PLANT SCIENCE TODAY
Vol 13(sp1): 1-11
https://doi.org/10.14719/pst.12017

eISSN 2348-1900

RESEARCH ARTICLE

Performance and stability of ridge gourd (*Luffa acutangula* (L.) Roxb. var. Arka Prasan) under integrated nutrient management in Telangana

Shailaja Gogu[1*], Pagadala Sai Priyanka[1], Mandava Hemalatha[1], Dulam Shivaraj[2], Kadarla Chaitanya[3], Chittem Vara Prasad[1], Shaik N Meera[4] & Rajneesh Kumar[5*]

[1]Krishi Vigyan Kendra, Medak-1 (Deccan Development Society), Zaheerabad, Sangareddy 502 228, Telangana, India
[2]College of Horticulture, Sri Konda Laxman Telangana Horticultural University, Hyderabad 500 030, Telangana, India
[3]Department of Horticulture, College of Agriculture, Professor Jayashankar Telangana Agricultural University, Hyderabad 500 030, Telangana, India
[4]ICAR-Agricultural Technology Application Research Institute, Zone-X, Hyderabad 500 059, Telangana, India
[5]Division of Genetics and Plant Breeding, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Wadura 193 201, Jammu and Kasmir, India

*Correspondence email - shailaja.gogu94@gmail.com; r4rajneesh1997@gmail.com

Received: 27 September 2025; Accepted: 02 February 2026; Available online: Version 1.0: 24 March 2026

Cite this article: Shailaja G, Pagadala SP, Mandava H, Dulam S, Kadarla C, Chittem VP, Shaik NM, Rajneesh K. Performance and stability of ridge gourd (*Luffa acutangula* (L.) Roxb. var. Arka Prasan) under integrated nutrient management in Telangana. Plant Science Today. 2026; 13(sp1): 1-11. https://doi.org/10.14719/pst.12017

Abstract

The increasing demand for organically grown vegetables necessitates adopting sustainable nutrient management practices. Thisfour-year study (2021–24) evaluated 7 Integrated Nutrient Management (INM) strategies on ridge gourd (*Luffa acutangular* (L) Roxb. cv. Arka Prasan). Key parameters assessed included Days to First Harvest (DFH), Fruit Yield per Hectare (FY/HA), Average Fruit Weight (AFW) and Benefit-Cost Ratio (BCR). Statistical analyses using Analysis of Variance (ANOVA), the Eberhart & Russell stability model and Principal Component Analysis (PCA) revealed significant treatment differences. Application of enriched compost at 2.5 t/ha (T_6) consistently outperformed other treatments, recording the highest mean yield (21.83 metric tonne/ha) and BCR (1.958). This treatment also showed perfect stability, with a deviation from regression (S^2di) of 0.000 for both yield and profitability, confirming reliability across environments. While T_6 was superior for yield and profitability, treatment T_2 (biofertilizer consortium + compost at 2.5 t/ha) was identified as the earliest to harvest. The findings suggest that enriched compost at 2.5 t/ha is the most effective, stable and economically viable option for ridge gourd cultivation and is strongly recommended for farmer adoption.

Keywords: biofertilizer; enriched compost; PCA; stability analysis; vermicompost; yield attributes

Introduction

Ridge gourd (*Luffa acutangula* (L.) Roxb.), a prominent member of the Cucurbitaceae family, is an economically significant vegetable crop cultivated extensively across Asia (1). In India, ridge gourd is cultivated over a modest yet significant area, with national estimates indicating approximately 9920 ha under cultivation, an annual production of about 3.17 lakh tonnes and an average productivity of ~31.95 t ha^{-1} (2). Hybrid evaluation trials further highlight the breeding potential and economic significance of ridge gourd under Indian agro-climatic conditions (3). In Telangana, smallholder farmers prefer rapid-cycle, low-input vegetables such as ridge gourd; however, yield instability caused by suboptimal nutrient management and environmental variability underscores the need for robust INM strategies.

The crop is valued for its tender fruits, which are rich in dietary fiber, vitamins and essential minerals, contributing significantly to human nutrition (4). The fruits are commonly consumed as a vegetable, which develops a mild sweetness upon cooking. They are light, easily digestible, low in calories and thus suitable for individuals with diabetes. In traditional medicine, ridge gourds have been recognized for its diuretic, laxative, expectorant and hypoglycemic properties. The peel, often considered as a waste, is a nutritionally valuable by-product rich in dietary fiber and is commonly used in the preparation of chutneys with reported health benefits (5). Both the fruit flesh and peel are utilized in diverse culinary preparations. Beyond its nutritional value, ridge gourd contains diverse phytochemicals, including saponins, flavonoids, sapogenin, luffangulin, oleanolic acid and cucurbitacin B, which contribute to its therapeutic potential. It is a source of essential vitamins including riboflavin (B_2), niacin (B_3), vitamin C, carotene and small amounts of minerals including calcium, phosphorus and iron, thereby supporting overall health (6). Pharmacological investigations have also demonstrated its hepatoprotective, antidiabetic, antioxidant, antifungal and abortifacient properties. Moreover, regular consumption of ridge gourd is reported to enhance immunity, lower body temperature, purify blood and act as a natural detoxifying agent. Owing to its low-calorie content and high fiber, it is also considered an ideal dietary component for weight management (7). In recent years, increasing consumer awareness of food safety and environmental health has driven a substantial rise in the demand for organically produced vegetables (8). This market trend presents a significant opportunity to develop and promote sustainable agricultural practices that move away from a reliance on synthetic inputs.

For decades, conventional agriculture has depended on chemical fertilizers to boost crop yields, but their overuse has led to soil degradation, nutrient imbalances and environmental pollution (9, 10). In response, INM has emerged as a scientifically sound and sustainable alternative (11). INM aims to maintain long-term soil health and productivity by optimizing the use of organic manures, biofertilizers and other biological inputs (12). Organic amendments like compost, farm yard manure and vermicompost are central to INM, as they improve soil structure, water retention and microbial activity (13). Vermicompost, in particular, is noted for its high concentration of plant-available nutrients (14). Furthermore, enriching compost with microbial inoculants can enhance its nutrient profile and efficacy (15). Biofertilizers, containing beneficial microorganisms that fix nitrogen and solubilize phosphorus, are another key component of INM, helping to make essential nutrients available to plants (16).

Yield stability is a critical consideration in vegetable production, where environmental fluctuations such as rainfall, temperature and soil variability can strongly influence crop performance. Unlike cereals, vegetables are more sensitive to abiotic and biotic stresses, making stability analysis essential for identifying management strategies that perform consistently across environments. Numerous studies have focused on hybrid evaluation and genotype × trait relationships in ridge gourd, including analyses of combining ability and correlations (17). However, the effectiveness of any agricultural treatment can vary significantly across different years or locations due to the treatment x environment (GxE) interaction (18).

A recent investigation of soil and nutrient uptake dynamics found that integrated nutrient inputs significantly affect seasonal nutrient availability, yet long-term stability analyses across years were not conducted (19). Given the growing emphasis on stress tolerance under field conditions, including ToLCNDV screening in ridge gourd, the identification of nutrient management regimes that perform stably across diverse environmental stresses has become imperative (20). This makes it essential to evaluate the stability of a practice over multiple seasons to ensure its reliability (21). Statistical tools such as the Eberhart–Russell model allow researchers to quantify genotype × environment interactions (22). Multivariate techniques, including PCA (23), help in understanding complex relationships among multiple traits. Together, these approaches facilitate the identification of superior treatments and the recommendation of reliable practices for farmers. Such studies not only ensure productivity but also reduce risks associated with seasonal variability, thereby improving the profitability and resilience of vegetable-based farming systems.

Materials and Methods

Experimental site

The present investigation was conducted as a multi-environment field experiment over 4 consecutive growing seasons (2021–2024) in four mandals encompassing the villages of Gangwar, Kasimpur, Kohir, Ranzole and Gopanpally, located in Sangareddy district, Telangana, India (17.61° N latitude, 77.92° E longitude). The region represents semi-arid agro-climatic conditions. For stability analysis, each growing season was considered as an independent environment.

Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications at each location to minimize spatial variability and ensure statistical precision (24). All experimental plots received uniform agronomic management practices throughout the study period.

Soil sampling and site characterization

Prior to the initiation of the experiment, composite soil samples were collected from each experimental field at a depth of 0–15 cm to determine baseline soil fertility status. The soils across locations were sandy loam to loamy in texture and slightly alkaline in reaction. Initial soil analysis revealed soil pH values ranging from 7.4 –7.8, organic carbon content between 0.48 and 0.56 %, available nitrogen from 210–245 kg ha^{-1}, available phosphorus from 18.5–24.2 kg ha^{-1} and available potassium ranging from 285-325 kg ha^{-1}.

