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The First English farm journal from the house of Kerala Karshakan

CARBON NEUTRALITY
THROUGH SUSTAINABLE NATURAL FARMING

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CARBON NEUTRALITY THROUGH SUSTAINABLE NATURAL FARMING

Climate Science indicates that input-intensive agriculture is both a contributor and a victim of climate change.

Agricultural activities are one of the main contributors to human emissions of greenhouse gases accounting for 25 per cent of total emissions, due to intensive fertilizer usage and deforestation, according to IPBES, 2019, Global Assessment Report on Biodiversity and Ecosystem Services. It is reported to have a negative impact on the well being of at least 3.2 billion people across

the globe. Another report from IPCC (Intergovernmental Panel on Climate Change) finds that about 30 per cent of global emissions leading to climate change are attributable to agricultural activities, including pesticide and fertilizer use.

The international initiative '4 per 1000', launched by France during 2015 at the COP 21 aimed to demonstrate that agriculture, and in particular, agricultural soils can play a crucial role where food security and climate change are concerned. An annual growth rate of 0.4% in the soil carbon stocks, or 4% per year, in the first 30-40 cm of soil, would significantly reduce the CO_2 concentration in the atmosphere related to human activities. However, this growth rate is not a normative target for each country. Hence, there is a need to identify alternative low-input farming practices that promise reduced input costs and higher yields for farmers, chemical-free food for consumers and improved soil fertility.

The countries around the world are now recognising the unique role that agriculture can play in sequestering carbon.

Reversing land degradation and improving soil's carbon absorption could provide more than a third of the most cost-effective greenhouse gases mitigation activities needed by 2030 to keep global warming under 2^0C (IPBES, 2018).This will also enhance food and water security, reviving biodiversity and supporting achievement of the Sustainable Development Goals (SDGs).

In this regard, Zero Budget Natural Farming (ZBNF) is a scalable model of low-input/ high output agriculture that eliminates the use of synthetic external inputs by utilizing local farm-based inputs and regenerates soil health.

The ZBNF is already reducing CO_2 emitted yearly from the agriculture sector with more than 4,09,400 hectares and over 20,000,00 farmers converted to natural farming in the country.

As per UNEP, the ZBNF practices are mitigating Climate Change (CC) effects and increasing yields. The Food and Agriculture Organisation (FAO) also urged the countries to consider ZBNF as an important move to agro-ecology adoption. As per IPBES, the ZBNF will reduce land degradation and enhance water and food security.

The practice is more significant as over 20 percent of food commodity samples are found laced with pesticide residues in the country. The fertilizer usage has enhanced from 23 to 54 kg/ha. Apple receives 8-12 sprays, while cauliflower, capsicum and tomato get 6-8 sprays. Pomegranate has gone to alarming 16 sprays.

With this background and to achieve the target of doubling farmers' income as envisaged by Prime Minister, Shri Narendra Modi (who categorically urged the states to adopt natural farming for sustainable agriculture at different platforms), the Himachal Pradesh government, which had launched 'Prakritik Kheti Khushhal Kisan Yojna (PK3Y)' in 2018, is giving priority to natural farming. This ZBNF technique was devised by Subhash Palekar from Maharashtra (Padma Shree awardee) so the Himachal Pradesh government renamed it as Subhash Palekar Natural Farming (SPNF).

The State Project Implementing Unit (SPIU) of PK3Y in the Himachal Pradesh government is promoting the non-chemical low cost climate resilient SPNF technique among farmers through sensitization, training, exposure visits and regular hand holding.

The strategy includes scalable awareness, training of trainers, farmer field schools, farming based package of practices, certified evaluation, sustainable food systems, traceability and transparency leading to doubling of farmers' income.

The SPNF involves farm inputs prepared from dung and urine of indigenous cows and some extracts from local plants, gram flour and jaggery. One indigenous cow supports 30 acre for natural farming.

