Best Practices in India

Moving to Responsible Agriculture
(Agriculture Water Pollution Control)

CARITAS Schweiz Suisse Svizzera Svizra

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ARTHACHARYA FOUNDATION

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Foreword

Agriculture, with its allied sectors, is the largest source of livelihoods in India. 70 percent of its rural households still depend primarily on agriculture for their livelihood, with 82 percent of farmers being small and marginal. While agriculture in India has achieved grain self-sufficiency but the production is, resource intensive, cereal centric and regionally biased. The resource intensive ways of Indian agriculture have raised serious sustainability issues too. Increasing stress on water resources of the country adding to the issues of Agricultural and Land based Water pollution.

The necessity to feed the billions of populations, the green revolution introduced hybrid cereal varieties with a sole aim of increased productivity to feed the billions. While achieving food sufficiency in production, India still accounts for a quarter of the world's hungry people and home to over 190 million undernourished people.

With over 15 agro-climatic zones across this huge country, India has rich traditional knowledge and wisdom on sustainable agriculture practices. But, the modern high fertilizer, pesticide and insecticide intensive agriculture resulted in water quality goes peril. Ground water pollution induced by nitrates is one of the major concerns in agriculture sector. The best practices in agriculture and allied sector in using less agricultural inputs and more inorganic and biological materials are reviewed for its applicability, replicability as well as adoptability by the farming community.

Though, DHAN Foundation under the project entitled, "South Asia Environmental Capacity Building – Land based Water Pollution", funded by US Department of States and Caritas Switzerland has collected and reviewed over 50 successful Low External Input Agriculture, it has documented about Seven such best practices and brings out as a compendium.

These practices based on evidences were followed by many scientists and farming households. We convey our sincere thanks to them. We strongly feel, this compendium of the best practices will help the primary stakeholders and the development practitioners and will provide an effective learning experience not only for knowledge development, but also for practice so as to curtail the agriculture water pollution in the near future.

M.P. Vasimalai
Regional Project Advisory Committee Member (RPAC)
Executive Director - DHAN Foundation

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Background

India is a vast country from the Himalayas in the North to Cape Kumari in South; Dhar Desert in the West and the Sundarbans in the East. India's net sown area is around 142 million ha, which is about 46% of its total geographical area. Agriculture is the main livelihoods of the people living in the country. Among the net sown area only less than 50% say 63.6 million ha is irrigated through wells, canals and tanks. About 60% of the net sown area is totally rainfed. The average cropping intensity of the nation rests at approximately 140%. India's population has risen by three times in last fifty years. However, total land under cultivation has only increased by 20%.

The rapid growing population since independence and necessity of the government to feed the whole population, Green revolution introduced High Yielding Variety into agricultural cropping system. This led to use of application of Nitrogen, Phosphate and Potash through inorganic fertilizers. The fertilizers consumption is on the rise. In the same line, application of pesticides also on increase. The total pesticide use in the country is estimated as 56 thousand million tons (MoA 2013).

Approx. 138.35 million farming operational land holdings exist in India with the following combination:

- Marginal farmers (67% operational land holdings)
- Small farmers (18% operational land holdings)
- Medium and Semi-medium farmers (14.3% operational land holdings)
- Large farmers (0.7% operational land holding)

(Source: Agricultural Census 2010-11 Report)

In order to reach food sovereignty and food self- sufficiency, the country and its top research institutes as well as agricultural universities attempted and succeeded in increasing the major cereal production viz. rice and wheat to the tune of 3 times and 8 times respectively since 1960 till 2013-14. India is the second-largest rice and wheat producing country in the world. The two crops have also been part of India's food security mission. In addition, area under oilseeds and sugarcane has been increased. These was mainly due to government policy on free electricity as well as subsidy on fertilizers.

India and Agriculture: A Preview

Agriculture has and continues to plan an important role in Indian economy. However, agriculture contribution to the overall Indian economy is steadily declining. As per Central Statistical Office (CSO), Agriculture's share in GDP was 44% in 1970-71. It declined to 31% in 1990-91 and it has further come down to about 15% in 2009-10. One of the important challenges faced by ailing Indian agriculture is size of farm holdings 67% of India's farm land is held by small and marginal farmers. Agriculture contribute to the contamination of water resources as much as 50 to 70%. (Lal and Stewart, 1994).

The nitrate pollution attributed by agro-chemicals in groundwater in India is alarmingly high. One of the renowned Institute namely, National Environmental Engineering Research Institute (NEERI) Nagpur conducted water quality assessment studies across 17 states and 27% of water quality sample studies have nitrate exceeding the potability standard of drinking water (Bulusu and Pande, 1990). The over dosage application of Urea with NPK and decomposed vegetative waste in more than recommended quantities, result in percolation of nitrate into aquifer and thereby contaminating the ground water. (Jack and Sharma, 1983)

The Contaminants

The agro-chemicals are classified into categories such as biocides, herbicides, fungicides, rodenticides and fertilizers. Over use of these chemicals as well as some pesticides destroy enzymes and block energy generating oxidation processes and lead to malignancy in the cells. Dichloro-diphenyl-trichlorethylene (DDT) is the most famous chemical applied on the crops to terminate the medical and agricultural pests.

Fertilizers Pollution

High Nitrate-Nitrogen ($NO_3 - N$) concentration found in surface and ground water is caused by agricultural fertilisers that can enter directly from the field into the streams and underground sources.

Field trials were conducted by V.Sunitha, B.Muralidhara Reddy et.al of Yogi Vemana University of Kadapa in Andhra Pradesh during 2012 on Groundwater contamination from Agro-Chemicals in Irrigated environment. The researchers concluded the study that:

- Sweep cultivation proved a better tillage option to minimize NO_3 – N leaching from the root zone.
- Light, but frequent irrigations checked nitrate movement to the deeper soil strata.
- Split application of fertilizer reduced NO_3-N leaching and nitrate redistribution to deep seated soil mantle.

Source: "Ground water contamination from Agro-chemicals in Irrigated Environment: Field trials by V.Sunitha, B.Muralidhara Reddy and M.Ramakrishna Reddy; Pelagia Research Library; Adv.App.Sci.Research 3(5): 3082-3086)

Agricultural Pollution vs Climate Change

According to a study, Nitrous Oxide has 310 times greater global warming potential over Carbon di Oxide. About 28% of Greenhouse Gas emissions in India are from agriculture and about 78 Per cent of Methane as well as nitrous oxide emissions are also from agriculture. India consumes 14 million tons of synthetic N every year. The GHG emissions from fertilizer manufacture and use in India had reached nearly 100 Mt of Carbon di oxide equivalent in 2006-07. (Roy et.al. 2010)

Globally, an average 50 per cent of nitrogen used in agriculture is lost to the environment. Significant amounts escape into the air or seep into the soil and ground water, from climate change and dead ones in the oceans to cancer and reproductive risks (Galloway et.al 2008)

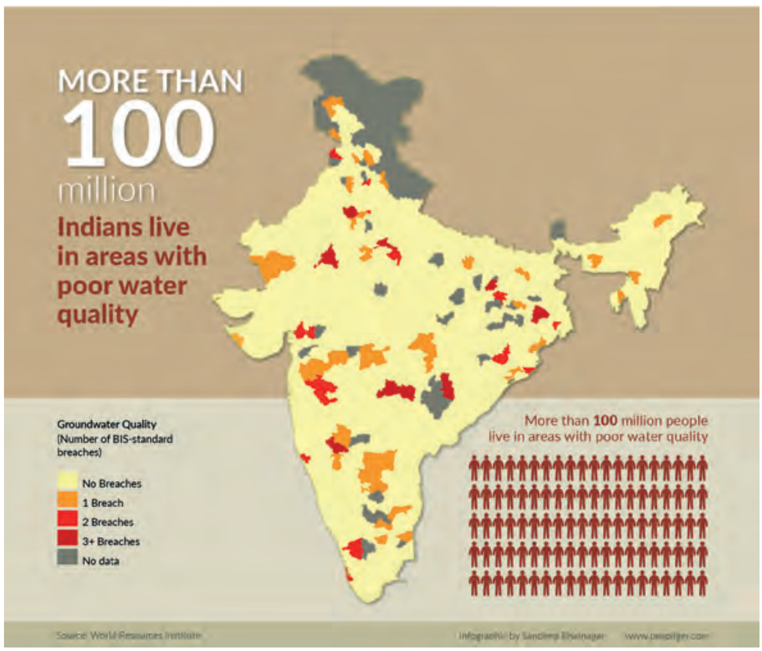
Sustainable agriculture practices viz. Ecological farming/organic farming/Low External Input Sustainable agriculture (LEISA) SRI and such others and approaches are now acknowledged for the wide set of ecological and economic benefits that would accrue to farmers and surrounding environment. (Source: Agrarian Crisis in India: The Way forward; Centre for Sustainable Agriculture, Secunderabad)

Water flows through three interlinked systems as shown below:

Hydrologic System ⟶ Livelihood System ⟶ Food production system

Agriculture accounts for about 82% of total fresh water in India. Moreover 60% of India's cropped area is rainfed. Rainfed regions which have relatively higher concentrations of poverty. Rainfall pattern in India has temporal as well as spatial dimensions. Majority of the rainfall falls in India in a short span of 4 months. Coupled with the fact that India has limited storage capacities, most of the rain water gradually drains off in to the sea. Projections of water supply and population growth rate in India are showing a challenging scenario for the future; while the average per capita supply of water would decrease by one-third by 2025 an water use is likely to increase by about 50% during the same period.

Fertilizers and pesticides enter the ground water through percolation and they are also carried through the water flow. This affect the quality of water seriously and many a times render it useless and harmful at the same time. Water quality is also affected negatively as a result of industrial waste being discharged into rivers without any form of treatment. Untreated sewage from the cities discharged into rivers causing heavy pollution. It has been studied that all the fourteen major river systems of the country are severely polluted. *(Source: Water resources of India; Rakes Kumar, R.D.Singh etal. NIH, Roorkee).*



India and River Pollution: A Snapshot

OUR RIVERS ARE TURNING WORSE

	2009	2015
POLLUTED RIVERS	121	275
POLLUTED RIVER STRETCHES	150	302
SEWAGE GENERATED	38K MLD	62K MLD
TREATMENT CAPACITY	11800 MLD	24K MLD

MLD (Million litres per day)

Objectives of Compilation of Best Practices Compendium

The objectives of the Best Practices Compendium of India is an effort to identify, list, assess the proven successful Processes, Methods, Techniques, compile and disseminate proven best practices that help in the mitigation of land based and agriculture water pollution in various ecosystems in the country.

Steps for Identification of Best Practices

1. Literature and Internet review during Inception document preparation
2. Consultation meeting at Tamil Nadu Agriculture College, TNAU on November 22,2017
3. Second Project Advisory Committee (PAC) Meeting on June 29, 2018
4. State level Roundtable on Agri-Water Pollution, March 22, 2018 at Anna University Chennai.
5. Discussion with experts at India Water Partnership and WAPCOS experts on Jul 31 - Aug 1, 2017
6. Project Coordinator along with Research and Advocacy Officer of CARITAS Project held discussion with US-DOS representative Ms.Priya and her colleague in US EMBASSY in New Delhi on July 31, 2018. Her colleague and subject matter expert have shared few best practices from IARI, New Delhi to be looked into such as Rainfed farming.
7. Expert meeting with Dr. Kannan, Dry land Agriculture Research Institute on Oct 3, 2018 at Kallal in Sivagangai district; Tamil Nadu India and Dr.B.J.Pandian of Water Technology Centre of Tamil Nadu Agricultural University
8. Consultation meeting with ICRISAT, Hyderabad and SACIWaters and Centre for Sustainable Agriculture, Hyderabad, Telangana State on Sep 22- 24, 2018.
9. Consultation with Regional Project Advisory Committee (R-PAC) Members from India
10. Field visits to select farms involved in Organic farming or Zero Budget Natural farming

Practice 1

Soil Health Management: Application of Biochar as an ideal soil conditioner to augment productivity of pulses in rainfed ecosystem

1. Keywords

Biochar, Black gram, Rainfed Cultivation, Alfisol, Tamil Nadu, India

2. Abstract

Developing nation India faces significant and severe land degradation combined with climate change issues in rainfed ecosystems. Agricultural scientists across the nation are keen to find appropriate management options so as to solve serious food security threats faced by the country. The cost-effective crop cultivation in rainfed farming ecosystem would find to be more viable and profitable. Application of Biochar is one of the viable eco-friendly approaches found suitable as well as very apt to combat climate change and improve the soil health with sustainable crop production.

Biochar is nothing but an anaerobic pyrolysis product derived from organic waste materials, resistant to further degradation and stored carbon in long-term in the terrestrial ecosystem. In order to understand the mechanism and harvest the benefits of biochar, field experiments were conducted using acacia biochar with required NPK fertilizers and other crop management practices. Soil physical changes, carbon build-up, nutrient availability and black gram yield were recorded under rainfed farming condition.

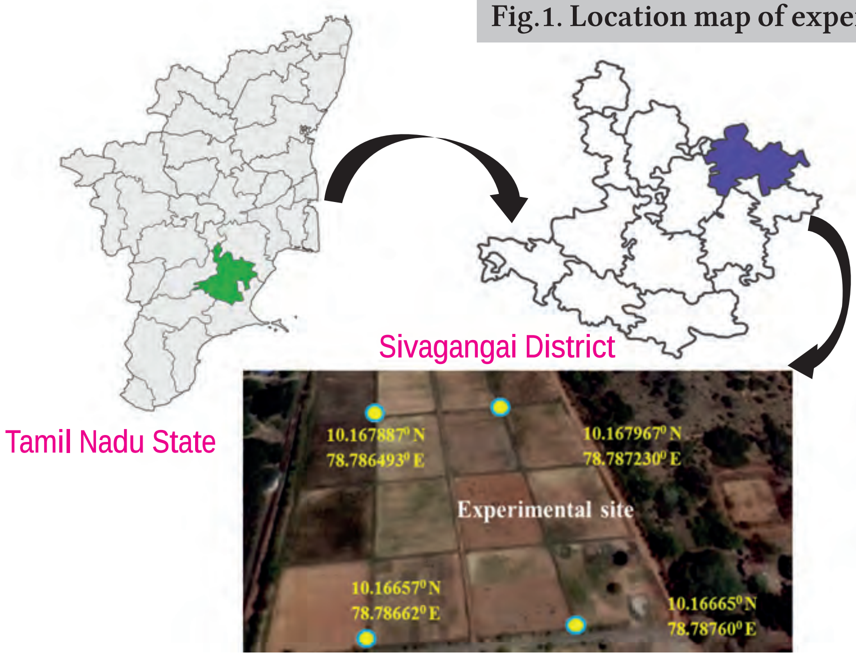
Application of acacia biochar 5t ha^{-1} increased the available soil moisture 3.1 and 3.4 per cent at 15 and 30 cm soil depth than control. Acacia biochar application showed positive trend in organic carbon content build-up (1.0 g kg^{-1}) N, P, K availability in soil and utility by crops over the control. Batch process initial experiment data supported that biochar has property of Phosphorous (P) adsorption potential and it also adsorbed 240 mg of P per gram of biochar, which indirectly reduce leaching loss of applied phosphate and slowly release it into soil and made available to plants. Reduction of leaching loss of nutrient resulted in increased nutrient utility

and reduced the eutrophication of water resources. Integrated application of biochar and phospho bacteria 2 kg ha^{-1} positively influenced the growth and yield attributes of black gram and boost the yield to the tune of 29 per cent over NPK alone applied plot under water deficit environment

3. Context

Sivagangai district is a backward region in Tamil Nadu State from the point of view of agriculture, industry and general economic conditions of the people. Many parts of this district are drought-hit. In this district, out of the total geographical area (4, 61,862 ha), only 1, 20, 480 ha is under agricultural cultivation. The farmers of Sivagangai District are mainly depending on the rain-dependent cultivation. Farmers are facing risk of rainfed farming due to intermittent and terminal drought and low response of applied chemical fertilizers especially nitrogen and phosphorous. Over the past 10 years, uneven distribution of rainfall with high intensity reduces the availability of applied chemical nitrogen and phosphorus to crops by leaching and volatilization process. The leached-out nitrate and phosphate enter into the water bodies and cause eutrophication, which led to environmental threats in irrigated and rainfed ecosystem. With the support of regional research station of Tamil Nadu Agricultural university, in order to overcome the nitrate and phosphate contamination, moisture constraints and to improve the carbon content in the rainfed ecosystem; biochar practice was introduced in this location.

Fig.1. Location map of experimental site



Experiments were conducted in an area of 2000 m^2 size plot at Chettinad village of Sakkotai block, Sivagangai district, Tamil Nadu state (Fig.1). Black gram (Vigna mungo) crop was raised under rainfed situation. Rainfall and the water stored in surface water bodies were used as source of irrigation for the cultivation of black gram.

