

ECONOMICS OF ECOLOGICAL AGRICULTURE

(An Over View of Conventional, Chemical and Ecological Crop Production Systems in Deccan Plateau)

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1. Introduction

In its most developed form, ecological farming is both a philosophy and a system of agriculture. The objectives of environmental, social, economic sustainability and dry land agro bio-diversity conservation lies at the heart of ecofarming. Ecofarming is a form of mixed cropping system still prevalent in dry land soils of Zaheerabad taluk of Deccan plateau. Even though rainfall of the region ranges from 850 to 1100mm, crop failures are quite common due to aberrant weather conditions such as prolonged dry spells, rains at harvest etc. To overcome these melodies, small farmers practice a system of agriculture with 12 or more traditional crops and following organic farming methods on their small land holdings, which is a blend of ethics, traditional experience, scientific knowledge and pragmatism. Their production systems are ecologically sound and economically remunerative than conventional mono cropping and chemical agriculture with hybrid varieties. A study was undertaken by Deccan Development Society to investigate how the bio-diversity of the region is maintained by some farmers on their land and to assess the economic viability of their practices before promoting them to other farmers.

2. Methodology

The whole study was participatory with night schoolteachers and scientists of Krishi Vigyan Kendra and it was progressed for 4 seasons starting from 1999 Rabi. There is a data collection format particularly developed for this purpose. The information of the farms in each village was recorded every alternate day by visiting each farmer's house at night and interacting with them about their activities in the farm. Night school teachers who are active investigators in this study collected the data. The purpose of selecting the night school teachers is that they are from same village and are not outsiders; this makes it easy for them to visit each farmer's house every alternate day to collect the relevant information. Further, they themselves are farmers and have a good rapport with other farmers.

Box 1 Research Team

A group team of spirited farmers of the respective village conducted the ecological study. They are all literate farmers and educated up to upper primary standard and have some experience of recording various farm activities. They documented the information by farmers. For this work, a small honorarium was paid. Apart from this work, they also teach non-formal education to children during night hours.

P. Lakshmaiah: Aged 42 years and studied up to class VIII. He is basically a medium farmer in Narsapur Village of Jharasangam Mandal. Apart from traditional millets, he is also raising other commercial crops like coriander, soap etc in his 6 acres of dry land. He is teaching adult literacy in the same village.

M. Raju: Aged 30 years and Studied up to class VII. He is basically a medium farmer (Owned 8.5 acres land) in Hulgera village of Raikode Mandal. Apart from traditional millets, he is also raising commercial crops like Sugar cane under irrigated situations.

B. Narayana: Aged 48 years and completed school education. He is a small farmer and raising traditional millets. He is educating 30 people in his Pyalaram village of Jharasangam Mandal.

M. Hanumantha Reddy: Aged 52 years, and studied up to class VIII. He is a large farmer owning about 15 acres of rainfed land. He is educating 52 people in his 'Bopanpally' village of Jharasangasm Mandal.

C. Sundar Raj: A young farmer from Jeeerlapally village and studied class XII. He had 6 acres of dry land.

P. Yadaiah: Aged 26 years and completed school education. He had 5 acres land and completely rainfed. He is educating 36 peoples in Devarampally village.

S. VijayKumar: Aged 18 years and School education complete. He is very young farmer and cultivating the diverse crops in his 7 acres dryland in Kalbemal village of Nyalkal Mandal.

B. Kistaiah: He is permaculture expert aged 30 and collecting the data in Bidaekanna village.

N. Ratnam: Aged 35 years, and studied up to Intermediate. He had 2 acres of dry land and cultivating the traditional varieties and collecting the data in Madri village.

3. Farms and Classification

Zaheerabad region is mostly an agrarian area. There are a number of crops and cropping systems are prevailing in this region. The range of crops is from Sorghum to commercial sugarcane under well irrigation. Three distinct farming system in operation and can be differentiated as below based on the guidelines set by FAO 2000 (See the box below) They are ecological, conventional and chemical types differentiated based on the type of inputs used for raising the crops.. The ecological farmers reuse their own seed, inputs and practice a subsistence of farming. The conventional farmers use seeds purchased from the seed outlets employ tractors and other things that have come in to life by way of modernization. Their choice of crops depends on the market rather than home needs. Another class use high yielding varieties, chemical fertilizers and pesticides for crop production.

Ecological Agriculture should fulfill the following requirements in order to be environmentally sound, non-consumptive, economically viable, socially just, and culturally compatible.

- Meet the demands of local geography, particularly climate and topography.
- Enhance and build on natural process, mainly through organic recycling such as organic recycling such as nutrient recycling, nitrogen fixation, and pest-predator relationships;
- Increase bio-diversity and genetic heterogeneity
- Generate only non-accumulative and bio-degradable waste and bio-products;
- Require low energy consumption, preferably using renewable resources and recycling more of their wastes and products;
- Use local materials and energy
- Require available capital investment and affordable maintenance;
- Build on locally understood technologies and use proven techniques to reduce the incidence of failure;
- Involve local people in its introduction and development and use existing or easily adaptive skills;
- Be accessible to, and self-reliant among farmers and rural people, and adaptable to their management capacities.

(FAO 2000)

Based on the available literature on ecological farming, the present study farms can be put under three categories as detailed below (See). The farms under category –I can be put under ecological farms, while under category –III as Chemical farms. The intermediate category as conventional as these farmers are having the past history of using fertilisers and pesticides and currently practicing monocropping (ignoring crop rotations), which is market oriented.

Table 1: Differentiation of farms in Deccan Plateau of Zaheerabad region.

