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Sustainable intensification of arecanut cultivation through improved agronomic, disease and pest management practices: Insights from frontline demonstrations in Karnataka

[1]MG Basavanagowda, [2]TG Avinash, [3]TN Devaraja and [4]DV Kolekar

[1]Subject Matter Specialist (Horticulture), ICAR-Taralabalu Krishi Vigyan Kendra, Davanagere, Karnataka, India

[2]Subject Matter Specialist (Plant Protection), ICAR-Taralabalu Krishi Vigyan Kendra, Davanagere, Karnataka, India

[3] Senior Scientist and Head, ICAR Taralabalu Krishi Vigyan Kendra, Davanagere, ICAR-Taralabalu Krishi Vigyan Kendra, Davanagere, Karnataka, India

[4] Senior Scientist, ICAR-ATARI, Bengaluru ICAR-Taralabalu Krishi Vigyan Kendra, Davanagere, Karnataka, India

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Corresponding Author: MG Basavanagowda

Abstract
Arecanut (*Areca catechu* L.) is an economically important plantation crop extensively cultivated in the humid tropics of India, providing livelihood security to millions of small and marginal farmers. However, productivity often remains below potential due to traditional cultivation practices, imbalanced nutrient management, and inadequate pest and disease control. To address these issues, Frontline Demonstrations (FLDs) were conducted during 2022 at Hirekogaluru village, Channagiri Taluk, Davanagere District under the supervision of ICAR-Taralabalu Krishi Vigyan Kendra. The objective was to assess the impact of improved scientific crop management practices over conventional farmer practices on yield, pest incidence, and profitability. Twenty demonstration plots (0.4 ha each) were established using an improved technology package that included soil test-based integrated nutrient management, green manuring, drainage improvement, integrated pest management, timely irrigation, and moisture conservation measures, while adjacent farmer-managed plots served as checks. Results indicated a substantial improvement in productivity and profitability under demonstration plots. The mean yield increased from 12.26 q ha^{-1} (check) to 22.39 q ha^{-1} (demonstration), showing an 85.22% gain. Gross returns rose from ₹5,49,922 to ₹10,07,077 ha^{-1}, while net returns increased by ₹4,57,738 ha^{-1}. The Benefit-Cost (B:C) ratio improved from 3.49 to 6.42, indicated higher profitability with similar cost of cultivation. The improved package also reduced pest and disease incidence—inflorescence dieback (↓52.0%), nut splitting (↓50.90%), hidimundige (↓35.80%), and spindle bug (↓31.80%)—and enhanced inflorescence production by 46.9%. Overall, the study highlights that adoption of the improved technology package significantly enhances yield, income, and resilience in arecanut cultivation. FLDs effectively bridge the technology-yield gap and promote sustainable arecanut production in Karnataka.

Keywords: Arecanut (*Areca catechu* L.), frontline demonstration, integrated nutrient management, pest management, yield gap, benefit-cost ratio, Karnataka

Introduction

Arecanut (*Areca catechu* L.) is an economically important plantation crop cultivated extensively in the humid tropics of India, providing livelihood security to millions of small and marginal farmers. Despite its commercial significance, arecanut productivity in many regions remains suboptimal due to traditional farming practices, imbalanced nutrient application, inadequate irrigation, and poor pest and disease management. Farmers often rely on inherited practices rather than scientific recommendations, leading to yield instability, increased production risks, and reduced profitability. To bridge this technology-yield gap, effective extension approaches are essential for demonstrating the benefits of improved agronomic and plant protection practices directly under farmers' field conditions.

The growing shift toward Arecanut cultivation in Karnataka highlights both opportunities and emerging challenges in the agricultural landscape. While the crop offers attractive economic benefits such as higher returns, year-round income through perennial yield, and growing domestic and export markets, it also introduces significant risks due to overdependence on a single commercial crop.

This mono-cropping trend, driven by the perceived profitability of Arecanut, makes farming communities, especially small and marginal farmers, highly vulnerable to multiple external shocks. These include market price volatility, pest and disease outbreaks (such as Yellow Leaf Disease), and unpredictable climate events like droughts or unseasonal rains. Unlike diversified farming systems, monocultures lack the resilience needed to absorb these shocks, which could lead to financial distress, increased debt burdens, and even land alienation or farmer suicides in extreme cases (Harish B P *et al*, 2025) [11]

Frontline Demonstrations (FLDs), implemented through Krishi Vigyan Kendras (KVKs), serve as a vital tool for accelerating the transfer of proven technologies from research stations to farmers. These demonstrations aim to assess the performance of improved practices in real farm situations while building farmers' confidence in adopting scientific interventions. In arecanut, recommended practices such as integrated nutrient management, integrated pest management, timely irrigation scheduling, and proper canopy and crop health maintenance have shown potential to significantly enhance productivity and reduce losses due to pests and physiological disorders.

Ravi Bhat *et al* (2024) [4] studied that the soil health should be assessed regularly, and the crop need is met as per the requirement for sustained production. Crop waste recycling through vermicomposting, use of microbial consortia, soil test-based nutrient application through organic and inorganic sources, practices of conservation agriculture and growing more than two crops per unit area for diversity in plant population are some of the technologies useful for maintenance of soil health and higher productivity.