Soil pH was determined using a glass electrode pH meter in a 1:2.5 soil-water suspension. Organic carbon content was estimated by the Walkley and Black wet oxidation method, available nitrogen by the alkaline permanganate method, available phosphorus by Olsen's method and available potassium by flame photometry following standard analytical procedures. Based on these parameters, the experimental soils were categorized as low to medium in fertility status, providing an appropriate framework for evaluating the response of ridge gourd to INM treatments under semi-arid conditions.

Plant material

The test crop was ridge gourd (*L. acutangula* var. Arka Prasan), a high-yielding cultivar developed by the Indian Institute of Horticultural Research, Bengaluru.

Treatments

Seven INM strategies were evaluated during the study:

T_1 (Control): Farm Yard Manure (FYM) at 10 t ha^{-1}

T_2: Biofertilizer consortium + compost at 2.5 t ha^{-1}

T_3: Biofertilizer consortium + compost at 5 t ha^{-1}

T_4: Biofertilizer consortium + vermicompost at 2.5 t ha^{-1}

T_5: Biofertilizer consortium + vermicompost at 5 t ha^{-1}

T_6: Enriched compost at 2.5 t ha^{-1}

T_7: Enriched compost at 5 t ha^{-1}

Biofertilizer consortium

The biofertilizer consortium consisted of a standardized mixture of beneficial microorganisms, including *Azospirillum brasilense* (nitrogen-fixing bacterium), *Azotobacter chroococcum* (free-living nitrogen fixer), *Bacillus megaterium* (phosphate-solubilizing bacterium) and *Pseudomonas fluorescens* (plant growth-promoting rhizobacterium). The inoculants were applied in recommended proportions to ensure functional complementarity for biological nitrogen fixation, phosphorus solubilization and enhanced rhizosphere activity. The consortium was applied as a soil application during land preparation, thoroughly mixed with compost or vermicompost according to the respective treatment combinations.

Preparation and composition of enriched compost

The enriched compost used in the experiment was prepared using goat manure, vermicompost and dry dung cake as base organic substrates. To enhance nutrient availability and microbial activity, the composting materials were inoculated with beneficial microbial cultures and allowed to decompose aerobically for 45–60 days with periodic turning to ensure uniform decomposition. The final enriched compost attained a stabilized nutrient composition with an N:P:K ratio of 2.4:1.2:1.6, facilitating gradual and synchronized nutrient release in accordance with crop demand. This enrichment process improved nutrient availability, microbial activity and overall soil biological health compared to conventional compost or vermicompost.

Observations recorded

The observations were recorded for the following traits: DFH, AFW, FY/P, FY/HA and BCR.

Statistical analysis

The recorded data were subjected to statistical analysis using Windostat Version 9.50 software (Indostat Services, Hyderabad, India). A combined ANOVA was performed across environments to partition the total variation and test the significance of environments, treatments and their interaction (25). Stability analysis was carried out using the Eberhart and Russell model (22), which evaluates treatment stability based on mean performance, regression coefficient (bi) and deviation from regression (S^2di). In addition, PCA was conducted on standardized data using Pearson's correlation matrix to examine multivariate relationships among traits and to identify superior INM strategies (23).

Results

ANOVA and mean performance

The combined ANOVA revealed highly significant differences ($P <$ 0.01) among the seven treatments for all traits studied, indicating that the choice of nutrient management had a substantial impact on crop performance (Table 1). The significant treatment × environment interaction observed for most traits underscores the need for stability analysis. Across the 4 years, Treatment T_6 (enriched compost at 2.5 t/ha) was the clear top performer (Table 2). It produced the highest mean for fruit yield per ha (21.833 metric tonnes/ha), average fruit weight (150.750 g) and BCR (1.958). In contrast, treatment T_2 (biofertilizer consortium + compost at 2.5 t/ha) was the earliest to mature (39.167 days taken for first harvest). The control treatment (T_1), consistently yielded the lowest results for all productivity and profitability metrics.

Stability analysis

The Eberhart & Russell stability analysis provided crucial insights into the reliability of each treatment (Table 3). Plots show the density distribution for days taken to first harvest shown in Fig. 1a and boxplot in Fig. 1b. Density distribution for fruit yield per plant shown in Fig. 1c and boxplot in Fig. 1d separated by season. The red curve represents the theoretical normal distribution for the data in that specific season. For fruit yield per ha, T_6 and T_5 showed perfect stability, with a deviation from regression of 0.000, meaning their performance was highly predictable. In contrast, T_3 and T_4 were significantly unstable. For the BCR, T_6, T_7 and T_4 were the most stable treatments. The regression coefficient for T_6 was less than 1 (0.561), indicating its wide adaptability and consistent performance even in less favorable years. Fig. 2 presents a plot of mean fruit yield on the x-axis against the deviation from regression (S^2di) on the y-axis. Treatments with high stability ($S^2di \approx 0$) are located near the horizontal axis. High-yielding, stable treatments like T_6 are found on the far right of the horizontal axis. Plots show the density distribution for fruit yield per ha shown in Fig. 3a and boxplot in Fig. 3b. Density distribution for average fruit weight shown in Fig. 3c and boxplot in Fig. 3d separated by season. The red curve represents the theoretical normal distribution for the data in that specific season.

Trait interrelation and PCA

The trait correlation matrix revealed a strong positive association among fruit yield per plant, fruit yield per ha, average fruit weight and BCR (r = 0.80 to 0.96) (Table 4). Days to first harvest, however, was not significantly correlated with any of the yield traits, suggesting that earliness and yield are independent characteristics in this study.

Table 1. Summary of combined ANOVA for all traits

Trait	Env	Genotype	Env x Genotype	Error
Days taken for first harvest	1.821**	107.103**	1.108**	0.358
Fruit yield per plant	0.806	398.151**	2.389	1.698
Fruit yield per ha	5.937**	23.484**	0.955**	0.344
Average fruit weight	4.778	738.5**	35.093**	11.472
B:C Ratio	0.006	0.104**	0.016**	0.004

** denotes high significance at $P < 0.01$; * denotes significance at $P < 0.05$

Table 2. Mean performance of treatments across four years

Trait	Days taken for first harvest	Fruit yield per plant	Fruit yield per ha	Average fruit weight	B:C Ratio
T_1	45.75	133.42	17.67	126.75	1.68
T_2	39.17	147.33	20.25	141.08	1.75
T_3	41.00	139.67	19.17	139.00	1.81
T_4	41.25	139.33	18.75	137.17	1.71
T_5	41.83	139.75	18.75	138.33	1.73
T_6	47.33	150.75	21.83	150.75	1.96
T_7	40.42	143.67	20.58	148.08	1.80
Mean	42.39	141.99	19.57	140.17	1.78
CV (%)	1.41	0.92	3.00	2.42	3.73
SEm ±	0.17	0.38	0.17	0.98	0.02

Table 3. Summary of stability parameters for key traits

Treatments	Days taken for first harvest			Fruit yield per plant		
	Mean	S^2Di	Bi	Mean	S^2Di	bi
T1	45.75	0.170	-0.869	133.417	0.000	0.448
T2	39.167	0.000	-0.458	147.333	0.631	1.241
T3	41	0.006	0.915	139.667	0.000	4.276
T4	41.25	0.222	2.15	139.333	0.340	1.655
T5	41.833	0.000	4.118	139.75	0.340	-5.345
T6	47.333	0.069	1.098	150.75	0.000	2.379
T7	40.417	0.000	0.046	143.667	0.000	2.345
Treatments	**Days taken for first harvest**			**Fruit yield per plant**		
	Mean	**S^2Di**	**Bi**	**Mean**	**S^2Di**	**bi**
T1	17.667	0.038	0.674	126.75	57.256**	5.547
T2	20.25	0.035	1.46	141.083	6.704	0.384
T3	19.167	0.378*	2.059	139	0.413	-0.744
T4	18.75	0.421**	1.591	137.167	0.000	0.93
T5	18.75	0.000	0.281	138.333	11.496*	2.279
T6	21.833	0.000	0.561	150.75	0.000	-0.523
T7	20.583	0.213	0.374	148.083	0.000	-0.872

** denotes high significance at $P < 0.01$; * denotes significance at $P < 0.05$

Table 4. Pearson correlation matrix

Traits	Days taken for first harvest	Fruit yield per plant	Fruit yield per ha	Average fruit weight	B:C Ratio
DFH	1	0.01	0.1	-0.04	0.39 *
FY/P	0.01	1	0.96 **	0.89 **	0.80 **
FY/HA	0.1	0.96 **	1	0.95 **	0.88 **
AFW	-0.04	0.89 **	0.95 **	1	0.84 **
BCR	0.39 *	0.80 **	0.88 **	0.84 **	1