Criteria Used	Category- I	Category II	Category III
Seeds	Purely local & land races. A part of farm produce is used a seed.	Use of Improved and some times local. Often purchased from Seed outlets.	New varieties, Hybrids. Purchased from seed out lets.
Livestock integration	Followed	Often followed	May or may not be followed
Energy	Animal traction	Mixed traction	Mixed traction
No of crops/varieties	Often more than 6 crops and each crop at least 2-3 varieties	Monocrop or intercropping	Monocrop or intercropping
Agriculture diversity	More	Less	No
Manures	Used	Often used	May or may not be used
Fertilizers	Never used	Often used	Used
Plant protection	Use of traditional practices	Use pesticides in the past history	Complete dependence on pesticides
Use of Own inputs	More	Low	Very low
Role of woman	Traditional role is maintained	Tends to be undermined (in terms of women employment)	Completely undermined
Economy of the farms	Mostly subsistence	Market oriented	Market oriented
Element of Risk (Crop loss)	Very less	High	Very High
Usage of farm produce	Wholly Consumed in home, and some part is conserved as seed	Some part consumed, some part marketed and some retained as seed	Wholly marketed and nothing is retained as seed
Type of farms	Purely organic farms	Organic farms by default	Chemical farms
Classified in to	ECOLOGICAL	CONVENTIONAL	CHEMICAL

The study was initially focussed in 14 villages belonging to 6 mandals of Zaheerabad region. The study initiated in 1999 Rabi season and continued up to 2001 Kharif season. In each village,

approximately 20 farms were selected for study Thus in the study 206 farms were studied out of which 65 are ecological, 92 are conventional and 49 are chemical farmers. These farms according to the above categorization were grouped and economic data was gathered. During the process any cultural significance and indigenous practices are also documented.

Table 2 Classification of the farms in the study

Sn o	Village	Ecological farmers	Conventional farmers	Chemical farmers
1	Basanthpur	Lalamma, Manickamma, Narasamma, Nelamma.	Bayamma, Kamalamma Malamma, Manick, Mogulappa, Nagamma, Pulamma Punyamma, Ratnamma Santhosamma, Siddamma	Eswaramma Kamalamma Laxamappa Nagappa
2	Bidaekanne	Bujjamma, Paramma Ratnamma, Sukeertamma Tukamma	C. Tulijamma, Chandramma Pushapmma, Rangamma Sammamma, Sangamma	Anushamma, Ashamma P. Tuljamma, Punyamma Sankaramma
3	Bopanpally		Balamani, Bharatamma. Manemma, Manemma Mogulamma, Nagamma Narsamma, Narsamma Ratnamma, Sammamma Tuljamma	Anishamma Mallamma
4	Danwar	Bichamma, Eswaramma Manemma, Nagamma Nigamma, Paramma Ratnamma, Sukamma	Ch Manemma	Hanumamma Manikayya
5	China Hyderabad	Bagamma, Bujjamma Kamalamma, Nagamma Nagamma (w/o Jateppa), Narasamma, Tukamma		Narasappa Yelappa
6	Devarampally	B. Ambamma, B. Sankaramma Bichamma, G. Ashamma G. Gangamma, N. Bichamma V. Sasikala, Y. Chandramma	Ch. Paramma, G. Gangamma G. Narasamma, G. Yellamma K. Paramma, K. Narasamma P. Narasamma	A. Veramma G. Mallanna G. Sivanna M. Narsimulu
7	Guntampally		Gangamma, Hamsamma Lakshamma, Mallamma P. Tulijamma, Tulijamma	Anjireddy, Narsimulu Sham Rao, Vital Reddy
8	Hulgera	Durgamma, G. Mogulapp	Manemma	Mosappa, Mahamudsab

		a Lingappa,M.Mogulapap Mastansaheb,Nagesh Narasamma,Narasappa Ramappa,Saidamma Siddappa.		Anjanna,Janamma Lingamma
9	Kalbemal		Bhagyamma,Fakruddin Gopamma,Kallamma Kantamma,Khajamouniddi n Mariyamma,Sangamma Saraswathi,Tippamma Tukkamma	Babupatel,Eswar
10	Jeerlapally		B. Balamma,B. Kistamma B . N a r a s a m m a , B . Pullamma B.Ratnamma,B.Sanganna D. Bichamma,D. Narasaiah D. Narrasamma,D.Ramamma D.Ratnamma,K. Bubamma K.Satyamma,N.Laxamma	B.Venu,B.Vittal Reddy G.Manaiah,N.Kistaiah N.Sanganna
11	Khanzamalpur	Bagamma, Manemma Pentamma, Ratnamma Sangamma,Sangamma (w/o Sangareddy),Singamma.	Chandramma Sangamma (w/oSangonda)	Bojireddy, Ramreddy Sangareddy, Vital Reddy
12	Madri	Anushamma, Balamma Balappa, Narasamma Narsamm, Shantamma Shivamma	Buvanamma, Kamalamma P.Narsamma, Padmamma Shantamma, Tejamma Tulijamma, Yelamma	B.Anjamma, Chandramam M.Anjamma, Manemma R.Anjamma
13	Narsapur	G.Lakshamma Sangamma	Anjamma, Kistraiah Lakshmayya,Lakshmayya Manemma,Nagamma Nagamma,Sankaramma Sankarayya	Anjireddy Manick Reddy Surareddy
14	Pylaram	Eswaramma, Narsamma Ningamma, Sammamma Tuljamma, Yellamma	Bagamma,Mallamma Paramma,Ratnamma Sankaramma	Gopanna Yellagonda

Note:-

- Sample farms used for the study
- This does not refers the actual proportion of farmers practicing each type of agriculture in a given village.

The reasons why these three categories of farmers raise crops are presented by taking a case study of three selected farms (SeeBox 2). We can visualize how the ecological farmers strive to minimise the risk factor inherent to arid regions through mixed farming and livestock diversification to derive the multiple benefits of crop diversity and to get milk, meet draught power by way of livestock diversification in dry land agriculture. The conventional and the chemical farmers do not follow these principles to some extent.

Box 2The Three categories of Farms in Deccan plateau

Category –I

Ex: Balappa and Narsamma, China Hyderabad.

They have raised 15 crops (8 varieties of cereals and millets, 2 oil seed crops, 5 varieties of pulse crops) in their 1-acre land. Their family size is 6 with 1man, 2 women and 3 children. They have 2 bullocks, 2 buffaloes, and 2 sheep. He is a classical ecological farmer and he never used any chemical fertilizers /pesticides and hybrid varieties.

