Efficacy of Natural Farming over Chemical Farming
The Case of Andhra Pradesh

S GALAB, C S MURTY, G BHASKARA RAO

A comparison of costs, yields, and returns from natural farming versus chemical farming in Andhra Pradesh during 2019–20 saw natural farming in better stead compared to chemical farming. The claim made by Das et al (2024) that natural farming could pose a threat to food security due to its low yields compared to conventional methods is critically examined. Natural farming is found to be effective in AP, using data from 2022–23. This is relevant, especially in light of the state's recent pre-monsoon dry sowing policy initiative.

The authors thank R Radhakrishna for his guidance in the IDSAP (2020) study. They also thank T Vijay Kumar for his encouragement at various stages while undertaking successive IDSAP studies. They are grateful to an anonymous referee for comments on an earlier draft of the paper, which helped improve it substantially.

S Galab (*sgalab@cess.ac.in*), C S Murty (*csmurty52@gmail.com*) and G Bhaskara Rao (*bhaskararao.gorantla@gmail.com*) are with the Institute for Development Studies Andhra Pradesh, Visakhapatnam.

It has been over 50 years since we began experimenting with the seed–fertiliser–irrigation technology in India. The technology was first given a try at a time when the excessive import of foodgrains became unavoidable to feed the country's population, and as a consequence, the sovereignty of the country was at stake. It promptly heralded a revolutionary increase in crop yields. However, all is not well with the technology. Introspection throws up many disturbing facets. It aided an increase in the yields merely of two crops, wheat and rice. It bypassed nutri-cereals and pulses, the regions lacking assured irrigation facilities, and in the initial years, the weaker sections, including small and marginal farmers and agricultural labourers. Thus, it aggravated regional disparities and interpersonal inequalities. The industries supplying fertilisers, pesticides, and agricultural machinery benefited more. The increase in crop yields, in the face of the increased cost of cultivation, did not translate into a proportionately higher farm business income for the farmers. While this is so, the response of yield to fertiliser use decreased gradually, necessitating farmers to apply ever greater doses of the chemicals to soils. This exacerbated the degradation of soils and added to costs.

Deteriorating soil health, declining yields, increasing inequalities, and mounting cost of cultivation warranted a fresh look at our agrarian scene. Natural farming, a chemical-free traditional farming method, evolved as a response to these nagging problems of chemical farming. The Government of India has taken the initiative and has been propagating natural farming in a campaign mode. Andhra Pradesh (AP) is at the forefront of this campaign. The AP government launched Zero Budget Natural Farming in 2016, under the aegis of Rythu Sadhikara Samstha (RYSS), which after changes in its focus and nomenclature, came to be called Andhra Pradesh Community Managed Natural Farming (APCNF or simply CNF). Under this, farmers are trained in the nuances of natural farming. The government aims to train all six million farmers, and in the process, cover eight million hectares of land in the state by 2031. The scheme has so far reached about 10.5% of the farmers. We take up several dimensions of natural farming and pit them against corresponding aspects of chemical farming to examine whether the prospects for the spread of natural farming are bright in the state. We also address some of the salient points raised in a National Bank for Agriculture and Rural Development (NABARD) and Indian Council for Research on International Economic Relations (ICRIER) report (Das et al 2024) questioning the superiority of natural farming over chemical farming.

Methodology

This paper is based on a larger study titled Impact Assessment of APCNF, conducted by the Institute for Development Studies Andhra Pradesh (IDSAP 2020), Visakhapatnam, for the state government, covering primarily 2019–20. Towards the end, it cites study results that subsequently covered 2022–23 (IDSAP 2024). The design of the experiment is such that it compares farmers adopting the CNF method with those following non-CNF practices. In the context of AP, the non-CNF practices involve farming with inorganic fertilisers and pesticides along with a modest amount of farm yard manure (FYM), whereas the package of practices that make up the core of CNF method are the concoctions laid down by Subhash Palekar and include treatment of local seeds with microbial (*beejamrutham*), incorporation of microorganisms into soil (*jeevamrutham*), cover crops for biomass mulching (*achadana*), and aeration (*waapasa*). To protect crops from pests and insects, CNF prescribes farm-made concoctions called *kashayams* and *asthrams*. The use of dung and urine of livestock (and not necessarily those of *desi* cow as prescribed by Palekar), neem leaves, chillies, jaggery, gram flour, garlic, tobacco, sour buttermilk, and so on are used as inputs for several of the practices. The CNF practices as followed in AP allow for the use of FYM as well.