However, empirical evidence generated through systematically conducted FLDs is crucial for understanding the actual impact of technology adoption on yield, profitability, and sustainability. Therefore, the present study was undertaken to evaluate the performance of improved technology packages in comparison to farmers' existing practices across multiple locations. The introduction of these interventions aimed not only to enhance yield but also to improve economic returns and minimize biotic and abiotic stresses. The results of these demonstrations provide valuable insights into the effectiveness of scientific crop management and highlight the scope for large-scale adoption to improve the livelihoods of arecanut growers.

The majority of the farmers are facing problems in production mammalians pest attacking on Arecanut bunch (73.56) in Davanagere district, high wage rates of labour in Chikkamagaluru and incidence of pest and diseases attack in Shivamogga and Dakshina Kannada districts. In case of arecanut marketing problems were lack of storage facilities, poor transport facility and price fluctuations. The need of present era is to increase the productivity of arecanut crop. This could be achieved by adopting improved production practice, high yield varieties and new technologies of crop (Hanumanthappa and Murthy, 2023) [6]

Materials and Methods

The present study was conducted through Frontline Demonstrations (FLDs) on Arecanut to evaluate the impact of improved scientific crop management practices in comparison with farmers' conventional practices. The demonstrations were implemented in Hirekogaluru village of Channagiri Taluk in the year 2022 under the supervision of ICAR-Taralabalu Krishi Vigyan Kendra. A total of 20 demonstration plots were established, with each plot 0.4 ha, depending on farmer landholding. Adjacent plots under farmers' practice were maintained as check for comparison.

1. Selection of Farmers and Sites

A benchmark survey was conducted to document existing practices, yield levels, and constraints. Progressive farmers possessing irrigated Arecanut plantations were selected based on their willingness to adopt scientific recommendations and representativeness of the local agro-climatic conditions. Each demonstration unit was 0.4 ha, with adjacent farmer-managed plots maintained as check (farmers' practice).

2. Treatment Details

Two treatments were compared:

- T_1 - Improved Technology Package from KSNUAHS, Shivamogga and AICRP on Arecanut, Shivamogga (Demonstration)
- T_2 - Farmers' Practice (Check)

Both treatments were laid out under real farm conditions, and data were recorded from multiple locations to capture variability.

3. Components of Improved Technology Package

Following technologies have been demonstrated for the farmers

- Soil test-based integrated nutrient management (INM) using FYM, recommended NPK dose (100:40:140 g NPK/plant/Year), secondary and micronutrients
- Green Manuring with Velvet Beans (4 Kg/ac)
- Opening of Drains for every alternative rows in undrained soil.
- Gypsum as soil amendment based on soil test
- Foliar Application of chlorpyrifos @ 2 ml/l and Mancozeb @ 2.5 g per liter of water to manage the inflorescence die back and inflorescence caterpillar
- Timely irrigation based on crop phenology
- Moisture conservation through mulching, basin management and growing of green manure crops.
- Spray of Thiamethoxon @ 0.3 g/l or Lamda Cylothrin @ 1 ml/ l for management of spindle bug.

4. Farmers' Practice (Check)

Check plots were managed with conventional methods such as:

- Imbalanced or delayed fertilizer use
- Irregular irrigation
- Pest management (only after visible damage)
- No micronutrient application and Soil amendments
- Poor basin and canopy management
- Indiscriminate use of pesticides

5. Data Collection

Field observations were recorded using standard formats from both demonstration and check plots.

Agronomic and Yield Parameters

- Number of inflorescences per plant
- Yield differences and percentage increase
- Yield (q/ha)

Economic Parameters

- Cost of cultivation (₹/ha)
- Gross return (₹/ha)
- Net return (₹/ha)
- Benefit-Cost (B:C) ratio

Disease, Pest and Physiological Disorder Incidence (%)

- Hidimundige

- Nut splitting
- Inflorescence dieback
- Spindle bug infestation

6. Statistical and Variability Analysis

- Mean, standard deviation, and variance were calculated for all parameters.
- Yield differences and B: C ratio differences were tested for significance using Critical Difference (CD) at 5%.
- Percentage reduction in pest, disease/disorder incidence and percentage increase in inflorescences were computed.

7. Monitoring and Capacity Building

KVK scientists conducted regular field visits, provided technical guidance, and ensured timely input application. Field days, group discussions, and farmer feedback sessions were organized to enhance adoption and assess practicality.

8. Economic Evaluation

Gross return was computed using prevailing market prices of fresh nuts. Net return was calculated as:
Net Return = Gross Return - Cost of Cultivation
The Benefit:Cost (B:C) ratio was derived as:
B:C Ratio = Gross Return / Cost of Cultivation

9. Interpretation of Impact

Improvements in yield, profitability, pest reduction, and uniformity of performance (lower variability) were used to assess the overall effectiveness and scalability of the improved technology package.

Results

The Front Line Demonstrations (FLDs) on arecanut revealed that substantial improvement in yield and profitability over farmers' practice (check). The mean yield under demonstration plots was 22.39 q/ha, which was 85.22% higher than the check yield of 12.26 q/ha. The difference in yield (10.13 q/ha) was statistically found significant (CD 5% = 1.538).