The reasons for raising particular crops narrated by him self are

- White Sorghum (*Tella Jonna*): The grain is the best for rote making and gives sufficient fodder for livestock, *Tella Jonna* is high yielder than other Sorghum varieties.
- Yellow Sorghum (*Patcha Jonna*): The grains are best for rote making and this rote can be kept for a long time.
- Bajra (*Sajja*): For rote making
- Fox tail Millet (*Korra*): as food, and valued for its quality to health.
- Little millet (*Sama*): The grains are used as food and gives cooling effect to body in summer
- Little millet (*Kodi Sama*): The grains are laxative and gives cooling effect to body in summer
- Arika (*Argulu*): The grains are more nutritive and good for health.
- Finger millet (*Ragi*): For preparation of malt and `polas`
- Blackgram (*Desi minumu*): for dhal and increases soil fertility through leaf fall.
- Creeper gram (*Teega Pesari*): for dhal and increases soil fertility through heavy leaf fall
- Cow peas (*Bebbarlu*): Eaten as boiled vegetable and increases soil fertility.
- Field Beans (*Anuvulu*): Eaten as boiled vegetable and increases soil fertility
- Redgram (*Togari*): Used as dhal and increases soil fertility by leaf fall
- Niger (*Gaddi Nuvvulu*): for chutneys and cooking oil extraction.
- Sesamum (*Manchi nuvvulu*): for chutneys and oil extraction.

Category-II

Ex: Lalappa and Pulamma, Basanthpur:

They have raised Sorghum crop in his 1-acre red chalka soil with mono crop Sorghum. They had the past history of using chemical fertilizers/ pesticides for their crops and stopped since from the past 2years. The reason for stopping the use of chemicals is due to bad effect on soil and health.

They had no bullocks but has 2 buffaloes and 15 goats. The reasons for raising mono crop Sorghum are to get more grain for their big family of 12 with 4men, 2women and 6 children (3 male and 3 female). Their farm is a classical conventional agricultural farm where forced to get more staple food and fodder for livestock.

Category-III

Ex: D. Lakshmappa, Basanthapur:

They have raised Hybrid Sorghum + Redgram in his 2 acre farm. His family size is 6 with 2 men and 4 women and no children. He had no livestock due to lack of children to look the animals. He is pure chemical farmer and totally dependant on synthetic fertilizers for crop production. He has used Hybrid Sorghum, which is high Yielding and needs chemical fertilizers for good returns. His farm is one of the best examples for chemical Agriculture with hybrid seeds and chemical fertilizers and pesticides.

4. Soils and Nutrient Status

After one year of the study, the soil samples were drawn from selected farms ie 19 from ecological, 92 from conventional and 30 ecological farms were drawn and sent to Soil Testing Laboratory, Sanagareddy for analysis. The laboratory report reveals the following:

Table 3 Chemical properties and Nutrient status of different farms.

Property	Ecological	Conventional	Chemical
Soil pH range	6.7- 7.8	6.6- 7.2	6.4- 7.4
Electrical Conductivity Range (dsm-1)	0.20-0.33	0.24-0.32	0.26-0.37
Organic Carbon status a) High b) Low c) Medium	High in 42% samples Medium in 58% samples No samples with low status	No sample with High organic carbon status Medium in 32% samples Low in 68% samples	No sample with high organic carbon status. Medium in 47% samples Low in 53% samples
Available Phosphorus Range (Kg/ha)	3.6-5.76	1.44-4.32	0.72-2.88
Available Potassium Range (Kg/ha)	240- 289	277-308	¹ 141-243

¹ Available P Content is Low (below 10 kg/ha), medium (10-24.6 kg/ha) and high (24.6 kg/ha). Similarly, Available K content is low (Below 108 kg/ha), medium (108-280 kg/ha) and High (above 280 kg/ha).

From the above results, it is clear that; soil pH is more or less same for all the soils. The analysis clearly shows that, relatively more number of samples indicated high organic carbon content in ecological farms than in conventional and chemical farms where none of the sample indicated high organic carbon content. The available P content of all the soils are low in status but relatively more P levels were found in ecological farms than in the conventional and chemical farms. Almost all the samples had indicated medium in potassium content except a very few samples in chemical farms in which available potassium levels were quite low.

5. Agro-Biodiversity of the Deccan Plateau

Unlike in coastal Andhra Pradesh, the Deccan area of Zaheerabad had a wide variety of cultivated crops with definite cultural significance. In the Deccan Plateau, genetic diversity is manifested in not only in food crops like sorghum, millets, pigeon pea, chickpea, groundnut, but also in fruit crops like mango (See Box 3). For instance, 18 crops including 55 varieties are in cultivation during the Kharif season. In rabi season, 12 crops including 36 varieties are in cultivation. Within sorghum, there are 9 varieties reported (Box 4). Thus, the Zaheerabad tract of Deccan plateau is one of the richest areas of the country in terms of agricultural crop diversity.

Box 3 Crops of the Drylands

Zaheerabad region of Deccan area is predominantly rainfed and is characterized by many land races, which were flourished once upon a time. They play a crucial role in festivities, rituals and ceremonies. A total of 86 traditional varieties representing 30 crops are in cultivation. These are well preserved and conserved by ecological farmers. These farmers raise 12-20 crop varieties in their fields with their own seeds and manure produced from his backyard livestock. These crops grow with nature and are commonly refer them as "Crops of Truth." A brief description of each crop varieties is presented here.

- ☒ Sorghum (*Sorghum Vulgare*): Five distinct varieties , white, yellow, red, spotted, creamy white grain types are in cultivation in addition to maldandu, Saya jonna and Kakimuttani jonnalalu .
- ☒ Bajra (*Pennisetum typhoides*): two distinct varieties of different sizes are in cultivation
- ☒ Maize (*Zea mays*): yellow variety
- ☒ Foxtail Millet (*Setaria italica*):white, red and black
- ☒ Finger Millet (*Eleusine coracana*): white and common red varieties.
- ☒ Little Millet (*Panicum miliaceum*): black and common white variety.
- ☒ Proso Millet (*Paspalum scrobiculatum*): Common Arika
- ☒ Dry Paddy (*Oryza sativa*): Bold, plumpy and red varieties
- ☒ Green gram (*Phaseolus aureus*): There are 4 different varieties that vary in size, colour and surface texture.
- ☒ Black gram (*Phaseolus mungo*): Two common diverse varieties of black gram that differ in pod length are commonly grown in this area .
- ☒ Red gram (*Cajanus cajan*): Four varieties with varied colours (white, spotted, black and red)
- ☒ Horse Gram (*Dolichos biflorus*): Three varieties with varied colours (white, black and common red).
- ☒ Cowpeas (*Vigna sinensis*): Three varieties with varied colours (white, black and red varieties).