The results of the study assume significance because the sample size is large and spread over the entire state and because yields of the sample farmers are estimated through crop-cutting experiments (CCEs) carried out as per the standard methodology laid down by the Indian Agricultural Statistics Research Institute (IASRI), followed by the National Sample Survey Office (NSSO), and the Directorate of Economics and Statistics (DES), Government of Andhra Pradesh. The results pertaining to 2019–20 presented in the paper follow from the village survey data collected from a sample of 1,040 farmers practising CNF and 650 farmers practising non-CNF in kharif, and a sample of 520 farmers practising CNF and another 520 practising non-CNF in rabi, and tests some contentious and a few established propositions advanced in the literature on natural farming.

Objectives and Hypotheses

For a farmer to take to a new practice, its efficacy should appeal to him. This applies equally to natural farming. Despite government support and propaganda, farmers are hesitant to practise natural farming. Although there are a few dissenting voices (Das et al 2024), it is generally agreed that natural farming is ecologically sustainable as it arrests soil degradation. However, its economic viability is questionable. The uneven adoption of natural farming across the country suggests that the costs, yields, and returns associated with it may not be sufficient to induce the farmer to blindly adopt it. Our purpose here is to compare the costs, yields, and returns of CNF with those of non-CNF to comment on the viability issue. We work with the village survey data of AP to know if the prospects for the spread of CNF are bright in the state. The prospects for the spread of CNF could be considered bright provided: (i) paid-out costs per hectare are lower under CNF compared to non-CNF; (ii) crop yields per hectare under CNF are higher than under non-CNF; (iii) CNF output commands a higher price per quintal than non-CNF output; (iv) the value of output per hectare is more under CNF compared to non-CNF; (v) gross returns per hectare from CNF are higher than under non-CNF, and (vi) net returns per hectare under CNF are higher than under non-CNF. Armed with the knowledge that CNF is efficacious, the government could work with conviction while propagating the farming method.

We scrutinise these issues by employing the survey data of the two groups of AP sample farmers. The comparison is attempted crop-wise to hold constant the crop-specific characteristics. Whatever differences we find in costs, yields, and returns should therefore be attributed to the farming method (CNF or non-CNF) and not to the crop grown. It may be noted in the passing that the characteristics of farmers also impact economic viability, and ideally, we should hold constant farmer-specific characteristics. This warrants that we compare the costs, yields, and returns of the farmers devoting part of their land to CNF and part to non-CNF, that is, we should work with mixed farmers. However, in this paper, we control only for crop-specific characteristics and not for farmer-specific attributes.

Results of the 2019–20 Survey

(i) **Paid-out costs:** Only the paid costs are considered in the survey. These include the actual expenses incurred in cash or in kind by an owner to procure seeds, inorganic fertilisers, FYM, pesticides, biological inputs, human labour, bullock labour, machine labour, and the cost of irrigation. The imputed value of family labour is not considered uniformly for both CNF and non-CNF. The paid-out costs as accounted for correspond to Cost A1 as laid down by the Commission for Agricultural Costs and Prices (CACP). To the extent that farmers practising CNF put in more family labour in cultivation, the cost arrived at by us is an underestimate. The paid-out costs incurred by farmers in kharif, rabi or both (in 2019–20) in the cultivation of 15 crops figure in the paper. Barring a couple of exceptions, the sample farmers under each crop are large, and therefore, our results assume significance.

To begin with, we test the hypothesis that paid-out costs are lower under CNF than those under non-CNF for each of the crops (Table 1, p 47). The statistic used to test this proposition is the ratio of the paid-out costs under CNF to the costs under non-CNF, expressed as a percentage. It is less than 100% in respect of all the crops (13 out of 13) in the kharif season and also less than 100% in the rabi season with three exceptions (out of 11). These observations generally validate our hypothesis that paid-out costs are lower under CNF than those under non-CNF (that too by a big margin). The statistic is invariably less than 100% with respect to the major crops such as paddy, groundnut, cotton, chillies and sugar cane. This is to be expected because the cost of inorganic fertilisers and pesticides accounts for the bulk of the paid-out costs and these are zero under CNF and quite large under non-CNF.

(ii) **Yields:** The apprehension, widely held among the stakeholders of natural farming, is that the yields under the method would be lower than under chemical farming. Such a worry garners support from not using inorganic fertilisers and pesticides (the use of which brought about a revolutionary increase in yields in the 1970s and 1980s) on the farms covered under natural farming. How true is this fear? We have arrived at the yields of major crops, based on CCEs, on the farms under CNF and those under non-CNF, crop-wise, and for the two seasons seeking to answer this question (Table 2).