The average gross return from the demonstration plots was ₹ 10,07,393/ha compared to ₹ 5,51,543/ha from the check plots, reflecting a profit enhancement of ₹ 4,55,850/ha. Similarly, the mean net return under demonstration (₹ 8,39,551/ha) was nearly double that of the check (₹ 4,11,011/ha). Gross cost did not differ significantly between treatments, indicating that the yield and income improvements were achieved without substantial additional expenditure (Table 1).

The B:C ratio improved markedly from 3.49 in the check to 6.42 in the demonstration plots, with a highly significant difference (CD 5% = 0.00486). The yield advantage can be attributed to timely input application, recommended fertilizer dose, pest and disease management, and better irrigation scheduling, which collectively enhanced percent nut set and size.

Ananda *et al* (2005) [1] reported similar results in his study, among the accessions VTL-28III and VTL-18I were found to be superior for chali yield performance and also showed consistency in yielding behaviour over the years compared to other accessions evaluated in the present study. The high heritability and genetic gains estimated in fresh fruit weight, dry kernel weight and dry fruit weight, which can be improved through simple selection method. Characters such as dry kernel weight, chali yield, dry fruit weight, kernel length and breadth
showed high magnitude of correlation with dry kernel yield.

Virupakshi Hirematha *et al* (2022) observed that, the highest positive significant for the association of fruit yield per palm was with the fresh kernel weight per palm (0.96g) followed by dry weight of husk per palm (0.89g) and fresh weight of husk per palm (0.89g). Path analysis revealed that nineteen out of thirty-four characters recorded that fruit volume (2.40cc) had highest positive direct effect on fruit yield per palm followed by fresh fruit weight (2.17g) and breadth of leaf sheath (2.11m). It can be concluded that growth and yield characters may be considered in selection criteria for the improvement of yield in arecanut.

Venkatesh *et al* (2025) [15] in his studies revealed that organic farming yielded a significantly higher soil quality index (0.61), followed by integrated nutrient management (0.58). The findings suggest that implementing organic farming techniques alongside effective crop management strategies is crucial for maximizing the potential of arecanut-based agroforestry systems to boost soil quality and achieve long-term sustainability

These results emphasize that adoption of the improved technology package in arecanut can significantly enhance productivity and profitability, and thus holds promise for wider dissemination among farming communities.

Incidence of major pest and disease parameters in Arecanut

The effect of the demonstration over the farmers' practice (check) on the incidence of major pests and physiological disorders of arecanut is presented in Table 2. A clear reduction in the mean incidence of Hidimundige was observed in the demonstration plots (8.95%) compared to the check plots (13.95%), representing a 35.85% decline. Similarly, the percentage of nut splitting decreased from 11.84% in the check to 5.82% in demonstration plots (50.85% reduction). Inflorescence dieback was also markedly lower in the demonstration plots (8.57%) than in the check plots (17.88%), indicating a 52.04% reduction over check.

Sujaina *et al* (2023) [13] showed that availability of N, P, K, S, Fe, Mn, Cu and B and also the content of exchangeable Ca and Mg was quite heterogeneous in both healthy and affected gardens. Whereas, available zinc status in the soil showed significant decrease in affected gardens compared to healthy gardens of Hiriyur, Chitradurga and Holalkere taluks.

Interestingly, the mean number of inflorescences per plant was higher under demonstration plots (4.85) compared to the check plots (3.30), showing a 46.97% improvement in reproductive output. The incidence of spindle bug infestation also reduced considerably from 12.38% in check plots to 8.44% in demonstration plots (31.83% reduction) (Table 5).

The variability in observations, as indicated by standard deviation and variance, was consistently lower in demonstration plots across most parameters, suggesting more uniform performance. For example, the standard deviation for Hidimundig*e* incidence was 1.06 in demonstration plots compared to 1.59 in check plots, and for nut splitting it was 1.18 vs. 1.25, respectively.

Overall, the results indicate that the improved practices adopted in demonstration plots not only reduced the incidence of key pests and physiological disorders but also enhanced inflorescence production, which is likely to translate into higher yields and economic gains.

Discussion

The results from the frontline demonstrations (FLDs) clearly revealed a substantial improvement in arecanut productivity under the demonstration plots compared to the farmers' practice. The mean yield recorded in demonstration plots was 22.39 q ha^{-1}, which was significantly higher than the check plots (12.26 q ha^{-1}), registering an average yield increase of 85.22%. The observed differences in yield were statistically significant, as indicated by the SEm± (0.735) and CD 5% (1.54), confirming the reliability of the performance gap between the two practices.

Paul S.C, *et al* (2015) [10] investigated the treatments included control (T_1), 100 per cent vermicompost (T_2), 200 per cent vermicompost (T_3), 100 per cent chemical fertilizer (T_4), 50 per cent vermicompost + 50 per cent chemical fertilizer (T_5), 1/3rd vermicompost + 2/3rd chemical fertilizer (T_6) and 2/3rd vermicompost + 1/3rd chemical fertilizer (T_7). The treatment T_7 produced highest fresh ripened arecanut yield of 16.7 kg i.e., about 3.6 kg dry chali per palm. Positive correlations were obtained between yield of arecanut and soil available N, P, K content. Significant and positive correlation was found between leaf N, P, K and available N, P, K content in surface and sub-surface soil. Available N, P and K content increased over the year under nutrient applied plot that reflected in yield of arecanut. The average yield in various treatments followed in the order of $T_7 > T_5 = T_6 > T_2 = T_3 > T_4 > T_1$. The application of targeted, sufficient and balanced quantities of organic and inorganic fertilizer will be the need of the hour to make nutrients available for higher yield, soil fertility maintenance and agricultural sustainability without polluting environment.

