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# Enhancing Groundnut Productivity: Cluster Front Line Demonstration Approach in Kachchh District, Gujarat

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## ABSTRACT

A field experiment was conducted during the *kharif* seasons (June to October) from 2019–2020 to 2021–2022 at farmers' fields through ICAR-CAZRI Krishi Vigyan Kendra Kachchh-II to investigate the impact of cluster frontline demonstrations (CFLDs) on groundnut productivity and profitability. During the experiment period, a total of 75 CFLDs on Integrated Crop Management (ICM) in groundnut with the high-yielding variety Girnar-2 were undertaken in a 30-hectare area across 12 villages in the Bhuj, Nakhatrana, and Anjar talukas of Kachchh district. The improved variety Girnar-2 with a full package of practices was demonstrated in the plots, while existing technology was treated as the farmer's practice (local check). Based on three years of data, the improved practice (IP) resulted in an average seed yield of 2215 kg $ha^{-1}$, which was an increase of 20.08% compared to the farmer's practice yield of 1826 kg $ha^{-1}$. The demonstrated technology showed an average extension gap, technology gap, and technology index of 389 kg $ha^{-1}$, 692 kg $ha^{-1}$, and 23.80%, respectively. The economic analysis of the demonstrations revealed the viability of the enhanced technology, with a net return of 72,881 ₹ $ha^{-1}$ and a benefit-cost ratio (BCR) of 3.01, compared to 57,691 ₹ $ha^{-1}$ and a BCR of 2.67 for conventional technology. The results revealed that the adoption of the high-yielding variety with a full package of practices significantly increased groundnut productivity and reduced both extension and technology gaps.

**KEYWORDS:** Cluster frontline demonstrations, groundnut, technology index, yield

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***Data Availability Statement:*** Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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## 1. INTRODUCTION

Groundnut, commonly known as peanut, is an essential oilseed-legume and supplementary food crop worldwide. In India, it is cultivated during the *kharif*, *rabi*, and summer seasons under various cropping systems. Globally, groundnut is the thirteenth most important food crop, the fourth most important source of edible oil, and the third most important source of vegetable protein. It is a significant source of oil (40–45%), protein (26%), carbohydrates (25%), minerals (phosphorus, calcium, and iron), and vitamins (vitamin B complex such as thiamine, riboflavin, niacin, and vitamin E) (Ali et al., 2023). Additionally, peanuts have a high proportion of unsaturated fatty acids, including essential fatty acids like linolenic and linoleic acids (Sacks et al., 2017; Sui et al., 2018). Known by various names such as "wondernut," "poor man's cashew nut," "monkey nut," "earth nut," or "king of oilseeds," groundnut not only provides substantial nutritional value for humans but also enhances soil fertility through nitrogen fixation (Dong et al., 2022; Stagnari et al., 2017). Groundnut plants can fix atmospheric nitrogen with the help of symbiotic bacteria called Rhizobium, enriching the soil with nutrients and improving soil fertility for subsequent crops (Sangwan et al., 2021; Fahde et al., 2023).

India, the world's second-largest groundnut producer, cultivates groundnuts on approximately 5.97 mha, yielding a total production of 10.2 mt with an average yield of 1,716 kg $ha^{-1}$ (Anonymous, 2023). In many developing countries, including India, groundnut is a crucial crop. In Gujarat, it is particularly significant in the districts of Sabarkantha, Banaskantha, Mahsana, and Kachchh, where it is grown in both the *kharif* and summer seasons. These regions cover 38,963 hectares, producing 63,533 metric tons with a productivity of 1,630.61 kg $ha^{-1}$. Gujarat leads India in groundnut cultivation, contributing 34.84% of the area and 44.31% of the country's production, with a productivity of 2,259 kg $ha^{-1}$, the second highest in the country (Anonymous, 2021–2022).

