization alternative for small and marginal guava growers compared to conventional practices.

Material and Methods

Experimental site and plant material

The field experiment was conducted at the Regional Horticultural Research and Extension Centre (RHREC), University of Horticultural Sciences Campus, GKVK, Bengaluru, Karnataka, India. The study was undertaken in an existing six-year-old guava orchard of cultivar *Lalith*, which had been established under high-density planting. The planting geometry was maintained at 3.0 m × 3.0 m, accommodating 444 plants per acre. The orchard was managed under uniform cultural practices, except for the imposed treatments. Prior to the initiation of the experiment, the plants were pruned to maintain uniform canopy structure and to facilitate tillage operations.

Soil characteristics

The experimental soil was classified as clay loam, with a textural composition of 32% silt, 37% sand, and 31% clay. The soil reaction was acidic, with pH < 6.0. Baseline soil samples were collected from the rhizosphere zone (0–30 cm depth) and analysed for physical and chemical properties. The parameters studied included bulk density, water-holding capacity, electrical conductivity (EC), organic carbon (OC), available macronutrients (N, P, K), and micronutrients (Zn, Fe, Mn, Cu). Standard analytical methods were adopted for soil characterization, such as the Walkley and Black method for organic carbon, the Kjeldahl method for nitrogen, Olsen's method for phosphorus, and Flame photometry for potassium, while micronutrients were analysed using atomic absorption spectrophotometry (Jackson, 1973; Lindsay and Norvell, 1978) [19, 20].

Experimental design and treatments

The experiment was laid out in a factorial randomized complete block design (RCBD) with five treatments and eight replications, using individual trees as experimental units. The treatments were:

- **T_1:** Zero tillage (control)
- **T_2:** Tillage once with mini-tiller
- **T_3:** Tillage twice with mini-tiller
- **T_4:** Zero tillage + mulching
- **T_5:** Tillage once with mini-tiller + mulching

A petrol-operated, four-stroke, single-cylinder Oleo-Mac MH-195 mini-tiller fitted with a 5 hp Honda engine (Fig. 1) was employed to carry out tillage operations. The depth of tillage was maintained at 5–10 cm, while the width of tillage was adjusted according to the canopy spread of each tree. The first tillage operation was performed in August, and the second (for T_3 treatment) was carried out approximately two months after the first operation. For mulching treatments, a locally available organic mulch (paddy straw) was applied at a thickness of 5–7 cm around the basin after tillage.

Data collection and observations

Soil parameters

During the experiment soil samples were collected at 0–30 cm depth from the root zone of representative trees in each treatment and analysed for physical properties (bulk density, water holding capacity, soil porosity) and chemical properties (pH, EC, OC, available NPK, and micronutrients) using standard procedures as described above.

Plant growth and yield parameters

Biometric observations were recorded periodically from tagged plants. Growth parameters included plant height, stem girth, and canopy spread (both N–S and E–W directions). The number of fruits per tree was recorded.

Statistical analysis

All the data were subjected to statistical analysis using SPSS version 25.0 software. Analysis of variance (ANOVA) appropriate to the factorial RCBD was performed, and treatment means were compared at the 5% level of significance ($p \leq 0.05$) using the least significant difference (LSD) test.

Fig 1: Oleo-Mac Mini-Tiller for tillage operation

Fig 2: Experimental field with different treatments

Results and Discussion

Effect of tillage on stem girth

The growth parameters of guava such as stem girth and plant height were recorded and are presented in Table 1. Statistical analysis revealed that the effect of different tillage treatments on stem girth increment was non-significant during both years of study. However, a differential response among treatments was evident. During the first year, the highest percent increase in stem girth (8.33%) was recorded in T_4: Zero tillage + mulching, followed by T_3: Tillage twice with mini-tiller (3.72%), while the lowest increment was observed in the control (T_1: Zero tillage). In the second year, a similar trend was noticed, wherein T_4 again exhibited the highest stem girth increment (4.81%), followed by T_5: Tillage once with mini-tiller + mulching (3.08%). These results suggest that the application of mulching, irrespective of tillage, contributed positively to stem girth development, possibly due to its role in conserving soil moisture, moderating soil temperature, and improving organic matter status in the rhizosphere. Although the effect was statistically non-significant, the numerical superiority of mulching treatments aligns with earlier findings in perennial fruit crops. Patel *et al.* (2010) [21] reported that mulching in guava improved stem girth and vegetative growth due to better soil moisture conservation and reduced weed competition. Similarly, Kumar *et al.* (2014) [22] observed that organic mulches significantly enhanced trunk girth and canopy spread in mango, which corroborates the present findings. In guava, Singh *et al.* (2017) [23] demonstrated that basin tillage combined with organic mulching improved vegetative growth and soil moisture availability compared to conventional tillage. Their results indicated that guava plants under mulched conditions exhibited better increment in stem girth, supporting the higher values obtained in T_4 and T_5 in the present study. The comparatively lower increment observed in treatments involving tillage without mulching (T_2 and T_3) may be attributed to increased soil aeration and reduced compaction, but these effects alone were not sufficient to sustain moisture for prolonged periods. In contrast, mulching provided a synergistic effect by improving the soil microenvironment. Similar observations were reported by Ghosh *et al.* (2018) [24] in litchi, where mulching significantly improved stem girth and root activity compared to non-mulched plots. The overall non-significant statistical differences among treatments could be due to the perennial nature of guava, where growth responses manifest more gradually over several years. As noted by Rani *et al.* (2016) [25], in long-lived fruit trees like guava and mango, incremental vegetative growth parameters are often subtle in the short term, requiring long-term evaluation to establish significant treatment effects.