Among the farmers, the highest yield increase (136.88%) was recorded in F9, followed by F1 (130.73%) and F3 (128.36%). These large gains indicated that the adoption of improved cultivation packages and scientific management practices—such as optimum fertilizer application, timely irrigation, and pest/disease management—played a decisive role in enhancing productivity. Conversely, comparatively lower yield advantages in F15 (35.84%), F8 (44.89%), and F20 (46.28%) may be attributed to constraints like sub-optimal irrigation scheduling, variable soil fertility, or partial adoption of recommended practices.

Keerthana *et al* (2025) [8] reveals that the higher microbial biomass carbon (270.20 mg kg^{-1}), microbial biomass nitrogen (28.42 mg kg^{-1}), dehydrogenase (18.55 ug TPF g-1 24 hr-1) and acid phosphatase (19.22 ug PNP g-1 h -1) activity was recorded at the surface soil (0-20cm) of organic farming practice followed by natural farming practice as compared to integrated nutrient management practice and chemical farming practice.

The economic analysis also reflected the superiority of demonstration plots over farmers' practice. The higher yields in demonstrations translated into markedly higher Gross Returns and Net Returns. For instance, in most cases, the Benefit-Cost (B:C) ratio in demonstrations exceeded 2.5, whereas in farmers' practice it was consistently lower, indicating better resource-use efficiency in the improved package. This aligns with earlier reports by (Sushita and Aparna, 2025) where adoption of recommended agronomic practices in arecanut increased net profitability by 40-120%.

The strong positive correlation between yield gain and economic returns underscores that bridging the yield gap directly impacts farm profitability. FLDs, by showcasing location-specific best practices in real farm conditions, are thus an effective extension approach to enhance farmers' income. Widespread adoption of these technologies can significantly boost arecanut productivity and profitability, contributing to the sustainability of the crop in the region.

Atapattu *et al* (2025) [2] provides a detailed and systematic review of the environmental, economic and social impacts of organic fertilization. Benefits include enhanced soil health, biodiversity promotion, carbon sequestration, cost effectiveness, quality improvement of the yield, food security and possibilities of creating rural income. Issues including resource accessibility difficulties, nutrient deficiencies, and intensive labor requirements are explored in detail, as well as future trends that focus on advanced technologies, new research areas, and policy approaches. Thus, the study reviews organic fertilization as a coherent concept that can be applied to coconut production and other goals of environmental protection, food security, and sustainable development of agriculture.

The improvement in yield directly translated into higher gross and net monetary returns. Demonstrations recorded a Gross Return of ₹ 10,07,077 ha^{-1}, which was ₹ 4,57,155 ha^{-1} higher than the farmers' practice (₹ 5,49,922 ha^{-1}). The Net Return advantage was even more pronounced, with demonstration plots generating ₹ 8,50,206 ha^{-1} compared to ₹ 3,92,468 ha^{-1} in the check plots—an increase of ₹ 4,57,738 ha^{-1}. The statistical significance of these differences was supported by low SEm± values and comparatively narrow CD ranges for the economic parameters.

The B:C ratio further highlights the profitability of the improved package, with demonstration plots achieving 6.420 compared to 3.492 in farmers' practice, showing a net gain of 2.928 points. This nearly twofold improvement in cost-benefit efficiency reflects the higher productivity coupled with optimal resource utilisation in the FLDs.

These findings are consistent with earlier studies (Anil K Choudhari *et al*,) reporting that adoption of recommended agronomic and management practices in plantation crops substantially increases farm profitability. The current results confirm that bridging the yield gap in arecanut through scientific interventions not only boosts production but also ensures significantly higher economic returns. The FLD approach thus serves as an effective tool to enhance farmers' incomes and promote wider adoption of improved cultivation technologies.

The results (Table 1) clearly demonstrate that frontline demonstration (FLD) practices substantially reduced the incidence of major pests and diseases in arecanut compared to the farmers' practice (check). The most pronounced reduction was recorded in inflorescence dieback, which declined from 17.88% in the check plots to 8.57% in demonstration plots, representing a 52.0% reduction. Similarly, nut splitting was reduced by 50.9% (from 11.84% to 5.82%), indicating the effectiveness of improved nutrient and water management along with timely plant protection measures.

The incidence of hidimundige disease decreased from 13.95% in the check plots to 8.95% under demonstration, accounting for a 35.8% reduction. Spindle bug incidence also reduced significantly (↓ 31.8%), suggesting that integrated pest management (IPM) strategies adopted in demonstrations played a crucial role in suppressing pest populations.

Farmers should implement control measures early in the crop cycle to manage leaf-feeding mites, and take appropriate action against perianth mites during the later stages. In conclusion, *Oligonychus tylus, Tetranychus fijiensis* and *Dolichotetranychus* species are becoming significant mite pest complexes in areca. Effective management strategies, exploration of natural enemies, supportive policies, and plant protection measures must be prioritised to address this growing concern as reported by Rajashekarappa *et al* (2025) [12].

