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Impact of Land Resource Inventory (LRI) Interventions on Groundnut, Chilli and Cotton Growth and Yield Performance

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Land Resource Inventory (LRI) provides location-specific guidance for sustainable crop management by integrating soil, water, climate and land-use information. This study evaluated the influence of LRI-based interventions on growth, yield and resource-use efficiency of cotton, chilli and groundnut in the Shirur sub-watershed of northern Karnataka. Four treatments were compared: Farmers with LRI cards, training and inputs (T1); LRI cards and training (T2); LRI cards only (T3); and non-LRI farmers (T4) (control). Crop growth and yield parameters, including leaf area index (LAI), total dry matter (TDM) and crop-specific yield attributes, were recorded and T-test was assessed to see the treatment effects. Results showed that T1 consistently outperformed other treatments across all crops. Groundnut under T1 had the highest pod number (24/plant), pod yield (36.25 q/ha), kernel weight (116.90 g/plant) and shelling percentage (69.35%). Chilli recorded maximum fruit number (32/plant), fruit yield (12.50 kg/ha) and TDM (159.16 kg/ha), while cotton exhibited the highest opened bolls (31), seed cotton yield (21.63 q/ha) and TDM (2028.50 kg/ha). T4 showed lower yields despite sometimes higher LAI, indicating that canopy expansion alone does not ensure productivity. Superior performance in T1 is attributed to timely sowing, balanced nutrient application, soil moisture conservation and favourable microclimatic conditions. The study demonstrates that LRI-based integrated management improves nutrient and water use efficiency, enhances crop development and increases yield stability. Adoption of LRI interventions is thus an effective strategy for improving productivity, resilience and sustainability in rainfed agriculture.

Keywords: Land resource inventory; chilli; groundnut; cotton; nutrient.

1. INTRODUCTION

Cotton, being a nutrient-exhaustive crop, requires substantial amounts of nitrogen (N), phosphorus (P) and potassium (K) for optimal growth and yield. However, indiscriminate or excessive fertilizer application particularly nitrogen while neglecting secondary and micronutrients, reduces nutrient use efficiency, causes soil acidification and increases environmental losses through leaching, volatilization and runoff (Patel et al., 2019; Ramesh et al., 2021). Similarly, chilli (*Capsicum annuum* L.), a high-value spice crop, requires balanced NPK nutrition for fruit quality and yield. Over-application of nitrogen and unbalanced fertilizers in chilli has been reported to decrease nutrient uptake its efficiency, increase soil salinity and elevate nitrate accumulation, while also raising production costs and degrading soil health (Ntare et al., 1998). In contrast, groundnut (*Arachis hypogaea* L.), a legume capable of fixing atmospheric nitrogen via symbiotic nodules, has low nitrogen requirements. Excessive nitrogen fertilization suppresses biological nitrogen fixation, reduces microbial activity and contributes to nitrate leaching and soil acidification (Singh et al., 2022; (Bandyopadhyay et al., 2019). These studies emphasize that site-specific, balanced nutrient management, guided by soil testing and location-specific recommendations, is essential to optimize nutrient use efficiency, maintain soil fertility and ensure sustainable crop productivity across cotton, chilli and groundnut cultivation systems (Ghosh et al., 2018).