In the kharif season, yields of three out of 13 crops, namely cotton, maize, and sugar cane cultivated under CNF lagged behind those under non-CNF. The yields under CNF as a percentage of those under non-CNF account for less than 100, but by a small margin. Again, in the rabi setting, four out of 11 crops, namely paddy, Bengal gram, chillies, and onion, recorded lower yields under CNF as compared to non-CNF; the relevant statistic is less than 100% for the four crops. These findings make us suspect the validity of the hypothesis (that crop yields are higher under CNF than under non-CNF). Note, however, that no single crop returned a lower yield in the former method compared to the latter, in both the kharif and the rabi seasons. This makes one pause before denouncing CNF.

(iii) **Prices commanded by crop output:** A priori, one can say that the output price of crops produced under the natural farming method commands a higher price than under chemical farming, as the former method is free of harmful chemical residues. Therefore, consumers willingly pay a premium for such output. To test the hypothesis that output prices are higher under CNF than under non-CNF, we arrived at the percentage of the former to the latter (Table 3). In the kharif season, except for cotton and maize (two out of 13 crops), the prices are higher for CNF output. On the other hand, the rabi prices are lower for CNF output in the case of five out of 11 crops, though not by a large margin. The benefit of higher prices commanded by crop output under natural farming may wane if more and more farmers take to natural farming and seek to sell their output in the market. Therefore, the price cannot be used as a criterion for promoting this method.

(iv) **Value of output:** Yield valued at market price gives the value of output, which we show in Table 4. The value of output under CNF as a percentage of that under non-CNF for different crops is not unexceptionally higher. The percentages are less than 100% for cotton, black gram, and maize in the kharif season. In the rabi season, they are less for Bengal gram, jowar, ragi, and onion. Our assessment of the relative value of output needs to be qualified because no single crop returned a lower value under CNF compared to non-CNF, in both the kharif and rabi seasons.

Table 1: Paid-out Costs under CNF as a Percentage of Those under Non-CNF by Crop and Season, 2019–20

Crop Name	Kharif	Rabi
Paddy	80.77	84.52
Groundnut	90.92	83.81
Cotton	64.03	NA
Bengal gram	66.55	72.55
Black gram	79.49	121.12
Maize	81.53	82.59
Red gram	66.70	NA
Chillies	74.23	71.13
Green gram	NA	129.16
Jowar	98.11	81.22
Sugar cane	96.68	NA
Sesamum	NA	123.68
Ragi	58.07	86.97
Onion	60.93	57.59
Turmeric	68.73	NA

Source: Authors' calculations based on IDSAP (2020).

Table 2: Yields under CNF as a Percentage of Those under Non-CNF by Crop and Season, 2019–20

Crop Name	Kharif	Rabi
Paddy	106.25	94.12
Groundnut	100.92	103.70
Cotton	97.08	NA
Bengal gram	106.67	87.50
Black gram	123.24	102.40
Maize	95.28	108.94
Red gram	106.24	NA
Chillies	108.70	92.00
Green gram	NA	114.62
Jowar	110.41	101.87
Sugar cane	98.86	NA
Sesamum	NA	132.83
Ragi	123.53	100.00
Onion	109.23	87.62
Turmeric	109.70	NA

Source: Authors' calculations based on IDSAP (2020).

Table 3: Prices under CNF as a Percentage of Those under Non-CNF by Crop and Season, 2019–20

Crop Name	Kharif	Rabi
Paddy	107.12	110.98
Groundnut	106.92	103.30
Cotton	99.84	NA
Bengal gram	106.51	106.41
Black gram	101.54	100.57
Maize	94.49	96.13
Red gram	111.37	NA
Chillies	102.83	123.64
Green gram	NA	114.00
Jowar	103.50	95.20
Sugar cane	111.28	NA
Sesamum	NA	96.78
Ragi	102.65	91.82
Onion	114.13	92.98
Turmeric	100.48	NA

Source: Authors' calculations based on IDSAP (2020).