- Field Beans (*Dolichos lablab* var. *Lignosus*): Three varieties with varied colours (white, black and red varieties).
 - Sesamum (*Sesamum indicum*): Two-varieties (Black and White seeded varieties).
 - Niger (*Guizotia abyssinica*): one variety
 - Castor (*Ricinus communis*): Two varieties vary in size and surface texture.
 - Hibiscus (*Hibiscus cannabinus*): Two flower types vary in colour (Red and white)
 - Safflower(*Carthamus tinctorius*): common bold seeded variety
 - Coriander (*Coriandrus sativus*): Small seeded variety.
 - Wheat (*Triticum vulgare*): 3 land races (*Mullu godhumalu, katte godhumalu and Budda godhumalu*)
 - Ground Nut (*Arachis hypogaea*): 2 land races ; Small podded and large podded types
 - Chickpea (*Cicer arietinum*): 3 local varieties differently coloured (Light brown, black and white)
 - Mustard (Brassica sps): 2 local varieties
 - Peas (*Pisum sativum*): 2 land races brilliantly colored red and white.
 - Lentil (*Lens ascularis*) one local variety.
 - Linseed (*Linum usitatissium*): one local variety.
 - Lathyrus (*Lathyrus sativus*) one local variety is reported.
 - Chillies (*Capsicum sp*) one stringent podded vegetable mirch.
 - Onions (*Allium sp*): brilliantly colored bulbs
- Besides these crops, commercial crops like cotton, ginger, turmeric and sugarcane are also in cultivation.

6. Crops and cultivars

In an ecological farm, mixed cropping with 12 or more food grains are done after the commencement of first shower of rains. (Mostly first fortnight of June) and harvesting commences in mid of September to January months depending on the duration of component crops. It is taken up mostly in shallow red soils where water-holding capacity of soils is very poor and Rabi cropping is not feasible. The fields are again prepared at the end of March; farmyard manure is applied and kept ready for pre shower sowings. In some instances, short duration Green manuring pulse crops like Green gram or black gram is raised in Kharif season. After picking up of pods from these crops, the biomass was ploughed and rabi cropping is taken up with at least 2 varieties of Sorghum, Bengalgram, and safflower, Coriander, Linseed etc. Where as, in conventional and chemical farmers use improved varieties and they mostly restricted to monocropping of Sorghum in Kharif and Bengalgram in Rabi. Besides these monocroppings some farmers also practice intercropping (Table 4 and Figure 1).

Table 4 Major crops and cropping systems in ecological, conventional and chemical agriculture.

Season	Soil type	Crops - Varieties		
		Ecological	Conventional	Chemical
Kharif	Black/red	Traditional crops and varieties <input checked="" type="checkbox"/> At least 2-4 varieties of Sorghum, 3-4 minor millets (Finger millet/Fox	Improved or traditional varieties are in use and Without any chemicals <input checked="" type="checkbox"/> Black gram/ greengram alone,	Improved or traditional varieties are in use and With Fertilisers and Chemicals. <input checked="" type="checkbox"/> Black gram/

		tail millet/Little millet/Aria), 4-5 pulse crops, 2-3 oilseed crops, 2 varieties of Hibiscus are cropped.	<input checked="" type="checkbox"/> Blackgram + fodder Sorghum, <input checked="" type="checkbox"/> Sorghum alone <input checked="" type="checkbox"/> Sorghum+ Red gram	greengram alone, <input checked="" type="checkbox"/> Blackgram + fodder Sorghum, <input checked="" type="checkbox"/> Sorghum alone <input checked="" type="checkbox"/> Sorghum + Red gram
Rabi	Black soils	Traditional varieties <input checked="" type="checkbox"/> Mixed cropping with at least 2 varieties of rabi Sorghum, chickpeas, safflower, linseed, coriander, lentil, lathyrus, mustard, vegetable chillies etc.	Either improved or local varieties. <input checked="" type="checkbox"/> Rabi Sorghum alone <input checked="" type="checkbox"/> Chickpea alone <input checked="" type="checkbox"/> Coriander alone <input checked="" type="checkbox"/> Safflower alone <input checked="" type="checkbox"/> Chickpea+safflower	Either improved or local varieties <input checked="" type="checkbox"/> Rabi Sorghum alone. <input checked="" type="checkbox"/> Chickpea alone <input checked="" type="checkbox"/> Coriander alone <input checked="" type="checkbox"/> Safflower alone <input checked="" type="checkbox"/> Chickpea+safflower

7. Economic functions of different production Systems:

7. 8Kharif Season:

In Kharif season, sorghum is the main crop in the ecological farm and they crop at least 2-3 varieties of these along with a wide choice of the crops as listed above (See Table 4 and Box 4 for more details) in varied dimensions.

<p>Box 4 Genetic Diversity of Sorghum in Deccan Plateau</p> <p>Sorghum is the common staple food crop of the Deccan people after rice. The region has a large genetic diversity in sorghum. Some of them are locally known by grain color while others have names of cultural significance.</p> <p><input checked="" type="checkbox"/> <i>Patcha Jonna</i>: The grain is yellow color and grown in Kharif season. The grain had excellent rote making quality and keeps well.</p> <p><input checked="" type="checkbox"/> <i>Tella Malle Jonna</i>: The grains are pure white in color and grown in Kharif season. Best for rote making.</p> <p><input checked="" type="checkbox"/> <i>Yerra Jonna</i>: The grains are brilliant red colored and kharif grown of mediocre quality for rote.</p> <p><input checked="" type="checkbox"/> <i>Atta kodalla Jonna</i>: The grains are dull white in color and often used for rote.</p> <p><input checked="" type="checkbox"/> <i>Maldandu Sorghum</i>: This is another white grain type grown in Rabi season.</p> <p><input checked="" type="checkbox"/> <i>Pelala Jonna</i>: The grains are having good popping quality, hence the name.</p> <p><input checked="" type="checkbox"/> <i>Kaki Muttani Jonna</i>: The seeds are differently spotted and it is early maturing land race. The crop comes to maturity in 3 months and when no crop comes to harvest, poor people often eat it. Hence the name "<i>Gharib Jonna</i>".</p> <p><input checked="" type="checkbox"/> <i>Sai Jonna</i>: This is Rabi variety and its grains are white in color. Excellent for rote making.</p> <p><input checked="" type="checkbox"/> <i>Thoka Jonna</i>: This variety is characterised by loose heads and good fodder yielder and resistant to Smuts. Rains at harvest cause little damage to the crop.</p>