Land degradation and the indiscriminate use of chemical fertilizers have resulted in a progressive decline in soil health and agricultural productivity across many regions. To overcome these challenges, the Land Resource Inventory (LRI) approach has been developed, which systematically maps and characterize land resources such as soils, water, topography, vegetation, climate and land use at a detailed scale. Using field surveys, soil sampling, laboratory analysis, GIS mapping and integration of climatic and hydrological data, LRI generates reliable and location-specific information to guide sustainable land use planning and management (Rajesh, 2022). The information is translated into LRI cards, which are provided to farmers with tailored recommendations on crop selection, soil fertility management, water use and conservation practices, thereby helping restore soil health, improve productivity and enhance climate resilience at the farm level. The objectives of LRI extend beyond farm-level advisories to encompass broader natural resource management goals. It aims to assess the capability and suitability of land for different crops and land uses, promote balanced nutrient and water management, support watershed development and provide a scientific basis for policymakers in planning sustainable interventions. Its components include soil resources (type, texture, depth, fertility, pH, organic matter), water resources (groundwater, surface water, drainage, moisture retention), topography (slope, elevation, erosion risk), climate (rainfall, temperature, humidity, radiation) and land use/land cover (cropping patterns, forests, settlements, wastelands). In agriculture, LRI serves as a vital tool for precision farming, crop planning based on resource endowments, identification of climate-resilient cropping systems and enhancement of farm income through site-specific and sustainable interventions. For instance, a study by Singh et al. (2022) demonstrated the effectiveness of LRI in land-use planning at a 1:10K scale, utilizing soil mapping and data integration for site-specific pedogenesis evaluation. Additionally, research by Ravi et al. (2022) highlighted the impact of LRI-based fertilizer recommendations in Karnataka, showing improved soil fertility and enhanced crop performance.

2. METHODOLOGY

The study was conducted in the Shirur sub-watershed, located in the northern part of Karnataka in Kundgol taluk of Dharwad district, Karnataka, India. It lies between 15^{0}10'30" - 15^{0}14'0" North latitude and 75^{0}12'30"- 75^{0}19'30" East longitude. The area falls under the Northern Transition Zone (Zone 8) of Karnataka and experiences a semi-arid tropical climate with distinct seasonal variation. The study area generally receives moderate rainfall, averaging around 650-750 mm annually, predominantly during the southwest monsoon season. The mean maximum temperature usually ranges between 28°C to 36°C, while the minimum temperature varies from 15°C to 22°C across the year, indicating warm summers and mild winters. Relative humidity in the region shows considerable fluctuation, generally ranging from 40 per cent to 90 per cent, with higher humidity during the monsoon and lower values during the dry season.

Four types of treatments have been selected considering 3 crops in each treatment cotton, chilli and groundnut, respectively

T1: LRI farmers with cards, training and inputs provided (Bhu Tharlaghatta)

T2: LRI farmers with cards and training provided (Kamdolli 2)

T3: LRI farmers with cards provided (Kamdolli 1)

T4: Non LRI farmers (Control) (Bhu Koppa)

For the study, 11 farmers were selected under Treatment 1, while 15 farmers each were selected under Treatments 2, 3 and 4. This farmer distribution helped us collect enough data from each treatment to compare crop performance and understand how different levels of LRI interventions influenced growth and yield.

Systematic observations on crop growth and yield parameters were recorded in majorly grown crops like cotton, chilli and groundnut across all LRI treatment levels during *kharif* 2024. In cotton, data were collected on monopodials, sympodials, number of opened bolls, seed cotton yield (g plant^{-1} and kg ha^{-1}), total dry matter and leaf area index (LAI). For chilli, the number of fruits per plant, fruit yield (g plant^{-1} and kg ha^{-1}), total dry matter and LAI were measured at harvest. In groundnut, parameters including number of pods per plant, 100-seed weight, pod yield (g plant^{-1} and kg ha^{-1}), shelling percentage, total dry matter and LAI were recorded. The LAI was measured using a portable LAI-2200C, while total dry matter accumulation was determined by oven-drying plant samples at 70°C until constant weight. These systematic observations facilitated a comprehensive assessment of crop yield performance under varying levels of LRI-based interventions.

The data obtained from different treatments were subjected to statistical analysis using the t-test to compare mean differences between groups. An independent samples t-test was applied to assess the significance of variation in crop growth and yield parameters under different treatments, assuming equal variance among samples. The calculated t-values were compared with the tabulated values at appropriate degrees of freedom and the level of significance was tested at 5% probability. The t test analysis was done using the WASP software.