Table 4: Values of Output under CNF as a Percentage of Those under Non-CNF by Crop and Season, 2019–20

Crop Name	Kharif	Rabi
Paddy	113.81	104.46
Groundnut	107.89	107.11
Cotton	96.93	NA
Bengal gram	113.61	93.09
Black gram	86.95	102.98
Maize	90.02	104.73
Red gram	118.34	NA
Chillies	111.77	113.74
Green gram	NA	130.66
Jowar	114.26	96.95
Sugar cane	110.16	NA
Sesamum	NA	128.55
Ragi	126.84	91.81
Onion	124.67	81.46
Turmeric	110.23	NA

Source: Authors' calculations based on IDSAP (2020).

(v) Gross returns: Together, the value of output (of crops) and by-products makes for gross returns. The percentage of gross returns from CNF to those from non-CNF is less than 100% only in the case of cotton and maize in the kharif season (Table 5). In other words, gross returns per hectare are higher under CNF than under non-CNF in 11 out of 13 crops in the season. In the case of rabi, the ratio is less than 100% for four crops, namely Bengal gram, jowar, ragi, and onion. However, in the case of the crops that returned less than 100%, it is so either in kharif or in rabi, but not in both seasons.

(vi) Net returns: Here, we address the question of whether the lower paid-out costs under CNF translate into higher net returns (gross returns minus paid-out costs) for the crops under consideration (Tables 6 and 7). In the kharif season, except in the case of maize, the percentage of CNF to non-CNF is much higher than 100% for all the crops. In the rabi season too, net returns are much higher under CNF than under non-CNF for all crops other than black gram and ragi, with the statistic far exceeding 100%. Thus, the data almost unexceptionally validate the hypothesis that net returns are higher under CNF than under non-CNF.

The above analysis considers the economic viability of only major crops and ignores a few other crops that are grown. The extent of land area devoted to each of the other crops is not always distinguishable, but they make a significant contribution to household income. These crops include bund crops, kitchen gardens, vegetables, fruits, flowers, tree crops, mixed crops, and so on. Animal husbandry, which is an integral part of CNF, is another source of income. If one were to consider the income derived from them, the estimate of household income could differ significantly. Thus, what we have is a diversity of income sources. One way to account for all these incomes, along with that from major crops, is to arrive at a diversification ratio of income (such as the Herfindahl index) at the household level, separately for CNF and non-CNF farmers (Reddy 2022). As we do not have income data separately for each of the other crops, we are unable to arrive at any such index. We, however, have net income data from animal husbandry which works out to ₹20,315 and ₹16,277 per household for the CNF and non-CNF farmers respectively. The attendant consequence of this is that the CNF farmers have a more stable cash flow than the non-CNF farmers.

Table 5: Gross Returns under CNF as a Percentage of Those under Non-CNF by Crop and Season, 2019–20

Crop Name	Kharif	Rabi
Paddy	113.14	102.05
Groundnut	105.53	106.33
Cotton	96.89	NA
Bengal gram	113.73	93.48
Black gram	125.21	102.43
Maize	89.03	104.40
Red gram	119.64	NA
Chillies	111.77	113.74
Green gram	NA	131.15
Jowar	111.28	97.50
Sugar cane	108.33	NA
Sesamum	NA	128.44
Ragi	118.08	88.77
Onion	124.67	81.46
Turmeric	110.26	NA

Source: Authors' calculations based on IDSAP (2020).

Table 6: Net Returns under CNF as a Percentage of Those under Non-CNF by Crop and Season, 2019–20

Crop Name	Kharif	Rabi
Paddy	165.72	114.60
Groundnut	123.81	121.67
Cotton	265.65	NA
Bengal gram	281.90	216.07
Black gram	167.08	98.08
Maize	94.74	121.31
Red gram	461.39	NA
Chillies	139.58	122.45
Green gram	NA	131.52
Jowar	123.51	173.62
Sugar cane	118.81	NA
Sesamum	NA	132.57
Ragi	149.36	90.28
Onion	143.06	113.27
Turmeric	126.20	NA

Source: Authors' calculations based on IDSAP (2020).