** denotes high significance at $P < 0.01$; * denotes significance at $P < 0.05$

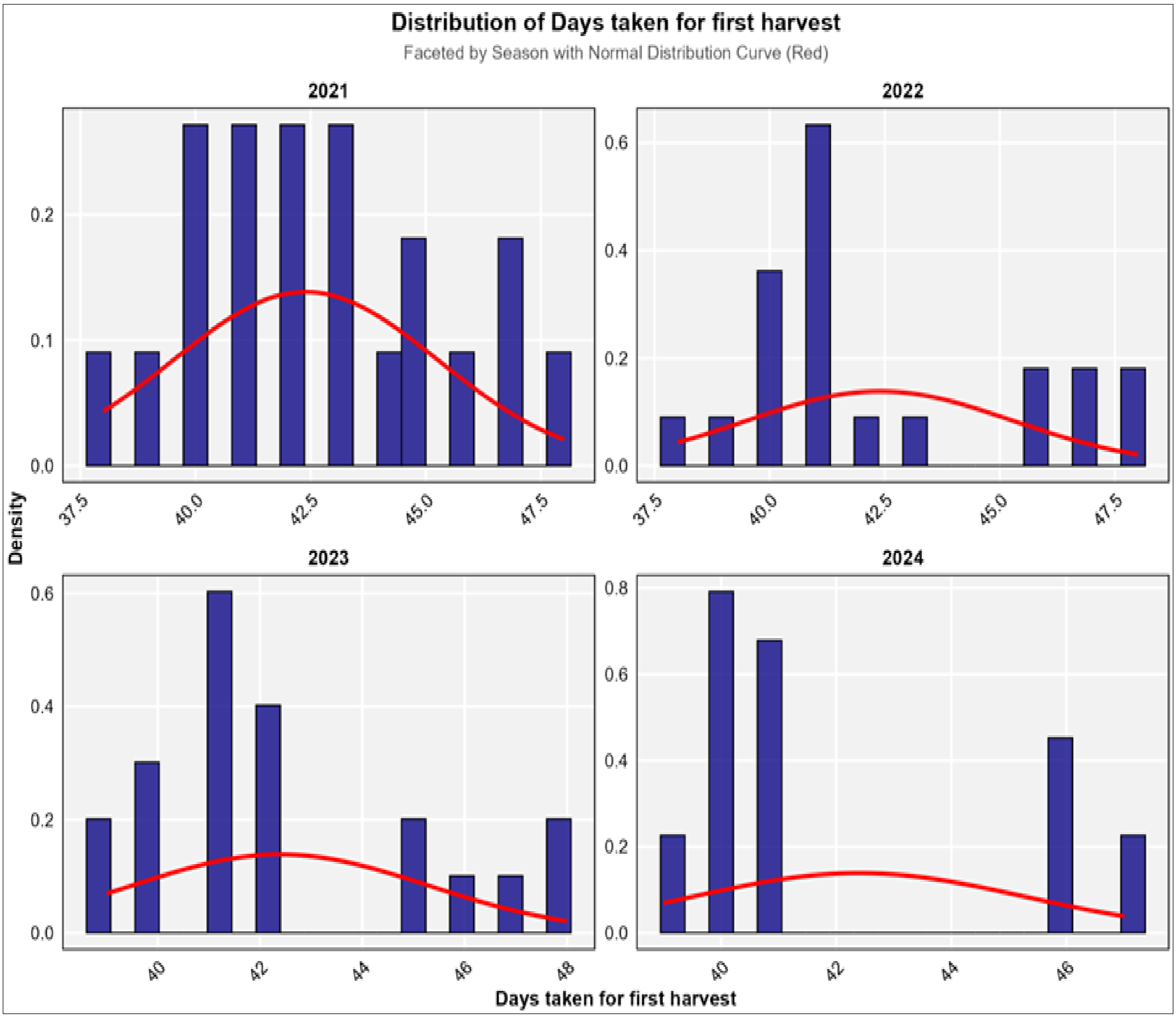

Fig. 1a. Plots show the density distribution for days taken to first harvest, separated by season. The red curve represents the theoretical normal distribution for the data in that specific season.

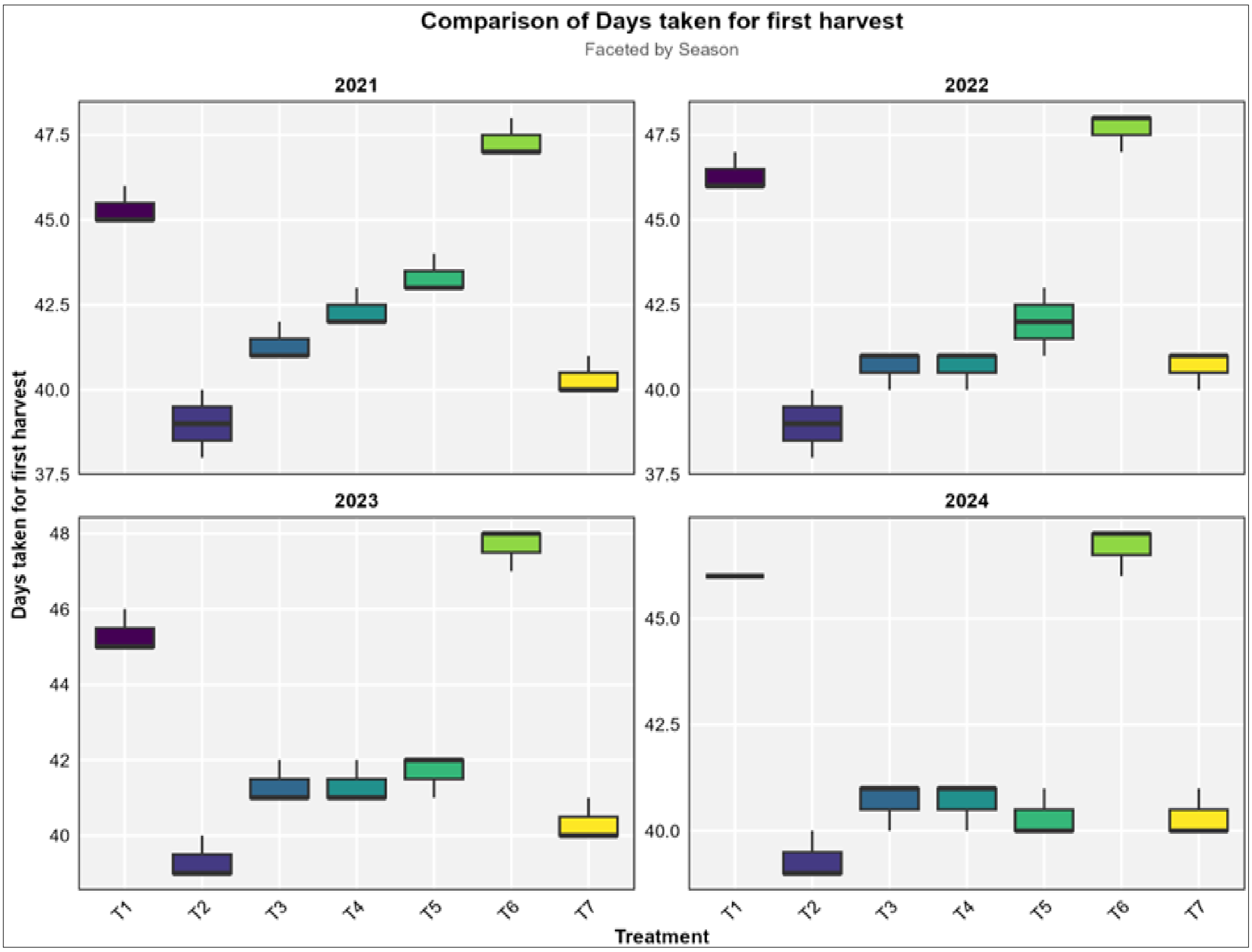

Fig. 1b. Plots compare trait performance across treatments, separated by season. Each boxplot displays the median, interquartile range and overall range of the data.