The preparation of all the decoctions is done in and around home/village and it cuts dependency on the market for inputs, thus reducing the cost of cultivation substantially.

The four wheels of natural farming- Beejamrit, Jeevamrit, Aachhadan and Vafasa help the soil in carbon assimilation, besides other important benefits. Beejamrit- a culture of micro organisms- is for seed treatment with indigenous cow urine-dung based formulations. Jeevamrit- best culture of fertility creating micro-organisms- is for ensuring soil fertility through cow dung and

urine concoctions. Aachhadan- covering of soil surface with live or crop residues- helps in preventing water evaporation and contributes to soil humus formation. Vafasa- soil aeration mixed with water vapours- is for ensuring favourable micro climate in the soil.

So far, 171353 farmers have been trained in natural farming technique in 3581 out of 3615 Panchayats in Himachal Pradesh, out of which 1,59,465 farmers are practicing it partially or fully on their land. The total land under natural farming in the hill state is 9212 hectare till 31 December, 2021. The farmers have adopted natural farming after testing on part of their fields and are satisfied with the results, even as they are doing certain innovations on their own to handle the problems they face day to day in natural farming.

According to scientific studies by the SPIU, PK3Y, the adoption of SPNF technique by farmers in Himachal Pradesh has resulted in cost reduction of 56.5 per cent in apple, 28.1 per cent in wheat, 14.3 per cent in cereals and pulses, 26.46 per cent in pulses and vegetables, 45.5 per cent in fruit, pulses and vegetables and 20.4 per cent in vegetables and pulses. The net returns increased by 27.4 per cent in apple, 63.6 per cent in wheat, 16.1 per cent in cereals, 18.8 per cent in pulses and vegetables, 21.5 per cent in fruit, pulses and vegetables and 11.8 per cent in vegetables and pulses.

The studies revealed that upto 9 crops were being concurrently grown by the farmers leading to crop intensification and increased crop diversity and 15 types of companion crops were being grown under apple orchards.

The incidence of Scab and Marssonina blotch in Apple and Yellow rust in wheat was lower when natural farming technique was followed vis a vis conventional practices.

The farmers observed that the SPNF crops have better drought resistance, better taste and flavour than chemically grown crops.

Natural farming is a climate friendly agriculture technique and is an agro-ecologically viable solution to the looming threat of climate change and soil degradation. This is evident from the fact that crops are able to withstand dry spells for much longer periods. Crops can also withstand heavy rains. As many as 99.1 per cent of farmers have said that their crop has shown better resilience to adverse climatic conditions.
In the cold desert region of the state, the SPNF has been able to maintain 1.5 – 7.8 per cent more moisture content in soil than chemical and organic farming.

Himachal Pradesh is in a leadership role for the outreach of natural farming in the country as well. While many other states, including Gujarat, are keen to adopt the Himachal Pradesh model of implementation of natural farming, the state is a regular contributor and collaborator in natural farming work by NITI Aayog. The SPIU, PK3Y is partnering and engaging global organisations which are custodians of Sustainable Food Systems i.e.

UN - FAO, IFOAM, INRAe, Biovision, WWF, ORFC etc. through various deliberations, workshops, and are constantly invited as speakers to share their vision, experience on an international platform with other countries.