7.1. 0Seeds

The ecological farmers has utilized seed produced from the farm by following the indigenous methods such as mixing with cow dung ashes and dried neem leaf and storing them in bamboo basket and plastering with dung. The cost of seeds was approximately Rs 76 when taken in to account. Even though there are a number of crops and varieties, the total expenditure on seeds was quite less when compared to chemical farming with hybrid varieties. In conventional farming, most of the case farmers have borrowed from other farmers by a custom (*Nagu*), which is more prevalent in this region. The chemical farmers has purchased Hybrid Sorghum seed from the market at the cost of Rs 100 for 4 kg and some times used the own seed of red gram from the produce of last year. The sorghum seed produced from his farm cannot be used for sowing in next year due to loss of hybrid vigor. The chemical agriculture with high yielding hybrids leads to total dependence on market for these inputs. Contrary to this, in ecological farming control lies on farmer's own hands.

7.1. 0 Ploughing and Harrowing

In most of the cases, ecological farmers with own or hired animal draught power has invested very less when compared to the conventional and chemical farms. The advantage with draught power and possession of live stock as narrated by most of ecological farmers are timely farming operations (such as ploughing, harrowing, sowings and inter cultivation,) which affects the crop yield besides subsidiary income from various livestock by-products such as milk, meet and manure for recycling of the crop residues. As a major provider of organic manure, livestock is crucial to the stability of dryland agriculture.

7.1. 0 Sowing

The ecological farmers invested very little for sowing Rs 60 while in the chemical farms the expenditure was Rs 155 which was to higher energy costs of farm tractor. Interestingly, when tractors are used on the farms the uncultivated flora was disappeared. This is attributed to the deep ploughing with tractor, which makes the seeds to fall into deeper layers of soil and unable them to germinate.

7.1. 0 Manures and Fertilisers

In ecological and conventional farms, the usage of crop residues recycled through livestock is important. The residues had pronounced effect on crops and had residual effect. In chemical farming, most of the farms receive either Urea or DAP (Diammonium Phosphate) but not the Potassic and other micronutrient fertilizers. This results in imbalances in fertilization. Even when the costs involved are taken into consideration, FYM is the cheapest nutrient reservoir for crops. On an average 1 ton of FYM costing Rs 200 supplies 7 kg Nitrogen, 14kg Phosphorus and 20kg Potassium besides ample quantities of different micronutrients that are essential for crop growth and quality grain production. Thus, the major nutrient value of FYM costs Rs 240 when supplied it through mineral fertilisers and its residual effects were spread over at least 3 seasons. Further, the Chemical fertilizers change the Soil pH and alter the beneficial soil micro flora and fauna. The chemical fertilisers has hardened the surface soil and resulted in growth of obnoxious weeds like *Parthenium* (Carrot weed) which was reported in most of the chemical agriculture data farms.

7.1. 0 Intercultural operations

The expenditure incurred on intercultural operations such as harrowing, weeding etc. were very less (Rs 190) in ecological farm. This is mainly due to two factors

- a) Crop density and smothering nature of creeper crops (like cowpea, field beans and creeper green gram which covers the ground quickly and prevent sun light entry on to the ground) and
- b) Competitiveness of crops among themselves, which limits weed growth.

In most of the ecological farms, the non crop plants such as *Amaranthus viridis* (Doggali kura), *Celosia argentic* (Gunugu), *Atakamamidi* (*Boerhavia diffusa*), *Doggali Kura* (*Amaranthus viridis*), *Gunugu/ Kodijuttu kura* (*Celosia argentic*), *Kamanchi/ Kasapandlu* (*Solanum nigrum*) *Mulludoggali* (*Amaranthus spinosus*), *Tagarancha* (*Cassia tora*), *Tummi* (*Leucas aspersa*) *Uttareni* (*Achyranths aspersa*), *Yeluka chevula aaku* (*Merremmia odorata*)etc were persistent. Even the small amount of the non crop plants were also effectively utilized as greens, medicinal herbs, fodder for livestock where as in chemical farm the weeds were unutilized and left on field bunds. Weeds take the advantage of quick acting chemical fertilizers and leading to a heavy flush of weed growth, resulting in higher weeding costs.

7.1. 0 Plant protection

On an average, the expenditure incurred on plant protection was quite low in ecological farms (Rs 100) compared to Rs 200 in conventional farms and Rs 400 in chemical farms. The low plant protection costs in ecological farms could be attributed to adoption of various indigenous pest

Figure 1: A Model Ecological Farm showing North South Orientation of crop rows and sunflower trap crop around the field bund for pest repellency and cereal legume cons associations in the mixtures

management strategies such as deep summer ploughing, planting of Marigold (as repellent), Sunflower (as trap crops), spraying of botanical pesticides like 5%NSKE (Neem Seed Kernel Extract), Chilly + Garlic extract or application of jaggery solution etc. options which are eco friendly. The traditional seeds, over the years through natural selection have got resistance for pests and diseases. Further more, the planting geometry of various component crops had also facilitated as barriers for pest attack. All these mechanisms interacted simultaneously and there by low plant protection costs. In most of the conventional and chemical farms the plant protection was by spraying of 5% NSKE followed by spraying of chlorinated hydrocarbons to synthetic pyrethroids and hence higher costs of plant protection in these farm.

7.1. 0 Harvesting and threshing

The expenditure involved is quite more in ecological farms (Rs 250) than in conventional (Rs 185) and chemical farms (Rs200). This is mainly due to differential maturity of crops in ecological farms, which needs harvest at different intervals and provide regular wage opportunities to family members. In monocropping or inter cropping, whole the crop comes to maturity at the same time in the region and in some instances, the labour wages go up to double during the peak time.

Table 5 Comparison of Cost of Cultivation (in Rupees / acre) of ecological, conventional and Chemical Agriculture farms.¹

Item	Ecological			Conventional			Conventional		
	Own	Hired/ Purchased	Total	Own	Hired/purc hased	Total	Own	Hired/pur chased	Total

¹ Based on average of 92 ecological, 128 conventional and 55 chemical agriculture data forms of 2000 and 2001Kharif Seasons.