4. About the Good Practice

Biochar is an anaerobic pyrolysis product derived from organic waste materials and used as a soil conditioner for past 7 years to improve the soil heath and combat the climate vulnerability. In order to avoid the burning of crop residue in the field and control the greenhouse gas emission, crop residue waste was converted into carbon rich biochar. Its surface properties and porous nature enticed to apply as soil moisture retainer in rainfed ecosystem. This practice was introduced to enhance the water retention and carbon content of rainfed Alfisol.

The Acacia holocercia plant self-seeded and fast grown tree and pose serious problem in wasteland and cultivable lands of red soil area of Tamil Nadu. Acacia wood was collected in the farm and biochar was produced at 350-400℃ pyrolysis temperature in absence of oxygen using biochar pyrolysis unit. After pyrolysis process, biochar was ground into small granules and pass through 2 mm sieve in order to have the uniform particle size as that of the soil. Prepared biochar was applied as basal while applying ensures that uniform spread and mixing with soil particles. In order to avoid/reduce drifting loss during application biochar should be mixed with native soil in the field or apply in the pellet form. Soil test-based nitrogen, phosphorus and potassium (12.5:25:12.5 kg/ha NPK) were applied in control and biochar applied field. Intercultural operation and pest & disease management practices followed as per the crop production guide for both control and biochar field.

Biochar application was tested in low base saturation and surface crusted coarse textured acid soil. Biochar has more surface area of 87.3 m^2/g and highly porous in nature with diverse organic functional groups, these properties were tapped for soil physical, chemical and biological improvement, which in turn influenced growth and yield attributes of pulse crop. Besides high surface area and different organic function group of biochar attract nitrogen and phosphorous by adsorption process and reduce the leaching and volatilization, their by curb the nutrient induced eutrophication of water resources and sustained the environment. Biochar versus soil interaction depicted in the figure 2.

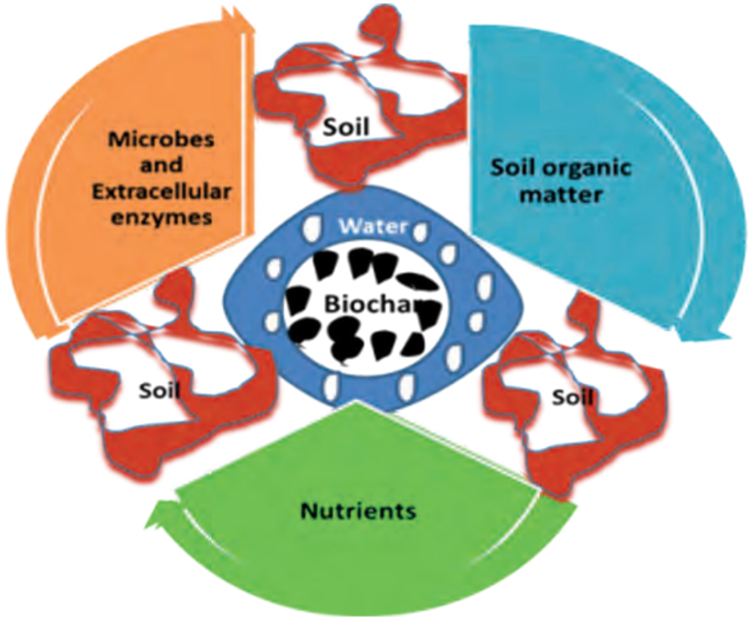


Fig.2. Biochar and soil interaction mechanism

This practice was recommended for wider adoption and popularized among the farmers through roll out programmes and farmers participatory demonstration to conserve water, enhance the N and P use efficiency and sustain the environment without any pollution

5. Demonstrated Impact of the Good Practice

Biochar production is a crop residue management and environmental clean-up technology. In this, waste was converted in to value added carbon material. The carbon rich material used as a soil conditioner for pulse crops. Impact of biochar application was tested during 2014-2018 in kharif season with black gram variety VBN 6 and 8 in typic alfisols under rainfed situation. Before biochar application field must be ploughed so as to keep good soil tilth condition. Biochar applied as basal mixing with native soil to avoid drifting loss. The following diagram explained the biochar production, application and its impact on soil health and crop productivity.

Biochar production

- Collection of farm waste
- Coversion of waste into biochar through pyrolysis
- Homogenise the size of the particle for soil application

Soil application & Impact

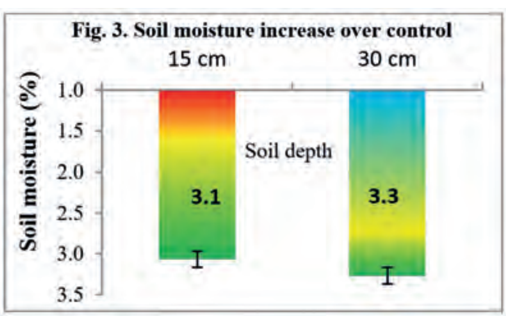
- Basal application & ensure unifrom mixing with soil particles
- Increase soil moisture 3 %
- Reduce the soil bulkdensity 0.2 unit
- Reduce the soil compaction
- Increase the CEC 1.1-1.4 Cmol(p+)/kg of soil

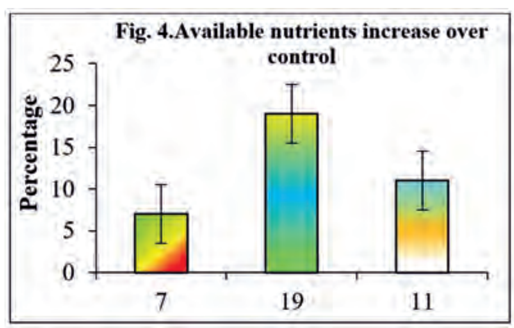
Crop response

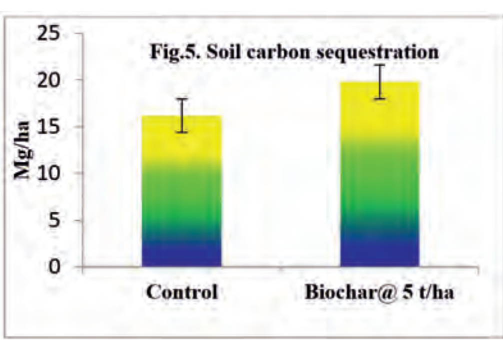
- Maintined higher relative water content of 61%
- Incresed cholorophyll index 2.1(SPAD)
- Regulated higher stomatal conductivty 2.7 S/c
- Increased the growth attributes mainly root length 2.1 cm
- Yield increase 29% noticed

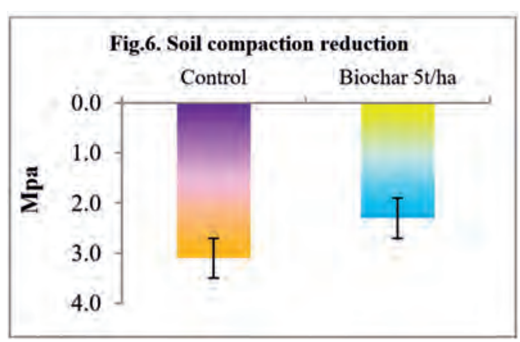
Waste to wealth with environment and farmers prosperity

Application of biochar resulted in increased the soil moisture retention 3.1 and 3.4 % at 15 and 30 cm soil depth, which extend the soil moisture availability 5-7 days than the without biochar. Biochar application enhance the nitrogen (7%), phosphorus (19%) and potassium (11%) availability and N, P&K uptake utility (5, 24 & 7 %) over the control due to its surface and organic functional groups, thereby reduce the nutrient losses and protect the environment especially water resources from chemical fertilisers contamination. Biochar has potential to adsorb 240 mg of phosphate per gram of biochar, which increase the P utility and reduce the leaching of P their by protect water bodies free of eutrophication. Further biochar application increased the organic carbon (4.2g/kg), bacteria population and improved the soil physical properties by reducing bulk density and soil compaction in rainfed soils. The positive interaction of biochar on soil health helped to regulate the plant physiological attributes viz., relative water content (61%) and SPAD (44.9) value. Besides biochar favoured better root development (12.9 cm) and high leaf area (318 cm^2/plant) over control (10.2 cm & 301 m^2/plant). Biochar application improved the soil health and regulated the plant physiological activity, these helps for better growth and enabled to reap higher economic produce of 542 kg/ha over control (421kg/ha) under water starved environment, which paved way for better livelihood security for rainfed farmers under changing climate.









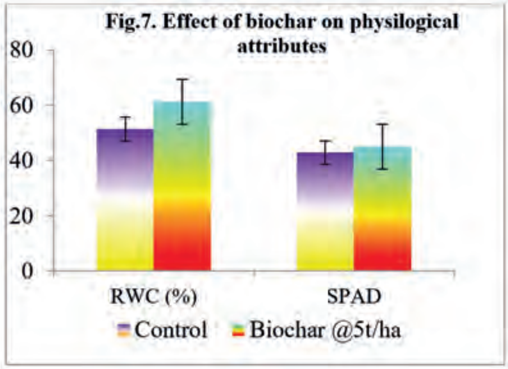


Fig.7. Effect of biochar on physilogical attributes

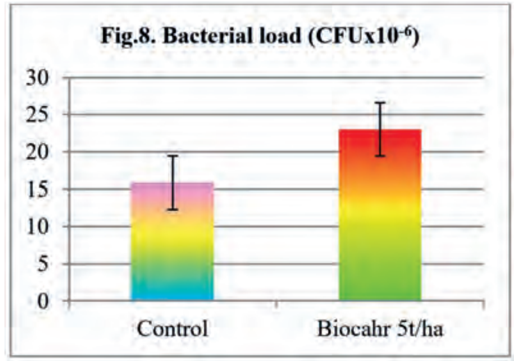


Fig.8. Bacterial load (CFUx10^{-6})

6. Replicability

Biochar has great scope to extent other crops in low pH soils. Waste recycling and environmental protection potential of biochar are key factors influencing to replicate other situations. Large quantum solid waste and its environmental menace pave way for biochar production. Biochar application is a carbon negative technology and it improves water conservation, quality and soil heath, which necessitated replicating this technology in large scale. Biochar application practiced 10 acres of pulse and groundnut crop are being practiced in Kothamangalam, and Ammeyenthal villages of Sakkotai and Thirupathur block. Crop residues are freely available in the farm holdings and it can be converted as biochar and apply as soil conditioner. For conversion of crop waste into biochar a low-cost biochar pyrolysis unit is to be needed.

7. Sustainability

Biochar production and applications continuously demonstrated and showcased to the dryland farmers at Dryland Agricultural Research Station. Farmers were convinced with this practice, but biochar production unit and biochar are not available in affordable price. Farmers demanding to provide subsidised biochar unit for converting their own farm waste in to biochar. Innovative farmers started to produce biochar in small kiln and practicing 10 acres of pulse and rice crop are being practiced in Kothamangalam, of Sakkotai block. Biochar is novel organic input produced from bio waste and it has a greater scope to reduce the greenhouse gas emission water conservation and soil quality in long run with ecological sustainability and livelihood security. To ensure sustainability and upscale this practice in large scale government should come forward to demonstrate biochar as organic input for soil health management and provide low cost pyrolysis unit for converting crop waste in to value added biochar.

8. Key Information

1. **Benefit cost ratio**: Application of biochar along with soil test based inorganic nitrogen, phosphorous and potassium fertilizer for black gram resulted higher gross return of Rs.2.10 per rupee investment. Farmers practice of inorganic fertilizer alone application gave gross return of Rs. 1.60 per rupee investment. Biochar application increased the additional net return of Rs. 50 paise over the famer practice
2. **Other crops for which the best practice can be adopted**: Biochar application can be recommended for green gram, cowpea, groundnut and red gram cultivated in low pH Alfisol under rainfed condition.
3. **Produtivity changes increase /decrease per hectare**: Application of biochar with inorganic fertilizer increased black gram productivity 121 kg /ha over the farmers practice of inorganic fertilizer alone application.

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Acknowledgement

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Kannan, P., Ponmani Subramaniayan, Prabukumar Gnasekaran and Swaminathan Chitraputhirapillai. 2016. Effect of Biochar Amendment on Soil Physical, Chemical and Biological Properties and Groundnut Yield in Rainfed Alfisol of Semi-Arid Tropics. **Archives of Agronomy and Soil Science**. http://dx.doi.org/10.1080/03650340.2016.1139086

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Practice 2

Soil Health Management: In-situ Sugarcane Trash Composting to maintain Soil Health and Minimize Pollution

1. Keywords

Sugarcane, burning, trash composting, soil health, mulching, yield

2. Abstract

Soil fertility is most important determinant on crop productivity in farming sector which greatly influence the profitability and sustainability. India, the second largest producer of Sugarcane next to Brazil, produces on an average 100 t/ha. Sugarcane has five varieties and cultivated as commercial farming in different regions of India. Sugarcane utilizes 208 kg of N, 53 kg of P, 280 kg of K, 30 kg of Sulphur besides micro-minerals like Manganese. Recently, decline in sugarcane productivity has been witnessed in traditionally sugarcane grown regions due to many reasons. Among so many reasons, burning trashes and nil addition of crop residue are the key root causes for soil health deterioration in sugarcane farming. Enriching soil health and minimizing soil and air pollution through in-situ trash composting is proven to be an effective approach on carbon sequestration to build up soil fertility.

Farmer's participatory research was conducted in 10 farmer's holdings with an area of 0.40 hectare each during 2013 to 2015 with an objective of improving the soil fertility and cane productivity in a sustainable approach as part of NABARD funded Sustainable Sugarcane Initiative (SSI) project was operated at Villupuram district, Tamil Nadu. Field experiments were conducted at Vikravandi, Koliyanur and Kanai blocks of Villupuram district. The imposed treatments were trash burning (T1), removal of trashes from the harvested field (T2), Retaining the trashes in the field itself without treatment (T3), Shredding the trashes +TNAU bio-mineralizer @ 2 litres per ton of trash (T4), Shredding the trashes + TNAU bio-mineralizer @ 2 litres per ton of trash + Disc off bearer (T5) in a randomized block design with an area of 800 m^2 as an individual plot size. This experiment was conducted in 10 farmers holding which were treated as 10 replications.

The result revealed that the shredding the trashes + TNAU bio-mineralizer @ 2 litres per ton of trash + Disc off bearer (T5) has significantly influenced soil organic carbon, available nitrogen, phosphorus and potassium. Among the nutrients, the organic carbon content of the soil after harvest of first ratoon crop was varied from 0.52 to 0.61 per cent and 0.63 second ratoon crop over initial status. Available soil N, P and K has been increased to 6.8 per cent N, 5.7 per cent P and 8.7 per cent K over check (trash burnt). The in Shredding the trashes + TNAU bio-mineralizer @ 2 litres per ton of trash + Disc off bearer (T5) gave higher cane yield of 163.8 t/ha over check (132.6 t/ha) during 2013-14 and 158.4 t/ha in (T5) over check (124.2 t/ha) during 2014-15. Similarly, the yield attributes also showed similar positive trend from shredding the trashes followed by addition of TNAU bio-mineralizer @ 2 litres per ton of trash than trashes burning. Since, the burning of sugarcane trashes lead to the soil compactness and destroyed the microbial load which hampers the soil fertility, ratoon crop performance, sprouting percentage, number of millable cane and cane yield. Shredding trashes coupled with TNAU bio-mineralizer @ 2 litres per ton of trash and disc off bearer exhibits positive influence on soil, plant and environmental conservation.

3. Context

Sugarcane is an important commercial and ancient crop with second largest agro based industry in India. As per the case study conducted in 2014 by World Bank, the expected production loss will be around 30% in the future due to climatic change and soil fertility losses. Generally, sugarcane crop is facing declining trend of productivity due to multifarious reason, of which soil fertility loss due to trash burning and climate change are key factors, which are greatly influencing the yield reduction in sugarcane.