Contentious Conclusions of the NABARD–ICRIER Report

Our conclusions, based on field surveys and reported in the Consolidated 2019–20 Report of the Institute for Development Studies submitted to the Rythu Sadhikara Samstha in Andhra Pradesh (IDSAP 2020), are contested in a research study of NABARD–ICRIER (Das et al 2024) based on the results of the field trials carried out by the Indian Council of Agricultural Research–Indian Institute of Farming Systems Research. The trials were conducted over the Basmati rice–wheat cropping system in at four location in northern India: Uttarakhand, Punjab, Haryana, and Uttar Pradesh for three years (rabi 2017 to kharif 2020). The NABARD–ICRIER study notes that notwithstanding the low input cost, returns from zero-budget natural farming (ZBNF) are low due to low yields. It notes that the cost of cultivation was lower for rice and wheat by 22.6% and 18.2% respectively, under ZBNF (under concoctions) than under the Integrated Crop Management (ICM) (which is said to approximate the conventional practice). The returns fetched were also 58% lower in ZBNF. The yield outcomes for Basmati and wheat were lower by 37% (in 2019–20) and 53.9% (in 2018–19) respectively than under ICM. The study also predicted a 32% and 59% decline in Basmati rice and wheat yields, respectively, from the current levels if ZBNF is adopted on a large scale, jeopardising food security.

Table 7: Summary Table, 2019–20

Costs and Returns	Kharif	Rabi
	Number and names of crops where CNF turns out an unfavourable statistic relative to non-CNF out of 13 crops	Number and names of crops where CNF turns out an unfavourable statistic relative to non-CNF out of 11 crops
Paid-out costs	0	3 (black gram, green gram, sesamum)
Yield	3 (cotton, maize, sugar cane)	4 (paddy, Bengal gram, chillies, onion)
Price	2 (cotton, maize)	5 (maize, jowar, sesamum, ragi, onion)
Value of output	3 (cotton, maize, black gram)	4 (Bengal gram, jowar, ragi, onion)
Gross returns	2 (cotton, maize)	4 (Bengal gram, jowar, ragi, onion)
Net returns	1 (maize)	2 (black gram, ragi)

Source: Compiled from Tables 1–6.

The differences between the conclusions reached in the two studies have much to do with the choice of the variables employed in comparisons. Our (IDSAP 2020) study compares CNF with non-CNF wherein the package of practices under CNF corresponds to concoctions as recommended by Palekar with the difference that FYM is also used, whereas, for those under non-CNF, the package comprises inorganic fertilisers, pesticides, and FYM. In the geographical setting of AP, the non-CNF as defined here corresponds to "conventional practices," and CNF is termed efficacious because it records yields at least comparable to non-CNF.

In contrast, the NABARD–ICRIER study compares yields under ZBNF with concoctions and ICM. These variables may be seen to be different from those employed in the IDSAP (2020) study. The test variable, ZBNF with concoctions, in the NABARD–ICRIER study, is at variance with CNF with concoctions under the IDSAP study as it does not account for the use of FYM. However, the use of FYM could have a decisive influence on yields (Kumar et al 2020). On the other hand, the control variable ICM in the NABARD–ICRIER study, which is said to approximate conventional methods of the region, differs from that under IDSAP and allows for the use of 50% of inorganic inputs and 50% of organic inputs. Thus, the comparison of the results of the IDSAP study with the NABARD–ICRIER study is not beyond reproach.

Next, it is possible to explain why the yields in the NABARD–ICRIER study under ZBNF concoctions are way below those under ICM. The quantum and composition of inputs used under the conventional method (ICM) are at variance between IDSAP and NABARD–ICRIER studies. What is time-tested in AP is different from that in the northern part. So much so that for the natural and chemical farming methods to give comparable results for yields, the natural farming inputs used in these two regional settings must also be tailored to their specific regional conditions. The package of practices followed under CNF in AP that returned yields at least on par with non-CNF should not be expected to do so in the north. It is suggested that the ZBNF practices laid down by Palekar need to be adapted to suit the regional needs to make it efficacious. Failure to accommodate a different quantum and composition of ZBNF inputs under field trials should be held responsible for the disappointing performance of ZBNF over ICM as reported in the NABARD–ICRIER study. One size does not fit all. To repeat, the set of ZBNF concoctions that return yields comparable to those under the conventional farming methods of AP need not bring in yields comparable to those under the conventional farming methods of northern India.

Let us now move away from questionable comparisons and concentrate on the larger issue of environmental sustainability and food security. Consider the following two arguments: (i) the NABARD–ICRIER report contends that natural farming endangers agroecological sustainability because its soil carbon content is low and its concoctions cannot supply the nitrogen adequate for the healthy growth of the plant. So, it is argued, that as time passes by, yields decline with natural farming; (ii) it is an acknowledged fact that yield response to inorganic fertiliser use has been on the decline over time. Since the unabated use of fertilisers has been going on for decades, it could also turn farming methods reliant on fertilisers (chemical farming) unsustainable; it could also undermine yields. To repeat, if natural farming is unsustainable as per (i), chemical farming too is unsustainable as per (ii).