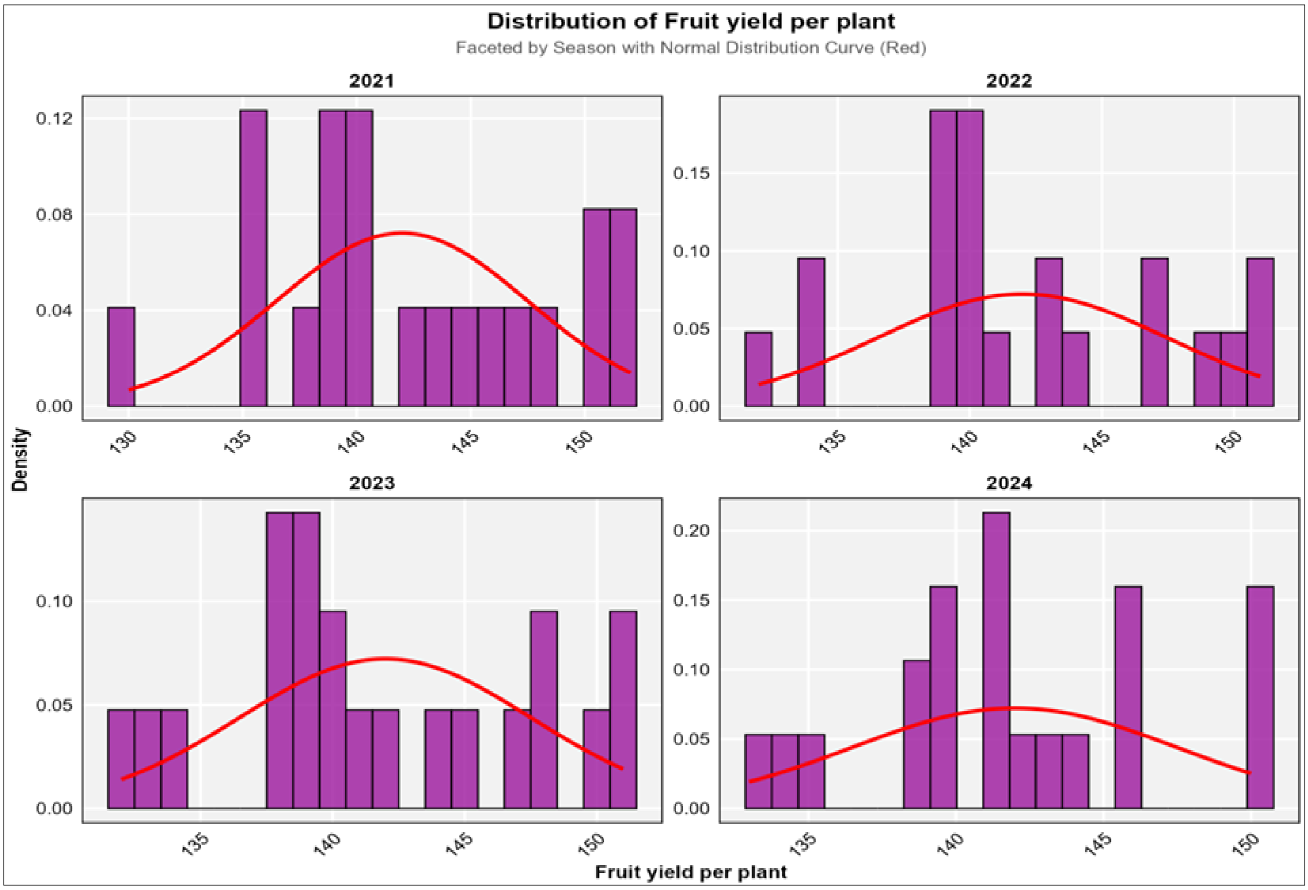

Fig. 1c. Plots show the density distribution for fruit yield per plant, separated by season. The red curve represents the theoretical normal distribution for the data in that specific season.

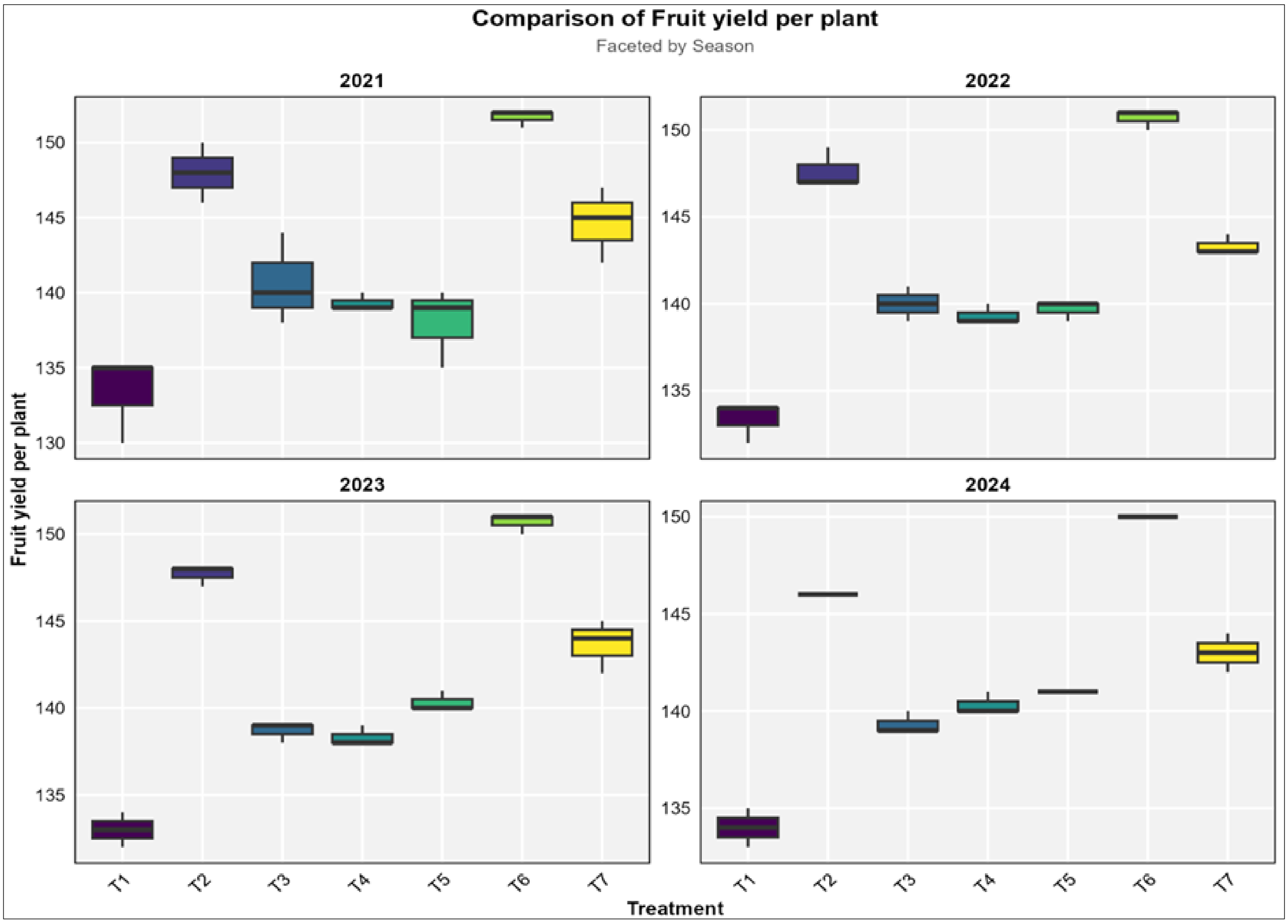

Fig. 1d. Plots compare trait performance across treatments, separated by season. Each boxplot displays the median, interquartile range and overall range of the data.