Groundnut is predominantly grown as a rainfed kharif crop, sown from June to July, depending on monsoon rains. It is critically important as a protein source for people, and its oilseed and cake are valuable as animal feed (Dash et al., 2021; Kotecka-Majchrzak et al., 2020). However, a significant yield gap between potential and actual yields persists due to several key production challenges. These challenges include labor shortages and the continued use of traditional farming methods, such as low-yielding crop varieties (Rai et al., 2020), broadcasting for sowing, inadequate plant population, and the absence of seed treatment (Singh et al., 2019). Additionally, farmers often fail to apply critical inputs, recommended fertilizer rates (Patil et al., 2018), gypsum during peg formation (Helmy and Ramadan, 2014), and are slow to adopt Integrated Pest Management (IPM) and Integrated Disease Management (IDM) practices (Priyanka et al., 2023).

Front line demonstration (FLD) is a systematic extension activity conducted by agricultural scientists in farmers' fields. It serves as a powerful tool for assessing and transferring technology to enhance agricultural production (Sangwan et al., 2021; Singh and Tetarwal, 2022). The primary aim of FLD is to promote the adoption of improved agricultural practices and technologies, crucial for innovation diffusion and enhancing productivity. Actual groundnut yield at the farm level depends significantly on management aspects related to socioeconomic and biophysical factors (Bindraban et al., 2020). By demonstrating the effectiveness of improved practices, FLD plays a vital role in bridging the yield gap and increasing profitability for farmers. Anticipated outcomes include a notable rise in productivity through the adoption of advanced cultivation techniques, better seed varieties, appropriate fertilization, and integrated pest management. Ultimately, FLD fosters rapid and widespread adoption of innovations, contributing to food security and economic stability for communities.

## 2. MATERIALS AND METHODS

The present study assessed the yield gap analysis through front line demonstrations (FLDs) on kharif (June to October) groundnut in farmers' fields in Kutch district, Gujarat, India. These FLDs were conducted during the *kharif* seasons from 2019–2020 to 2021–2022 by ICAR-CAZRI, Krishi Vigyan Kendra, Kukma, Bhuj, in the adopted villages of Anjar, Bhuj, and Nakhatrana talukas. A total of twelve villages were randomly selected for cluster front line demonstrations (CFLDs) in the three talukas of Kutch district. Materials and methods adopted for the FLDs are given in Table 1. A total of 75 CFLDs were conducted over 30 hectares at different locations, as shown in Table 2.

Before conducting the CFLDs, fundamental data on crop production techniques, soil characteristics, high-yielding varieties, and the occurrence of insect pests were collected through field PRA surveys and farmer meetings. This data helped determine the current state of groundnut production and identify necessary improvements in cultivation practices. Each FLD ranged from 0.4 to 0.8 hectares, and farmers allocated some area for cultivating existing varieties using traditional methods. Improved practices with high-yielding groundnut variety Girnar-2 and a comprehensive package of practices were demonstrated across 30 hectares. The soils in the research area were sandy to sandy loam, mostly saline-alkaline, with pH values ranging from 8.5 to 9.2 and EC values from 0.9 to 4.5 $dSm^{-1}$. The soils were low in available nitrogen, phosphorus, essential micronutrients,

Table 1: Details of compared between technological interventions and farmers practice under cluster front line demonstration programme under kharif groundnut