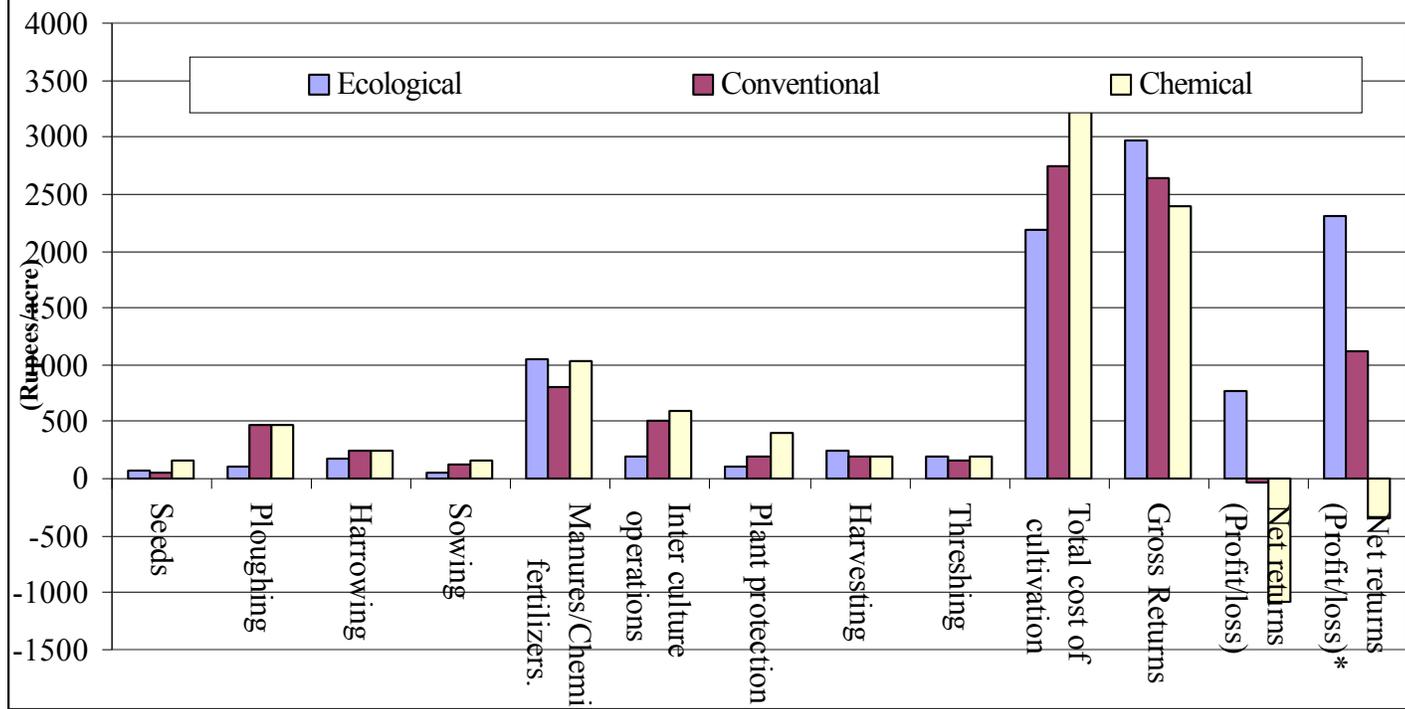
Seeds	76	0	76	20	40	60	90	70	160
Ploughing	55	55	110	120	360	480	0	480	480
Harrowing	50	120	170	80	160	240	0	240	240
Sowing	40	20	60	0	120	120	25	130	155
Manures/Chemical fertilizers.	800	250	1050	600	200	800	480	560	1040
Inter culture operations	120	70	190	180	320	500	140	460	600
Plant protection	65	35	100	50	150	200	0	400	400
Harvesting	180	70	250	110	75	185	0	200	200
Threshing	120	65	185	75	90	165	0	200	200
Total	1506	685	2191	1235	1515	2750	735	2740	3475

7.1. 0 Total cost of cultivation

The total cost of cultivation was Rs 2191 for ecological farming, Rs 2750 for conventional farming and Rs 3475 for chemical farming. The expenditure incurred in chemical agriculture was quite high when compared to other types of agriculture. The value of own inputs used by these 3 farmers when taken into account, the usage of own inputs i.e. FYM, draught power from own livestock, seeds produced from own farm conserved and preserved when taken in to account, the expenditure incurred was very low for Ecological farm. The use of own resources when taken in to account is very high in ecological agriculture. In the chemical agriculture, usage of own resources is very low and is moderate in conventional agriculture. Moreover the role of women is more important in ecological agriculture than in the other production systems due to their involvement in different works such as sowing, manuring, weeding, seed selection and storage. Woman handles these operations which are unique by bio-diverse farming, while the men do ploughing, threshing, bagging operations.

7.1. 0 Cost Benefit Ratio:

Cost of cultivation and returns between ecological, conventional and chemical agriculture



The balance sheet of different production systems is presented below (See Table 6). The cost benefit ratio was high in ecological agriculture (1.35) and it is 4.32 when the own resource use is deducted from cost of cultivation. Any value above 2.0 is considered safe, as the farmer gets Rs 2 for every rupee invested. Therefore one can say ecological agriculture is more remunerative and economically sustainable.

Table 6 Balance sheet between ecological, conventional and chemical agriculture

Particulars	Ecological Agriculture	Conventional Agriculture	Chemical Agriculture
Cost of cultivation	2191	2690	3475
Cost of cultivation after deduction of own resources	685	1515	2740
Crop returns	2443	2450	2150
Uncultivated foods	50	0	0
Byproducts value	520	180	240
Gross Returns	2963	2630	2390
Net returns (Profit/loss)	772	-30	-1085
Net returns (Profit/loss)*	2308	1115	-350
Cost Benefit ratio	1.35	0.91	0.67
Cost Benefit Ratio*	4.32	1.85	0.69

*After considering the use of own resources.