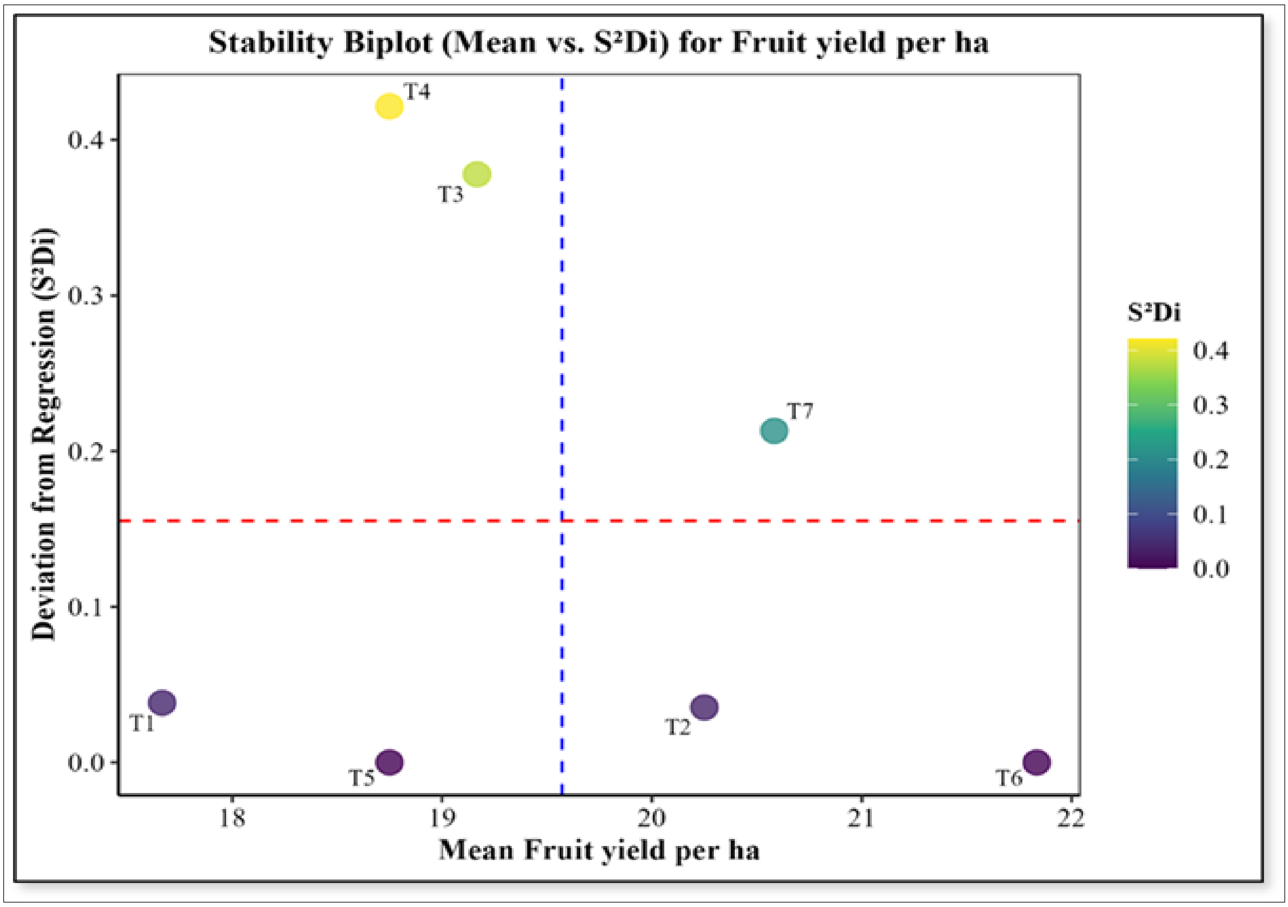

Fig. 2. Stability Biplot for fruit yield per hectare.

The plot shows the mean fruit yield (x-axis) against the deviation from regression (S^2di) (y-axis). Treatments with high stability (S^2di ≈ 0) are located near the horizontal axis. High-yielding, stable treatments like T_6 are found on the far right of the horizontal axis

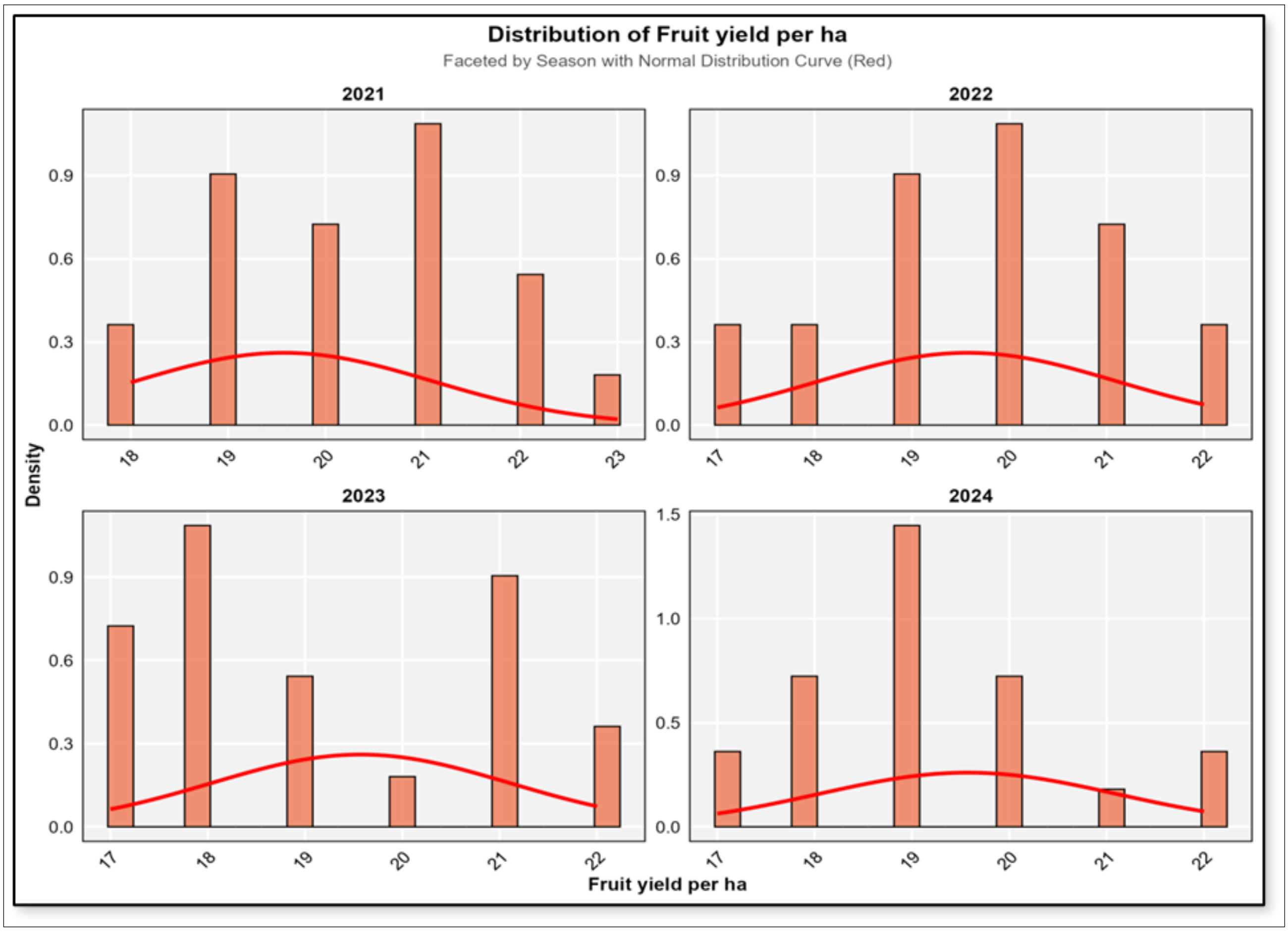

Fig. 3a. Plots show the density distribution for fruit yield per ha, separated by season. The red curve represents the theoretical normal distribution for the data in that specific season.