Balanagoda Patil *et al*., evaluated the commonly used and newly developed 12 oomycete-specific fungicidal products with different application strategies in 2018 and 2019 at Malnad regions. Fungicides *viz*., Bordeaux mixture, Mandipropamid, Metalaxyl+Mancozeb and Fosetyl-Al were the most effective in reducing FRD and efficiently controlling (70-80%) the disease with a statistically significant difference compared to untreated control ($p \leq 0.05$)

In addition to reducing biotic stress, the FLD technology package positively influenced yield-attributing traits. The number of inflorescences per plant increased by 46.9% (from 3.30 to 4.85), which directly correlates with potential nut yield. This improvement can be attributed to better crop nutrition, timely irrigation, and preventive plant health measures, all of which contributed to enhanced plant vigour and reproductive potential.

These findings are in line with earlier reports (Maheshwarappa H P, and Sumitha S, 2018) [9] that integrated crop management practices in arecanut can effectively reduce pest and disease pressure while simultaneously improving yield-contributing traits. The significant reduction in pest and disease incidence not only helps in securing higher yields but also contributes to reduced pesticide usage, lowering production costs and environmental impact.

Table 1: Performance of Arecanut for yield and Income in ICM Demonstration

Sl. No.	Farmer	Check (GR)	Demo (GR)	Check (GC)	Demo (GC)	Check (NR)	Demo (NR)	Check (BC)	Demo (BC)
1	F1	461250	1064250	132598	165845	328652	898405	3.478559	6.417136
2	F2	466200	946800	132458	154694	333742	792106	3.519606	6.12047
3	F3	506250	1156050	121548	141695	384702	1014355	4.165021	8.158721
4	F4	568800	1228950	136948	161519	431852	1067431	4.153401	7.608702
5	F5	595800	1019250	135694	171418	460106	847832	4.390762	5.945992
6	F6	546750	1120050	134897	165647	411853	954403	4.053092	6.761668
7	F7	488700	996300	124587	161351	364113	834949	3.92256	6.174737
8	F8	627750	909000	130365	171894	497385	737106	4.815326	5.288143
9	F9	561150	1329300	124698	181945	436452	1147355	4.500072	7.306054
10	F10	608850	931050	131315	163594	477535	767456	4.636561	5.691223
11	F11	495900	921600	141561	166932	354339	754668	3.503083	5.520811
12	F12	471600	973800	131419	177879	340181	795921	3.588522	5.474508
13	F13	509400	1096200	141212	175469	368188	920731	3.607342	6.247257
14	F14	607050	966600	154698	163695	452352	802905	3.924097	5.904884
15	F15	645750	877050	146823	186594	498927	690456	4.398153	4.700312
16	F16	561600	906300	165423	174586	396177	731714	3.394933	5.191138
17	F17	627750	931050	147856	166325	479894	764725	4.245685	5.597775
18	F18	496800	919350	162183	169548	334617	749802	3.063206	5.422358
19	F19	564300	948600	158978	166326	405322	782274	3.549548	5.703257
20	F20	619200	906300	155369	169875	463831	736425	3.985351	5.335099
Mean		551542.5	1007393	140531.5	167841.6	411011	839551	3.944744	6.028512

Table 2: Performance of Arecanut for the Pest and Disease incidence in ICM Demonstration

Sl. No.	Farmer	Hidimundige (%)		Nut Splitting (%)		Inflorescence Dieback (%)		Inflorescence /plant(Number)		Spindle Bug (%)	
		Check	Demonstration	Check	Demonstration	Check	Demonstration	Check	Demonstration	Check	Demonstration
1	F1	12.65	8.32	11.36	6.25	16.59	10.32	4	5	13.25	9.32
2	F2	13.45	8.16	12.25	5.23	17.02	9.45	5	5	12.25	8.65
3	F3	12.64	10.24	12.63	7.62	19.65	8.32	4	5	12.3	8.94
4	F4	14.95	9.61	11.25	5.15	18.26	8.26	3	6	12.45	9.41
5	F5	11.23	7.26	13.48	5.36	18.04	9.14	4	5	12.32	7.06
6	F6	15.62	9.26	14.36	6.14	19.31	10.45	3	4	12.03	8.4
7	F7	14.36	8.3	11.02	5.03	19.47	11.65	4	6	12.59	8.35
8	F8	17.62	10.48	11.96	7.12	20.14	8.14	3	4	13.45	9.01
9	F9	14.23	11.36	12.2	5.61	18.35	7.36	3	5	11.58	7.83