7.1. 0 Crop Yields

In the present study, there are across a wide range of crops in these farms that has made very difficult for yield comparisons. Hence, the yields of three selected study farms (see Box 2 for more details) were presented in Table 7. The sorghum grain yield was 410 kg in ecological farm, while in conventional mono cropped sorghum, the yield was 500 kg. The red gram yield was also higher in ecological farm than in the conventional farm. This could be attributed to less pest incidence, symbiosis in different component crops, which have facilitated higher pod yield. Further, in ecological farms, different component crops such as millets, different pulse crops have generated subsidiary yields, which were utilized for household consumption. While, the conventional and chemical farmers were sold most of the produce in the market.

Interestingly, despite hybrid sorghum in chemical farming, the grain yield was less. The low yield could be attributed to the failure of the hybrid to perform under local situations. The non-popularizations of various private and public sector varieties /hybrids in the region were mainly due to low yielding under adverse situations coupled with poor grain and fodder quality. The HYV sorghum fodder was not sold at same price that of traditional varieties. Further, high yielding varieties with their compactness of ear heads were much effected with rains at harvest than the traditional varieties, resulting in mold growth and consumer resistance in the former than the later.

Table 7 Comparison of crop yields and returns between ecological, conventional and chemical Agriculture (Rupees/acre).

Crops	Ecological Agriculture		Conventional Agriculture		Chemical Agriculture	
	Yield (Kg)	Value (Rupees)	Yield (Kg)	Value (Rupees)	Yield (Kg)	Value (Rupees)
White Sorghum	400	1600	500	2000	400*	1600
Yellow Sorghum	10	40				
Foxtail Millet	3	15				
Little millet	7	35				
Kodo Millet (<i>Arika</i>)	3	15				
Little millet (black grain)	3	15				
Niger	1	18				
Sesame	4	80				
Cow peas	5	50				
Bajra	15	40				
Finger millet	5	25				
Creeper green gram	4	60				
Red gram	25	375			20	300
Field beans	4	40				
Hibiscus seeds	5	45				
Uncultivated foods	10	50				
Weed fodder	10	50	10	50		

(Bundles)						
Hibiscus fiber	2	50				
Sorghum Straw (Bundles)	400	400	400	400	400	200
Red gram haulm (Baskets)	10	20			5	10
Red gram stems (Bundles)	10	10			8	8
Total returns (Rupees)		3033		2450		2343

7.2. 0 RABI SEASON:

In Black soils, the kharif is sown with short duration pulse crops like greengram, black gram and after picking the pods, the biomass was ploughed in and rabi cropping is taken up. In ecological farms the common crops in cultivation are rabi Sorghum (Saya Joonna), chickpea, safflower, coriander, peas, Mustard, Linseed, wheat, lathyrus, chillies etc field crops besides winter vegetables like ridge guard, brinjal, and cucumbers. Conventional and chemical farms, either monocrop of chickpea, Sorghum or intercropping of these two are in practice. The comparison of different economics in rabi season in black soils reveals the same as described above. However, the net income to the ecological farmer was more in Rabi season than in Kharif.

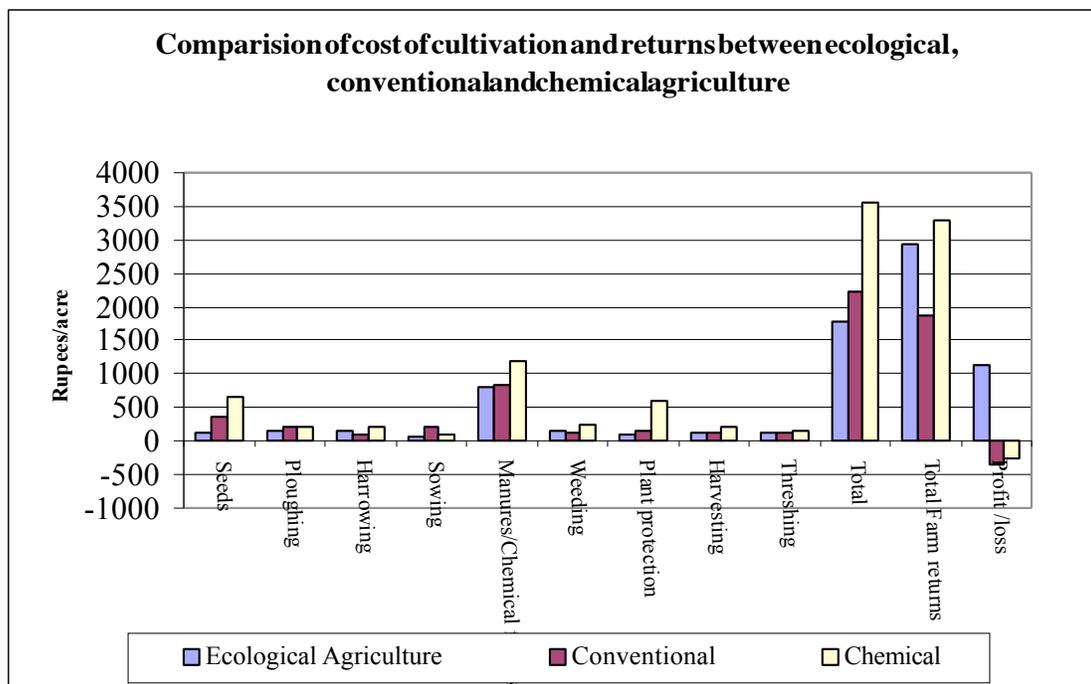


Table 8 Comparison of Cost of Cultivation of ecological, conventional and Chemical Agriculture farm (Rupees/acre)¹

Item	Ecological Agriculture (Rupees)	Conventional Agriculture (Rupees)	Chemical Agriculture (Rupees)
Seeds	130	360	670
Ploughing	150	200	200
Harrowing	150	100	200
Sowing	60	200	100
Manures/Chemical fertilizers.	800	830	1200
Weeding	150	135	240
Plant protection	80	150	600
Harvesting	130	120	200
Threshing	130	120	150
Total	1780	2215	3560
Total Farm returns	2936	1870	3293
Profit /loss	1144	-345	-267

8. Ecological Functions of different Production Systems

In practice, the farmer's decisions with respect to choice of adoption of crops and cropping systems is influenced by several forces related to infrastructure, socio-economic factors, technological developments, soil and climate, trade and marketing, government policies such as subsidies on fertilizers and seeds, etc. all operating interactively at micro-level. An insight into the different ecological functions of these three production systems is proposed reviewed.

8. 9 Soil Fertility

¹ Based on average of 64 ecological farms, 96 conventional and 73 chemical farms of 1999 and 2000 rabi seasons.