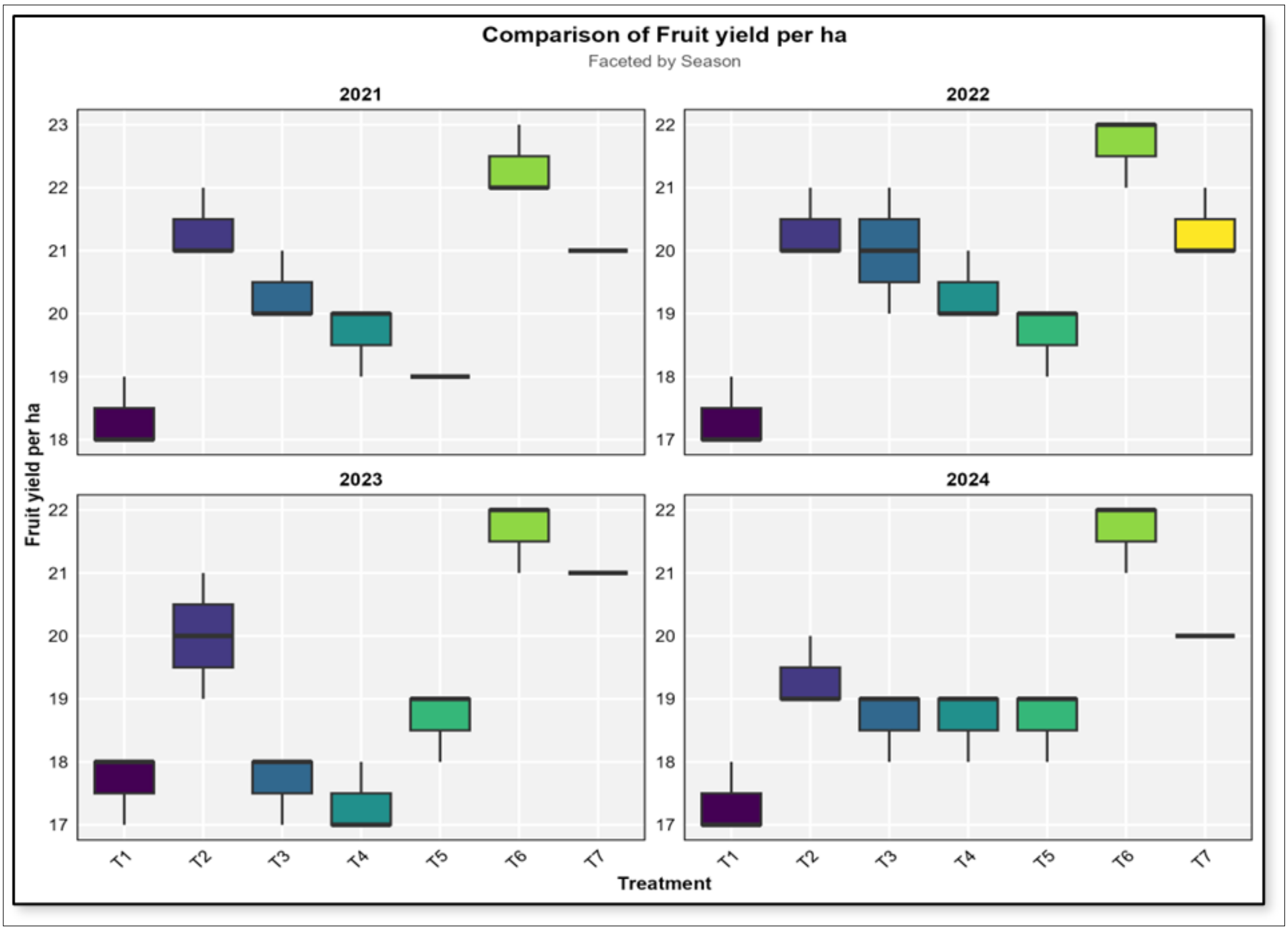

Fig. 3b. Plots compare fruit yield per ha performance across treatments, separated by season. Each boxplot displays the median, interquartile range and overall range of the data.

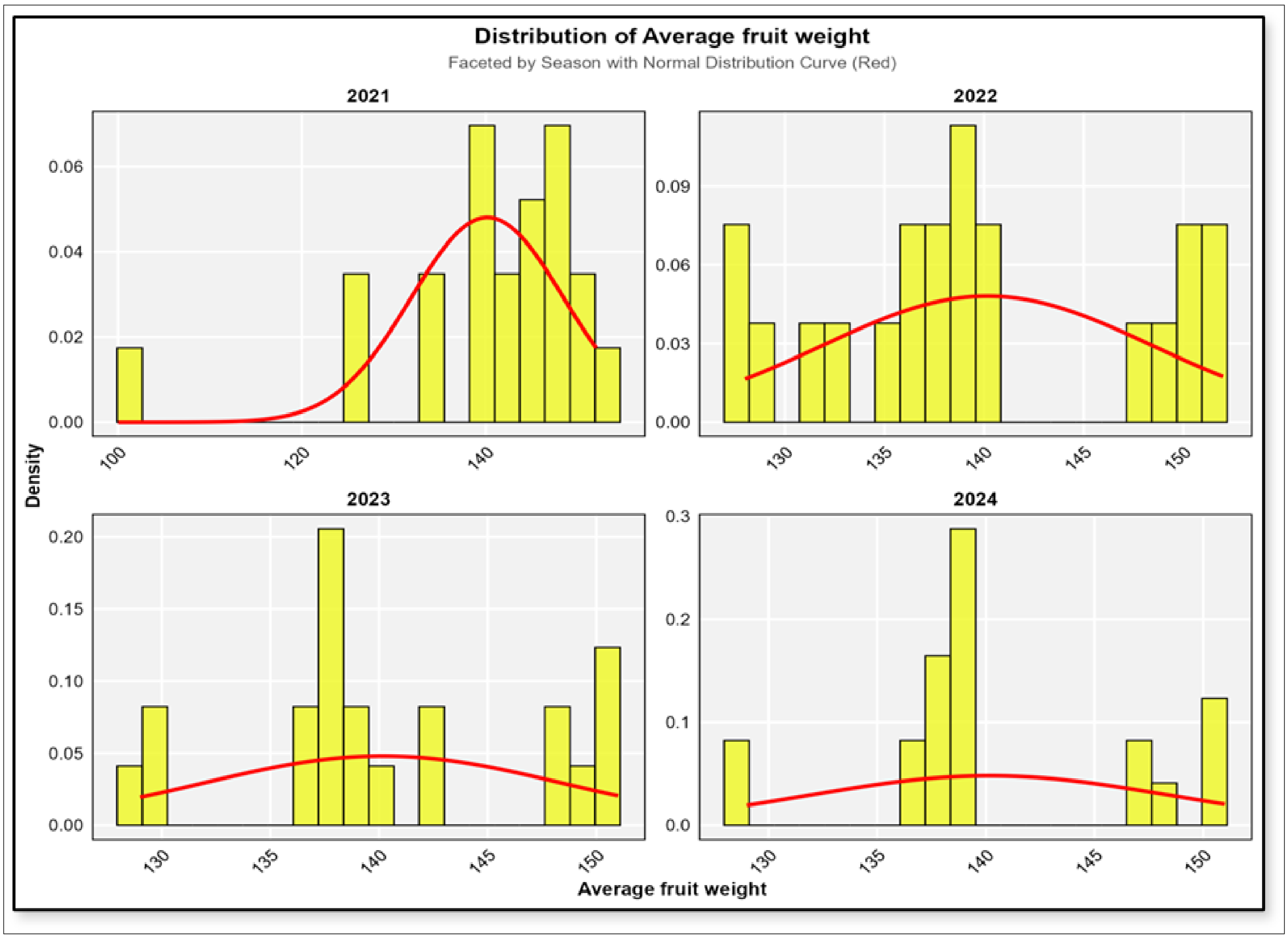

Fig. 3c. Plots show the density distribution average fruit weight, separated by season. The red curve represents the theoretical normal distribution for the data in that specific season.

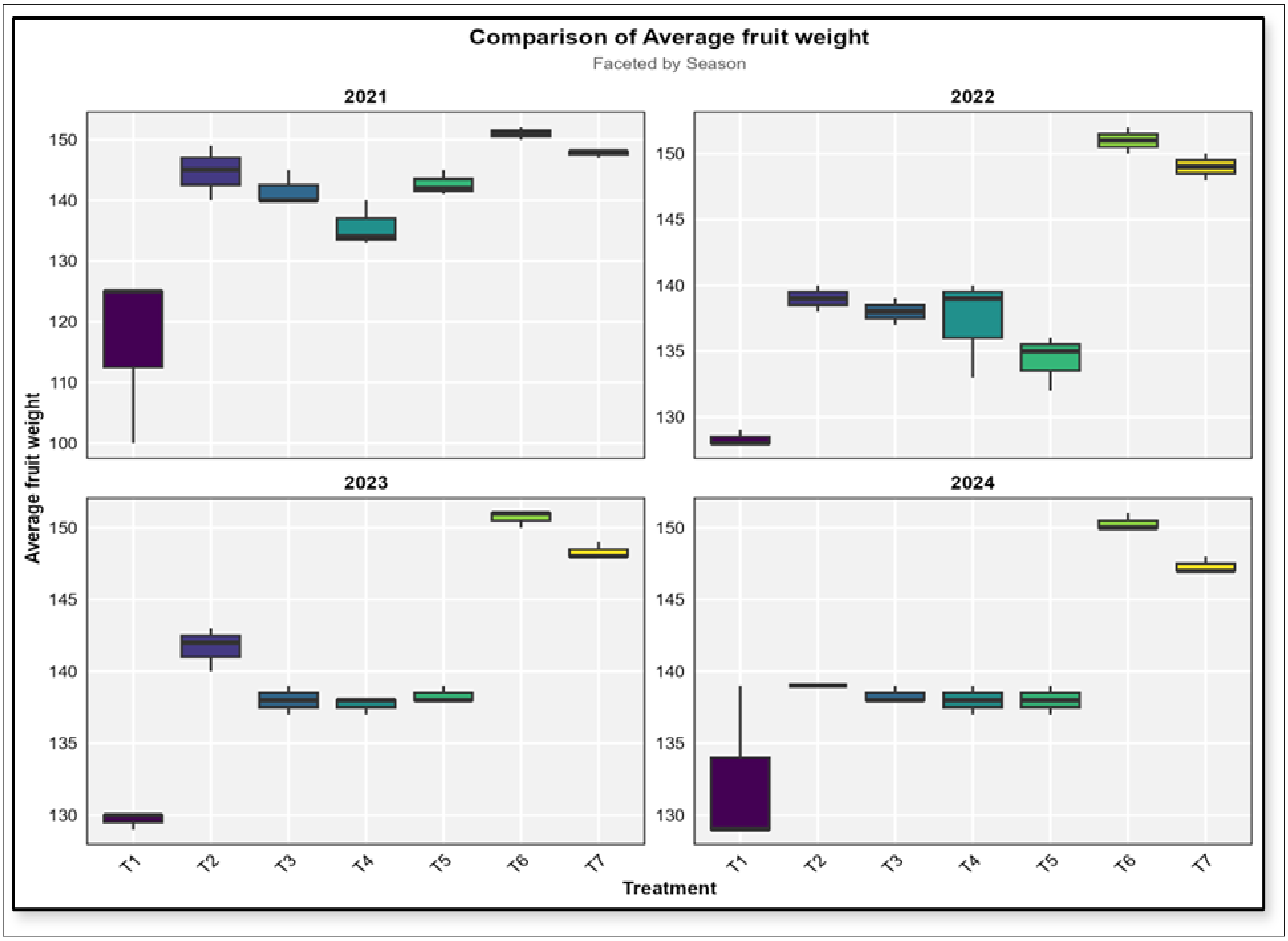

Fig. 3d. Plots compare average fruit weight performance across treatments, separated by season. Each boxplot displays the median, interquartile range and overall range of the data.