10	F10	12.36	8.14	13.25	5.98	19.02	9.15	2	4	11.36	9.13
11	F11	14.25	9.35	11.02	4.15	18.01	9.45	4	4	12.36	8.64
12	F12	12.36	8.3	10.42	4.44	17.36	9.04	3	5	14.59	8.88
13	F13	15.32	9.25	10.48	6.26	16.35	8.06	5	5	12.76	9.17
14	F14	13.32	7.26	11.64	5.03	18.31	7.98	2	5	12.61	8.46
15	F15	16.25	8.36	14.61	5.04	16.04	7.26	3	4	11.35	8.01
16	F16	14.23	10.05	10.78	8.62	16.25	8.61	3	4	12.49	9.47
17	F17	11.25	9.4	10.36	5.31	17.05	6.08	4	5	12.34	7.33
18	F18	14.26	8.89	11.01	4.02	19.98	5.36	2	6	11.53	8.1
19	F19	15.25	7.56	12.23	7.62	18.26	9.17	3	5	11.59	7.06
20	F20	13.34	9.36	10.48	6.46	14.05	8.17	2	5	12.36	7.66
Mean		13.947	8.9455	11.8395	5.822	17.8755	8.571	3.3	4.85	12.378	8.444
Standard Deviation		1.59	1.06	1.25	1.18	1.51	1.40	0.9	0.65	0.75	0.74
Variance		2.68	1.19	1.66	1.48	2.4	2.09	0.86	0.45	0.59	0.58

Table 3: Yield and percentage increase in arecanut under farmers' practice and frontline demonstrations.

Sl. No.	Farmer code	Yield (q ha⁻¹) - Check	Yield (q ha⁻¹) - Demo	Yield increase over check (%)
1	F1	10.25	23.65	130.73
2	F2	10.36	21.04	103.05
3	F3	11.25	25.69	128.36
4	F4	12.64	27.31	116.01
5	F5	13.24	22.65	71.04
6	F6	12.15	24.89	104.92
7	F7	10.86	22.14	103.87
8	F8	13.95	20.20	44.89
9	F9	12.47	29.54	136.88
10	F10	13.53	20.69	52.94
11	F11	11.02	20.48	85.86
12	F12	10.48	21.64	106.46
13	F13	11.32	24.36	115.25
14	F14	13.49	21.48	59.23
15	F15	14.35	19.49	35.84
16	F16	12.48	20.14	61.36
17	F17	13.95	20.69	48.39
18	F18	11.04	20.43	85.07
19	F19	12.54	21.08	68.11
20	F20	13.76	20.14	46.28
Mean	-	12.26	22.39	85.22

SEm± = 0.735; CD (P=0.05) = 1.54

Note: Percentage increase calculated over respective farmers' practice yields.

Table 4: Yield and economics of Arecanut under farmers' practice and FLD demonstrations

Parameter	Check (Mean)	Demo (Mean)	Mean Difference	SEm ±	CD (5%)
Yield (q/ha)	12.26	22.39	10.13	0.735	1.538
Gross Returns (₹/ha)	5,49,922	10,07,077	4,57,155	32,994	69,057.
Gross Cost (₹/ha)	1,57,454	1,56,870	-583.4	6,316.30	13,220
Net Returns (₹/ha)	3,92,468	8,50,206	4,57,738	26,865	56,230
B:C Ratio	3.492	6.420	2.928	0.00232	0.00486

Table 5: Incidence of major pests and diseases, and yield-attributing traits in Arecanut under check and demonstration conditions

Parameter	Check (Mean ± SD)	Demonstration (Mean ± SD)	% Change over Check
Hidimundige (%)	13.95 ± 1.59	8.95 ± 1.06	↓ 35.8
Nut Splitting (%)	11.84 ± 1.25	5.82 ± 1.18	↓ 50.9
Inflorescence Dieback (%)	17.88 ± 1.51	8.57 ± 1.40	↓ 52.0
Inflorescence/plant (Number)	3.30 ± 0.90	4.85 ± 0.65	↑ 46.9
Spindle Bug (%)	12.38 ± 0.75	8.44 ± 0.74	↓ 31.8

↑ = increase, ↓ = decrease

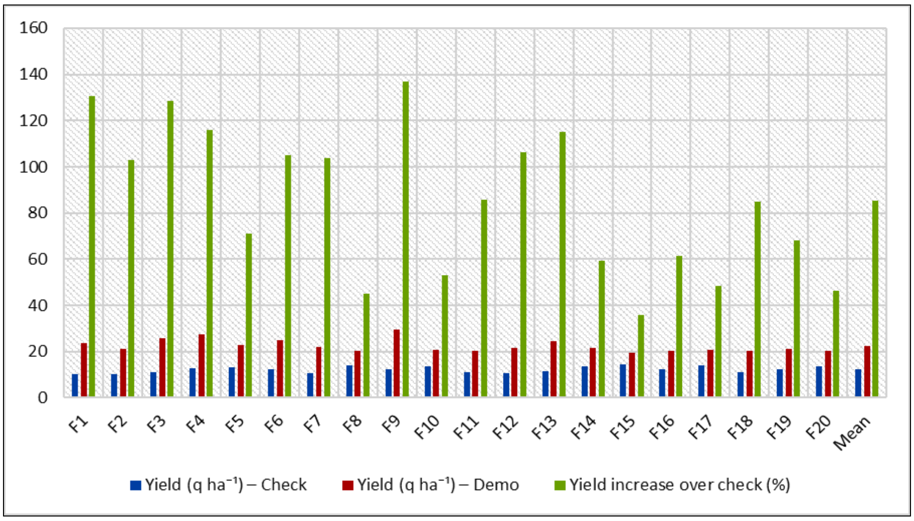

Fig 1: Yield and percentage increase in arecanut under farmers' practice and frontline demonstrations.