It follows, therefore, that the unsustainability problem is not unique to only one of the farming methods. Meanwhile, CNF in AP, coupled with the now popular pre-monsoon dry sowing (PMDS), appears to slow down or even reverse this process because it facilitates crop diversification and increases land use efficiency. We now turn to look at the data pertaining to 2022 and 2023 to reflect on the impact of the AP government's initiatives of the recent past.

Recent Developments

In AP, the institutional infrastructure with RYSS at the helm is propagating PMDS among the farmers covered under CNF in recent years. PMDS is a system of sowing, tilling, and tending the land wherein the farmer grows crops in the non-farming season. It rests on the principle that land should always be kept covered. PMDS protocol involves the use of 12 kilograms of seed per acre of land, treating seeds with beejamrutham, pelletising the seeds with *ghanajeevamrutham*, spraying *dravajeevamrutham*, and later mulching and using a layer of soil to protect mulching. The mulching material spread on the

field as part of PMDS acts as a catalyst to harness water vapour from the atmosphere that drops to the field in the form of early morning dew. This may have given further impetus to the diversified cropping pattern, which in general is the hallmark of CNF. This has now taken deep roots. Under PMDS, a number of food, vegetables, fodder, and leguminous crops are grown during the dry period (March–May/June) before the onset of monsoon. This helps fix nitrogen in the soil, keep crop cover over fields and thereby retain moisture, besides supplementing household income. In 2021–22, the average paid-out cost (Cost A1) per hectare under PMDS cultivation is estimated in an interim report of IDSAP (2022) at ₹21,140 and the average gross return per hectare at ₹39,075. Thus, in the summer months, when the farmers' cash flow is at its lowest, PMDS enabled CNF farmers to reap a surplus of ₹17,935 per hectare.

We are now in a position to report the costs, yields and net returns of CNF and non-CNF farmers for the agricultural year 2022–23 based on our field survey of 1,331 CNF and 731 non-CNF farmers in kharif and 917 CNF and 586 non-CNF farmers in rabi (Table 8). We comment on the economic viability of CNF households who were chosen from among those who practised PMDS in the pre-monsoon season of 2022. We henceforth call them, PMDS+CNF practitioners. Unlike in 2019–20, when the difference in paid-out costs between CNF and non-CNF farmers turned out to be negative and favourable for almost all the major crops considered, in 2022–23 it was positive and statistically significant for one crop and not significantly different for the rest of the 10 crops. There is a definite sign that paid costs are on the increase under PMDS+CNF and this will have a dampening effect on per-hectare net returns.

The curious case, however, is the yields of the major crops. The tests show that the yields under PMDS+CNF are significantly greater for three crops and about the same in the case of the remaining eight. Next, the difference in net returns between the PMDS+CNF and non-CNF farmers is positive in eight cases and negative in three. It is greater by 27% on average under PMDS+CNF. In recent years it is observed that paid-out costs and gross value of output are both increasing under PMDS+CNF. While the increase in the former has a dampening effect on net returns, the increase in the latter has an enhancing effect on it. Therefore, PMDS together with CNF is generally found to return yields at least on par with non-CNF and positively impacts net returns.

Table 8: Percentage Difference between PMDS+CNF and Non-CNF (Select Parameters, Kharif + Rabi, 2022–23)

Crop Name	Paid-out Costs	Yield	Net Returns
Paddy	-13*	-0.68	36
Groundnut	2	1.60	8
Cotton	-1	4.67	+ Very large
Bengal gram	-5	9.44*	17
Maize	-11*	9.15*	31
Black gram	21*	6.84	-1
Red gram	1	10.72	+ Very large
Chillies	-28	-4.59	42
Green gram	10	-5.61	-12
Ragi	19	-1.64	-32
Tomato	1	24.31*	+ Very large
Average	-9		27

* Significantly different.
Source: IDSAP (2024).

Table 9: Mean Values of LER for PMDS+CNF Farmers and Non-CNF Farmers (Kharif + Rabi, 2022–23)

Type of Farm	Land Equivalent Ratios of		Difference in the Ratios between PMDS+CNF Farmers and Non-CNF Farmers	
	PMDS+CNF Farmers	Non-CNF Farmers	Difference	Percentage Diff
Multi-crop farm (MCF)	3.33	2.81	0.52	18.51
Sole-crop farm (SCF)	1.12	1.00	0.12	12.00
Difference in the ratios between MCF and SCF	2.21	1.81	–	–
Percentage difference	197.32	181.00	–	–

Source: Authors' calculations from field surveys.