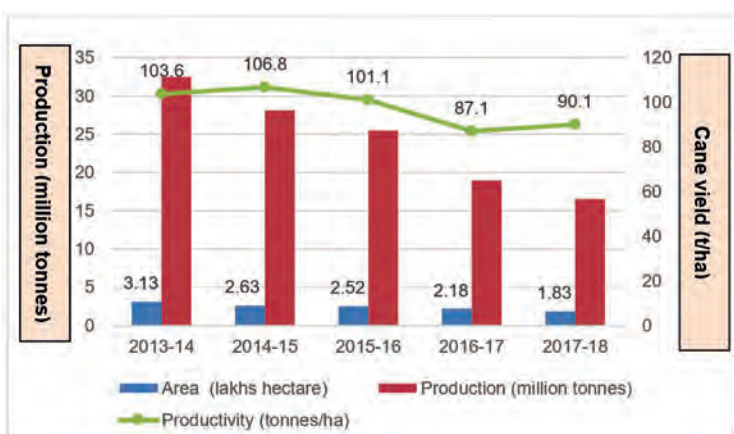


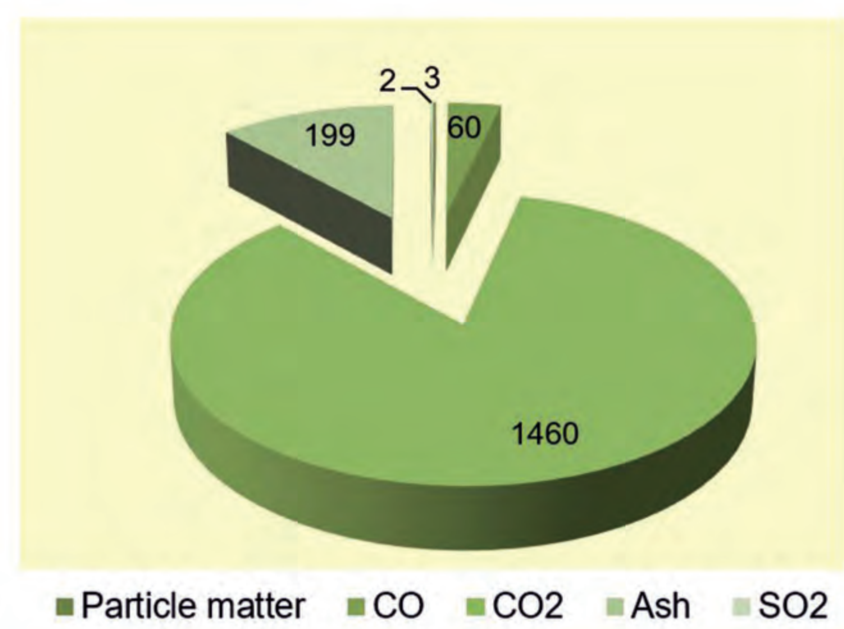
Figure.1. Facts about Sugarcane Cultivation in Tamil Nadu (over 5 years)

Productivity decline was about from 103.6 t/ha in 2013-14 to 90.1 t/ha in 2017-18 in Tamil Nadu, found 13 % decreases over 5 years period. Ultimately area under sugarcane cultivation also being shrinked due to lesser profitability from sugarcane farming.

Sugarcane trash burning is practiced immediately after the harvest of the main crop in the same land leads to loss of soil fertility and beneficial microorganisms due to excess soil heating (600-1000^0 c) in addition to environmental pollution (soil and air pollution) which is hazardous to human beings and livestock.

Human interference has strong impact on physical and chemical characteristics of the environment. Sugarcane trash burning immediately harvest of the sugarcane crop is one such activity of manmade hindrance on environment through release of green- house gas emission like 60 kg CO, 1460 kg of CO_2, 199 kg of ash and 2 kg of SO_2 in the air from 1 ton of straw as per the study report by Centre for Sustainable Agriculture, Hyderabad.

Trash burning leds green house gas emmission (kg/tonne)



Punjab Agricultural University has conducted study on loss of nutrients from burning of sugarcane trashes during 2010, found that 6-7 kg of N, 1-1.17 kg of P,14-26 kg of K and 1.2-1.5 kg of S. This leads to additional expenditure to replenish the soil with chemical fertilizers and as faces productivity decline.

Nutrient content in the sugarcane raw and burnt trash

Sample	Total N %	Total P_2O_5 %	Total K_{20} %	Quantity (t/ha)
Raw trash	0.53	0.09	0.42	10-12
Trash Ash	Traces	0.11	0.56	0.75-1.0

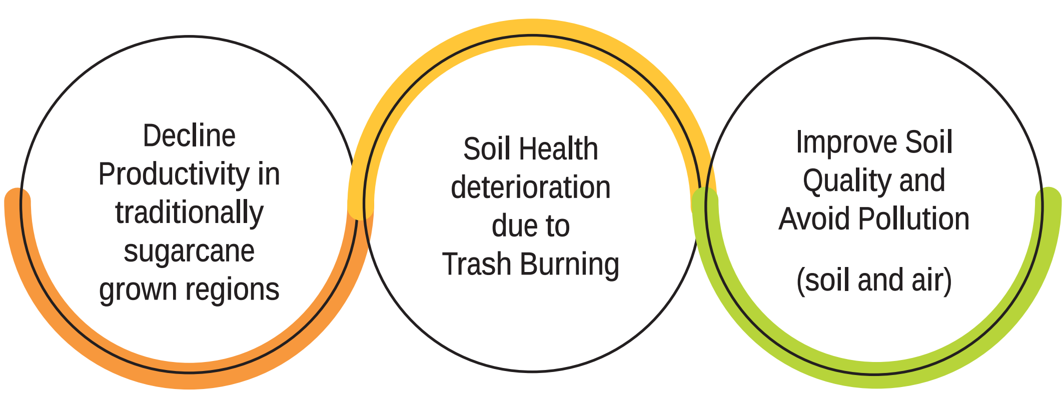
Trash ash samples showed more total phosphorous and potassium compared to raw trash, but the quantity of ash produced after burning is quite low compared to raw trash, which ultimately results in low input for one-hectare area.

4. About the Good practice

Addition of valuable biological material over the soil which harbor multi various microbes for the decomposition and undergo mineralization process which in turn owes credible improvement of soil organic carbon, water holding capacity of soil, and nutrient status, besides owing strong binding with beneficial living organism to enrich the soil fertility.

Villupuram district is major dominating area (1.0 lakhs hectare) and production of sugarcane crop with more number of sugar factories (8 Nos.) have tradition of trash burning due to easy to practice than manual removal which laborious and incur cost as wages. Due to availability of machineries (Trash shredder) and TNAU bio-mineralizer has eye opened opportunity proceed in-situ trash composting. In-situ trash composting and bio mulching would be a viable alternative to mitigate above issue and also conserving soil health for sustainable farming.

Soil health is vital for enhancing the Cane Productivity by reaching through in-situ trash composting cum mulching as non-monetary input in the sugarcane grown fields. Per hectare 8-12 tons of sugarcane trashes are being burnt without knowing the biological value and its multiple merits, on improving soil physical, chemical



and biological properties which helps to enhance the soil fertility and reduces the environmental pollution

Hence with the objective of enriching soil health and minimize soil and air pollution through in-situ trash composting was mooted. Farmer's participatory research was conducted in 10 farmer's farm holdings with an area of 0.40 hectare each during 2013 to 2015 with an objective of improving the soil fertility and cane productivity in a sustainable approach as part of NABARD funded Sustainable Sugarcane Initiative (SSI) project was operated at Villupuram district, Tamil Nadu. Field experiments were conducted at farmer's holding in Vikravandi, Koliyanur and Kanai blocks of Villupuram district. The imposed treatments were trash burning (T1), removal trashes from the harvested field (T2), Retaining the trashes in the field itself without treatment (T3), Shredding the trashes +TNAU bio-mineralizer @ 2 litres /t of trash (T4), Shredding the trash + TNAU bio-mineralizer @ 2 litres /t of trash + Disc off bearer (T5) in a randomized block design with an area of 800 m2 as an individual plot size. This experiment was conducted in 10 farmers holding which were treated as 10 replications.

Addition of bio mineralizer along with soil moisture hastens the decomposition process within 60 days, it releases the beneficial effect to soil and plant. Shredded trashes help to conserve soil moisture by lesser evaporation and also smothering the weeds at early stage supports growth and development of the crop. Besides reduces the early shoot borer incidence in sugarcane which is greater menace at early stage of the crop.

Trash burning

Trash Shredder

Spouting

Disc off bearer

Awareness Creation

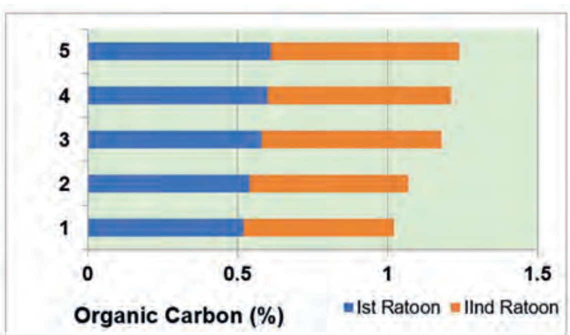
Trash Shredded

After decomposition (45-60days)

5. Demonstrated impact of the Good practice

The result revealed that the, shredding the trash + TNAU bio-mineralizer @ 2 litres per ton of trash + Disc off bearer has influenced soil organic carbon, available nitrogen, phosphorus and potassium. Organic carbon content of 0.09% increase over trash burn treatment.

Available soil N, P and K has been increased to 6.8 per cent N, 5.7 per cent P and 8.7 per cent K over check (trash burnt) and it contributes 44 kg of N,9 kg of P and 53 kg of K from 10 tons of sugarcane trashes. The cane yield was163.8 t/ha in shredding the trash + TNAU bio-mineralizer @ 2 litres per ton of trash + Disc off bearer (T5) field over check (132.6 t/ha) during 2013-14 and 158.4 t/ha in (T5) over check (124.2 t/ha) during 2014-15). Similarly, the yield attributes also been showed similar positive trend. Considering the positive effects of shredding the trash + TNAU bio-mineralizer @ 2 litres per ton of trash + Disc off bearer (T5) treatment, the farmers can adopt this technology to enhance the soil fertility and cane productivity in sugarcane through participatory in-situ trash composting approach by farmers at Villupuram District of Tamil Nadu to increase the yield and to minimize the environmental pollution. Trashes addition along with bio mineralizer triggers the decomposition process and enable to release organic compounds and nutrients to meet the crop requirement.



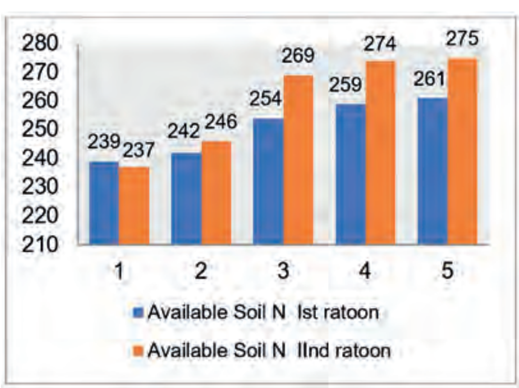
T1: Trash burning

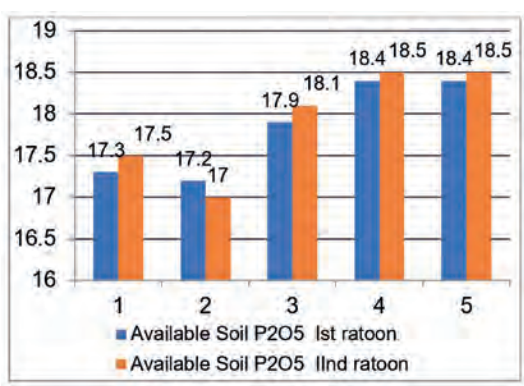
T2: Removal trashes from the harvested field

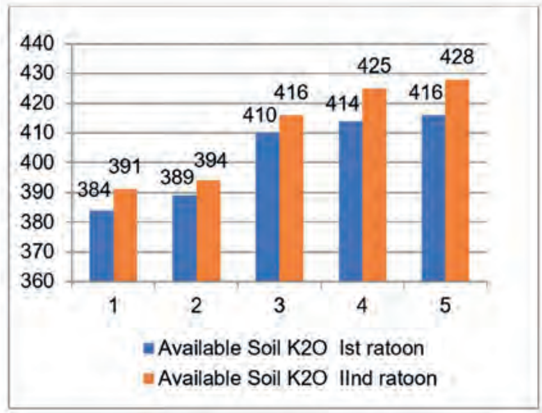
T3: Retaining the trashes in the field itself

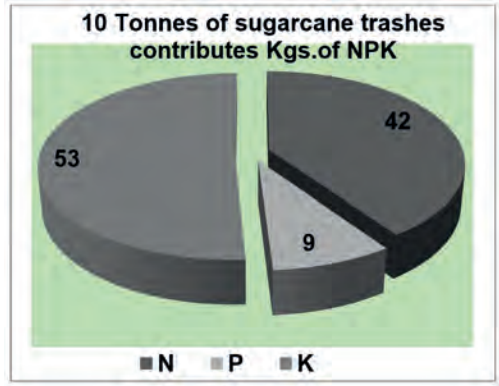
T4: Shredding the trashes +TNAU bio-mineralizer @ 2 litres /t of trash

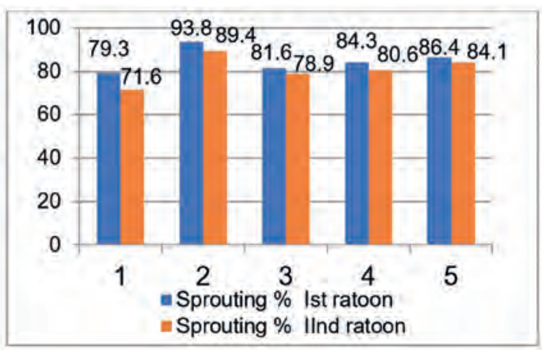
T5: Shredding the trashes + TNAU bio-mineralizer @ 2 litres /t of trashes + Disc off bearer.

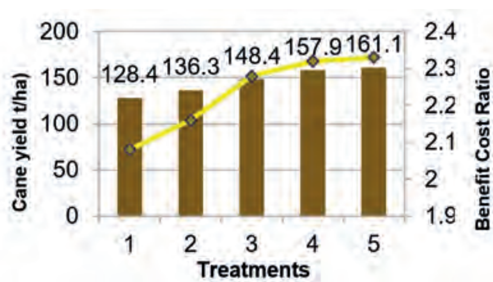












Sprouting increased to 7 % than trash burning which in turn ensures maximum number of millable cane and cane yield. In-situ addition of trashes with mineralizer enhances the microbial consortia in the rhizosphere and facilitate for the nutrient mobility and uptake. Higher return of Rs.2.3 per rupee invested was accrued from shredding the trashes and adding bio mineralizer due to higher cane productivity. Initial wed smothering and retention of soil moisture favored crop growth rate and devilment of yield attributes in sugarcane.

6. Replicability

Effective recycling by in situ trash composting has great treasure of biological value to the soil which in turn helps to buildup soil microbial load and organic acids exudation during mineralization pave ways for maintaining soil chemical properties like pH, EC and CEC. Significant addition of major nutrients and micronutrients to the soil. Besides, it also helps to act as bio-mulch, there by soil moisture retention by minimizing the evaporation and curbing the weeds emergence at initial stage of the crop leads to better growth. After realization of the so many benefits accrued from the ISTC, recommended the shredding the trashes + TNAU bio-mineralizer @ 2 litres /t of trash + Disc off bearer in large scale demonstration at Villupuram district > 100 farmer's holdings and also publicized the activities through mass media for horizontal expansion of the technology among the sugarcane farmers to step up the cane productivity rather than going for burning. Continuing this practice helps to maintain the soil fertility and add huge biological value and protecting the environmental pollution by effective way of recycling the crop residue as in-situ.

7. Sustainability

Ensure the availability of shredder on subsidy by the Government of Tamil Nadu for further promotion through subsidy for cane farmers/farmers association/ NABARD farmers club for wider scale adoption. As environmental concern to curb the green gas emission from the cane field and its huge negative impact on human health viz., skin disorder, nose itching asthma and breathing related issues apart, causes for soil health. Massive adoption helps to increase the cane productivity as climate resilient technology to address the key issue of soil health deterioration and profitability from sugarcane farming. Educating the benefits of ISTC among the farmers would make sustainability at positive level.

Key information

1. **Cost Benefit Analysis**: Shredding the sugarcane trash and adding TNAU bio-mineralizer @ 2 litres per ton of trash with Disc off bearer operation has the Cost Benefit ratio of Rs.2.35 per rupee invested than trash burning as traditionally practiced by the framers which have Cost Benefit ratio of Rs.2.21 per rupee invested .In-situ trash composting improves the soil health and curbing the environmental pollution through trash burning which causes the more health hazards and soil productivity.
2. **Other crops for which the best practices can be adopted**: This can be practiced for the row spaced crops so that the easier to handle the voluminous trashes and again it incur additional cost. Hence, wherever the weeds menace and moisture stress, adoption of sugarcane trash bio mulching could be advisable for the adoption. Best management practices could be scale up to the organic farming to control weeds and retains the soil moisture apart improves the soil properties.
3. **Productivity changes increase/decrease/hectare**: Addition of the crop residue and in-situ decomposition improves the soil properties, increase the water holding capacity and minimize the weeds emergence. Shredding the sugarcane trash and adding TNAU bio-mineralizer @ 2 litres per ton

of trash with Disc off bearer operation has influenced soil organic carbon, available nitrogen, phosphorus and potassium. Organic carbon content of 0.09% increase over trash burn treatment. The cane yield was163.8 t/ha in shredding the trash + TNAU bio-mineralizer @ 2 litres per ton of trash + Disc off bearer (T5) field over check (132.6 t/ha) during 2013-14 and 158.4 t/ha in (T5) over check (124.2 t/ha) during 2014-15). Regarding additional productivity increase that the conventional practice (trash burning) by the farmers are 23.5 % cane increase in 2013-14 (1st ratoon) and 27.5 % in 2014-15 (2nd ratoon) over trash burnt.