| Sl. No. | Operation | Demonstration plots | Farmer's plots |
|---|---|---|---|
| 1. | Variety | Girnar-2 | TG37A, GJG HPS-1 |
| 2. | Soil and seed treatment | Bavstin @ 2 g $kg^{-1}$ and Thiamethoxam @ 7 g $kg^{-1}$ or Trichoderma virde @ 10 g $kg^{-1}$ seed before one day of sowing | Generally, not practiced |
| 3. | Date of sowing | 15th June to 1st week of July | $20^{th}$ June to $15^{th}$ July |
| 4. | Method of sowing and spacing | Sowing: R×P=45×10 $cm^2$ | Line sowing, but proper spacing not maintained |
| 5. | Fertilizer N-P-K-S and Application time | FYM 5 t $ha^{-1}$, 25 kg $ha^{-1}$ N+50 kg $P_2O_5$ and soil application of zinc sulphate 33% @ 12.5 kg $ha^{-1}$ | FYM: None and 80:60:0 kg N:P:K $ha^{-1}$ |
| 6. | No. of irrigation | 12 irrigations (1–2 extra irrigations in sandy soils) | 16–18 irrigations |
| 7. | Weed management | Hand weeding/intercultural operation done twice at 20 and 40 days after sowing (DAS) | One hand weeding at 25–30 DAS and |
| 8. | Plant protection | Seed treatment with thiamethoxam 30 FS @ 7 g $kg^{-1}$ seed and bavistin @ 2 g $kg^{-1}$ seed<br>With the appearance of capsule borer and whitefly, foliar spray of chloropyriphos+cypermethrin @ 1.5 ml $l^{-1}$ and thiamethoxam 7 g $l^{-1}$ water at 15 days interval | Seed treatment not practiced. Broadly used fungicide was mancozeb (Dithane M-45) |
| | Integrated pest management | Set of pheromone traps @ 2 traps $ha^{-1}$ to monitor adult (moth) population, dusting of carbaryl 50 WP at 2 kg $ha^{-1}$ | No practices of pheromone traps<br>Spraying with dimethoate @ 0.05% or profenophos 35 ml $pump^{-1}$ |
| | Integrated disease management | Stem and collar rot: Trichoderma @ 2.5 kg $ha^{-1}$ mixed with 25 kg FYM+Seed treatment with Trichoderma @ 10 g $kg^{-1}$ seed early and late leaf spot: Two foliar spray carbendazim & mancozeb mixture @ 2 g $l^{-1}$ water) | Stem and collar rot: seed treatment Bavistin @ 2 g per kg seed, leaf spot and rust: Dithane M 45 at 0.2% spray 2–3 times at 2–3 weeks interval |

and organic carbon.

Each year, sowing was done between mid-June and the first week of July under rainfed conditions, while harvesting took place between the last week of September and the first week of October. The crop was harvested and dried for threshing when the pods and hulls turned pale yellow. As indicated in Table 1, farmers received essential inputs such as improved seeds, balanced fertilizer use, and plant protection chemicals. Farmers selected for CFLDs were instructed and provided with information on how to properly cultivate groundnut using the recommended package of practices. Conversely, farmers were permitted to carry out their own practises in the farmer's practise. Awareness programs on the importance of improved varieties and new production technologies for groundnuts were conducted by KVK staff before the season began at all locations.

For comparison, data on various parameters such as seed yield and the percentage of insect-pest and disease incidence were collected separately from both improved practice (IP) and farmer's practice (FP). The data were tabulated and analyzed using statistical tools like frequency and percentage. The extension gap, technology gap and technology index were worked out by Samui et al. (2000) as given below.

Tech. gap=Potential yield-Demo. Plot yield

Ext. gap=Demo. Plot yield-Farmer's plot yield

$$\text{Technology index} = \frac{\text{Pi-Di}\times 100}{\text{Pi}}$$

Where Pi=Potential yield; Di=Demonstration yield

Additional returns (₹ $ha^{-1}$)=Nrit-Nrfp

Where, Nrit=Net returns of improved technology (₹ $ha^{-1}$)

Nrfp=Net returns of farmers practice (₹ $ha^{-1}$)

## 3. RESULTS AND DISCUSSION

### 3.1. *Impact on yield gap*

The yield of groundnut was significantly higher in the demonstration plot compared to the farmers' practice (local check) during the *kharif* seasons from 2019–2020 to 2021–2022. According to the data shown in Table 2, better technical interventions led to a 20.08% increase in groundnut seed production, with 2215 kg $ha^{-1}$ compared to the local check yield of 1826 kg $ha^{-1}$ recorded with existing techniques (farmers' practice). Similar observations regarding the gap between improved technologies and farmers' practices were also reported by Rai et al. (2020) and Tetarwal and Singh (2021).

The average percent increase in yield of improved practices over the local check was significantly higher at 20.08%. The main reasons for the low yield of local practices in the adopted villages were the use of local variety seeds and traditional cultivation methods, along with imbalanced use of plant nutrients and poor weed management practices (Pradhan et al., 2019) However, KVK scientists used improved seed varieties and adopted scientific cultivation practices such as timely sowing, proper spacing, balanced fertilizers, timely weed control, and Integrated Disease Management (IDM) and Integrated Pest Management (IPM) measures under CFLDs, which enhanced the yield of groundnut compared to farmers' practices.