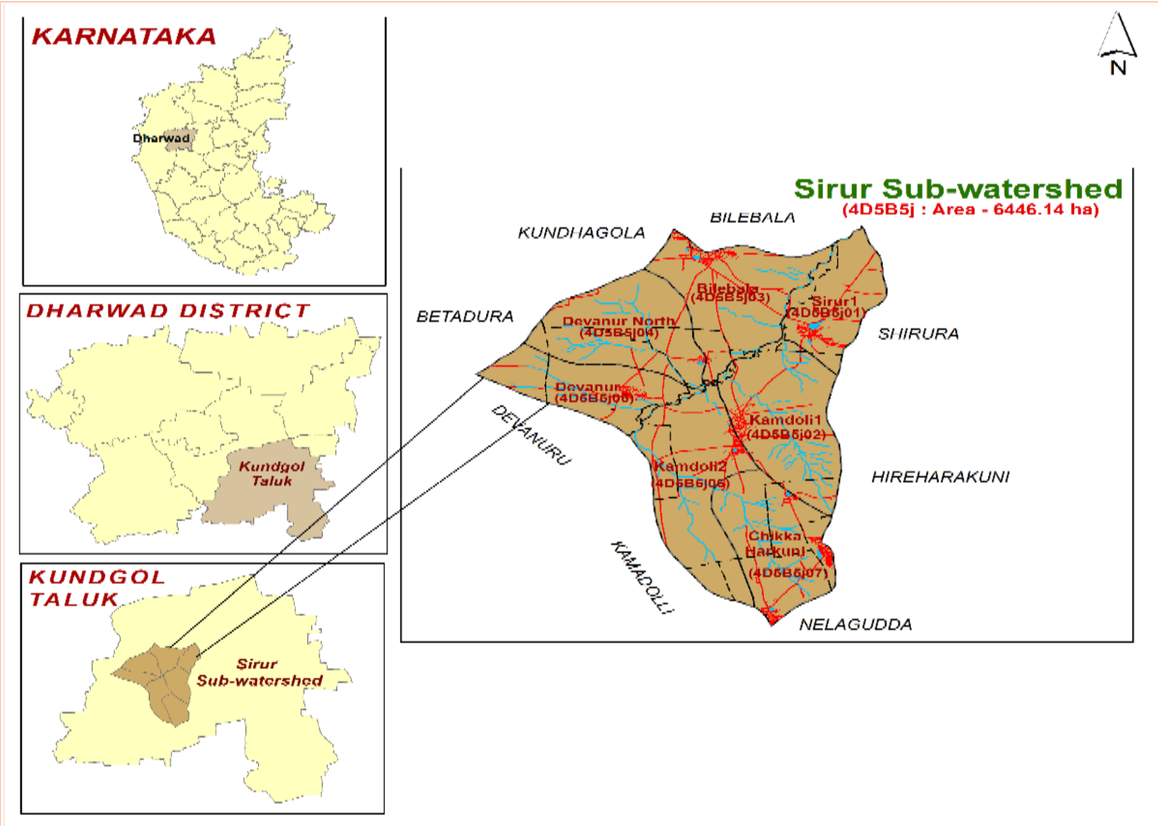

Fig. 1. Location map of the study area

$$t = \frac{(x_1 - x_2)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

where,

x_1 = observed mean of 1st sample x_2 = observed mean of 2nd sample

s_1 = standard deviation of 1st sample s_2 = standard deviation of 2nd sample

n_1 = sample size of 1st sample n_2 = sample size of 2nd sample

3. RESULTS AND DISCUSSION

3.1 Groundnut

Groundnut growth and yield parameters varied significantly among the four treatments (T1-T4) (Table 1) (Fig. 2). Treatment T1 (LRI farmers with cards, training and inputs) recorded the highest number of pods per plant (24.00), pod weight (142.93 g/plant), kernel weight (116.90 g/plant), shelling percentage (69.35%) and pod yield (36.25 q/ha), followed by T3 and T2, while T4 (non-LRI farmers) showed the lowest performance (24.32 q/ha). The T-test analysis revealed significant differences between T1 and other treatments for most yield attributes particularly pod yield, kernel weight, shelling percentage and total dry matter (TDM) indicating a strong influence of LRI interventions on crop productivity. Significant variations were also observed among non-LRI treatments (T2, T3 and T4), suggesting differential management efficiency among farmers. The leaf area index (LAI) ranged from 1.52 in T3 to 2.23 in T4, showing that a wider canopy did not necessarily translate into higher yield efficiency under sub-optimal management. The superior performance of T1 is attributed to improved agronomic practices and favourable microclimatic conditions under LRI guidance, ensuring timely sowing, balanced nutrient use and effective soil moisture conservation. Adequate rainfall and optimum soil moisture during pod initiation enhanced flowering and pod filling. Similar results were reported by Sarkar et al. (2020), who found that improved soil health and moisture conservation increased pod and kernel yields in semi-arid systems. Higher