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Practice 3

Returning to Traditional Organic Farming - Evidence on improvement in soil health and groundnut productivity in rainfed ecosystem

1. Keywords

Organic Nutrient, Soil Health, Rainfed and Groundnut

2. Abstract

Organic agriculture is not a destination to reach, but it is a journey to a mission. It is one among the ways to maintain soil health. Needless to say, traditional agriculture prior to Green revolution in India was based on Organic cultivation. The post era of green revolution has led to environmental pollution due to excessive use of agrochemicals and fertilizers and thus threatened the fragile ecosystem. Organic nutrient application conserves the soil health and maintains the environmental sustainability. Indian farmers are basically an organic grower but for the past three decades adapted to the green revolution technology also known as exploit agriculture. Introduction of high yielding varieties, chemical fertilizers and pesticides were paved way for self-sufficient in food grains production. Now we achieved self-sufficient in food production but we lost our healthy soil and evergreen environment, which cause multiple health problems (diabetic, anaemic and obesity) especially for women and infants.

Organic application is a one of the viable eco-friendly approaches to combat climate change and improve the soil health with sustainable crop production. In order to understand the soil health improvement potential and yield benefits of organics in long term basis, field experiments were conducted for the last ten years using FYM (12.5 t/ha) and Inorganic fertilizers (10:10:45 kg/ha NPK) in 10 cents size plots with standard crop management practices. Soil physical changes, carbon build-up, nutrient availability and groundnut yield were recorded under rainfed condition. Application of FYM @12.5 t/ha increased the available soil moisture 3.1 and 3.5 per cent at 15 and 30 cm soil depth than inorganic fertilizer. Organic application showed positive trend in organic carbon content build-up (1.2 g kg^{-1}) N, P, K availability in soil and utility by crops over the inorganic.

Organic manure application slowly releases the nutrients in to soil, which met out the exact crop requirement without any leaching and volatilization loss of nutrient as against inorganic nutrient. Besides organics increase the biological activity, which reduce unwanted chemical elements in the soil there by protect the water resource without any pollution. Organic nutrient application positively influenced the growth and yield attributes of groundnut and boost the yield to the tune of 15-18 per cent over NPK alone applied plot under water deficit environment

3. Context

Sivagangai district is one of the most backward regions of Tamil Nadu. This is mainly due to small area under agriculture, extensive area of uncultivable waste, lack of industry and general economic conditions of the people. Frequent occurrence of drought in the district is a proven truth. About one fourth of total geographical area i.e. 1,20,480 ha is used for crop production. In the absence of perennial rivers, canal irrigation systems in the district; the farmers are facing risk of rainfed farming due to intermittent and terminal moisture stress.

Rainfed farmers are widely using inorganic fertiliser to meet the crop nutrient requirement. Uncertainty and uneven distribution of rainfall in the past 10 years led to severe soil moisture stress in critical stage of crops, which mismatch the nutrient requirement and applied inorganic nutrient. Nitrogen and phosphorous are highly prone to leaching and excess application cause eutrophication of water resources. So, in order to overcome the nutrient mismatch, leaching and improves the water quality and carbon content in the rainfed ecosystem organic practice was re-introduced in this location.

Experiments were conducted an area of 2000 m^2 size plot at Chettinad village of Sakkotai block, Sivagangai district, Tamil Nadu state (Fig.1). Groundnut (Arachis hypogea) crop was raised under rainfed situation. Agriculture mainly depends on the rainwater and rainwater harvested in tank water and utilized for crops.

4. About the Good Practice

Organic nutrient application is being practiced for the past 10 years to assess the soil health improvement potential, crop yield enhancement and climate change mitigation ability. In order to overcome the mismatch of nutrient requirement and availability under rainfed situation, organic nutrient management is a viable option, which has capable to tailoring the soil physical condition and biological properties in long-term. Long term application of organics slowly releases the nutrients and matching the nutrient requirement of crop, which helps to sustain the crop yield

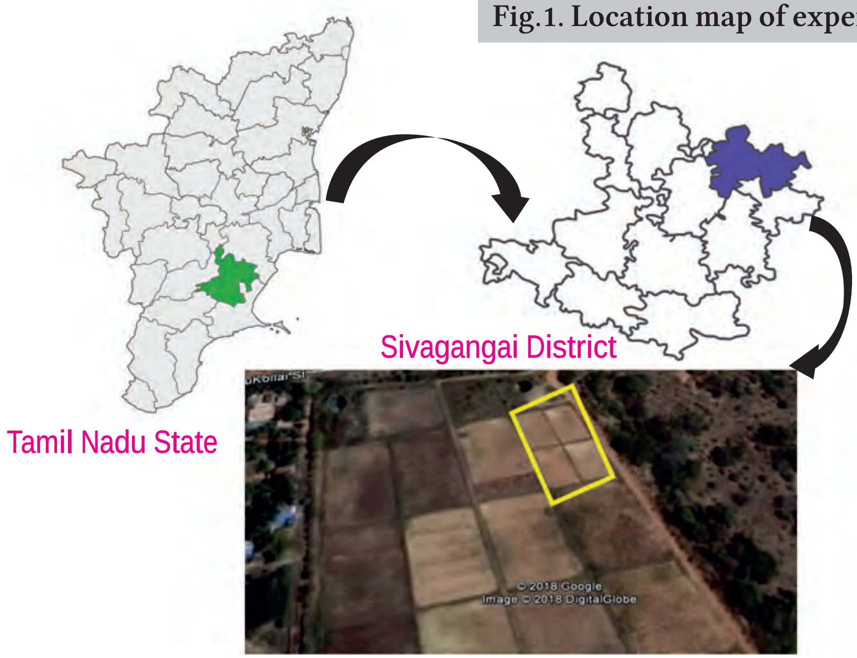

Fig.1. Location map of experimental site

with higher nutrient utilization. Its multifold benefits enticed to apply as soil health promoter in rainfed ecosystem. Farm yard manure and inorganic fertilizer were tested in large size plots (400 m^2) from 2010 to 2018 in groundnut under rainfed situation. Soil test-based nitrogen, phosphorus and potassium (12.5:25:12.5 kg/ha NPK) were applied in inorganic plot. Intercultural operation and pest & disease management practices followed as per the crop production guide for both organic and inorganic. Besides different functional group of organic attract phosphorous by organic chelation process and reduce the leaching, there by restrict the nutrient induced eutrophication of water resources and sustained the environment.

Organic and inorganic nutrient application was tested in low base saturation and surface crusted coarse textured acid soil. FYM is multi nutrient supplier and improves aeration and water retention, these properties were tapped for soil physical, chemical and biological improvement, which in turn influenced growth and yield attributes of groundnut crop.

This practice was recommended for wider adoption and popularized among the farmers through roll out programmes and farmers participatory demonstration to conserve water, enhance the N and P use efficiency and sustain the environment without any pollution.

5. Demonstrated Impact of the Good Practice

Organic nutrient management is a traditional practice of our country but after green revolution inorganic fertiliser application get increased day by day in crop production. In this context, to reduce the inorganic fertilizer application and show case importance organic nutrient application and its impact on soil health and crop productivity under rainfed ecosystem is very imperative. Impact of organic and Inorganic nutrient application was tested during 2010-2018 in Rabi season with Groundnut variety TMV7 in typic haplusalfs under rainfed situation. Before nutrient application field should be ploughed and kept good soil tilth condition. FYM is applied as basal 10 days before sowing and ploughed. The following diagram explained the organic nutrient application and its impact on soil health and groundnut productivity.

Soil application & Impact

- Basal application & ensure unifrom mixing with soil particles
- Increase soil moisture 3.5 %
- Reduce the soil bulkdensity 0.04 Mg/m3 unit
- Reduce the soil compaction
- Increase the CEC 1.2-1.5 Cmol(p+)/kg of soil

Crop response

- Maintined higher relative water content of 52%
- Incresed cholorophyll index 2.7 (SPAD)
- Regulated higher stomatal conductivty 2.2 S/c
- Increased the growth attributes mainly root length 2.7 cm
- Yield increase of 11-15% was recorded

Organic nutrient management with environment and farmers prosperity

Application of FYM @12.5 t/ha increased the soil moisture retention 3.1 and 3.5% at 15 and 30 cm soil depth, which extend the soil moisture availability 3-5 days than the inorganic fertilizer. Organic application enhances the nitrogen (11%), phosphorus (21%) and potassium (5.5%) availability and N, P&K uptake utility (11, 15 & 3 %) over the inorganic due to its multi nutrient supplying capability, reduce the nutrient losses and protect the environment from chemical fertilisers contamination. Organic application slowly releases nitrogen in the form of NH_4 and NO_3 and it match the crop requirement, but in the case of in organic fertilizer, nitrogen and phosphorous released immediately after application. The high amount of N and P released in to soil solution, part of these nutrients utilised by crops and remaining underwent leaching and entered in the water bodies, which cause the eutrophication and human health hazard. Organic has potential to chelate phosphate, which increase the P utility and reduce the leaching of P their by protect water bodies free from eutrophication. Further FYM application increased the organic carbon (1.2g/kg), bacteria population and improved the soil physical properties by reducing bulk density and soil compaction in rainfed soils. The positive interaction of organics on soil health helped to regulate the plant physiological attributes viz., relative water content (53%) and SPAD (38.9) value. Besides organics favoured better root development (12.3 cm) and high leaf area (688 cm^2/plant) over inorganic (10.7 cm & 601 m^2/plant). Organic application improved the soil health and regulated the plant physiological activity, these helps for better growth and enabled to reap higher economic produce of 1041 kg/ha over inorganic (861kg/ha) under water starved environment, which paved way for better livelihood security for rainfed farmers under changing climate.

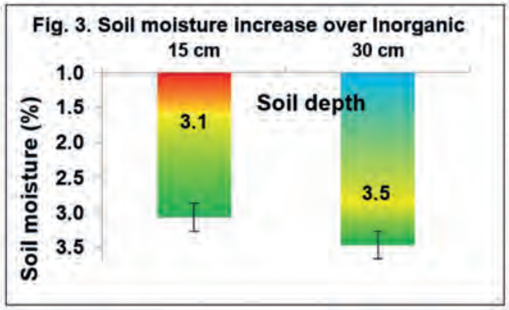

Fig. 3. Soil moisture increase over Inorganic

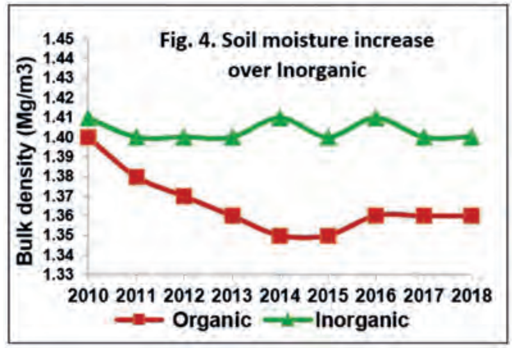

Fig. 4. Soil moisture increase over Inorganic

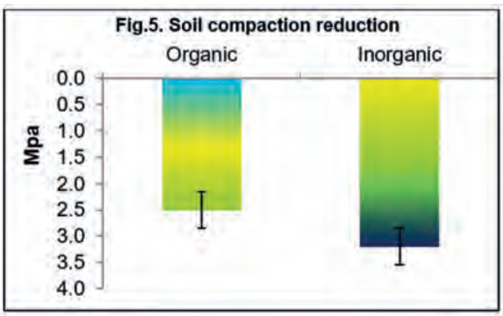

Fig.5. Soil compaction reduction

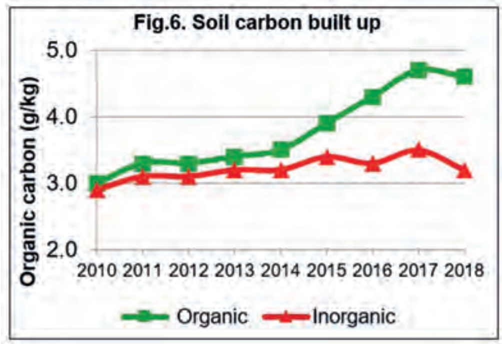

Fig.6. Soil carbon built up

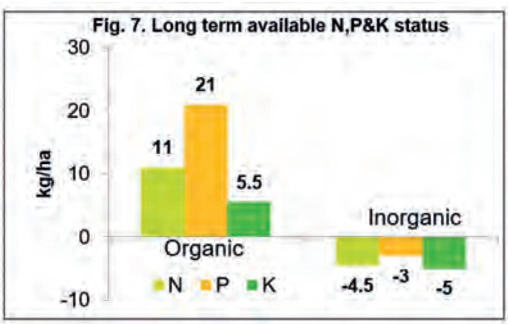

Fig. 7. Long term available N,P&K status

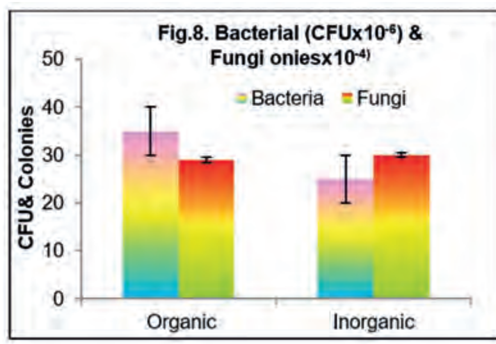

Fig.8. Bacterial (CFUx10-6) & Fungi oniesx10-4)

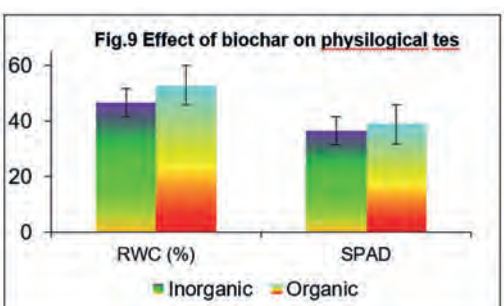

Fig.9 Effect of biochar on physilogical tes

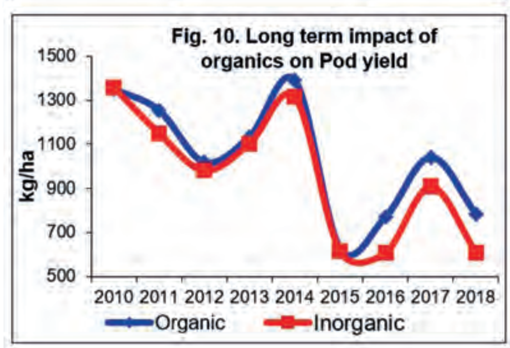

Fig. 10. Long term impact of organics on Pod yield

6. Replicability

Organic nutrient application has great scope to extend other crops in low fertility soils. Most of the rainfed farmers not fully realised the yield potential of groundnut due to the mismatching of nutrient requirement and availability. Mismatch is mainly due to soil moisture stress at critical stage of the crop, because inorganic nutrient availability highly water dependent. Organic nutrient application is an environmental friendly and it improves water conservation, quality and soil heath, which favoured to replicate this technology in large scale. Organic nutrient application practiced 20 acres of groundnut crop are being practiced in Ammeyenthal, Kothamangalam and Kalaiyarkovil villages of Thirupathur, Sakkotai and Kalaiyarkovil block. FYM are freely available in the farm holding and some farmers outsourcing from nearby villages and apply as organic nutrient sources. Recently farmers showing interest to rare the traditional breeds' in order to meet out their FYM requirement. Based on the above impacts, now organic rice production is picking up large scale in Sakkottai block of Sivaganga, where in which organic rice is being exported to Singapore.

7. Sustainability

Organic nutrient applications continuously demonstrated and showcased to the dryland farmers at Dryland Agricultural Research Station. Farmers were convinced with this practice, but FYM are not available in affordable price. Farmers were educated the importance of organic and alternate way of producing organic manure from farm waste. Innovative farmers having FYM and started to produce vermicompost from organic waste and practicing 20 acres of groundnut and rice crop are being practiced in Kothamangalam, of Sakkotai block. Organics application has a greater scope to improve the water quality and soil health in long run with ecological sustainability and livelihood security. To ensure sustainability and upscale this practice in large scale already government of India is demonstrating organic farming in large scale for water quality and soil health management and provide low cost vermicompost techniques for converting crop waste in to value added vermicompost.