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ADOPTION OF PRECISION FARMING TECHNOLOGY

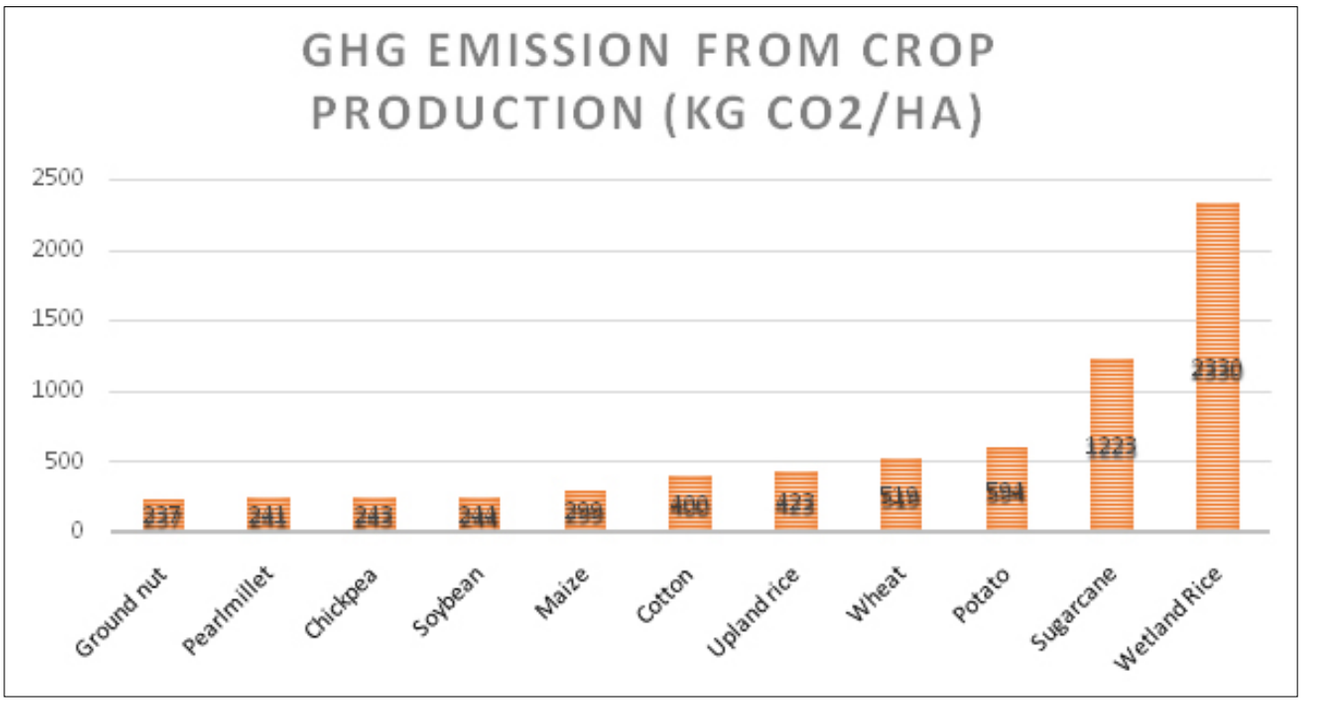
THE ONLY WAY OUT FOR REDUCING GHG EMISSION AND CLIMATE CHANGE IN AGRICULTURE

Global WARMING is the slow increase in average temperature of the Earth atmosphere. The increased amount of energy striking the Earth from the Sun is being trapped in the Earth atmosphere (do not get radiated back to Space) as a result of GHG's (Green house Gases) present in ever increasing amount in the atmosphere. The main GHG s are CO_2., Methane gas, N_2O, Choloro-fluorocarbons (CFC), Hydro fluorocarbons (HFC), Hydrochloro flurocarbons (HCFC), and Sulphur Hexa fluoride (SF_6). GWP (Global warming Potential) of these GHGs are measured in reference to CO_2. GWP is a measure of how much Energy the emission of 1 ton of a Gas would absorb over a period of time relative to the emission of 1 ton CO_2. Larger the GWP, the more a given gas warms the earth compared to CO_2 for that time period.

CO_2 has a GWP of 1 and it remains in the system for thousands of years.CO_2 is emitted when anything is burned; coal, petroleum , biomass. 55% of all GHGs is CO_2.

Methane gas has a GWP estimated 28-36 times. Though Methane emitted once will last for only 10 years, it absorbs

Fig 1. CO2 emission from crop cultivation



(traps) much more energy than CO_2. Methane Gas is Emitted by Combustion process and by Anaerobic Decomposition of organic material (in paddy fields, Pig and Cow stomachs).