Table 2: Effect of cluster frontline demonstration on yield and percentage increase of groundnut

| Year | No. of demo | Area (ha) | Potential yield (kg $ha^{-1}$) | Demo (IP)* yield (kg $ha^{-1}$) | Local (FP)* Yield (kg $ha^{-1}$) | % yield increased over FP |
|---|---|---|---|---|---|---|
| 2019–20 | 25 | 10 | 2907 | 2372 | 1958 | 17.45 |
| 2020–21 | 25 | 10 | 2907 | 2090 | 1725 | 21.16 |
| 2021–22 | 25 | 10 | 2907 | 2183 | 1795 | 21.62 |
| Average | 75 | 30 | 2907 | 2215 | 1826 | 20.08 |
| SD | | | 0 | 143.70 | 119.55 | 2.29 |
| SEm± | | 0 | 82.96 | 69.02 | 1.32 | |
| CV(%) | | | 0 | 6.49 | 6.55 | 11.39 |

### 3.2. *Impact on economics returns*

The economic analysis of *kharif* groundnut cultivation presented in Table 3 showed the viability of improved technology over farmers' practice, calculated based on the prevailing cost of inputs and output prices, and represented in terms of the benefit-cost ratio (B:C Ratio). The three-year average cost of cultivation of *kharif* groundnut was ₹ 34,585 $ha^{-1}$ for local practices and ₹ 36,566.7 $ha^{-1}$ for demonstrations. The net returns from the demonstrations were ₹ 72,881 $ha^{-1}$, compared to ₹ 57,691 $ha^{-1}$ from farmers' practices. The B:C ratio in the demonstrations was calculated as 3.01, compared to 2.67 in farmers' practices. The additional returns over farmers' practices were significantly higher in 2021–2022 (20,116 ₹ $ha^{-1}$), followed by 2019–2020 and 2020–2021 (19,604 ₹ $ha^{-1}$ and 5,850 ₹ $ha^{-1}$, respectively).

The economic analysis indicates that the net returns and B:C ratio were higher in demonstration plots compared to farmers' plots. The higher net returns and B:C ratio in the demonstrations might be due to increased yields and higher market prices because of the better quality of output achieved through the adoption of improved technologies. Similarly, FLDs have demonstrated superior economic returns compared to traditional practices, with higher gross and net returns, as well as an improved B:C Ratio, underscoring the profitability and economic viability of adopting improved technologies in oilseed crops (Singh et al., 2019).

### 3.3. *Impact on technological gap and index*

The difference between the demonstrated yield and the yield under existing farmers' practices is known as the extension gap. The extension gap indicates increasing trends in each consecutive year of the study (Table 4). The extension gap ranged between 365–414 kg $ha^{-1}$, with an average of 389 kg $ha^{-1}$ during the reporting period. This emphasizes the need to educate farmers through various means for the adoption of improved agricultural production technologies to reverse the trend. Similar findings were reported by Singh et al. (2019), who noted extension gaps of 230 kg $ha^{-1}$ for sesamum and 280 kg $ha^{-1}$ for mustard variety CS-56. These results highlight the need for enhanced educational initiatives to promote the adoption of improved agricultural practices. Additionally, the evaluation of CFLDs by Tetarwal and Singh (2021) revealed an average technological gap of 457 kg $ha^{-1}$ in groundnut productivity and an extension gap of 418.5 kg $ha^{-1}$. This further emphasizes the necessity for targeted initiatives to facilitate the adoption of improved agricultural technologies, ultimately enhancing productivity and profitability in groundnut cultivation.