The PCA successfully condensed 95.72 % of the total dataset variance into the first two principal components. Principal component 1 explained 73.63 % of the variance and was strongly associated with all four yield and profitability traits, thus representing the "yield & profitability" dimension. Principal component 2 explained 22.09 % of the variance and was almost exclusively driven by DFH, representing the "earliness" dimension. The PCA biplot graphically illustrates these relationships (Fig. 2).

The Fig. 4 biplot displays the first two principal components, accounting for 95.72 % of the total variance. Principal component 1 (73.63 %) represents 'Yield & Profitability,' and principal component 2 (22.09 %) represents earliness. Treatments (points) positioned to the left indicate higher yield, while those in the upper portion indicate an earlier harvest. Trait vectors (arrows) show their correlation with the principal components.

Discussion

The findings of this four-year investigation demonstrate that INM strategies markedly enhance both the productivity and profitability of ridge gourd cultivation. Among the treatments evaluated, T_6 (enriched compost at 2.5 t/ha) consistently outperformed others, highlighting the superior nutrient composition and synchronized nutrient release of enriched compost, which more effectively meets the crop's nutritional requirements than conventional manures (26). These results agree with prior studies emphasizing the advantages of enriched compost for vegetable crops (27). The role of microbial activity was also evident, as treatments incorporating a biofertilizer consortium exhibited strong performance (28). Notably, T_2 (biofertilizer + compost) achieved the earliest harvest, offering practical benefits by enabling farmers to capitalize on early market windows that often yield premium prices (29).

The observed significant treatment × environment interaction underscores the necessity of evaluating agricultural interventions across multiple seasons, as conclusions drawn from a single year may be misleading. Stability analysis was therefore essential to identify treatments that are not only high yielding but also reliable. The perfect stability of T_6 for both yield and profitability (deviation from regression = 0.000) is particularly noteworthy, ensuring predictable returns and minimizing economic risk for farmers (22). Its wide adaptability, indicated by a regression coefficient of less than 1, further supports its recommendation across diverse farming conditions.

Principal component analysis provided an integrated perspective of the complex dataset, effectively partitioning the five measured traits into two independent dimensions: "Yield & Profitability" (principal component 1) and "Earliness" (principal component 2). The orthogonality of these components suggests that simultaneous selection for high yield and early harvest is feasible. The PCA biplot clearly visualized overall performance,

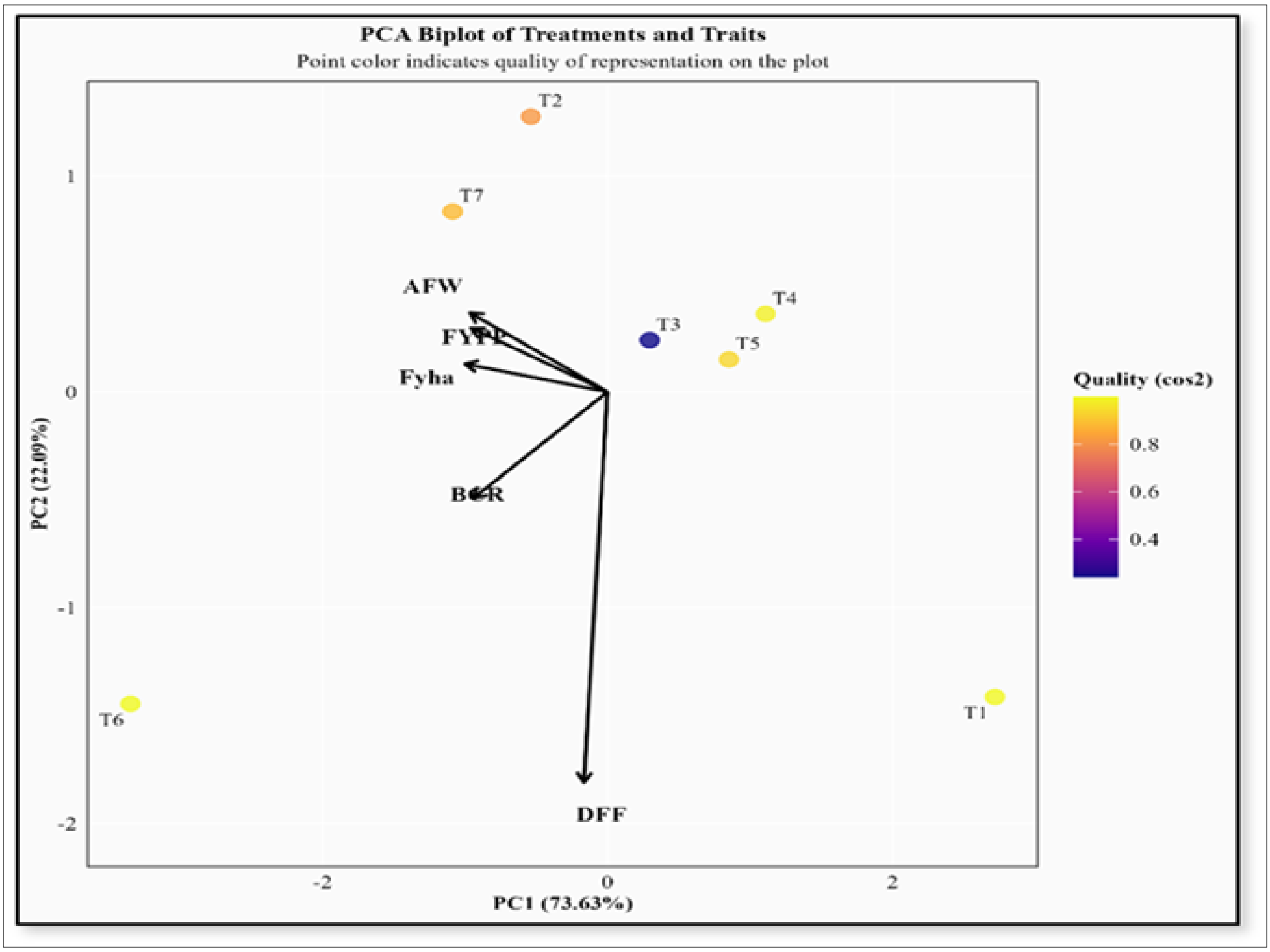

Fig. 4. PCA biplot of treatments and traits.

The biplot displays the first two principal components, accounting for 95.72 % of the total variance. Principal component 1 (73.63 %) represents 'Yield & Profitability,' and principal component 2 (22.09 %) represents 'Earliness.' Treatments (points) positioned to the left indicate higher yield, while those in the upper portion indicate an earlier harvest. Trait vectors (arrows) show their correlation with the principal components.

positioning T_6 as the most productive treatment and T_2 as the leader in earliness, thereby facilitating tailored recommendations according to farmers' specific objectives, whether maximizing yield or targeting early market opportunities.

The integration of organic and inorganic fertilizers has been shown to enhance nutrient availability and uptake, leading to improved growth and yield in vegetable crops. A study demonstrated that the combined application of organic manures and inorganic fertilizers significantly increased the growth and yield of ridge gourd *L. acutangula* cv. GARG-1 (30). This aligns with our findings, where treatments incorporating enriched compost and biofertilizers exhibited superior performance compared to conventional manures.

Furthermore, the application of biofertilizers has been recognized for its role in promoting plant growth and nutrient uptake. Another study reported that the use of biofertilizers in combination with organic and inorganic fertilizers improved plant growth and yield in ridge gourd (31). In the present study, the inclusion of a biofertilizer consortium in treatments T_2 and T_4 contributed to early harvests and enhanced productivity, highlighting the importance of microbial inoculants in sustainable agriculture.

