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RESEARCH ARTICLE

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A Study on Yield and Value Sustainability in Groundnut (*Arachis hypogea*) Through Cluster Frontline Demonstrations Approach in Cuddalore District of Tamil Nadu

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ABSTRACT

Background: Groundnut is a prominent oilseed crop in India but its productivity is far below the potential yield because of lack of knowledge along with adoption of enhanced varieties and technologies. The technology gap is a main issue in the production of groundnut in North Eastern zone of Tamil Nadu State in which Cuddalore district falls. A scientific and systematic effort was made to study the impact on yield by assessing the technological gap present in several components of the groundnut cultivation through cluster frontline demonstrations with scientific technologies.

Methods: Cluster frontline demonstrations were implemented in groundnut to improve the production potential of improved varieties and new technologies through Krishi Vigyan Kendra. The study with one of its objectives to assess yield and technology gap in groundnut was conducted with 175 demonstrations during the period from 2020-21 to 2022-23 covering seven blocks in an area of 70 hectares in the Cuddalore district following cluster random sampling method. Groundnut varieties VRI 8 and VRI 10 along with improved technologies were demonstrated in the farmer's field by providing necessary critical inputs along with seed drill sowing.

Result: There resulted 53.34 per cent rise in yield as observed in demonstration plots over farmers' practices in groundnut. The study revealed that in groundnut, the average extension gap of 13.95 q/ha, the average technology gap of 14.52 q/ha and the average technology index of demonstrations is 26.41 per cent. The higher average net returns (Rs. 149758/ha) were recorded in the demonstration plot (BCR 2.4) compared to the farmers' plot. The Sustainability Yield Index (SYI) and Sustainability Value Index (SVI) in demo plots are higher consistently than in farmers' plots mainly due to the effect of cluster frontline demonstrations with the proper application of inputs/technologies *viz*., VRI 8 and VRI 10 varieties, treatment of seed by using bio-fertilizers, biocontrol agents, a test of soil based nutrient management, application of TNAU crop booster groundnut rich and gypsum application.

Key words: Groundnut improved technologies, Sustainability value index, Sustainability yield index, Technology index.

INTRODUCTION

Groundnut (*Arachis hypogea*) "king" of oilseeds is a self-pollinated, important edible oilseed crop commonly known as "wonder nut" and the "poor man's cashew nut", having immense significance as both a staple food and a cash crop in our country and serves as a valuable source of essential nutrients. It provides 570 calories/100 g serving an excellent source of several vitamins B and vitamin E (Rai *et al*., 2020). In India, the groundnut crop accounts for around 37 percent of the overall oilseed output, but the productivity of the groundnut crop is far below the potential yield because of a lack of knowledge along with the adoption of improved practices (Singh *et al*., 2019). Worldwide, India stands first in the Groundnut area (54.20 lakh ha.) and second biggest producer in the world with 101 lakh tones of production and 1863 kg /ha productivity in 2021-22 (agricoop.nic.in). "In Tamil Nadu, it is an essential and major oilseed crop, covering an area of 338300 hectares with a production of 783200 tonnes with 70% of the area under rainfed crops and 30% under irrigated conditions. In Tamil Nadu, the North Eastern Zone accounts for 43% of the total groundnut area (comprised of Cuddalore, Villupuram, Tiruvannamalai, Vellore, Kancheepuram, Tiruvallur districts and parts of Ariyalur district). Because of this, this agroclimatic zone is" regarded as a primary oil seed production zone, particularly for groundnuts (https://www.ikisan.com/tn-groundnut-history.html).