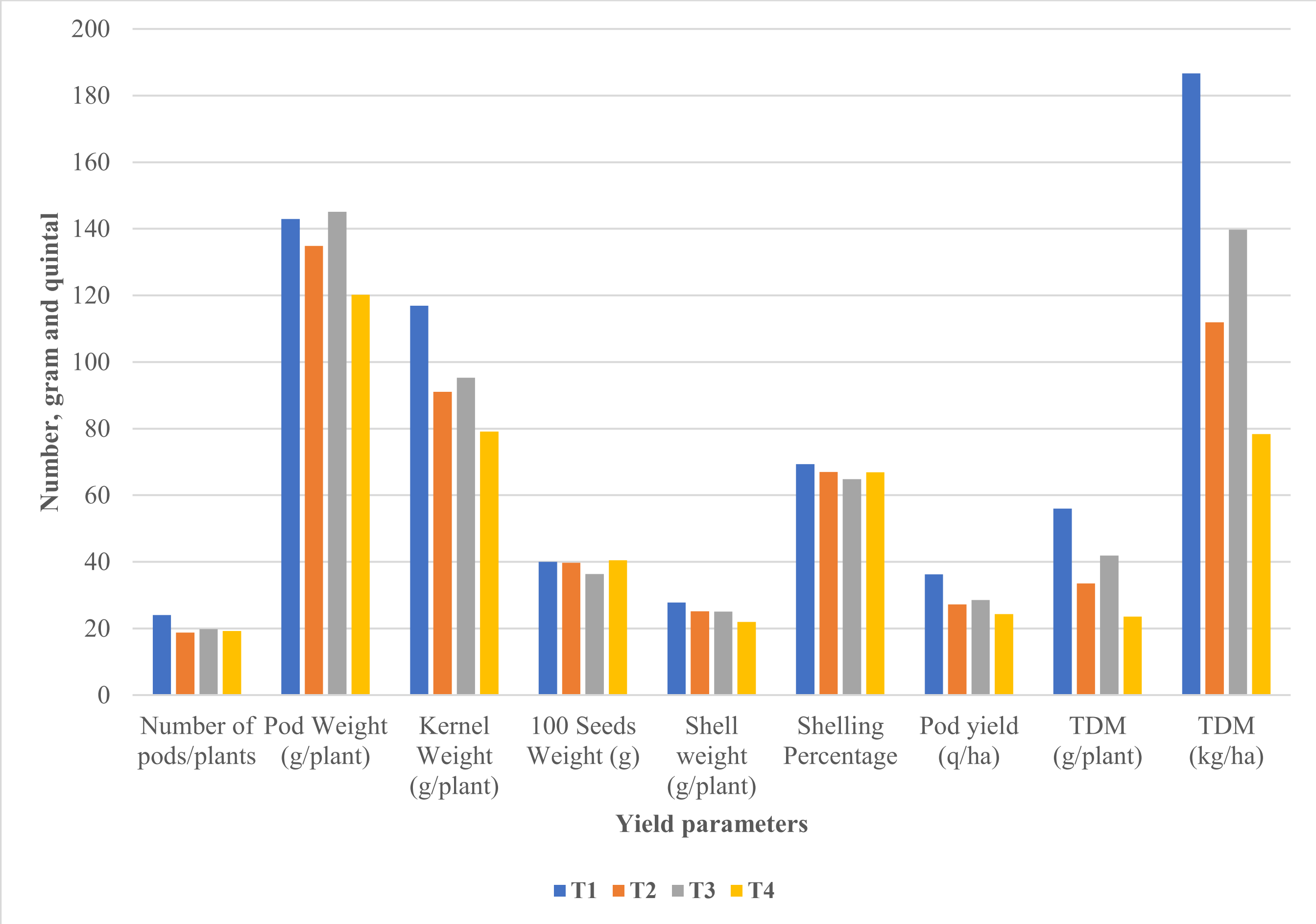

Fig. 2. Groundnut crop yield parameters as influenced by LRI based interventions

Table 1. T test of Groundnut yield parameters for all four treatments

	Average									
Treatment	**Number of pods/plants**	**Pod Weight (g/plant)**	**Kernel Weight (g/plant)**	**100 Seeds Weight (g)**	**Shell weight (g/plant)**	**Shelling Percentage**	**Pod yield (q/ha)**	**TDM (g/plant)**	**TDM (kg/ha)**	**LAI**
T1	24.00	142.93	116.90	39.98	27.83	69.35	36.25	56.00	186.65	1.63
T2	18.80	134.90	91.06	39.70	25.12	66.95	27.21	33.56	111.88	1.60
T3	19.80	145.14	95.26	36.38	25.10	64.79	28.57	41.91	139.70	1.52
T4	19.20	120.20	79.08	40.52	21.94	66.87	24.32	23.52	78.41	2.23

	T-Test																			
Treatment	**Number of pods/plants**		**Pod Weight (g/plant)**		**Kernel Weight (g/plant)**		**100 Seeds Weight (g)**		**Shell weight (g/plant)**		**Shelling Percentage**		**Pod yield (q/ha)**		**TDM (g/plant)**		**TDM (kg/ha)**		**LAI**	
	V	**R**	**V**	**R**	**V**	**R**	**V**	**R**	**V**	**R**	**V**	**R**	**V**	**R**	**V**	**R**	**V**	**R**	**V**	**R**
T1 vs T2	7.16	S	3.36	S	4.31	S	4.47	S	2.59	S	4.83	S	4.59	S	2.48	S	2.48	S	3.42	S
T1 vs T3	5.06	S	2.16	NS	3.13	S	4.03	S	1.78	NS	5.35	S	3.84	S	2.43	S	2.43	S	4.67	S