A new dimension of agriculture in recent years is the rise of inter-cropping/multi-cropping. Both PMDS+CNF and non-CNF households are participating in these methods. Inter-cropping/multi-cropping is known to increase yield stability, increase total yield, control pests and diseases, help in weed management, and contribute to soil fertility (Yahuza 2011). It can augment the land available for cultivation. To arrive at the land use efficiency under inter-cropping/multi-cropping, we employ the land equivalent ratio (LER) (Reddy 2022; Yahuza 2011; Deb and Dutta 2022). It is well understood that LER indicates the yield advantage of multi-crop farms over sole-crop farms.

$$LER = \sum (IY_i/SY_i)$$

where i is the number of crops grown either one after the other or simultaneously during 2022–23 on a given piece of land; IY is the intercrop yield (yield per hectare of each crop where multiple crops are grown); and SY is the sole-crop yield (yield per hectare on mono-cropped land).

While calculating the LER of a farm, it is required to arrive at the partial LERs for each crop grown first and then add them to know the LER of the farm in question. The LERs reported in Table 9 are the means of the individual farms. The denominator used while calculating the partial LERs is the sole-crop yield, which in our exercises is the average sole-crop yield of the corresponding crop attained on the non-CNF farms.

If we are assessing the LER of a sole-crop farm (under PMDS+CNF or non-CNF), we need to divide the sole-crop yield on the farm with (as chosen here) the average of sole-crop yields on non-CNF farms. Next, crops other than the major crops (11 in all and listed in Table 8) are also considered when calculating LER provided it is possible to assess their yields (per hectare). (Another point by way of clarification is that in cases where a crop is not harvested on the date of survey, the corresponding LER is taken as 1.)

It is expected that LER for the multi-crop farms would be greater than that for the sole-crop farms under PMDS+CNF because PMDS along with CNF practices could positively impact the intensity of land use and yield. That is, there could be within-group variations (variations among PMDS+CNF farms) in LER.

It is further expected that LER for PMDS+CNF farms would be greater than for non-CNF farms when we consider sole-crop farms and multi-crop farms separately due to the adoption of PMDS and CNF practices. The corresponding differences in LER are called between group variations (that is, variations between PMDS+CNF and non-CNF farms).

To repeat, we expect: (i) the LER of sole-crop farm under PMDS+CNF to be greater than that under non-CNF, (ii) the LER of multi-crop farm under PMDS+CNF to be greater than under non-CNF, and (iii) the LER of multi-crop farm to be greater than sole-crop farm both under PMDS+CNF and non-CNF.

The LERs reported in Table 9 demonstrate that the overall crop yields of multi-crop farms are superior to those of solo-crop farms irrespective of whether one follows PMDS+CNF or non-CNF. Further, as expected in (i), the sole-crop farms of PMDS+CNF farmers are on average 12% more efficient than those of non-CNF farmers. Next, corresponding to (ii), the multi-crop farms of PMDS+CNF farmers are 18.51% more efficient than those of non-CNF farmers. As per (iii), the multi-crop farms are 197.32% more efficient than the sole-crop farms under PMDS+CNF, whereas in the case of non-CNF farmers, they are 181% more efficient. Note that within-group variations in land use efficiency are larger than between-group differences. What matters most is that PMDS+CNF farmers do not trail behind non-CNF farmers; yields under PMDS+CNF are not lower than those under non-CNF to endanger food security.

Conclusions

To conclude, PMDS and CNF can generate income year-round by virtue of their land-augmenting character. It facilitates crop diversification, is income-enhancing, and does not endanger food security. Now the question is: Can one justify CNF without PMDS?

In conclusion, PMDS and CNF can generate income throughout the year due to their land-augmenting character. This facilitates crop diversification and increases income, all without endangering food security. The question now is: Can CNF be justified without PMDS?

The question may be dismissed as purely hypothetical because CNF farmers now recognise the income-stabilising influence of PMDS. Even if one were to assume this as a serious question. We submit that CNF can: (i) prove to be efficacious as it was in 2019–20 before PMDS came into effect, (ii) supplement and stabilise household incomes by making animal husbandry an integral part, (iii) reduce the reliance on the farmer in the imperfect market for agricultural inputs, especially credit, (iv) secure the health of the farm family as also of the public at large, (v) ensure better crop health, (vi) make the standing crops climate resilient, (vii) absorb surplus labour, (viii) beget respect for the CNF community of farmers, and (ix) contribute to the sustainability of the environment.