Key information

1. **Benefit cost ratio**: Long term application of farmyard manure for groundnut resulted higher gross return of Rs.2.70 per rupee investment. Farmers practice of inorganic fertilizer alone application gave gross return of Rs. 1.60 per rupee investment. Organics application increased the additional net return of Rs. 90 paise per rupee investment over the famer practice

2. **Other crops for which the best practice can be adopted**: Organic application can be recommended for nutri millets, millets, green gram, cowpea, groundnut, red gram and cultivated in all type of soil under rainfed condition.
3. **Produtivity changes increase /decrease per hectare**: Long term application of farmyard manure increased groundnut productivity 200 kg /ha over the farmers practice of inorganic fertilizer alone application.

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Practice 4

System of Rice Intensification (SRI) Practice

1. Keywords

Rice, bamboo stake, yellow sticky trap, bird perches, alternate wetting and drying, irrigation

2. Abstract

System of Rice Intensification (SRI) is a holistic agro-ecological crop management technique seeking alternatives to the high-input oriented agriculture and one among the scientific management tool of allocating irrigation water based on soil and climatic condition to achieve maximum crop production per unit of water applied. Limited irrigation of alternate wetting and drying (AWD) irrigation is one of the important components in SRI reduces the water loss, nutrient loss, methane emission, increases the use efficiency of applied water and enhances better root development and grain yield.

The adaptive research trials were carried out in Villupuram, Tamil Nadu, during rabi, 2010 in wetland. Irrigation water quantification with two methods of rice cultivation viz., farmers practice and SRI was conducted at Melpakkam tank at 5 farmers' field. For quantification of irrigation water, parshall flumes with 15 cm throat width were erected in the field channels to quantify the irrigation water. Field level bamboo stake marker, also fixed in each field to control irrigation water to a desired depth 2.5 cm in SRI. A single tool serves as three purpose as water level indicator, yellow sticky trap and bird perches.

A bamboo pole at an height of 3 feet were used to indicate the water level and the same have been utilized for the attraction of certain hoppers (Brown plant hopper, Green Leaf Hopper, White backed plant hopper). The birds actually utilized the bamboo pole as perches. The bird sits in the bamboo pole and predate the insect stages viz., egg, larvae, pupae of caterpillars as well as resting place for the birds.

Average grain yield of 6592 and 5689 kg/ha was obtained under SRI and farmer practice (FP) from the 5 ARTs. There was 15.9 per cent increased grain yield with

water saving of 292 mm and higher water use efficiency (WUE) of 7.29 kg/ha-mm over FP (4.73 kg/ha-mm). In terms of water productivity, 1396 litres of water required to produce per kg of paddy through SRI whereas, 2135 litres/kg is needed through FP. SRI method of rice cultivation also reduced the number of irrigation (15 Nos.) over FP (22 Nos.). Thus, Water saving technique through SRI, triggered tillering and aeration in the rhizosphere coupled with microbial activity facilitated for nutrient uptake and higher productivity over conventional planting.

3. Context

Rice and Water: Two of the World's most precious commodities that are so intimately linked. All the rice land receives 35–45% of the entire world's irrigation water (which uses some 70% of all the world's developed water resources). Rice- "profligate" user of water.

Rice is the major food grain for more than one third of the world's population with 75% of the world's rice supply from 79 million ha of irrigated rice production in Asia. The daily consumptive use of water in rice varies from 6-10 mm and total water of 1100 to 1250 mm.

India has over 24 million ha under irrigated paddy with huge consumption of water. As agriculture currently consumes the bulk of the available water resources, the efficiency and productivity of water use in this sector may contribute to the relaxation of the demand for water. Need on-farm water productivity enhancing approach to enhance agricultural productivity, with positive effects on the natural environment is obvious.

Tank fed irrigation system is being practiced from the ancient period in Tamil Nadu with multifarious utility in agriculture and allied activities. The uniqueness of then tank fed irrigation system is collectiveness and people's participation in water sharing and maintenance of system. Of late, the participation and involvement is found to be at low level. After inception of the TN-IAMWARM Project has eye opened towards the acquainting knowledge about the water saving technologies. Further, created the strong base among the tank level WUA members regarding the water budgeting and effectiveness of the water saving technologies maximizing water productivity and profitability from the cropping is obvious.

Hence, on farm quantification of irrigation water with the help of the water level indicator made up of bamboo stakes painted with red and yellow colours AWDI was attempted adaptive research trials in different locations to ascertain the water measurement as well as helpful for water sharing mechanism at tank fed irrigation among the water user organization members. Irrigation water quantification with two methods of rice cultivation viz., farmers practice and SRI was conducted at Melpakkam tank at 5 farmers' field during 2010-11.

Very minimum farmers are using the Good Agricultural Practice (GAP) for the management of pests as well as water problem. Main Choice of the remaining farmers was only insecticides, though it leads to cause the many changes in the ecosystem. Though they knew about cultural, physical, mechanical, biological, botanicals, etc. methods to manage the pest incidence, they are not able to follow the practices in their field; rather, they need instant control after the application of insecticides. Keeping this view, the study has been conducted to minimize the insect population and utilization of water to the paddy crop.

Limited irrigation water maximize the productivity with reducing the methane emission, is key for environmental conservation and road map for sustainable farming in low land ecosystem

4. About the Good practice

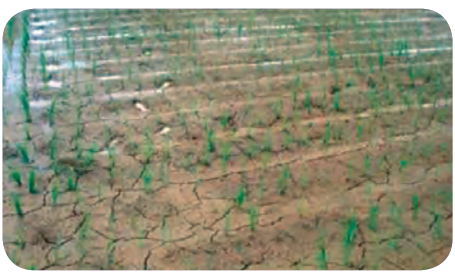
System of rice intensification is one of the water saving technologies widely demonstrated in TN-IAMWARM (Tamil Nadu - Irrigated Agriculture Modernization and Water-Bodies Restoration and Management) World Bank Project by Tamil Nadu Agricultural University. The main components implemented were less seed rate 7.5 kg ha^{-1}, raising mat nursery, young seedling (14-15 days old), square and single seedling transplanting per hill in wider spacing (25 x 25 cm), mechanical weeding 4 times (10, 20, 30 and 40 DAT), intermittent irrigation. Studies on water productivity with SRI were undertaken as a part of the project from 2010-11. The measurement of irrigation water in fields was carried out by PARSHALL flume. The adaptive research trials were conducted in 5 locations in Vilupuram district Tamil Nadu.

System of Rice Intensification Principles (YOSCI)

Young Seedlings (14-15 days) through Mat nursery

One seedling with Square planting (25 x 25 cm spacing)

Cono weeding



Intermittent Irrigation

Through Farmers Participatory Adaptive Research Trials (FP-ART) under TN-IAMWARM (Tamil Nadu- Irrigated Agriculture Modernization and Water-Bodies Restoration and Management)-World Bank Project undertaken by Tamil Nadu Agricultural University.

- Area-40 cents (5 for SRI and 5 for Farmers practice)
- Variety-Medium duration-ADT-39
- The measurement of irrigation water in fields was carried out by PARSHALL flume with 15 cm throat.
- Placing 2.5 cm painted sticks in four corners of field for maintenance of irrigation up to 2.5 cm.
- Allowing the field to hair line crack formation
- Next irrigation up to 2.5 cm depth.



A single tool serves as 3 purpose as water level indicator, yellow sticky trap and bird perches

Water level indicator: Field level bamboo stake marker, also fixed in each field to control irrigation water to a desired depth 2.5 cm in SRI.

Bamboo Yellow stick trap: The bamboo sticks were painted with a coating of highway yellow oil paint for 3 feet from the top of the stick and the same were erected in the field for the insect attraction. Castor oil has to apply at the top of the yellow paint for catching the insects. Once the insect attracted or weekly once the attracted insects will be removed and replace the same for the insect catches. It will be continued till the flowering initiated.

Bird Percher: The birds actually utilized the bamboo pole as percher. The bird sits in the bamboo pole and predate the insect stages viz., egg, larvae, pupae of caterpillars as well as resting place for the birds.

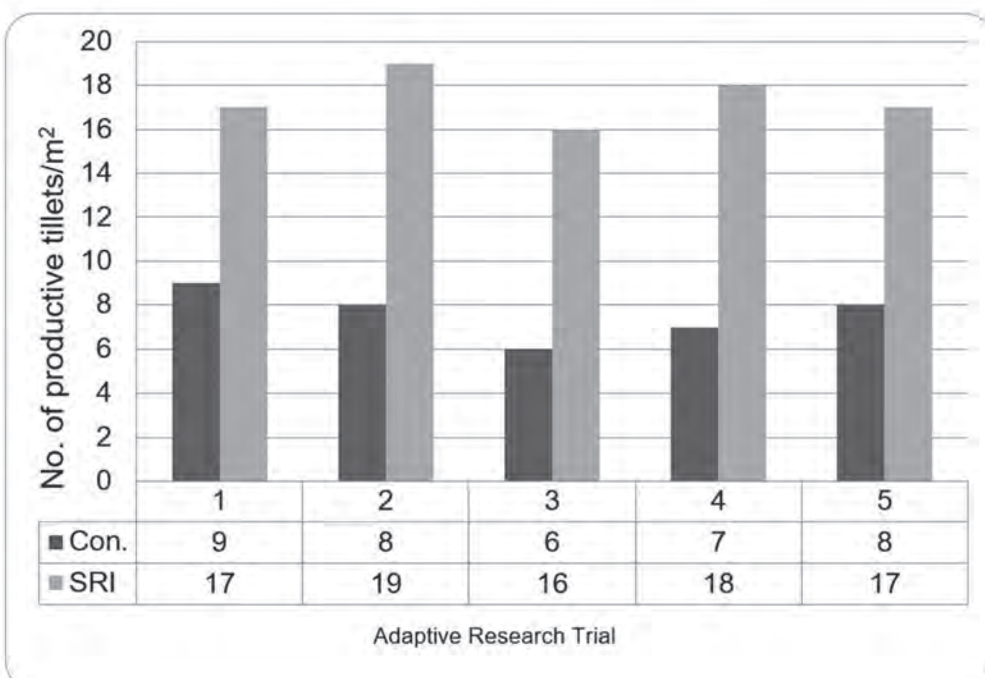
5. Demonstrated impact of the Good practice

The adaptive research trials were carried out in Villuppuram, Tamil Nadu, during rabi, 2010 in wetland. Medium duration rice, ADT 39 was grown. Irrigation water quantification with two methods of rice cultivation viz., farmers practice and SRI was conducted at Melpakkam tank at 5 farmers' field. An area of 0.4 hectare was selected for conducting each ART. The area was divided in two plots of 0.20 hectare each. Farmers practice and SRI cultivation with improved water management was adopted. For quantification of irrigation water, parshall flumes with 15 cm throat width were erected in the field channels to quantify the irrigation water. Field level bamboo stake marker, also fixed in each field to control irrigation water to a desired depth-2.5 cm in SRI. Irrigation requirement was calculated by accumulating the depth of each irrigation by accounting the different losses viz., percolation and evapotranspiration during crop period.

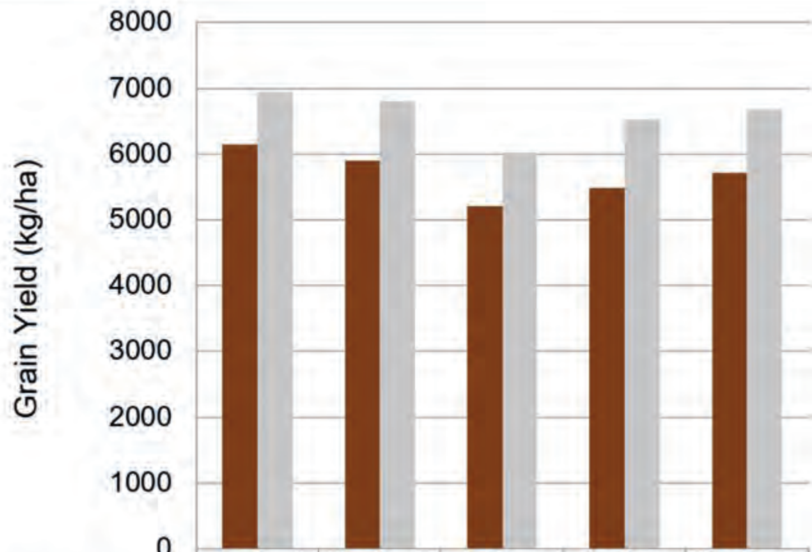
Alternate wetting and drying irrigation (AWDI) through System of Rice Intensification (SRI) and continuous flooding in farmers practice (FP).

Average grain yield of 6592 and 5689 kg/ha was obtained under SRI and farmer practice (FP) from the 5 ARTs. There was 15.9 per cent increased grain yield with water saving of 292 mm and higher water use efficiency (WUE) of 7.29 kg/ha-mm over FP (4.73 kg/ha-mm). In terms of water productivity, 1396 litres of water required to produce per kg of paddy through SRI whereas, 2135 litres/kg is needed through FP. SRI method of rice cultivation also reduced the number of irrigation (15 Nos) over FP (22 Nos).

Yield and yield attributes

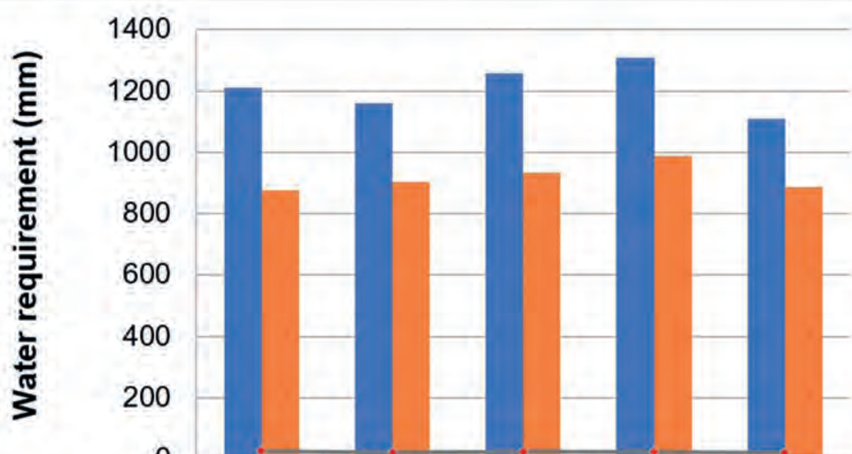


No. of Productive tillers/m2 b/w Conventional &SRI



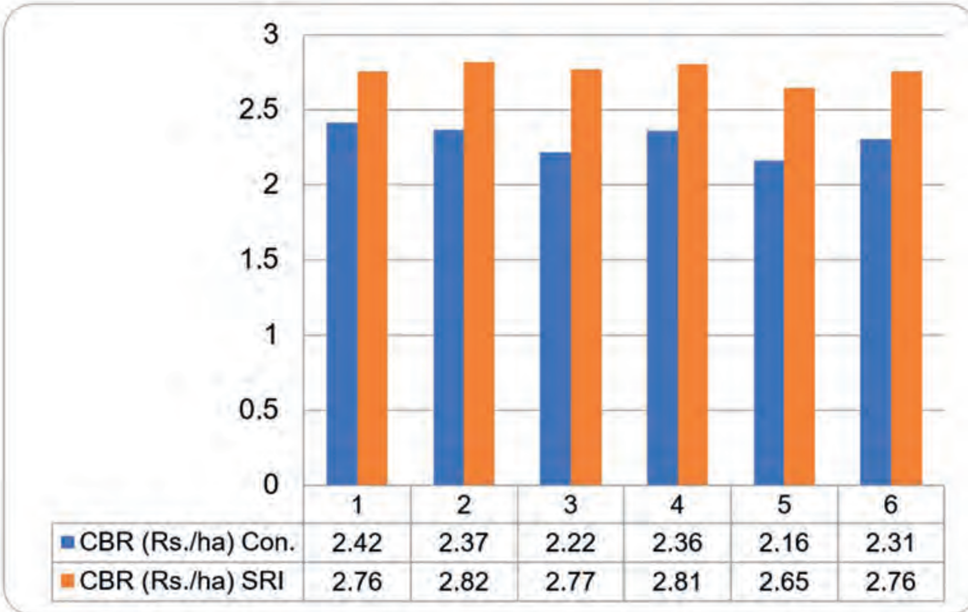
	1	2	3	4	5
Grain Yield (kg/ha) Con.	6142	5894	5214	5487	5708
Grain Yield (kg/ha) SRI	6945	6796	6024	6521	6675

Grain yield /ha between Conventional & SRI method



	1	2	3	4	5
Con.	1209	1159	1259	1309	1109
SRI	876	902	935	987	885
% water saving	27.6	22.8	25.7	24.6	20.2

Water requirement for Con. &SRI & % Water saving

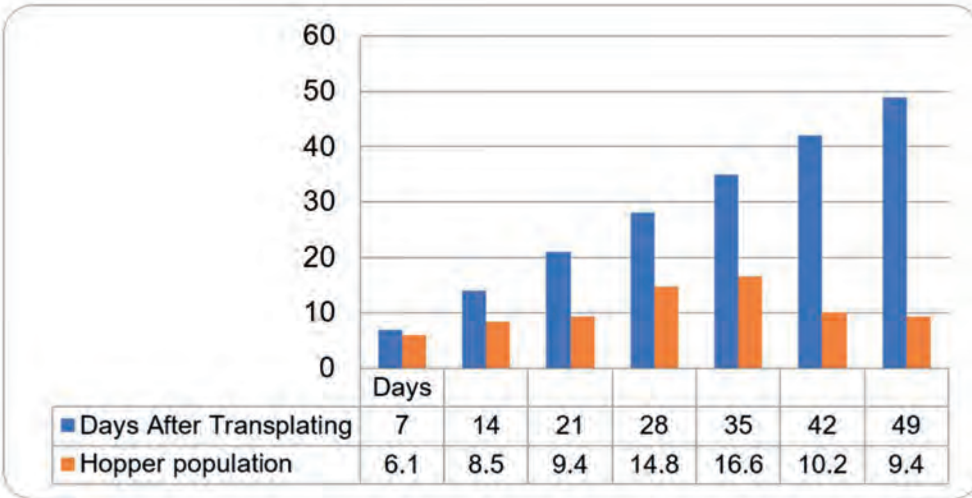


Cost Benefit Ratio (Rs.) b/w Conventional &SRI

Yellow Sticky Trap: A bamboo pole at an height of 3 feet were used to indicate the water level and the same have been utilized for the attraction of certain hoppers (Brown plant hopper, Green Leaf Hopper, White backed plant hopper). Castor oil has to apply at the top of the yellow paint for catching the insects. Once the insect attracted or weekly once the attracted insects have to be removed and replace the same for the insect catches. It has to be continued till the flowering of rice crop.