Krishi Vigyan Kendra's (KVK) are grassroots-level organizations designed to apply technology *via* evaluation and refinement along with demonstration of the proven

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techniques in various micro-farming conditions within a given area. The various efforts from KVK scientists to familiarize the improved production and protection technology for groundnut cultivation in cluster mode facilities were undertaken by Bordoloi *et al.* (2021). Therefore, the Indian Council of Agriculture and Research (ICAR) introduced a program called "Cluster Frontline Demonstration" (CFLD) for Oilseeds in 2015-16 implemented through ICAR- ATARI by KVKs to improve the production potential of improved varieties and new technologies in oilseeds for better production, productivity and profitability (Swami and Verma, 2022 and Kumar *et al.*, 2019). The objective of the current research is to analyze the effect of CFLD on yield and net returns to farmers growing groundnuts by adopting improved production technologies in Cuddalore district on a sustainable basis.

MATERIALS AND METHODS

Through KVK, Cuddalore and CFLD under the National Food Security Mission (NFSM), 175 demonstrations were conducted during the period from 2020-21 to 2022-2023 in groundnut covering seven blocks *viz.* Kurinjipadi, Vridhachalam, Mangalur, Nallur, Cuddalore, Kattumannarkoil and Parangipettai covering a total area of 70 hectares in the district (Table 1) were taken into the study and the data gathered have been evaluated for Extension gap, Technology gap, Technology index, SYI and SVI. The latest TNAU short-duration groundnut varieties VRI 8 and VRI 10 demonstrated through CLFDs along with enhanced production technologies such as treatment of seed by using biofertilizer *Rhizobium, Phosphobacteria,* biocontrol agent *Trichoderma viridi*, seed drill sowing, gap filling and thinning, Integrated Weed Management, post-emergence application of herbicide, Integrated Nutrient Management, spraying of micronutrient supplement - TNAU MN mixture and Groundnut rich, application of gypsum and earthing up, Integrated Pest Management and Integrated Disease Management, farm mechanization, post-harvest management and value addition and marketing (Table 1) were demonstrated in the farmers field under CFLDs and compared with farmers local practices. Further awareness was created through training, field days, leaflets, folders and AIR Messages. KVK had formed a considerable effect on the increase in yield and income of groundnut growers in the Cuddalore district through new varieties introduction and yield maximizing technologies under CFLD.

Using the computations described by Marlabeedu *et al.* (2022) for analysing the "technology gap, technology index, extension gap and economic parameters in comparison with farmers' practice, the percent yield comparison of enhance practice with local check, district and state averages was computed. The yield impact was also evaluated.

$$\text{Impact yield} = \frac{\text{Yield of demo plot - Yield of farmer plot}}{\text{Yield of farmer plot}} \times 100$$

Extension gap = Yield in demo plot - Yield in farmer plot

Technology gap = Potential yield - Demo plot yield

$$\text{Technology index} = \frac{\text{Potential yield - Demo plot yield}}{\text{Potential yield}} \times 100$$

The SYI and SVI were computed by utilizing the following formulas to calculate the sustainability yield indices.

$$\text{SYI/SVI} = \frac{Y - O}{Y_{max}}$$

Whereas,

O = Standard deviation.

$$Y = \frac{\text{Estimated average yield}}{\text{Net return of practices over the year}}$$

$$Y_{max} = \frac{\text{Max yield}}{\text{Max net return}}$$

Periodically, the fields were observed and regularly observed at critical stages of crop sowing, vegetative, flowering, pod development and maturity by the scientists of KVK and collected yield parameters data at the time of harvest from both the demonstrated and farmers' plots. The farmers provided information on the cultivation costs and profit margins for both plots, which were then analyzed to calculate the benefit-cost ratio (BCR) and evaluate the groundnut yield and technology gap demonstrations. The findings are shown below:

RESULTS AND DISCUSSION

Performance of groundnut yield maximizing technologies through CFLD demonstrations

Yield

To estimate the yield gap, the crop's potential yield and the demonstration plot's yield were compared. The yield gap analysis was then assessed using the technology index, extension gap and technology gap. The extension gap, which displays the variation in yield among the farmers' plot and the demonstration, varied from 10.2 to 16.8 q/ha over the course of the investigation, averaging 13.95 q/ha over the course of three years (Table 2). This led to a yield increase of 53.34 percent over the farmers' plot and it is necessary to educate along with train farmers on the adoption of yield-maximizing technologies to close this significant practice gap.