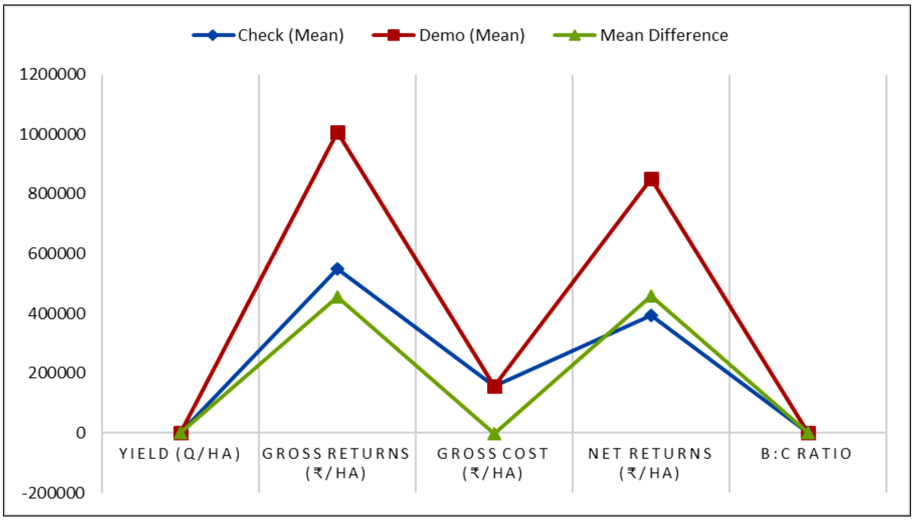

Fig 2: Yield and economics of Arecanut under farmers' practice and FLD demonstrations

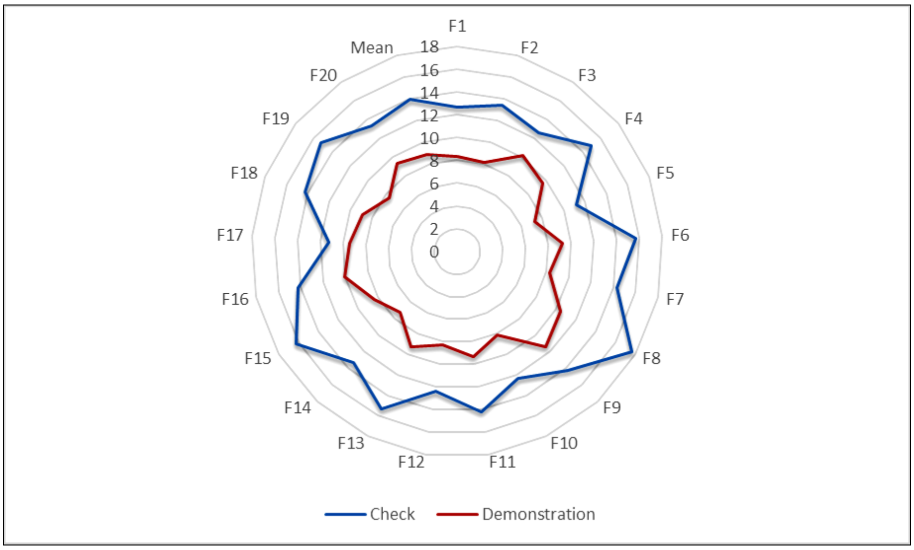

Fig 3: Performance of Arecanut for the Hidimundige incidence in ICM Demonstration

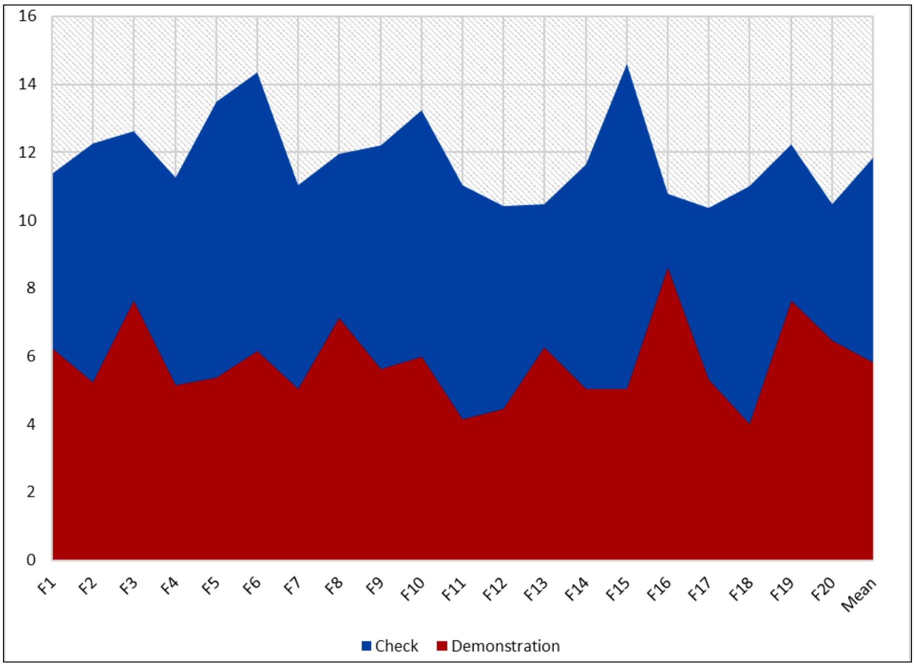

Fig 4: Performance of Arecanut for the Percent Nut Splitting incidence in ICM Demonstration