Bird Perches: The bird sits in the bamboo pole and predate the insect stages viz., egg, larvae, pupae of caterpillars as well as resting place for the birds. In addition, the Bamboo pole will be utilized for hanging the egg cards for the management of stem borer and leaf folders. All the methods are eco-friendly, safe, easily available, easily accessible, simple, low cost technology etc.

The farmers from Villupuram district were adopted bamboo pole to reduce the water and alternate wetting and drying method to reduce the brown plant hopper population. They have satisfied the bamboo pole usages, though it reduces the insect population less than 2 percent and also it reduces one insecticide spray.



Days After Transplating	7	14	21	28	35	42	49
Hopper population	6.1	8.5	9.4	14.8	16.6	10.2	9.4

6. Replicability

The AWD irrigation is a water-saving technology that lowland rice farmers are practicing to reduce their water use in irrigated fields. Shallow irrigation under AWD system could save water up to 25 % without any yield loss. Irrigation intervals vary with soil texture. Fine textured clayey soil with higher field capacity need irrigation at longer intervals while coarse textured light soils with lower water holding capacity require irrigation frequently.

The farmers were given adequate knowledge through trainings, demonstrations and exposure visit to have confidence on role of each components of SRI. Method demo had triggered towards the technology spread of limited irrigation through system of rice intensification or machine translating method. Periodical drought, also eye opened the farmers to go for the need-based irrigation after realized the benefits accrued from the demonstrations.

Capacity Building Programme World Bank Team Visit (Large scale adoption)



Harvest Mela for sensitizing the neighboring farmers and create impact & Adoption



Large scale demonstrations of SRI in tankfed irrigation system –Conserves water, enhances crop productivity, profitability and with livelihood security of farmers.

7. Sustainability

Large scale demonstration of SRI in tank fed irrigation system not only conserves the water, it also enhances the crop productivity and profitability in rice farming and prospering the farmer's livelihood security.

The farmers are forced to spray the insecticides; otherwise they may loose their yield. Moreover, farmers are not able to adopting the good agriculture practice, though they knew the same. The farmers from Villupuram district were adopted bamboo pole to reduce the water and alternate wetting and drying method to reduce the brown plant hopper population. They have satisfied the bamboo pole usages, though it reduces the insect population less than 2 percent and also it reduces one insecticide spray

In addition, the Bamboo pole will be utilized for hanging the egg cards for the management of stem borer and leaf folders. All the methods are eco-friendly, safe, easily available, easily accessible, simple, low cost technology.

Noteworthy merits in the alternate wetting and drying irrigation management through paves way for the conservation of precious resource water and minimize the methane gas emission there by it also conserves the environmental. Realization of benefits by the farmers continues their adoption level. Currently, State Government is promoting among the farmers through TN-IAMP project. Thus, forms a road map for water saving and ecofriendly pest management for sustainable farming.

Key Information

1. **Cost Benefit Analysis**: Adaption of best management practice of system of rice intensification with wetting and drying irrigation Cost Benefit ratio of Rs.2.76 per rupee invested than flood irrigation as traditionally practiced by the framers which have Cost Benefit ratio of Rs.2.31 per

rupee invested . Practicing resource conservation technology minimizes the production cost and also maximizes the profitability.

2. **Other crops for which the best practices can be adopted**: This technique was developed only for the irrigated paddy crop, but the principle of yellow sticky trap and the owl birches could be adopted for all other crops for the eco friendly pest management tool. Alternate wetting drying irrigation reduces the water requirement and increase the crop and water productivity in rice crop. Like, need based irrigation with scientific approach called, irrigation scheduling increases the crop and water productivity in other irrigated crops. Hence the methodology couldn't be worked out for the other crop, but the principle may adopted for minimizing the crop water requirement.
3. **Productivity changes increase/decrease/hectare**: There was 15.9 per cent increased grain yield with water saving of 292 mm and higher water use efficiency (WUE) of 7.29 kg/ha-mm over FP (4.73 kg/ha-mm) in SRI with alternate wetting and drying irrigation. In terms of water productivity, 1396 litres of water required to produce per kg of paddy through SRI whereas, 2135 litres/kg is needed through Farmers practice.

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Practice 5

Making Wealth at Homestead from Biological Waste to Improve the Livelihood Security of Small and Marginalized Farmers

1. Keywords

Crop residue, earthworms, vermicompost, Vermi bag, silpauline and soil health

2. Abstract

The current agricultural production is trying to create sustainable management when it comes to maintaining a balance between the intake and the output of nutrients in the soil. Although the use of industrial fertilizers provides a sufficient content of nutrients into the soil and the influence on yield is evident, on the other hand, it only has a one-time effect. With the current price escalation of chemical fertilizers with Government subsidy and the decline in production of organic fertilizer due to the dwindling of livestock numbers, it is necessary to pay attention to other appropriate alternatives to improve this negative situation. Re-evaluation of waste i.e. composting has an important position in this context. Compost, as a result of composting waste materials, can be regarded as a suitable alternative to organic fertilizers.

Training programme was conducted at Water technology centre during 2010-11 under TN-IAMWARM project for the scientist as a master trainer. Subsequently, each district one day training programme was organized for extension functionaries 100 Nos. in 4 batches from Assistant Director to field officers. In pursuance, training was given to the progressive farmers by the master trainer at TNAU research stations and KVK's and Identified farmers have given the portable vermi bag for the homestead production of vermicompost within the available area and resources.

Small and marginal farmers owing livestock were identified by the Department of Agriculture 50 Nos./district and supplied the vermi bag worth of Rs.1500 at free of cost to promote self-dependency on organic input to their homestead gardens, crops and selling the excess to neighbours. Each entrepreneur has opportunity to

produce 3-4 cycle of vermicompost production depends on the availability of the crop residue and cow dung.

As the cost of production of this compost works out to about Rs.2.5 per kg, it is quite profitable to sell the compost even at R.5.0 per kg. Received a net profit of Rs.8250/year /unit. During 2010-11 through TN-IAMWARM Project 1400 units of vermi bags were given in Tamil Nadu in different districts. Approximately yield from 3 times is 1800 kg vermicompost/unit/year x 1400 units gave 2520 tons / year was obtained/year. A ton of vermi compost supplies 32 kg urea,18.75 kg SSP and 9.2 kg MOP. Vermicompost owes nutri-rich components within it, helps for the supplementary to the chemical fertilizers and pave ways for the sustainable farming.

3.Context

Growing concerns relating to land degradation, the inappropriate use of inorganic fertilizers, atmospheric pollution, soil health, overgrazing, soil biodiversity and sanitation have rekindled global interest in organic recycling practices such as vermicomposting. The potential of vermicomposting to turn on-farm waste materials into a farm resource makes it an attractive proposition. Vermicomposting offers benefits such as enhanced soil fertility and soil health that engender increased agricultural productivity, improved soil biodiversity, reduce ecological risks and a better environment. However, many farmers, and especially those in developing countries find themselves at a disadvantage as they fail to make the best use of organic recycling opportunities using earthworm. Thus, vermicomposting could be one of the valuable options for farmers to restore or enhance their agricultural soil physical, chemical and biological properties.

Agricultural production of India increased remarkably during 60s to 80s as a result of “Green revolution”. India has achieved self-sufficiency in agriculture by an increased use of chemical fertilizers. These agrochemicals deteriorate soil health and environment got polluted. Human beings and cattle were adversely affected due to the residues of these agrochemicals in food products. So, organic manures like vermicompost can be a good substitute for chemical fertilizers to overcome their adverse effects. Vermicompost is finely-divided mature peat-like materials which are produced by a non-thermophilic process involving interactions between earthworms and microorganisms leading to bi-oxidation and stablisation of organic material. Vermicompost is proven as an effective organic fertilizers and biocontrol agents.

4. About the Good practice

Vermi compost is popularly known as Black gold because of rich in nutrients, growth promoting substances, beneficial soil micro flora, having properties of inhibiting pathogenic microbes and synergistic relationship in plant rhizospheres. Mixture of leguminous and non-leguminous crop residues enriches the quality of vermi compost. Its moisture content remains in between 45- 65% which is ideal for land applied compost and pH values near neutral due to the production of CO_2 and organic acids. Other by products of microbial activities is also known which promote plant growth, disease antagonists and growth influencing substance like hormones.

Nutrient Content in vermicompost

Organic carbon	:	9.5 – 17.98%
Nitrogen	:	0.5 – 1.50%
Phosphorous	:	0.1 – 0.30%
Potassium	:	0.15 – 0.56%
Sodium	:	0.06 – 0.30%
Calcium and Magnesium	:	22.67 to 47.60 meq/100g
Copper	:	2 – 9.50 mg kg-1
Iron	:	2 – 9.30 mg kg-1
Zinc	:	5.70 – 11.50 mg kg-1
Sulphur	:	128 – 548 mg kg-1

Than big unit for vermicompost, small homestead vermi bag production unit supports for small households/marginal farmers and women folks to be part of their daily life by using the available livestock and farm waste as entrepreneurship.

Phase of vermicomposting

Phase 1 Processing involving collection of crop residues, shredding and storage of organic wastes.

Phase 2 Pre digestion of organic waste for twenty days by heaping the material along with cattle dung slurry. This process partially digests the material and fit for earthworm consumption. Cattle dung and biogas slurry may be used after drying. Wet dung should not be used for vermicompost production.

Phase 3 Preparation of earthworm bed by using portable silpauline material of 250 GSM thickness with 12x 4x2' size having net weight of >4 kg. Add saw dust of coir waste up to 15 cm height. Then add partially degraded material along with worms @ 10 kg/unit.

Phase 4 Collection of earthworms after vermicompost collection. Sieving the composted material to separate fully composted material. The partially composted material will be again put into vermicompost bed.

Phase 5 Storing the vermicompost in proper place to maintain moisture and allow the beneficial microorganisms to grow.

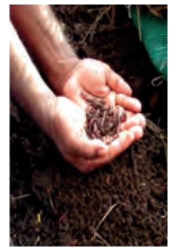
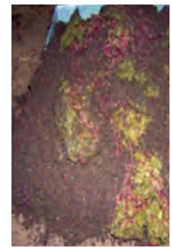
Portable low cost vermibag made up of Silpaulin brand Tarpaulin

Make a shade preferably with hay, straw etc., at a height of 6-7 feet to provide shade to the portable vermi bag

- The cow dung and other organic wastes and form a heap.
- Spray cow dung slurry over the heap and watering is done once in 3 days to maintain the moisture upto 55-60%
- Turn the heap twice (15th and 30th days) and check the temperature. When no heat is felt, it is the right moment to add the worms to the compost.
- Earthworms released (Eudrilus eugeniae) @ 10 kg / bed of 12'x 4'x 2'.
- Sprinkling water to maintain moisture content of 55- 60% and provide shade to filter sunlight t direct hit over the vermi compost unit





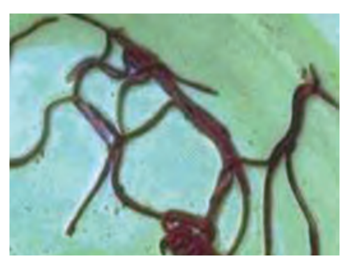
- Harvesting of vermi compost in 45-50 days.
- Shade drying
- Sieving and Packing and keep it in cool place.



Height of the waste material heaped is around 1 foot, the produced vermicompost will be harvested after the process is over.

- Vermicast does not need curing, but fresh casts undergo 2 weeks of nitrification where ammonium transforms to nitrate, a form that plants can uptake.





African earthworm Tiger worm or Red wrinkle Asian worms
(Eudrillus euginiae) (Eisenia foetida) (perinonyx ecavatus)

Being stable, multifunctional organic manure, which enriches the soil quality by improving physio-chemical and biological properties it must be promoted. Vermicompost is becoming popular day by day as it provides quality products through major component of organic farming system

5. Demonstrated impact of the Good practice

Training programme was conducted at Water technology centre during 2010-11 under TN-IAMWARM project for the scientist as a master trainer. Subsequently, each district one day training programme was organized for extension functionaries 100 No in 4 batches from Assistant Director to field officers. After that training was given to the progressive farmers by the master trainer at TNAU research stations and KVK's, identified farmers have received the portable vermi bag for the self-production of vermicompost in the homestead itself within the available area by engaging family members.

Small and marginal farmers owing livestock were identified by the Department of Agriculture 50 Nos./district and supplied the vermin bag worth of Rs.1500 at free of cost to promote self-reliance on organic input for their homestead garden, farm and sell to neighbours on cost basis. Each entrepreneur has opportunity to produce 3-4 cycle of vermicompost production dents on the availability of the crop residue and cow dung.

Vermi bag has capacity of 1 ton /batch, partially decomposed compost put into the bag and it undergoes composting process of 45-50 days. Casting can be harvested up to 600 kg/batch with earth worm of 5 kg additionally through multiplication. In Tamil Nadu 1400 demonstrations were made through systematic way to encourage the farmers towards organic input production under World bank funded TN-IAMWARM project.

Cost Benefit Analysis

I. Investment for establishment of homestead very compost production unit

1. Silpauline vermi bag 250 GSM (12'x4'x2')	=	Rs.1500
2. Earthworm 10 kg @ Rs.250/kg	=	Rs 2500
3. Maintenance cost (4 months)	=	Rs.500
4. Total expenditure	=	Rs.4500

II. Receipt

1. Vermicompost yield	=	600 kg
2. Per kg market price	=	Rs.5 /kg
3. Income from vermicompost	=	Rs.3000
4. Earth worm yield	=	5 kg
5. Income from the earthworm @ Rs.250/kg	=	Rs.1250
6. Per batch income	=	4250
7. 3 batch /year	=	12750
8. Net profit/year	=	12750-4500
		Rs. 8250/year

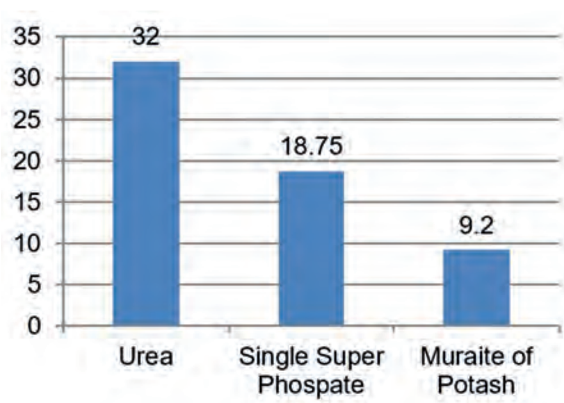
1400 units of vermin bag were given in Tamil Nadu in different districts during 2010-11.