Fertilizer recommendations based on soil tests and soil testing are crucial for providing crops with the right balance and quantity of nutrients (Ramamoorthy and Velathuyam, 2011). In comparison to farmers' practices, soil-test-based fertilization and gypsum application increased yield, BCR of groundnuts and soil fertility (Chari *et al.*, 2020). Because of its judicious use of fertilizers, there was a significant improvement in the soil fertility status at harvest in the demonstration plot compared to farmers' practice (local check) will save fertilizer doses (Thentu and Nagarjuna, 2023 and Naveen and Senthilkumar, 2021).

Table 1: Cluster random sampling method and demonstrated groundnut technologies under CFLD during 2020-21 to 2022-23.

CFLD year/total demos	Cluster	Blocks	No. of villages	Area in ha	No. of demos	Demonstrated groundnut technologies under CFLD
2020-2021	I	Kurinjipadi	22	10.4	26	**Seed and sowing**
(100)	II	Vridhachalam	5	15.6	39	➢ TNAU short duration varieties VRI 8 and VRI 10.
	III	Mangalur nallur	3	12.4	31	➢ Seed treatment with biofertilizer *Rhizobium,* Phosphobacteria@ 1 kg/ha and bio control agent trichoderma viridi @ 4 g/kg of seeds.
	IV	Cuddalore	5	1.6	4	
		Kattumannarkoil				➢ Seed drill line sowing (30 x 10 cm) @seed rate 80 kg/ha.
2021-2022	I	Kurinjipadi,	7	5.2	13	**Intercultural operations**
(25)	II	Parangipettai	1	4.8	12	➢ Gap filling and thinning.
2022-2023	I	Kurinjipadi,	11	13.2	33	➢ Integrated weed management - Hand weeding @ 15th and 35th DAS or Post emergence application of herbicide on 20-25th DAS @ 500 ml/ha.
(50)	II	Mangalur	1	6.8	17	
	Total		53	70	175	**Integrated nutrient management**
						➢ Soil testing and NPK application; basal application and top dressing @ 20 DAS followed (Available NPK 152:12:184 kg/ha and applied fertilizers are 55 kg urea, 315 kg superphosphate and 125 kg potash).
						➢ Soil application of TNAU micro nutrient mixture @ 12.5 kg/ha; Foliar spray of TNAU groundnut rich @ 5 kg/ha at peak flowering and pod development stages.
						➢ Application of gypsum @ 400 kg/ha at 40-45 DAS and earthing up.
						Integrated pest and disease management
						Harvest and post-harvest management
						➢ Farm mechanization- Hand pulling and stripping by machine.
						➢ Post-harvest management and value addition and marketing.

Table 2: Performance of groundnut technologies under CFLD on yield, extension gap, technology gap and technology index during 2020- 21 to 2022-23. (n= 175)

Year	No. of demos	Variety		Yield (q/ha)		Increase of yield over the control (%)	Extension gap (q/ha)	Technology gap (q/ha)	Technology index (%)
		Demo plot	Farmers plot (control)	Demo plot	Farmers plot (control)				
2020-21	100	VRI 8 and IT	GJG7	38.45	28.25	36.11	10.20	16.55	30.09
2021-22	25	VRI 8 and IT	VRI 2	41.68	26.83	55.35	14.85	13.32	24.22
2022-23	50	VRI 10 and IT	G7	41.30	24.50	68.57	16.80	13.70	24.91
Total/average	175			40.48	26.53	53.34	13.95	14.52	26.41

• IT- Improved technologies.