In 2018, when the union government set the ambitious target of doubling farmers' income by 2022–23, it sparked intense debate across the country over the feasibility of accomplishing the goal. Many scholars argued that the focus should be on doubling the real income of farmers from alternative sources, rather than solely on income from agricultural cultivation. For example, Chandrasekar and Mehrotra (2016) analysed data from the Situation Assessment Surveys of 2003 and 2013. They made the necessary adjustments to ensure that the two surveys were comparable and concluded that the real income of farmers did not double between 2003 and 2013. Similarly, Dev (2023) compared the Situation Assessment Surveys of 2013 and 2018–19 and concluded that there was a marginal rise in farmers' real income from ₹6,426 to ₹7,775. This amounts to only a 21% increase in farmers' real income in six years.

Both Chandrasekar and Mehrotra (2016) and Dev (2023) show that farmers' incomes in real terms had not doubled even over a period exceeding five years. This period coincides with the widespread practice of chemical farming. Will the situation change with the practice of natural farming? It is likely that the real incomes of farmers could double within five years if we replace chemical farming with natural farming? Can natural farming succeed where chemical farming failed? Scholars are doubtful about natural farming's potential (Narayanamoorthy and Alli 2023; Das et al 2024). We have not experimented with natural farming long enough to answer this question definitively. However, our study shows that farmers derive higher net returns from CNF than non-CNF. Therefore, other things remaining the same, the prospect of doubling farmers' real income is better with CNF than with non-CNF. Our study shows that net returns from CNF are higher than those from non-CNF, suggesting a higher income for farmers practising CNF. Since income from cultivation constitutes a significant portion of farmers' total income, accounting for 48% in 2013 (Chandrasekar and Mehrotra 2016), the prospects of doubling farmers' real income are more promising with the CNF method of farming than with the non-CNF alternative.

REFERENCES

Chandrasekhar, S and N Mehrotra (2016): "Doubling of Farmers' Incomes by 2022: What Would it Take?" *Economic & Political Weekly*, Vol 51, No 18, pp 10–13.

Das, S, M Khurana and A Gulati (2024): "Zero Budget Natural Farming: Implications for Sustainability, Profitability and Food Security," NABARD-ICRIER, NABARD Research Study No 43.

Deb, D and S Dutta (2022): "The Robustness of Land Equivalent Ratio as a Measure of Yield Advantage of Multi-crop Systems over Monocultures," *Life Science and Biomedicine, Experimental Results*, Vol 3, No e2, pp 1–13.

Dev, S Mahendra (2023): "Agriculture and Rural Areas in Budget 2023-24: A Need for Comprehensive Approach for Transformation," *Economic & Political Weekly*, Vol 58, No 12, 25 March, pp 50–53.

IDSAP (2020): "Impact Assessment of APCNF, Consolidated Report, 2019–20," Institute for Development Studies Andhra Pradesh, Visakhapatnam.

— (2022): "Assessing the Impact of APCNF: Pre-monsoon Dry Sowing, First Interim Report 2021–22," Institute for Development Studies Andhra Pradesh, Visakhapatnam.

— (2024): "Assessing the Impact of APCNF, Final Report, 2022–23," Institute for Development Studies Andhra Pradesh, Visakhapatnam.

Kumar, R, S Kumar, B S Yashavanth, P C Meena, P Ramesh, A K Indoria, S Kundu and M Manjunath (2020): "Adoption of Natural Farming and its Effect on Crop Yield and Farmers' Livelihood in India," Collaborative Research Project Report, Indian Council of Agricultural Research—National Academy of Agricultural Research Management, Hyderabad.

Narayanamoorthy, A and P Alli (2023): "Zero-budget Natural Farming: Can It Double Farmers' Income?" *Economic & Political Weekly*, Vol 58, No 10, 11 March, pp 27–29.

Reddy, N D (2022): "Agroecology and Sustainable Smallholder Agriculture: An Exploratory Analysis with Some Tentative Indications from the Recent Experience of 'Natural Farming' in Andhra Pradesh," *IASSI Quarterly: Contributions to Indian Social Science*, Vol 41, No 3, pp 233–71.

Yahuza, I (2011): "Review of Some Methods of Calculating Intercrop Efficiencies with Particular Reference to the Estimates of Intercrop Benefits in Wheat/faba Bean System," *International Journal of Biosciences (IJB)*, Vol 1, No 5, pp 18–30.