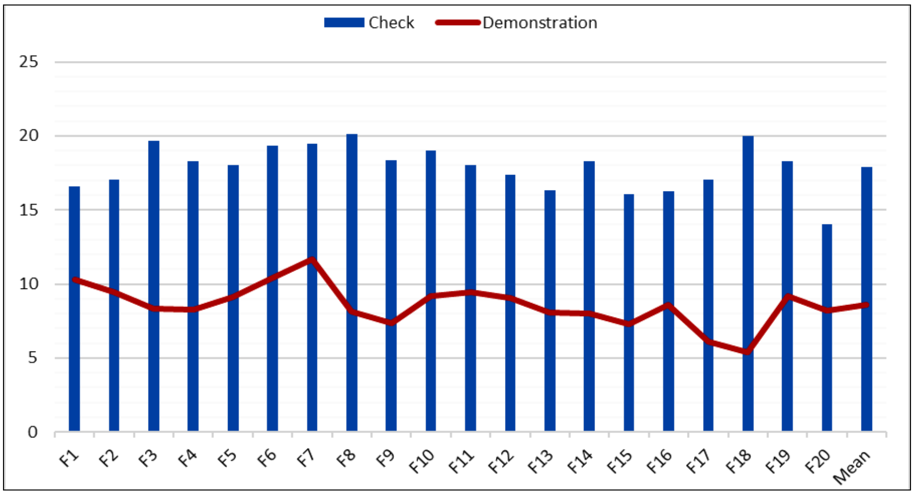

Fig 5: Performance of Arecanut for the Percent Inflorescence Die back incidence in ICM Demonstration

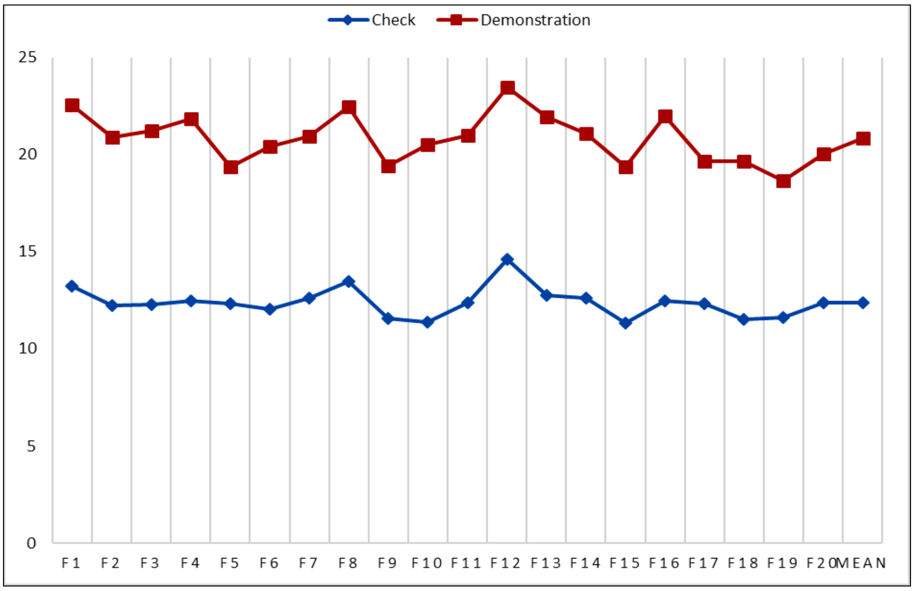

Fig 6: Performance of arecanut for the percent Spindle Bug incidence in ICM demonstration

Fig 7: Practical Orientation on Management of Pest and Diseases

Fig 8: Diagnostic Field Visits to Arecanut Plot

Fig 9: Dhaincha as green manure crop in Arecanut

Fig 10: Demonstration of Open Drainage in Undrained Soils

Fig 11: Inflorescence in the Control Plot

Fig 12: Inflorescence after the ICM Demonstration

Fig 13: Increased Fruit Set in Demonstration

Conclusion

The frontline demonstrations on arecanut clearly established the superiority of the improved technology package over farmers' practice in terms of productivity, profitability, and pest/disease and physiological disease management. Adoption of recommended agronomic practices, integrated nutrient and pest management, and timely irrigation resulted in an average yield increase of 85.22%, without significant additional production cost. This yield gain translated into substantial economic benefits, with demonstration plots achieving 2.17 times more net returns and nearly doubling the B:C ratio compared to the check.

Furthermore, the improved practices effectively reduced the incidence of major pests and physiological disorders—inflorescence dieback, nut splitting, hidimundige, and spindle bug—while enhancing key yield-attributing traits such as inflorescence production. The combined effects of reduced biotic stress and improved plant vigour contributed to consistent yield improvements across locations.

The study reaffirms that FLDs are an effective extension approach for showcasing the tangible benefits of scientific crop management in real farm conditions. Wider adoption of the demonstrated package has the potential to significantly enhance arecanut productivity, profitability, and sustainability, thereby improving farmers' livelihoods in the region.

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