Table 3: Impact of improved production technologies under CFLD on economics of groundnut during 2020-21 to 2022-23. (n=175)

Year	Cost of cultivation (Rs/ha)		Gross returns (Rs/ha)		Net returns (Rs/ha)		BC ratio		Additional returns in improved practices			
	Demo	control	Demo	control	Demo	control	Demo	control	Additional cost of cultivation (Rs/ha)	Additional gross returns (Rs/ha)	Additional net returns (Rs/ha)	Incremental BC ratio
2020-21	99314	106763	240735	156533	141422	49771	2.42	1.47	7449	84202	91651	11.30
2021-22	125613	106563	248204	151563	122591	45000	1.98	1.42	-19050	96641	77591	-5.07
2022-23	102558	98787	287820	146731	185262	47944	2.81	1.49	-3771	141089	137318	-37.41
Average	109162	104038	258920	151609	149758	47572	2.4	1.5	-5124	107311	102187	-10.39

*Demo- Improved groundnut technologies; Control- Farmers plot practices.

Technology gap

The technology gap depicts the gap of the potential yield of the crop over the demonstration yield and varied from 13.32 to 16.55q/ha having an average of 14.52 q/ha (Table 2). Farmers are being negatively impacted by the technology gap as a result of poor extension efforts and noncooperation in the demonstration of improved technologies. This could be explained by a number of factors, including crop suitability, soil fertility status, fluctuations in sowing dates and meteorological factors.

Technology index

The viability of various varieties and other yield-maximizing technologies in farmers' fields is indicated by the technology index. The more feasible something is, the lower its technology index value is. The technology index is a percentage (%) that is based on the technology gap. The lower adoption of enhanced technologies by farmers is indicated by the higher value of the technology index. With an average of 26.41 per cent, the three-year technology index in demonstrations ranged from -24.22 to 30.09 per cent (Table 2). The KVK Scientists' interventions and the farmers' adoption of yield-maximizing groundnut practices were the reasons for the lower technology index. The lower technology index was supported by timely and need-based recommendations from KVK scientists and extension staff, as well as by favourable climate conditions and a low prevalence of pests and diseases.

Same observations have been observed by Arunkumar *et al.* (2023) observed 22.24 per cent groundnut pod yield hike in demonstration plots than farmers' practices. Having higher mean net returns and a B: C ratio of 2.35 than local practices, the demonstration plots' average means for the technology gap, extension gap and technology index have been computed to be 564 kg/ha, 281.20 kg/ha and 26.75 per cent, respectively. This suggests that enhance agronomic technological practices have a higher potential to rise the productivity of groundnut through CFLD. Same findings have been registered by Lakhani *et al.* (2020), Dash *et al.* (2021) and Ali *et al.* (2022). Similar findings in the Extension gap were observed by Patil *et al.* (2018), the Technology gap by Thentu and Nagarjuna (2023) and the Technology index by Pawar *et al.* (2018) and Nagar and Solanki (2020).

Economics

The yield, variable costs and variations between the market price and minimum support price are the primary determinants of economic returns. Input cost and labor wage values fluctuated over time. Based on the input and output costs that were in effect at the time of the study, the economic viability of enhanced methods over farmers' practices has been determined. When compared to farmers' practices (Rs. 104038, 151609 and 47572/ha, respectively), with an average BCR of 1.5, improved practices recorded a higher average cost of cultivation (Rs. 109162/ha), gross returns (Rs. 258920/ha) and net returns (Rs. 149758/ha) (Table 3). Furthermore, an additional gross return of Rs. 107311/ha and an additional net return of Rs. 102187/ha were observed over an average of three years in improved practices compared to farmers' practices, with an incremental BCR of 10.39 (Table 3).

According to Lakhani *et al.* (2020), average net returns and gross returns in CFLDs were found to be higher than those of farmers' practices, with average net returns being 52.21 percent higher (BCR 2.49 in CFLD and 1.86 in farmers' practices). Groundnut productivity significantly increased as a result of CFLD of improved variety combined with proven technology intervention techniques in farmers' fields. This raised farmer income levels and enhanced the standard of living for the farming community. These findings are consistent with those of Sonawane *et al.* (2016), who found that groundnut IBCR increased when mechanization was applied, as well as Thentu and Nagarjuna (2023).

Table 4: Effect of improved technologies on pod yield, net returns, SYI and SVI in groundnut during 2020-21 to 2022-23.