In ecological farming Sorghum is grown along with other crops like different coarse grain millets, green gram, black gram, sesame, niger, hibiscus which occupy different spatial dimensions. Cowpeas, creeper green gram etc climb on the tall Sorghum plants. Thus, an efficient utilization of natural resources takes place in this system. Further, a sort of symbiosis prevails between legume and cereals that enhance soil nutrient build up. A large part of the nutrients flowing from different crops are again recycled to same fields through livestock, composting and leaf litter fall, which enhances organic matter buildup in the soil. Organic matter is essential for conserving the soil moisture during the drought periods. But in case of conventional agriculture, the recycling pathways are limited, and as most of the produce is sold and thus nutrient export takes place. In chemical agriculture, most of the farmers are applying nitrogen and phosphate fertilizers only and leaving the potassic and micronutrient fertilizers. With only these fertilizers applied, other nutrients like calcium, magnesium, sulphur, zinc, boron are mined from the soil. Application of nitrogen fertilizer also increases the rapid mineralisation of organic matter there by decreasing the carbon source, which is essential for beneficial microorganism's growth (Stockdale et al 2001). The soil PH changes also takes place and in subsequent years, the soils totally become unproductive. Therefore, there is an urgent need to follow the principles of ecological farming in dry lands.

8. 9 Nutritional Value of the different production systems:

The multiple reasons for growing not just one or two, but up to five or six varieties of sorghum (Box 4) reveal that the logic of diversity applies not only across cropping systems and crops but also within the confines of genetic variability within a single crop. There are multiple benefits of ecological farming when nutritional point of view is considered. The unleavened bread (Rote) prepared from Sorghum gives energy sufficient to do heavy work for whole the day. The vitamins, minerals like calcium rich millet based preparations like ragi malt give strength to the body. Further, these are produced organically and are safe foods to the body. Pulses like green gram, black gram, cowpeas provide required proteins and immunity to the body. The oilseeds give cooking oil for household use and cake to live livestock. Similarly, there are naturally occurring plants in ecological farms, which are consumed as greens (see Box5) They provide Vitamin-A, which is essential for better eyesight and prevention of blindness. In monocropped conventional and chemical agriculture, there is no probability of getting the diverse food grains. Moreover, the chemically produced food contains residues, which are not considered as safe foods to the body.

Box 5 Weeds! Greens! ! Medicinal Herbs!

There are numerous uncultivated foods natural flora associated with ecological agriculture while in chemical farms they are removed as weeds. While they are consumed as greens or used as medicinal herbs for curing small ailments of humans and livestock by ecological farmers. Ecological farmers listed a few of them in the data forms are;

Greens:- Atakamamidi (*Boerhavia diffusa*),Doggali Kura (*Amaranthus viridis*),Gunugu/ Kodijuttu kura (*Celosia argenticia*),Kamanchi/ Kasapandlu (*Solanum nigrum*),Mulludoggali (*Amaranthus spinosus*),Tagarancha (*Cassia tora*),Tummi (*Leucas aspersa*),Uttareni (*Achyranths aspersa*),Yeluka chevula aaku (*Merremmia odorata*)

MedicinalPlants:- Garika (*Cynodon dactylon*),Nattu (*Imperata cylindrica*),Guntakalagara (*Eclipta alba*) etc.

8. 9Pests and disease Resistance:

In ecological agriculture, there are low levels of pest and disease incidence. Even if exists, only one or two crops in the mixture are get affected. Because of the rich bio-diversity, rest of the crops is unaffected. In conventional and chemical agriculture, there is a greater likely hood of total crop loss.

Box 6How Diversity Can Keep Away Serious Pest in Pigeonpea !!

Pigeonpea is the highly valued pulse crop and is the major source of proteins for dry land people. The total cropped are accounts to20,934ha and the productivity crop is 192 kg/ha in Medak District of Andhra Pradesh. The major constraints of low productivity is due to much devastating pest *Heliothis armigera* (Gram Pod Borer), which feeds on flowers and tender pods not only of Pigeonpea but also Chickpea, Cotton, Tomato, Brinjal, chillies etc. crops extensively. This serious pest accounts to 40-80% crop loss in pigeon pea. Surprisingly the nature has provided short duration black grain type which is sown in most of the ecological farms. The plant has pubiscent foliage leaves and is oviposition deterrent and early instars of larvae do not feed on the foliage even if laid . It comes to early maturity before the devastating pest assumes its severity. There are many public sector varieties of State Agricultural Universities and ICRISAT and no way had proved resistant to this devastating pest. Can we ignore this and promote new varieties and Hybrids?

Table: Extent of pod damage by Gram pod borer in KVK instructional farm, Raikode

Variety	Develope d by	No.of Pods damaged/plant
ICPL 332	ICRISAT	32
LRG30	APAU	38
Local Black grain type	--	0

8. 9Financial and Food Security:

In ecological agriculture, the farmers preserve and use indigenous varieties of seeds, which are more tolerant to drought situations and disease and insect resistant. The use of own inputs is high in ecological agriculture than in conventional agriculture (See table 3) External inputs like fertilizers, pesticides, hybrid seeds and mechanization increase the cost of production in chemical agriculture. The market is flooded with many spurious seeds and pesticides. Moreover, in the event of scanty rains, crop failures are quite common and making the farmer into debts trap. The market-oriented monocropping drives farmer to purchase his bread from market. Therefore, there is an urgent need to revitalise the ecological farming.

9. Conclusions

After studying these three Sorghum based crop production systems in red soils, which have several inherent problems such as poor fertility, crusting, easily erodability, weather abnormalities etc. one can conclude ecological agriculture is more sustainable. Since, it is a real blend of ethics, traditional practices and more scientific and pragmatic. The crops raised in Eco-farm have uniform nutrient removal from different depths of soil and give basic human need – 'food', where as the conventional farm has its own draw back i.e. food security. If the Sorghum crop has lost due to pests or draughts in eco-farm, the other crops may ensure food security to farmer. It is totally subsistent type of farming. Further the legume components enhance the soil fertility by symbiotic n fixation and heavy leaf fall. The chemical agriculture with high yielding crops make the farmers to depend on seed and fertilizer companies over which they have no control. Therefore, there is need to revitalize the ecofarming.

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