Effect of tillage on plant height

The effect of different tillage and mulching treatments on plant height of guava during the first and second year of study is presented in Table 1. Statistical analysis revealed a non-significant influence of treatments on plant height in both years; however, considerable differences in the percent increase were recorded among the treatments. In the first year, maximum increment in plant height was observed in T_4: Zero tillage + mulching (22.33%), followed by T_3: Tillage twice with mini-tiller (14.49%), while the minimum increment was recorded in T_5: Tillage once with mini-tiller + mulching (5.30%). In the second year, a similar trend was maintained, with T_4 (20.74%) and T_3 (15.04%) showing superior performance compared to other treatments, whereas the lowest increase was found in T_1: Zero tillage (9.36%). The consistent superiority of mulching treatments (T_4 and T_5) and repeated tillage (T_3) suggests that these practices created a more favourable soil environment for root activity, leading to enhanced vegetative growth. Mulching helps in conserving soil moisture, moderating soil temperature, and reducing weed competition, all of which positively influence canopy growth and plant vigor. Similar findings were reported by Singh *et al.* (2015) [26] and Patel *et al.* (2018) [27], who observed that mulching improved plant height and overall vegetative growth in guava. Likewise, the positive impact of tillage on soil physical properties, particularly reduction in bulk density and improved aeration, has been highlighted in earlier studies (Nkakini *et al.*, 2008; Kumar *et al.*, 2011) [12,18]. Although treatment differences did not attain statistical significance, the biological trend clearly demonstrates the role of mulching and repeated tillage in improving plant height compared to zero tillage. The relatively high coefficients of variation (9.5–14.5%) indicate variability among individual plants, which may have masked treatment effects statistically. Nevertheless, the trends are in agreement with earlier research emphasizing the importance of soil management practices in enhancing vegetative growth and orchard sustainability in guava (Lal, 1993; Blevins *et al.*, 1998) [15, 16].

Effect of tillage on plant spread

The data on plant spread in North–South (NS) and East–West (EW) directions during the first and second year of study are presented in Table 2. Statistical analysis revealed a non-significant effect of different tillage and mulching treatments on plant spread. However, notable treatment-wise differences in the percent increase of plant spread were observed. In the first year, the maximum increase in plant spread (NS: 19.36%; EW: 18.04%) was recorded in T_4: Zero tillage + mulching, followed by T_3: Tillage twice with mini-tiller (NS: 10.97%; EW: 14.59%), whereas the minimum increase was observed in T_1: Zero tillage (NS: 6.77%; EW: 6.27%). A similar trend was observed during the second year, where T_4 (NS: 12.05%; EW: 12.47%) and T_3 (NS: 11.91%; EW: 11.11%) recorded higher increments compared to other treatments, while the lowest increase was found in T_1 (NS: 6.91%; EW: 3.22%). Although differences were statistically non-significant, the consistent superiority of treatments involving mulching (T_4, T_5) and repeated tillage (T_3) indicates their positive role in improving canopy spread of guava. Mulching possibly contributed to soil moisture conservation and moderated soil temperature, thereby enhancing root activity and subsequent canopy growth. Similar beneficial effects of mulching on canopy development and vegetative growth in guava were also reported by Singh *et al.* (2015) [26] and Patel *et al.* (2018) [27]. The favourable effect of repeated tillage may be attributed to improved soil physical conditions such as reduced bulk density, better aeration, and enhanced root penetration (Nkakini *et al.*, 2008; Kumar *et al.*, 2011) [12,18]. The observed variation may also be due to tree-to-tree growth differences, as indicated by the relatively high coefficients of variation (15–18%). Nevertheless, the biological trend clearly suggests that integration of mulching with soil tillage practices enhances guava plant spread compared to zero tillage. These findings corroborate with earlier reports on the role of soil management in sustaining vegetative growth and canopy expansion in fruit crops (Lal, 1993; Blevins *et al.*, 1998) [15, 16].