Particulars	2020-21		2021-22		2022-23	
	Demo	Control	Demo	Control	Demo	Control
Pod yield (q/ha) max	44.1	33.1	46.39	30.12	50.2	29.9
Pod yield (q/ha) min	32.8	23.4	36.97	23.54	32.4	19.1
Mean pod yield (q/ha)	38.45	28.25	41.68	26.83	41.30	24.50
SD	5.65	4.85	4.71	3.29	8.90	5.40
CV %	14.69	17.17	11.30	12.26	21.55	22.04
Net returns (Rs/ha) max	152626	54980	146251	58146	224649	59940
Net returns (Rs/ha) min	130218	44561	98931	31854	145875	35948
Mean net returns (Rs/ha)	141422	49771	122591	45000	185262	47944
SD	11204	5210	23660	13146	39387	11996
CV %	7.92	10.47	19.30	29.21	21.26	25.02
SYI	0.74	0.71	0.80	0.78	0.65	0.64
SVI	0.85	0.81	0.68	0.55	0.65	0.60

*Demo- Improved groundnut technologies; Control- Farmers practices; SD- Standard deviation; CV- Coefficient of variation; SYI- Sustainability yield index; SVI- Sustainability value index.

Sustainability yield index and sustainability value index

The higher values of SYI and SVI have been observed in the demo plot than in the farmers' plot. The SYI ranged from 0.65 to 0.80 in the demo plot while in the farmers' plot recorded 0.64 to 0.78. SVI was 0.65 to 0.85 in the demo plot whereas, in the farmers plot, it was 0.55 to 0.81 (Table 4). The enhanced method exhibited the highest coefficient of variance and standard deviation in contrast to the farmer's practice (Table 4). Variations in yield in farmers' fields resulting from improved practices could be the cause. Based on the data, it can be inferred that the enhanced technology is more environmentally friendly than farmers' practices. Reager *et al*. (2022) shared a similar opinion, stating that improved methods produced a higher and more sustainable yield over time in comparison to farmers' practices. By comparing it to the farmer's practice, the mean pod yield registered with enhanced practices was 24.39% high. Improved methods also outperformed farmers' practices in terms of incremental BCR (30.1), gross water productivity (16.58~m^{-3}), net water productivity (11.89~m^{-3}), SYI (0.63), SVI (0.47) and water expense efficiency (74.92 kg ha^{-1} cm^{-1}). *Rabi* pulses had lower SYI (0.45-0.60) as compared to *Kharif* (0.67-0.83) with black gram SYI 0.67 and summer (0.67) indicating clearly that *Rabi* pulses can be further exploited for their potential yield especially in lentil and chickpea by improving per unit production to get highest SYI level (Singh *et al*., 2023).

CONCLUSION

The research disclosed that the scientific method of groundnut cultivation adopting high-yielding varieties and modern scientific technologies resulted in 53.34 per cent rise in yield than the traditional method of farmer's practices which is detrimental to soil health and the environment. Through the efforts of CFLD in groundnut the average technology gap, extension gap and technology index have been 13.95 q/ha, 14.52 q/ha and 26.4 per cent correspondingly. The higher average net returns (Rs. 149758/ha) were recorded in the demonstration plot (BCR 2.4) in comparison to the farmers' plot. The SYI (0.65 to 0.80) and SVI (0.65 to 0.85) in demo plots are consistently higher than farmers' plot mainly due to the effect of integration of improved groundnut technologies *viz*., short-duration groundnut VRI 8 and VRI 10 varieties, treatment of seed by using bio-fertilizers, soil test based nutrient management, use of biocontrol agents, application of TNAU crop booster groundnut rich and gypsum application. By trying to teach the farming community to adopt more advanced production technologies for groundnut productivity that is sustainable, cluster front-line demonstrations could significantly increase the yield potential of groundnuts.

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Ethics and conflict of interest

The research is carried out as per research ethics and no conflict of interest is involved.

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