1400 units x Rs. 8250/unit/year= Rs.1, 15, 50,000/year

1800 kg vermi compost/unit/year x 1400 units= 2520 tons /year

It supplies 7.56 tons of N,1.51 t of P and 2.8 t K

1 ton of vermi compost supplies Kg Urea, SSP & MOP



Vermicompost paves way for Organic farming

Vermicompost is a safe, non-polluting and one of the most economical and convenient way of solving the waste disposal problems and recycling of organic waste. It is an excellent form of natural manure which is cost effective, easy to make, handling and contain high nutrients with growth hormones and are 4-5 times powerful growth promoter than all other organic fertilizers and over 30-40% higher than the chemical fertilizer. Various workers reported that vermicompost contain 17-36 % Humic acid and 13-30% Fulvic acid of total concentration of organic matter. Besides, vermicompost has adequate amount of micronutrient and macronutrients depend on sources of feedstock. Earthworms and vermi-compost can promote growth 50-100 per cent than compost and 30-40 per cent over chemical fertilizers.

6. Replicability

There is a growing realization that vermi-composting provides the nutrients and growth enhancing hormones necessary for plant growth. The fruits, flowers and vegetables and other plant products grown using vermi-compost are reported to have better keeping quality. A growing number of individuals and institutions are taking interest in the production of compost utilizing earthworm activity. Some of them ventured into commercial production and marketing with brand value. As the cost of production of this compost works out to about Rs.2.5 per kg, it is quite profitable to sell the compost even at R.5.0 per kg.

The success of any production system is basically depending on need, availability of inputs and marketing channels by which one can marketed with remunerative price by using locally available resources. The key to the success of organic farming system is the production of all inputs like, manures, plant protection etc., and on-farm utilizing the local resources wherein animal husbandry plays a catalytic role. Direct marketing of vermicompost from producer to consumer was found to be strongest marketing channel.

7.Sustainability

Ensure the availability of vermi bag on 80-90 % subsidy by the Government of Tamil Nadu to vermicompost production helps for further promotion towards wider scale adoption. Promotion of homestead vermicompost production to meet their own requirement and also getting income by selling to the nearby farmers will improve the livelihood security of small and marginal farmers and facilitates for organic farming. Helps to cut down the 30 % of chemical fertilizers which are hindering the soil health.

Vermi composting is a method of waste handling that:

- is clean, socially acceptable, with little to no odour
- requires no energy input for aeration

- reduces the mass of waste by 30%
- produces a valuable vermicast byproduct
- even generates worms as fishing bait/worm sales
- vermi wash as nutria rich foliar application

Massive adoption helps to increase the organic input availability as ecofriendly input to address the key issue of soil health deterioration, besides generating additional income for households from the farm waste. It is essential to clearly define a national policy on organic farming by supporting private sector groups, NGOs or associations, and encouraging farmers to produce their own fertilizer in respective regions to meet their requirement. Production led subsidy may be given for the bio input industry to strengthen the rural livelihood and pollution free agriculture.

Key Information

1. **Cost Benefit Analysis:** Gross income/cost of production: 12750/4500= Rs 2.83 was obtained. The net profit from one vermi compost unit Rs.1.83 per rupee invested, besides claiming soil health restoration and curbing the environmental pollution are the ecological benefits. Basal application of vermi compost @ 1 tonne/hectare as bio manure inpsite of Farm yard manure 12.5 t/ha minimizes the burden and drudgery to the farmers and also available larger extent. That FYM we could make vermi composting and enhancing the nutrient values and also minimize the bulky manure application. Many experiments have conducted on integrated nutrient management by including vermi compost as a source of organics. Vermicompost addition has showed positive influence on soil properties and productivity. An average of Rs.0.7 to 0.8 was additional income for every rupee invested for the vegetable crops while Rs.0.3-.0.4 was obtained as per rupee invested in cereal crops.

I. Investment for establishment of homestead very compost production unit

1. Silpauline vermi bag 250 GSM (12'x4'x2')	=	Rs.1,500
2. Earthworm 10 kg @ Rs.250/kg	=	Rs 2,500
3. Maintenance cost (4 months)	=	Rs.500
4. Total expenditure	=	Rs.4,500

II. Receipt

1. Vermicompost yield	=	600 kg
2. Per kg market price	=	Rs.5 /kg
3. Income from vermicompost	=	Rs.3,000
4. Earth worm yield	=	5 kg
5. Income from the earthworm @ Rs.250/kg	=	Rs.1,250
6. Per batch income	=	4,250
7. 3 batch /year	=	12,750
8. Net profit/year	=	12,750-4,500
		Rs.8250/year

2. **Other crops for which the best practices can be adopted**: This can be practiced for the high value crops so that the return will be more when compared to the field crops. Since it contains more organic content and the plant growth promoting substances, highly suitable bio- input for the organic cultivation of vegetables and fruit crops. Best management practices could be scale up to the organic farming. Vermi wash collected from the vermi compost serves as excellent growth promoter which triggers the flowering and enhances the fruit setting. Hence, it owes credible potential for the adoption to vegetables and fruit crops.

3. **Productivity changes increase/decrease/hectare**: Addition of the bio-input naturally improves the soil biological properties and vermicompst contains >10 % Organic carbon. Soil productivity and exchange of nutrients are depends on the organic carbon present in the soil. For organic farming soil health is foremost important requirement. Enriching the soil organic carbon level increase the soil productivity in a sustainable approach. Integrated nutrient management enhances the productivity in many crops ranges between 10% to 45% than the chemical fertilizer alone. Chemical fertilizer application alone leads t deteriorate the soil quality.

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Case let 1

Ethnoveterinary practices: On the cusp of revival

“Understanding and using traditional knowledge in a way which is more consistent and goes beyond a level of what is being done in allopathic medicine are the challenges before us (promoters of ethnoveterinary practices). That’s how we can avoid the danger of traditional knowledge becoming extinct very fast,” believes Anil Kakodkar, Chairman, Rajiv Gandhi Science and Technology Commission in Mumbai. His remarks remind us how this folk knowledge has repeatedly come to the rescue of veterinarians and the livestock.

In 2018, for example, 12 cases of Newcastle disease were confirmed in chicken farms in Tirupur District of Tamil Nadu. The symptoms were very clear in those affected birds: ruffled feathers, greenish diarrhea and respiratory distress. Newcastle is a highly contagious and fatal disease among domestic chickens and even wild avian species caused by a virulent virus. For such a disease, morbidity and mortality rates are as high as 100% and 80% respectively. Antibiotics do not affect viruses, so they can only prevent secondary bacterial infections.

The affected birds were administered a concoction of Phyllanthus amarus (a tropical herbal plant), cumin seeds and onion, ground along with jaggery. This herbal medicine was recommended by the Ethno Veterinary Herbal Research Centre for Poultry in Namakkal. The birds showed significant signs of recovery within five days of treatment.

It is a classic case of traditional wisdom or ethnoveterinary medicine prevailing upon modern medicine in treating serious ailments in livestock. What this combination of Phyllanthus amarus (antiviral), cumin (antibacterial and antifungal), onion (anti-inflammatory, antiseptic, and antispasmodic) and jaggery (anti-toxic) achieved is not just a therapeutic success, but also environmental co-benefits. Unlike the antibiotics and other chemical drugs applied for therapeutic use, it did not leave any harmful residue.

Dual challenge of water contamination and antimicrobial resistance

The importance of ethnoveterinary medicine—primarily because of its fewer damaging side-effects than conventional medicine—is increasingly felt at a time when scientists and policy makers recognise the antimicrobial resistance problem and the role of natural environment, which includes land and water. A recent large-scale assessment of antibiotic pollution in rivers on 711 sites across 73 countries in six continents found presence of 14 different antibiotics. Similarly, a study done by researchers from the Banaras Hindu University, which was released in March 2019, showed that a large number of bacteria in River Ganga are resistant to commonly used antibiotics.

The cause is not difficult to comprehend. When an antibiotic is administered on an animal, typically between 30–90% of the active compound is excreted on the farms and into slurry pits, which often run off into rivers, lakes or groundwater. Antibiotics used in fish farms also add to the pollution burden in India's waterways. Even wastewater treatment plants cannot remove all the antibiotics.

Possibility of increasing disease burden

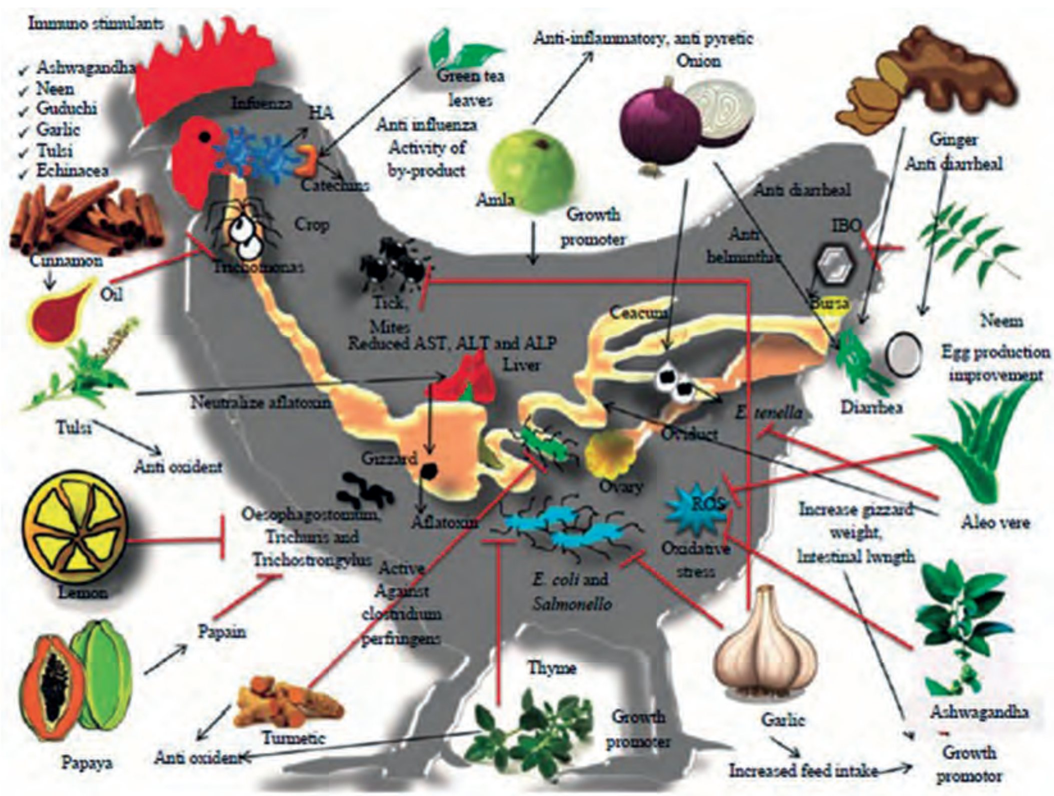
The challenge looks even more onerous when we realise that there is one major factor that will rapidly increase the disease burden among livestock, and hence, the need for administering antibiotics. That factor is climate change. It may affect livestock disease through direct and indirect pathways. The direct effects on animals are likely to be most pronounced in vector-borne, water-borne, soil-related, and temperature or humidity-related diseases. For example, heat stress, depending on its intensity and duration, causes metabolic disruptions and immune suppression among animals, leading to infections and death.

The indirect effects of climate change are primarily those linked to quantity and quality of feed and drinking water as well as survival and distribution of pathogens. Higher humidity levels increase the rate of development of parasites and pathogens. Changes in temperature and rainfall pattern may affect both the distribution and availability of disease vectors, so can the change in frequency of extreme events. In fact, marginal changes in vector characteristics can cause substantial changes in disease. Some livestock, which will already have low immunity owing to climate stress (heat, poor quality of food), can be severely exposed to new pathogens and vectors as their diversity increases.

How can ethnoveterinary practice come to the rescue?

With livestock population increasingly being affected with several bacterial, viral, parasitic and metabolic diseases, market forecast suggests that antibiotic use in livestock might increase by 67 per cent by 2030. As antibiotics in waterways and soils continue to stoke a rise of antibiotic resistance can we not think of a sustainable solution?

As the focus of international agencies shift from food security to food safety, the heydays of indiscriminate use of antibiotics and chemical drugs might soon be over. The livestock industry will have to be ready with a viable alternative, which is where the potential of ethnoveterinary treatment can be realised.



Source: Science Alert

History bears testimony to the fact that long before antibiotics became a wonder supplement for farmers and modern industrial livestock farming embedded it in nearly every step of the livestock-raising process, people had been developing their own ways of keeping animals healthy and productive using age-old natural remedies.

Records suggest that people's association with and treatment of animals started over 14,000 years ago, first with a dog, followed by sheep and goats by 9,000BC in the fertile Nile Valley, and then with cattle in Egypt from 4000BC. These associations were based on economic, cultural, social and religious beliefs attached to each type of animal. It was during this time that veterinary medicine evolved to take care of the health of these animals.

Records of such veterinary medical activities survive in different parts of the world—be it the veterinary therapeutic techniques of Egyptian healers in the veterinary Papyrus of Kahun (1900 BC) or the ethnoveterinary practices in the Indian subcontinent in Sanskrit texts from the Vedic period (1800-1200BC).

Ethnoveterinary knowledge continues to be recognised at a global level as a resource that reflects people's commitment and experience in life. Cost, inaccessibility and side effects associated with the conventional western health care system have encouraged constant dependence on such traditional rural wisdom. They are safe, time-tested and based on local resources and strengths.

Pan-India examples

Ethnoveterinary medicine may not be always as potent as modern allopathic medicine, it can be used to treat common and chronic diseases as well as initial stage of critical diseases, as an alternative to chemical drugs, reducing the cost of treatment and avoiding contamination of soil and water. Therefore, it is important to focus on the conservation of this rich ethnoveterinary wisdom, which makes use of many medicinal plants, most of which are endemic and some of them are at the verge of extinction due to over exploitation. Examples from different corners of the country suggest that these indigenous practices, which are often known only to few individuals and communities, are still in use.

For example, in Uttarakhand, Alaknanda catchment and its adjoining areas have a rich tradition of indigenous medicines and traditional health care practices for curing diseases of domestic animals. A total of 73 medicinal plant species of different plant groups (41 herbs, 10 shrubs, 18 trees and 4 climbers) belonging to 70 genera and 45 families are in use. These medicinal plant species—collected by local communities from the forests and alpine meadows—are used for curing 34 animal ailments such as mastitis, poisoning, foot and mouth disease, dermatitis, arthritis, burning, pneumonia, dysentery, etc. These ailments, according to the researchers at G.B. Pant Institute of Himalayan Environment and Development, are found in nine types of livestock, including buffalo, cow, sheep, goat and mule.

If we look to the east, there is a complex wealth of knowledge and skills in the villages of Kendrapara region of Odisha, where locals are still dependent on folk medicines for their livestock treatment. A study by the researchers from North Orissa University established that 44 plant species are used for ethnoveterinary practices as remedy for 23 types of animal ailments, ranging from dysentery to ulcer and mastitis to different cuts and wounds.

To the west, in Maharashtra's Dhule district, we find evidence of ethnoveterinary practices. Villagers residing around Satpuda Hills use at least 12 plants, including aloe vera, neem, turmeric, durva grass, eucalyptus, asafoetida (hing), tulsi and castor oil, to treat various veterinary diseases. While these examples suggest that ethnoveterinary practices are still popular in different corners of the country, there is still a huge scope for expanding its adoption.

Way Forward

One of the factors limiting the propagation of ethnoveterinary medicine as a form of primary health care for rural animals is the fact that this medicine, developed by farmers in field and barns rather than in scientific laboratories, is less formalised and generally transferred by word of mouth rather than writing. Hence, to protect and promote this indigenous rural wisdom, experts recommend a multi-pronged approach.

Scientific validation and modification through research and development is considered important as the lack of it is a major reason for non-adoption of ethno-veterinary medicine by field veterinarians. Scientific evaluation helps ascertain the degree and direction of change through formal research whose adoption will be rewarding for the veterinarians.

There is also a strong need of integrating western medicine (allopathic) and ethno-veterinary medicine, which can play an important role at grassroots development, empowering people by enhancing the use of their own knowledge and resources. This can help in making a very strong case for re-orienting livestock health by giving the highest priority to identifying, testing and modifying traditional practices.

Haryana is arguably the first state in India that has taken a step towards mainstreaming ethnoveterinary practice by acknowledging its importance in animal health care sector. The state animal husbandry department has reportedly prescribed Ayurveda for treating livestock and prepared an action plan to help farmers choose between allopathy and Ayurveda for treatment of their animals.

The action plan will also enable them to record the progress so that the state can document the effect of this treatment and contribution to reduction in antimicrobial resistance. Under the action plan, all veterinary surgeons and veterinary livestock development assistants will be trained in ethno-veterinary practices.