T1 vs T4	3.82	S	1.73	NS	1.99	NS	4.40	S	2.10	NS	3.96	S	5.47	S	3.76	S	3.76	S	2.01	NS
T2 vs T3	10.28	S	10.65	S	8.82	S	32.57	S	13.74	S	22.90	S	24.94	S	4.32	S	4.32	S	7.99	S
T2 vs T4	10.28	S	10.65	S	8.82	S	32.57	S	13.74	S	22.90	S	24.94	S	4.32	S	4.32	S	7.99	S
T3 vs T4	6.34	S	6.26	S	5.04	S	20.99	S	6.62	S	16.31	S	27.79	S	4.52	S	4.54	S	7.56	S

V: T table value R: Result S: Significant NS: Non-significant

Table 2. T test of Chilli yield parameters for all four treatments

Treatment	Average					
	Number of Fruits/plant	**Yield (g/plant)**	**Yield (kg/ha)**	**TDM (g/plant)**	**TDM (kg/ha)**	**LAI**
T1	32.00	25.86	12.50	71.62	159.16	4.06
T2	20.20	18.68	10.92	61.82	137.36	1.57
T3	19.60	22.22	11.04	50.31	111.80	1.42
T4	12.80	11.56	8.74	46.35	103.00	1.37

	T test											
Treatments	**Number of Fruits/plant**		**Yield (g/plant)**		**Yield (kg/ha)**		**TDM (g/plant)**		**TDM (kg/ha)**		**LAI**	
	V	**R**	**V**	**R**	**V**	**R**	**V**	**R**	**V**	**R**	**V**	**R**
T1 vs T2	3.13	S	2.64	S	2.45	S	1.85	NS	1.85	NS	0.99	NS
T1 vs T3	2.52	S	1.52	NS	1.84	NS	2.54	S	2.54	S	2.31	NS
T1 vs T4	4.36	S	3.76	S	2.58	S	2.81	S	2.81	S	1.48	NS
T2 vs T3	14.50	S	13.73	S	16.01	S	15.13	S	15.13	S	10.23	S
T2 vs T4	14.50	S	13.73	S	16.01	S	15.13	S	15.13	S	10.23	S
T3 vs T4	7.48	S	7.56	S	19.49	S	16.61	S	16.61	S	7.85	S