The integration of enriched compost and biofertilizers within an INM framework has demonstrated significant benefits in ridge gourd cultivation. These strategies not only enhance yield and profitability but also promote sustainable agricultural practices. The findings of this study align with recent research by (32), which underscores the importance of INM in improving soil fertility, optimizing nutrient supply and increasing crop yields and quality in vegetable crops. Such approaches are essential for achieving long-term agricultural sustainability and meeting the growing food demands.

Conclusion

A comprehensive 4 year evaluation demonstrates that the application of enriched compost at 2.5 t/ha (T_6) constitutes the most effective nutrient management strategy for ridge gourd *L. acutangula* cv. Arka Prasan. This treatment consistently delivered the highest fruit yield, superior fruit size and optimal economic returns, while exhibiting excellent stability across variable seasonal conditions. For producers prioritizing early harvest, the application of a biofertilizer consortium with compost at 2.5 t/ha (T_2) provides a reliable and effective alternative. Adoption of these evidence-based INM practices can enhance both the sustainability and profitability of ridge gourd cultivation, offering a scientifically validated framework for improved crop management.

Acknowledgements

The authors gratefully acknowledge the support of ICAR, New Delhi for providing financial aid for the study. We also thank the Krishi Vigyan Kendra, Medak-1 (Deccan Development Society), Zaheerabad, for facilitating field experimentation. Special thanks are extended to all collaborating farmers for their active participation and cooperation throughout the multi-season trials.

Authors' contributions

SG conceptualized and executed the experiment, collected field data and performed statistical analyses. PSP and MH assisted in trial implementation, data collection and manuscript preparation. DS and KC contributed to the research design, field monitoring and provided technical guidance. RK and CVP reviewed the experimental design and critically revised the manuscript. SNM and RK provided overall research guidance, technical advice and final manuscript approval. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

References

1. Peter KV, Abraham Z. Biodiversity in horticultural crops. New Delhi: Daya Publishing House; 2017.
2. Shodhan Jain HS, Vasudevan SN, Hanumantharaya BG, Vishwanath K, Marappa N. Comprehensive assessment of ridge gourd (*Luffa acutangula* (L.) Roxb.). Pharma Innov J. 2023;12(12):743.
3. Tasnim KN, Singh D, Singh V, Alexander K. Evaluation of ridge gourd hybrids for growth, yield and quality (*Luffa acutangula* L.). Int J Chem Stud. 2025;9(8S):5214. https://doi.org/10.33545/26174693.2025.v9.i8Sj.5214
4. Gopalan C, Sastri BVR, Balasubramanian SC. Nutritive value of Indian foods. Hyderabad: Natl Inst Nutr; 2007.
5. Pullaiah T. Encyclopedia of world medicinal plants. Vol. 4. Hyderabad: AP Regency Publications; 2006. p. 1962-4
6. Kandoliya UK, Marviya GV, Bodar NP, Bhadja NV, Golakiya BA. Nutritional and antioxidant components of ridge gourd (*Luffa acutangula* L. Roxb.) fruits of promising genotypes and varieties. Sch J Agric Vet Sci. 2016;3(5):397-401.
7. Manikandaselvi S, Vadivel V, Brindha P. Review on *Luffa acutangula* L.: ethnobotany, phytochemistry, nutritional value and pharmacological properties. Int J Curr Pharm Rev Res. 2016;7(3):151-5.
8. Willer H, Lernoud J, editors. The world of organic agriculture: statistics and emerging trends 2019. Frick (Switzerland): Res Inst Org Agric (FiBL) & IFOAM-Organics Int; 2019.
9. Savci S. An agricultural pollutant: chemical fertilizers. Int J Environ Sci Dev. 2012;3(1):73-80. https://doi.org/10.7763/IJESD.2012.V3.191
10. Choudhary M, Datta A, Jat HS, Yadav AK, Gathala MK, Sapkota TB, et al. Pan-India assessment of soil health. Curr Sci. 2018;114(5):988-96.
11. Aulakh MS, Grant CA. Integrated nutrient management for sustainable crop production. J Crop Improv. 2008;21(1):35-90. https://doi.org/10.1201/9780367803216
12. Thakur AK, Uphoff N, Antony E. Integrated nutrient management: a way forward for sustainable agriculture. J Soil Water Conserv. 2021;20(4):365-73.
13. Adhikary S. Vermicompost: the story of organic gold. J Clean Prod. 2012;23:91-8.
14. Lazcano C, Domínguez J. The use of vermicompost in sustainable agriculture: impact on plant growth and soil fertility. In: Miransari JI, editor. Soil nutrients. New York: Nova Science Publishers; 2011. p. 1-23
15. Biswas DR, Narayanasamy G. Rock phosphate enriched compost: an approach to improve phosphorus availability in soil. Nutr Cycl Agroecosyst. 2006;74(2):143-55.

16. Mahanty T, Bhattacharjee S, Goswami M, Bhattacharyya P, Das B, Ghosh A, et al. Biofertilizers: a potential approach for sustainable agriculture development. Environ Sci Pollut Res. 2017;24(4):3315-35. https://doi.org/10.1007/s11356-016-8104-0

17. Singh J, Munshi AD, Singh D, Meena BR, Singh AK, Nagar A, et al. Identification of new stable resistant sources and agro-morphological performance of sponge gourd germplasm against tomato leaf curl New Delhi virus incidence. Front Plant Sci. 2024;15:1373352. https://doi.org/10.3389/fpls.2024.1373352

18. Ceccarelli S. Genotype by environment interaction and breeding for marginal conditions. Euphytica. 2015;198(1):1-17.

19. Senta PB, Purohit VL. Influence of integrated nutrient management on soil properties, nutrient content and uptake by ridge gourd (*Luffa acutangula* L.). Pharma Innov J. 2023;12(12):927.

20. Khaytan N, Perez GA, Tongyoo P, Reanwarakorn K, Chunwongse J, Wongpraneekul A, et al. Screening for ToLCNDV tolerance in ridge gourd germplasm, inheritance study and SNP marker identification using GWAS based on DArTseq. Sci Hortic. 2025;339:113867. https://doi.org/10.1016/j.scienta.2024.113867

21. Crossa J. Statistical analyses of multilocation trials. In: Brady NC, editor. Adv Agron. Vol. 44. Cambridge (MA): Academic Press; 1990. p. 55-85. https://doi.org/10.1016/S0065-2113(08)60818-4

22. Eberhart SA, Russell WA. Stability parameters for comparing varieties. Crop Sci. 1966;6(1):36-40. https://doi.org/10.2135/cropsci1966.0011183X000600010011x

23. Jolliffe I. Principal component analysis. In: Lovric M, editor. Int Encycl Stat Sci. Berlin: Springer; 2011. p. 1094-6 https://doi.org/10.1007/978-3-642-04898-2_455

24. Gomez KA, Gomez AA. Statistical procedures for agricultural research. New York: John Wiley & Sons; 1984

25. Sukhatme PV. Statistical methods for agricultural workers. New Delhi: Indian Council Agric Res; 1957

26. Yadav BK, Lourduraj AC, Kumar S. Effect of organic and inorganic fertilizers on growth, yield and quality of tomato. J Pharmacogn Phytochem. 2019;8(3):4441-4.

27. Meena RK, Jain PK, Kumar S. Effect of integrated nutrient management on growth and yield of cucumber. Ann Plant Soil Res. 2017;19(1):108-11.

28. Asha K, Singh A, Verma R. Exploitation of beneficial microbes as biofertilizers for sustainable crop production. J Pharmacogn Phytochem. 2018;7(1):1845-51.

29. Singh R, Kumar S, Singh YV. Effect of integrated nutrient management on growth, yield and quality of sponge gourd. Indian J Hortic. 2010;67(3):336-9.

30. Patel HS, Patel NB, Sarvaiya JP, Chawla SL. Integrated nutrient management on growth and yield of ridge gourd (*Luffa acutangula* L.) cv. GARG-1. Pharma Innov J. 2021;10(8):1064-9.

31. Choudhary K, Paliwal R, Mahariya JS, Singh H, Gupta NK. Plant growth improvement in ridge gourd through integrated nutrient management practices. Int J Curr Microbiol Appl Sci. 2020;9(3):1-9. https://doi.org/10.20546/ijcmas.2020.903.143

32. Ali A, Niu G, Masabni J, Ferrante A, Cocetta G. Integrated nutrient management of fruits, vegetables and crops through the use of biostimulants, soilless cultivation and traditional and modern approaches: a mini review. Agric. 2024;14(8):1330. https://doi.org/10.3390/agriculture14081330

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.