While antibiotics can be a substantial aid in the control and prevention of livestock diseases, their use, according to experts, should never be intended to replace the need for good management practices, given that the use of antibiotics will eventually lead to polluted waterways and emergence of resistance. In May 2019, delegates at the 72nd World Health Assembly in Geneva agreed on three resolutions: strengthening infection prevention and control measures, including water, sanitation and hygiene; enhancing participation in global antimicrobial surveillance system, and ensuring prudent use of quality-assured antimicrobials.

A Madurai-based farmer has already demonstrated that control and prevention of livestock diseases is very much possible. Ponn Vairan, a government officer-turned poultry farmer, treats common ailments among the poultry using self-acquired knowledge, native wisdom and easily available materials. He has solutions for things that cause concern for a poultry farmer: smell, disease, weight of the fowl and, importantly, profitability.

He uses ordinary materials and feed grown at the farm: panchakavya, azolla, hydroponic fodder, maize and effective micro-organisms. The application of micro-organisms keeps the farm odour-free. He uses simple concoctions of herbs as a shield against the attack of pathogens.

If the country wants to protect its natural environment from being infested with superbugs and at the same time ensure eco-friendly ways of treating livestock and maintaining animal productivity, it needs to emulate this Madurai farmer and focus on optimal combinations of various alternatives coupled with good husbandry.

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Case let 2

Faecal Sludge: Disposal problem or a value proposition?

"We are a generation of lost rivers. How many will we lose before we remember that unless sewage is managed, the river-cleaning operations will not work?" Sunita Narain, one of the noted environmentalists and Director General of the Delhi-based Centre for Science and Environment, had quipped at a workshop on sanitation back in 2016.

Fast forward to October 11, 2019. The headline of a story on the Times of India read: Why clean rural Tamil Nadu is also home to dirtiest river. The headline is less intriguing than the facts which the story unfolds. Tamil Nadu was adjudged best among larger states in terms of rural cleanliness, according to the Centre's Swachh Survekshan Grameen Survey. In fact, villages such as Odanthurai and Kurudampalayam in Coimbatore district have often been in the news for setting new benchmark for sanitation and cleanliness, even before the Centre's Swacch Bharat Mission (SBM) kicked in. At the same time, not very far from these villages, flows the dirtiest river in the country. According to the 2018 CPCB study, Vasishta river is the most polluted river with the biochemical oxygen demand 200 times more than the standard limit. This dichotomy is staggering, which needs probing.

Fundamental issues with faecal waste management

India reportedly generates a staggering 1.7 million tons of faecal waste (a mix of black water and excreta) a day, but an estimated two-thirds of the country's households with toilets aren't connected to the sewer system. It means, 60 per cent of this human waste is dumped in open water and on open land, thus, contaminating drinking water sources. But why should we fret? Faecal sludge—which is a mixture of human excreta and water—bears disease-carrying bacteria and pathogens that need to be safely treated before disposal into the environment. Moreover, when untreated organic matter enters lakes or rivers, it undergoes aerobic decomposition, reducing the levels of dissolved oxygen levels and killing the aquatic life.

In large parts of the country, faecal sludge is collected by private service vendors who use vacuum pumps loaded onto trucks/vehicles that can enter high-density areas. The collected and untreated material is usually dumped in nearest water bodies like lakes and rivers, polluting them, and thus, defeating SBM's very purpose of safe sanitation by controlling open defecation.

A 2019 report—Health, Safety and Dignity of Sanitation Workers: An Initial Assessment—published by the World Health Organization, the International Labour Organization, the World Bank and WaterAid, expressed a concern. It argued that in the past five years, over 10 crore toilets were built under SBM, but a large number of these toilets have been constructed using technologies that would require periodic emptying and offsite treatment of faecal matter. In absence of adequate sewerage system, SBM recommended on-site sanitation systems such as septic tanks and pit latrines. A recently released report, based on a survey carried out by the National Statistical Office, revealed that over 96% of toilets in rural India have either septic tanks or different kinds of pits to collect human excreta.

Lately, the government has been discouraging the idea of septic tanks, which are a chamber made of concrete, fibre glass, or PVC, into which domestic wastewater (sewage) flows. Building a proper septic tank is expensive and after a few years, when the tank gets filled, it needs to be emptied by a special cleaning vehicle that pumps out the faecal matter. In many cases, vehicle operators dispose the waste into fields, water bodies or open spaces, contaminating those areas, and increasing the threat of disease to those in the vicinity.

SBM has been promoting the 'twin-pit' technology, instead. It obviates the need for human handling of faecal matter by moving it to a compost chamber. However, analysis of raw data from the National Annual Rural Sanitation Survey, 2017-18, suggests that no more than 13% of the toilets constructed under SBM had twin pits, while 38% had septic tanks with soak pits and 20% had single pits—both needing manual scavenging.

Onsite sanitation system: Devil is in the design

With the large proportion of on-site installations taking precedence, limited attention has been accorded to proper construction of single-pit latrines and the septic tanks connected to them. They are often reported to be ineffective in treating faecal sludge. While pit toilets save the embarrassment and address hygiene woes to some extent, studies have shown that the leachate from single-pit toilets cause havoc to the ground water. Single pits may be appropriate in areas where water is scarce and where there is a low groundwater table, but they are not suitable in areas that flood frequently, wherein they become susceptible to failure/overflowing.

This is where the benefits of twin-pit toilets become prominent.

These toilets comprise two pits, each measuring 3.5 feet deep and one metre in diameter. They have honeycombed walls and earthen floors that allow liquid to percolate into the surrounding soil. The distance between the two pits is one metre. Both the pits are connected to the toilet with a 'Y' like junction. When one pit gets filled up in roughly three-five years, the household starts using the other pit. Within a year, the waste in the filled pit decomposes and turns faecal sludge into safe-to-handle compost that's rich in NPK (nitrogen, phosphorus, potassium) nutrients.

The National Annual Rural Sanitation Survey 2018-19 reported an increase in the coverage of twin-pit toilets, but still, only 26.6% of rural households use the recommended twin-pit system. Coverage is not the only problem. The devil lies in the design. In both well-constructed honeycomb pits and septic tanks, the liquid is discharged either into the ground or in drains and the solid (faecal sludge) is allowed to remain in the pit or tank till it is decomposed and is safe to use. But this depends on construction quality. If the honeycomb pit or septic tank is not built to specifications, the waste will not decompose, and when removed, it will have pathogens that will contaminate water and soil.

Reports from across the country demonstrate how faulty design of twin-pit toilets has undone the efforts at establishing safe in-situ sanitation system. For example, in Bihar, high water table and poorly constructed deep dug toilets reportedly contaminated water at times. This is because the given dimension of 1 metre in diameter and 3.5 ft depth is hardly followed, as rural communities believe that small pits will fill sooner and hence, they dig deeper ones.

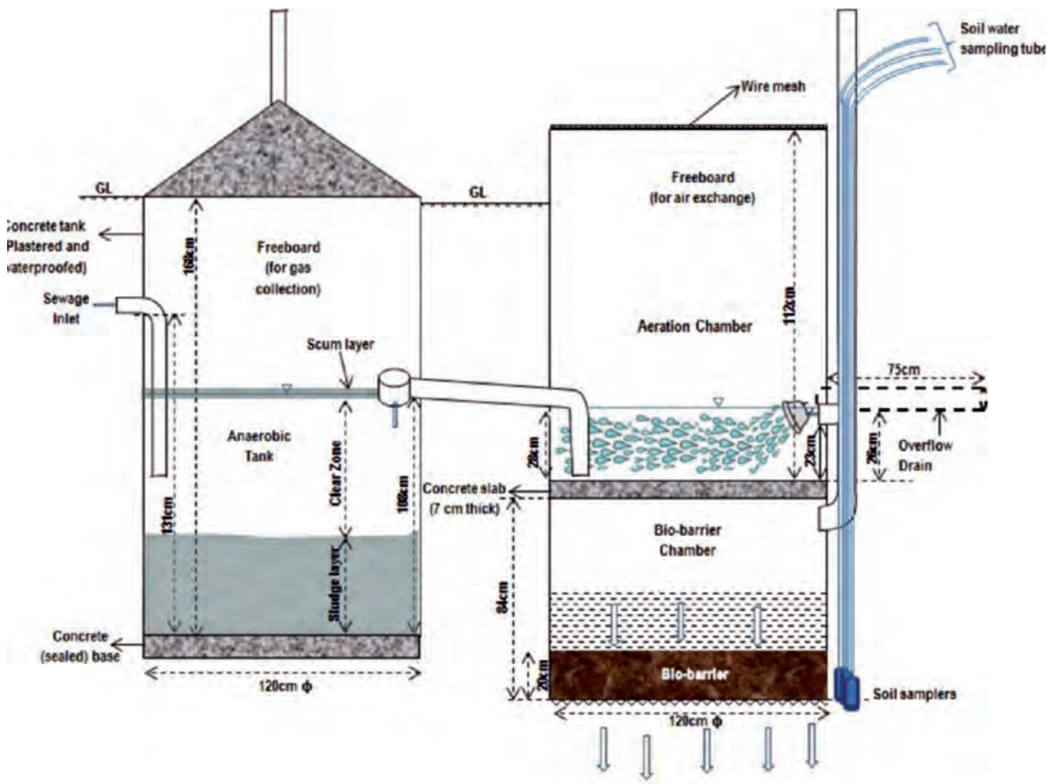
Gonda district of Uttar Pradesh had reported similar challenges, but here, the reason is topography. Construction of twin-pit system in Gonda district involved digging pits at the depth of 1 metre below the ground. The groundwater brochure of the district suggests that in most of the blocks, pre-monsoon depth of the groundwater varies between 3 and 5 metre below the ground level and in the post-monsoon, the groundwater level rises to 1 to 3 metre below the ground level. This increased the chances of the pits interfering in areas of shallow groundwater level.

Faecal sludge in twin-pit toilets poses a different problem in north east India. People residing along the floodplains of Brahmaputra open the lids of their pits when flood water rushes in. They think that the flood will clean the pits and carry the sludge with them. This practice contaminates surface water. Hence, it is a blend of engineering disasters, unfavourable topography and behaviour that perpetuates this problem.

Solutions at hand

Researchers from the Indian Institute of Science (IISc), Bangalore have designed a modified twin-pit toilet system, which solves another commonly observed issue of nitrate load in treated sewage. In common twin-pit toilets, nitrate is conserved as ammonium. Upon release of leachate to the sub-surface, ammonium ions transform to nitrate under conditions of adequate oxygen availability. Nitrate originating from pit toilet leachate can expose about 65 million households in rural and urban India to risks of drinking nitrate contaminated groundwater, according to Professor Sudhakar Rao at IISc Bangalore.

To reduces the nitrate load and ensure that the treated sewage seeps into the soil beneath the pit toilet, Professor Rao and his group from the Department of Civil Engineering, IISc, Bangalore has come up with a modified design.



The first pit serves as an anaerobic chamber, and the second pit facilitates aerobic reactions in the upper half and is equipped with a bio-barrier in its lower half. The wastewater overflowing from the first pit enters the upper half of second pit that serves as a nitrification chamber. Nitrified wastewater from upper half of the second pit enters the lower half containing sand, gravel and cow dung at the base. Cow dung serves as affordable organic carbon source and gravel improves permeability of the barrier. "Eventual migration of treated leachate to aquifer should cause minimal degradation of groundwater/surface water quality," according to Professor Rao.

Another eco-friendly solution that is yet to see a widespread adoption is a urine-diverting dry toilet, popularly called 'Ecosan', short for "ecological sanitation". An Ecosan toilet has two toilet pans connected to separate concrete chambers below to store excreta. After defecating, one has to sprinkle ash and close the lid. No flushing is required. There are separate outlets for urine and washing, which ensures that no water enters the excreta chamber, which would have otherwise taken the nutrients away and increased the chances of polluting nearby waterbodies. This also prevents insect breeding and foul smells, besides accelerating decomposition.

A family would use one pan and chamber for five or six months. Once full, the first chamber is sealed and the second chamber is then used. By the time the second chamber fills up, the excreta in the first chamber becomes odourless compost and can be used as farm manure. The urine and water, which is collected in a separate container, can be used in the fields as fertiliser.

Success stories from the villages and farmlands have started pouring in, with farmers getting hooked on to this solution. In villages of Maharashtra, the usefulness of compost and urine has got farmers interested. From tomato to coriander and pea crops to areca nuts, the use of these nutrient-rich compost and urine demonstrated better yield.

Scaling up of FSTPs and converting STPs to co-treatment facilities

Safe management of faecal sludge does not mean only safe containment of excreta, but also regularly emptying and transporting the waste to a faecal sludge treatment plant (FSTP). This is especially true when no more than 56.4% of India's urban homes—where 377 million people live—are connected to sewer lines, while only 36.7% of rural areas—where 833 million people live—have drainage, according to a 2017 report of the National Sample Survey Office, which has the latest data.

India, for now, has only 20 FSTPs in operation. The number is too small to treat the huge quantity of sewage being produced and taken out. States across the country are, however, trying hard to scale-up construction of FSTPs across the urban areas. The state of Odisha is leading this effort; it has already commissioned 10 FSTPs through funding from the Atal Mission for Rejuvenation and Urban Transformation (AMRUT).

According to researchers from the Administrative Staff College of India (ASCI), Hyderabad, in cities that have a mix of underground sewerage and on-site sanitation systems, converting sewage treatment plants (STPs) to co-treatment plants offers a considerable advantage in terms of cost, water quality and reuse. This is the convergence of STPs with faecal sludge treatment, wherein a small facility is designed that can hold faecal matter, and installed at the inlet of the existing STP. The facility acts as a holding tank for sludge collected from households, and screened to remove objects such as rags, paper, plastic, etc. Post-screening, the sludge makes its way into the inlet chamber of the STP where it gets mixed with the wastewater coming from the underground drain and gets treated.

They cite the example of Hyderabad. By virtue of having converted just four STPs to co-treatment facilities, the city prevented approximately 900 trucks of faecal sludge from being deposited in water bodies over a period of five months. This has increased the efficiency and utilisation rate of the STP treatment, while providing large quantities of treated wastewater to the city.

Changing the way, we look at faecal sludge

Solving the sanitation problem will not only require innovative approaches in infrastructure and technology, but also in thinking. There is a need to consider treatment products as a source of revenue generation from resource recovery, as opposed to a disposal problem

Evidence suggests that resource recovery from faecal sludge could provide a financial incentive for sanitation service provision. So far, use of treated sludge as soil conditioner is the most common form of resource recovery, which does not always generate as much revenue as energy producing options. Possibilities for resource recovery in the form of fuel and building materials can be explored. It is also important to consider the local market when selecting and designing treatment and end use, as markets vary significantly among locations. The results of such interventions can help policymakers in evaluating potential options for managing the sanitation service chain.

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About DHAN Foundation

Development of Humane Action (DHAN) Foundation is a pan-Indian not-for-profit development organisation based at Madurai, Tamil Nadu. Two decades of its intensive engagement in building scalable models of community-led microfinance programme and conservation and development of water resources has led to a nation-wide reach and impact in poverty reduction with over 1.5 million poor households. The Foundation also works on the themes of rainfed farming, democratising Panchayats, ICT for Development, Coastal Conservation and Livelihoods. The success lies in its unique way of attracting and engaging high quality human resources at the grassroots, nurturing young Professionals to transform them into highly competent Development Professionals. DHAN's works in the fields of microfinance, water resources conservation and development, and building human capital for the social sector have resulted in hundreds of sustainable and self-governed institutions of the poor, mutually beneficial partnerships with public and private institutions, tens of thousands of grassroots leaders, a larger pool of highly motivated and committed professionals for social sector.

About The DHAN Academy

The DHAN Academy, an institution for Development Management, started in 2000 is the result of a partnership between the DHAN Foundation and Sir Ratan Tata Trust, Mumbai. The Academy commenced its work in December 2000 and aims to become a Centre of Excellence in Development Management. The Academy works for inducting and grooming development professionals through specially designed programs. The Academy offers a two-year postgraduate program in development management (PDM). The emphasis is on the principles of 'practitioners to teach', and 'learning and building knowledge' through action-reflection-action mode and on building high quality techno-managerial competence supported by appropriate motivations, values and attitudes to work with people, particularly the disadvantaged.

The Academy also offers short programs to NGOs, academicians, researchers, government agencies and others. It emphasises research for generating case studies and teaching materials. It has promoted specialised Centres like Advanced Centre for Skill and Knowledge in Mutual Insurance (ASKMI), Advanced Centre for Enabling Disaster Risk Reduction (ACEDRR), Water Knowledge Centre (WKC) for advancing the practices through appropriate knowledge management systems including research, documentation, publication, training, education, and policy advocacy.

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