V: T table value R: Result S: Significant NS: Non-significant

Table 3. T test of Cotton yield parameters for all four treatments

Treatment	Average							
	Number of Monopodials	Number of Sympodials	No of good opened bolls	Seed cotton yield (g/plant)	Seed cotton yield (q/ha)	TDM (g/plant)	TDM (kg/ha)	LAI
T1	2.37	18.27	31.00	169.18	21.63	146.08	2028.50	2.55
T2	3.26	18.54	25.00	163.92	19.65	147.20	2016.60	3.108
T3	2.48	18.86	23.80	133.98	18.17	138.16	2014.00	3.08
T4	2.42	13.65	11.80	133.40	16.55	135.11	1880.20	3.51

T test																
Treatments	Number of Monopodials		Number of Sympodials		No of good opened bolls		Seed cotton yield (g/plant)		Seed cotton yield (q/ha)		TDM (g/plant)		TDM (kg/ha)		LAI	
	V	R	V	R	V	R	V	R	V	R	V	R	V	R	V	R
T1 vs T2	1.88	NS	4.22	S	6.02	S	3.47	S	1.96	NS	4.15	S	4.15	S	3.71	S
T1 vs T3	1.88	NS	4.42	S	3.14	S	5.26	S	2.95	S	3.95	S	3.95	S	3.16	S
T1 vs T4	2.84	S	7.34	S	6.99	S	5.26	S	4.61	S	4.46	S	4.46	S	2.83	S
T2 vs T3	6.92	S	10.49	S	5.89	S	12.94	S	16.51	S	52.79	S	52.79	S	10.12	S
T2 vs T4	6.92	S	10.49	S	5.89	S	12.94	S	16.51	S	52.79	S	52.79	S	10.12	S
T3 vs T4	15.22	S	7.14	S	18.5	S	8.01	S	39.59	S	48.24	S	48.24	S	8.43	S