Table 3: Effect of cluster frontline demonstrations on economic parameters of *kharif* groundnut at farmers' field

| Year | Cost of cultivation (₹ ha$^{-1}$) | | Gross return (₹ ha$^{-1}$) | | Net return (₹ ha$^{-1}$) | | Additional return (₹ ha$^{-1}$) | B:C Ratio | |
|---|---|---|---|---|---|---|---|---|---|
| | IP* | FP | IP | FP | IP | FP | | IP | FP |
| 2019-20 | 36200 | 33873 | 119999 | 99055 | 84786 | 65182 | 19604 | 3.41 | 2.92 |
| 2020-21 | 36500 | 34300 | 86200 | 78150 | 49700 | 43850 | 5850 | 2.36 | 2.28 |
| 2021-22 | 37000 | 35582 | 121157 | 99623 | 84157 | 64041 | 20116 | 3.27 | 2.80 |
| SD | 404.2 | 889.4 | 19856.6 | 12236.8 | 20077.8 | 12000.2 | 8092.73 | 0.57 | 0.34 |
| Average | 36566.7 | 34585 | 109118.7 | 92276 | 72881 | 57691 | 15190 | 3.01 | 2.67 |
| SEm± | 233.3 | 513.5 | 11464.2 | 7064.9 | 11591.9 | 6928.3 | 4672.3 | 0.33 | 0.20 |
| CV (%) | 1.11 | 2.57 | 18.20 | 13.26 | 27.55 | 20.80 | 53.28 | 18.92 | 12.76 |

1USD=₹ 82.32 INR (Average monthly for the harvesting month)

Table 4: Effect of cluster frontline demonstration on extension gap, technology gap and technology index

| Year | Extension gap (kg ha$^{-1}$) | Technology gap (kg ha$^{-1}$) | Technology index (%) |
|---|---|---|---|
| 2019–2020 | 414 | 535 | 18.40 |
| 2020–2021 | 365 | 817 | 28.10 |
| 2021–2022 | 388 | 724 | 24.91 |
| SD | 24.52 | 143.70 | 4.94 |
| Average | 389 | 692 | 23.80 |
| SEm± | 14.15 | 82.96 | 2.85 |
| CV (%) | 6.30 | 20.77 | 20.77 |

The difference between the potential yield of the variety and the yield of demonstration plots is known as the technology gap. The technology gap ranged between 535 and 817 kg ha$^{-1}$, with an average of 692 kg ha$^{-1}$ during the study period. The wider gaps between farmers' practices and improved practices, with encouraging results in subsequent years, are shown in Table 4. The observed technology gap might be attributed to dissimilarities in poor soil fertility, balanced use of soil nutrients, especially with organic inputs, and the adoption of IPM and IDM practices, as well as climatic conditions such as rainfall and temperature. Dash et al., 2021, also opined that depending on the identification and use of farming situation-specific interventions, these may have greater implications in enhancing system productivity. The results indicated that the cluster front-line demonstrations have positively impacted the farming community in the demonstrated villages, motivating them to adopt improved agricultural practices and realize the gap between these and existing practices in the Western Gujarat districts. In the case of the technological index, a lower value indicates greater feasibility of the technology.

The ratio between the technology gap and potential yield, expressed as a percentage, is known as the technology index. The technology index shows the feasibility of the evolved technology at the farmers' field. A higher technology index reflects insufficient extension services for the transfer of technology. The wide range in the technology index (18.40% to 28.10%) during the study period may be attributed to differences in soil fertility status, weather conditions, non-availability of irrigation water, and insect-pest attacks on the crop. The average technology index was observed to be 23.80% from 2019–2020 to 2021–2022, as shown in Table 4. Tetarwal and Singh (2021) identified a 16.76% technology index in CFLDs for *kharif* groundnut, underscoring the yield improvements achievable through modern agricultural practice Similarly, Singh et al. (2019) reported technology indices of 37.22% for sesamum and 24.64% for mustard, underscoring the importance of educational initiatives to close yield gaps through the increased adoption of improved farming methods. Similarly, Singh et al. (2019) reported technology indices of 37.22% and 24.64% for sesamum and mustard, respectively, emphasizing the importance of educational initiatives to bridge yield gaps through enhanced adoption of improved farming methods.

## 4. CONCLUSION

The Front-line Demonstrations (FLDs) had proven the effectiveness of adopting advanced agricultural technologies in groundnut cultivation, leading to notable yield and economic improvements. Continuous extension activities like training, field days, and exposure visits, FLDs could bridge yield gaps, enhance productivity, and contribute to the agricultural development and economic stability of farmers, fostering the horizontal spread of improved practices across the region.

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