Table 1: Influence of different intercultural tillage treatments on stem girth (cm) and plant height (m)

Treatments details	Stem Girth (cm): First year			Stem Girth (cm): Second Year			Plant height (m): First Year			Plant height (m): Second Year		
	Initial	After 6 months	% increase	First Year	Second Year	% increase	Initial	After 6 months	% increase	First Year	Second Year	% increase
T_1	20.87	21.25	1.79	21.25	22	3.53	1.950	2.105	7.949	1.975	2.16	9.367
T_2	22.62	22.75	0.55	22.75	23.38	2.75	2.025	2.182	7.753	2.017	2.297	13.882
T_3	23.50	24.37	3.72	24.38	25.00	2.56	2.050	2.347	14.488	2.075	2.387	15.036
T_4	24.00	26.00	8.33	26.00	27.25	4.81	1.935	2.367	22.326	2.025	2.445	20.74
T_5	23.62	24.38	3.17	24.38	25.12	3.08	2.075	2.185	5.301	2.102	2.307	9.752
S.Em±	1.22	18.47		18.47	16.25		0.037	0.065		0.056	0.115	
CD (5%)	NS	NS		NS	NS		NS	NS		NS	NS	
CV%	15.08	18.09		18.09	16.38		9.543	11.539		11.967	14.587	

Table 2: Influence of different tillage treatments on plant spread-NS & EW (m)

Treatments details	Plant spread - NS (m): First Year			Plant spread - NS (m): Second Year			Plant spread - EW (m): First Year			Plant spread - EW (m): Second Year		
	Initial	After 6 months	% increase	Initial after pruning	After 6 month	% increase	Initial	After 6 months	% increase	Initial after pruning	After 6 month	% increase
T_1	1.95	2.08	6.77	1.77	1.89	6.91	1.92	2.04	6.27	1.87	1.93	3.22
T_2	2.04	2.18	7.22	1.85	2.03	9.64	1.93	2.04	5.71	1.90	2.09	9.62
T_3	2.12	2.35	10.97	2.10	2.35	11.91	1.89	2.16	14.59	1.94	2.15	11.11
T_4	2.03	2.42	19.36	1.95	2.19	12.05	1.89	2.23	18.04	1.93	2.17	12.47
T_5	2.05	2.24	9.02	1.93	2.10	9.09	2.08	2.27	9.16	2.02	2.15	6.69
S.Em±	0.11	0.12		0.11	0.15		0.11	0.12		0.11	0.15	
CD (5%)	NS	NS		NS	NS		NS	NS		NS	NS	
CV%	16.12	15.38		17.58	18.68		16.69	15.57		16.69	17.99	

Table 3: Observed number of fruits per tree in guava for different tillage treatments

Treatments details	Number of fruits/tree First Year	Number of fruits/tree Second Year
T_1: Zero tillage	224	233
T_2: Tillage once with mini-tiller	238	247
T_3: Tillage twice with mini-tiller	252	259
T_4: Zero tillage + mulching	249	255
T_5: Tillage once with mini-tiller + mulching	266	275

Table 4: Soil physical and chemical properties (Mean values)

Treatments	Soil water holding capacity (%)	Bulk density (g/cc)	pH	EC (ds/m)	OC (%)	Avl. N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	Ca	Mg	Fe	Cu	Mn	Zn
T_1	23.81	1.125	5.56	0.21	0.73	200.70	42	189.60	4.3	2.8	3.01	0.17	8.91	0.74
T_2	24.75	1.131	5.87	0.38	0.75	188.16	25	228.00	5.0	3.7	2.57	0.80	9.59	2.77
T_3	28.96	1.151	5.73	0.33	0.78	150.53	48	235.20	4.9	2.4	2.50	0.17	7.66	2.72
T_4	24.01	1.140	5.26	0.33	0.72	225.79	17	144.00	3.3	2.7	2.26	0.14	10.0	1.04
T_5	24.85	1.087	5.18	0.27	0.84	188.16	21	165.60	4.2	2.4	2.49	0.15	9.05	2.10

Conclusion

The study revealed a non-significant effect of different tillage treatments on growth and yield parameters of guava during the experimental period. Nevertheless, clear trends were observed among the treatments. T_4: Zero tillage + mulching consistently recorded higher increments in stem girth, plant height, and plant spread, followed by T_3: Tillage twice with mini-tiller, indicating the positive influence of mulching on vegetative growth. In terms of yield, although statistically non-significant, T_5: Tillage once with mini-tiller + mulching produced a greater number of fruits per tree compared to other treatments. These findings suggest that integrating mulching with tillage operations can create a more favourable soil environment, supporting better tree growth and fruit yield in guava under field conditions.

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