V: T table value R: Result S: Significant NS: Non-significant

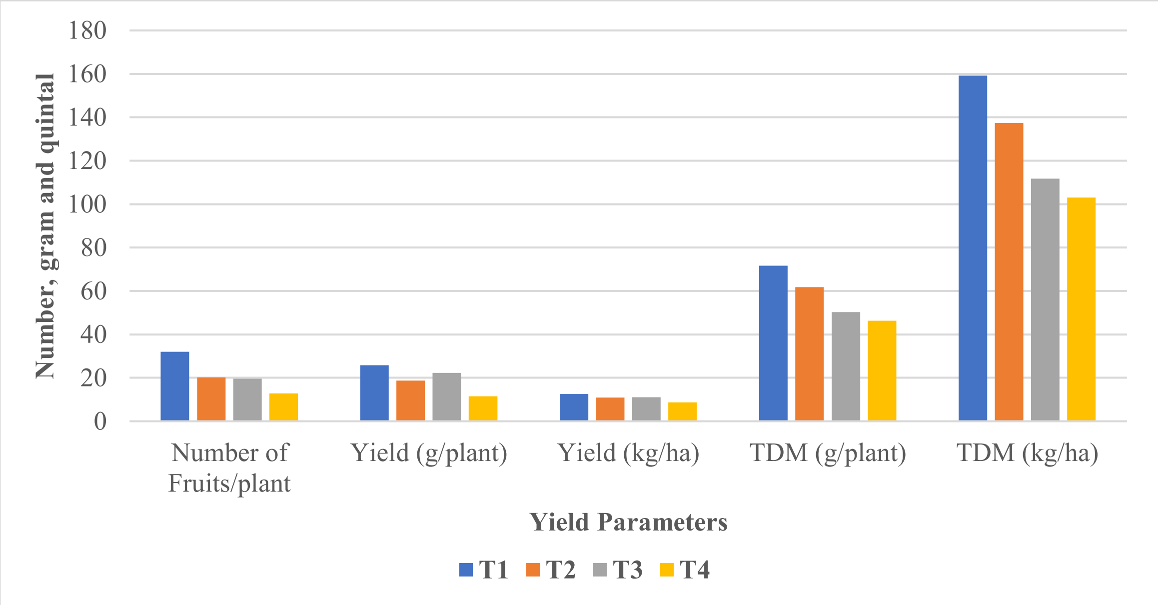

Fig. 3. Chilli crop yield parameters as influenced by LRI based interventions

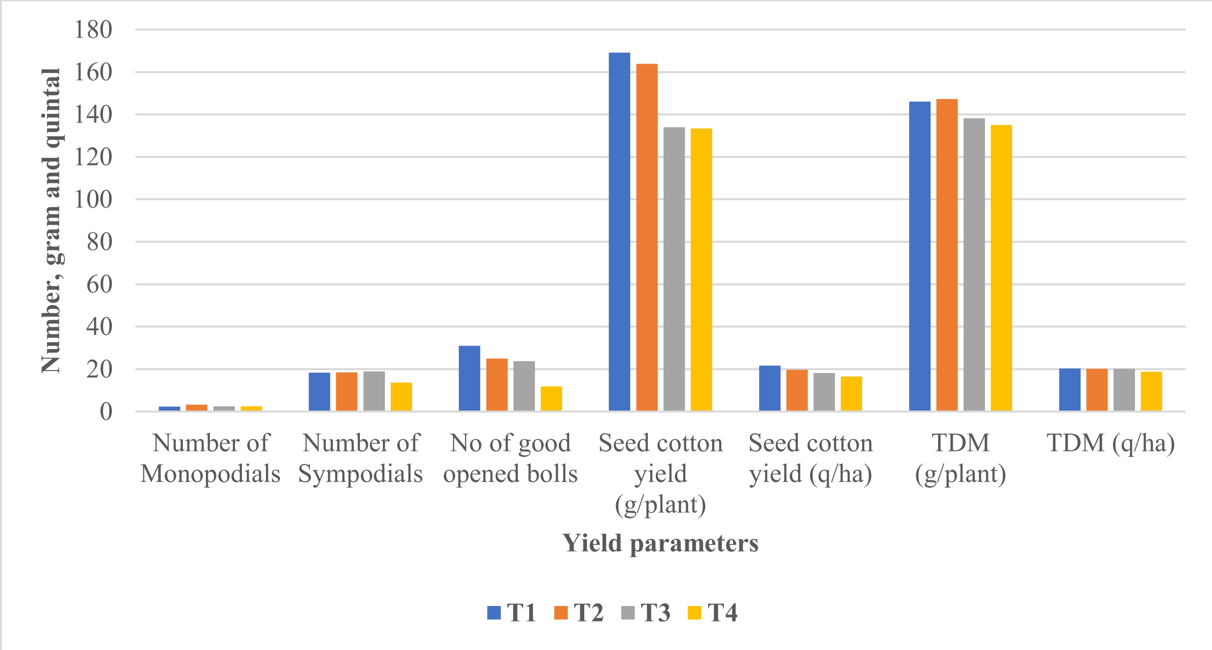

Fig. 4. Cotton crop yield parameters as influenced by LRI based interventions

kernel weight and shelling percentage in T1 indicate efficient assimilate partitioning, consistent with Kumar and Singh (2019). Lower yields in T4 likely resulted from erratic rainfall, poor soil moisture and nutrient imbalance, aligning with Sharma and Dharmaraj (2017), who highlighted the benefits of site-specific soil and weather-based management. Overall, significant T-test results confirm the pivotal role of LRI interventions in enhancing groundnut productivity and resource-use efficiency under variable climatic conditions.

3.2 Chilli

Chilli yield parameters varied significantly across the four treatments (T1–T4) (Table 2) (Fig. 3). Treatment T1 (LRI farmers with cards, training and inputs) recorded the highest number of fruits per plant (32.00), fruit yield per plant (25.86 g), total yield (12.50 kg/ha) and total dry matter (TDM, 159.16 kg/ha), followed by T3 and T2, whereas T4 (non-LRI farmers) showed the lowest performance (8.74 kg/ha). The T-test revealed that most parameters between T1 and other treatments were significant, particularly for fruit number, yield per plant and total yield, indicating that LRI interventions strongly influenced chilli productivity. Differences among non-LRI treatments (T2, T3 and T4) were also significant, reflecting variability in management efficiency. Leaf area index (LAI) was highest in T1 (4.06), supporting a greater photosynthetic capacity and higher assimilate accumulation compared to other treatments. The superior performance of T1 can be attributed to timely sowing, optimized nutrient management and effective soil moisture conservation under LRI guidance. Adequate rainfall and favourable temperature during flowering and fruit set likely enhanced fruit formation and dry matter accumulation. Similar findings were reported by Singh et al. (2019) who observed higher fruit number and yield in chilli under integrated nutrient and moisture management practices. Increased TDM and yield per plant in T1 suggest efficient assimilate partitioning toward reproductive structures, consistent with other researchers. Conversely, lower yields in T4 were likely due to poor moisture retention, nutrient imbalance and sub-optimal agronomic practices. Overall, the significant T-test results across treatments confirm that LRI -based integrated management substantially improves chilli productivity, resource-use efficiency and canopy utilization under semi-arid conditions.

3.3 Cotton

Cotton growth and yield parameters varied significantly across the four treatments (T1–T4) (Table 3) (Fig. 4). Treatment T1 (LRI farmers with cards, training and inputs) recorded the highest number of good opened bolls (31.00), seed cotton yield per plant (169.18 g), seed cotton yield per hectare (21.63 q/ha) and total dry matter (TDM, 2028.50 kg/ha), followed by T2 and T3, whereas T4 (non-LRI farmers) showed the lowest performance (16.55 q/ha). T-test analysis revealed significant differences among most parameters, particularly number of opened bolls, seed cotton yield and TDM, indicating that LRI interventions substantially enhanced cotton productivity. Although LAI was higher in T4 (3.51), it did not translate into higher yield, suggesting that canopy development alone was insufficient under poor management. The superior performance of T1 can be attributed to improved agronomic practices and favourable microclimatic conditions facilitated by LRI guidance, which ensured timely planting, optimal nutrient application and efficient moisture management. Adequate rainfall and soil moisture during boll formation likely promoted better reproductive development and assimilate partitioning. Similar results were reported by researchers, who observed higher boll number and seed cotton yield under integrated soil, water and nutrient management. Higher TDM and seed cotton yield in T1 reflect efficient resource allocation toward reproductive structures, consistent with Singh and Kumar (2020). Conversely, lower yields in T4 were attributed to erratic rainfall, sub-optimal nutrient use and poor moisture retention. Overall, the significant T-test results across treatments confirm that LRI-based integrated management improves cotton productivity, dry matter accumulation and resource-use efficiency under semi-arid conditions.

4. CONCLUSION

The study clearly demonstrates that Land Resource Inventory (LRI)-based interventions significantly enhance crop growth, yield and resource-use efficiency in cotton, chilli and groundnut under semi-arid conditions. Among the four treatments, farmers who received LRI cards along with training and inputs (T1) consistently recorded superior performance across all measured parameters. Groundnut showed the highest pod number, pod yield, kernel weight and shelling percentage; chilli exhibited the greatest fruit number, fruit yield and total dry matter; and cotton recorded the maximum number of opened bolls, seed cotton yield and total dry matter. Treatments without complete LRI interventions or non-LRI management exhibited lower productivity, despite sometimes higher leaf area indices, indicating that effective canopy development alone is insufficient for achieving high yields. The improved performance under T1 is attributed to timely sowing, balanced nutrient management, efficient moisture conservation and favourable microclimatic conditions. Overall, the study highlights that LRI-based integrated management provides a systematic framework for site-specific crop planning, optimizing input use and enhancing yield stability. Adoption of LRI interventions can therefore serve as a practical strategy for improving agricultural productivity, resource-use efficiency and sustainability in rainfed farming systems, supporting farmers in achieving higher and more reliable crop yields under variable climatic conditions.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Open AI ChatGPT (GPT-5) have been used during the editing of manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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