Puddled and flooded Paddy cultivation is a major source of Methane gas.

N_2O has a very high GWP (265 to 298 times that of CO_2.) and the emission will remain in the earth's atmosphere more than 100 years. N_2O is emitted mainly by the chemical fertilizers during their production and when they are applied to the soil.

CFC, HFC etc. were created by humans as refrigerants.These gases have GWP range of 1800-8000 and also are very long lasting.

Black carbon (10 micron) particles comes from incomplete burning of fossil fuels.The atmosphere carries them to glaciers and begin melt the ice. (Causing ocean level to rise). BC is second to CO_2 as a GW agent.

Human activities causing global warming

Fossil fuels, coal and petroleum are the most important sources of GHGs and black carbon activities like power generation, industry, transportation, buildings etc. generate GHGs.

Agriculture is the second most important GHG generating human intervention. The following activities generates high volumes of GHGs.

1. Flooded paddy cultivation among other irrigated crop farming activities.
2. Animal keeping; ruminants like cows and pigs generate methane as a belch during digestion of their feed.
3. Feed production itself
4. Chemical- intensive crop production,
5. Deforestation driven to expand cultivated areas or infrastructure and urbanization.

How conventional agriculture results in high GHG generation?

Inefficient use and imprecise dosage of inputs-fertilizers, irrigation water and pesticides causes GHG formation in Agriculture.

Events of excess irrigation causes land degradation and salination making further crop production impossible. Excess water in the top soil bring in anaerobic digestion of organic matter by microbes and generation of high volumes of green (GHG) like Methane or Nitrous oxide.

Conventional application of Urea fertilizer in one or two splits results in high mineral load on the land and generates

1. High doses of Nitrous oxide (N_2O).
2. Partial production of Ammonia from excess urea leading to climate change.
3. Excess urea generates excess nitrate (NO_2) that will move to

water channels, streams and wells causing pollution and ends up in the human food chain. As fertilizer additions increase, N_2O emissions appear to remain quite static across a broad range of rates (roughly between 90 and 150 kg N ha-1), maybe near the crop demand levels. At higher N rates, emissions tend to increase nonlinearly.

When Phosphorus fertilizer or organic manure (both containing soluble phosphorus) is added in large quantities the build-up of phosphorus in soil occurs. Excess soil phosphorus reduces the ability of plants to take up micro nutrients like Zn and Fe.

The effect of excess Potassium in the soil, however is less impacting the climate compared to those by Nitrogen and Phosphorus fertilizers.

How does Climate change affect crop production?

Changes in the onset, depth and duration of monsoon rains affect growth and development pattern of several crops- impacting flowering time, flower survival, fruit growth and overall crop calendar and production.

High intensity rain fall events flood or water log fields and destroy crop, causes fruit drop. High intensity rain fall causes landslides and top soil loss in many place resulting in total crop loss.

Higher wind speed damages crops like Banana. Prolonged drought incidences reduces crop survival and yield. Unusually high temperatures during grain fill in cereals cause low filling rate resulting in more chaff. Reduction in chilling and non-coincidence of chilling time with crop stage results in poor or low flowering in temperate fruit trees.

Unusually lower temperature for longer duration causes long frost periods that kill crops. Increase in temperature during Anthesis of many crops result in low pollen viability that lead to lower fruiting. One degree rise in temperature reduces wheat production by 4.5 million ton and rice production declines by 10% (IARI, The Earth Institute, 2010).

Increase in temperature due to global warming also result in the alteration in the distribution and intensity of insect and disease pests.

Can carbon sequestration by photosynthesis fully remove the CO_2 emission to the atmosphere?

Not fully; and in fact not much effective in removal. 25% CO_2 emission produced by human activity is absorbed by plants. A similar amount ends up in Ocean. But 50% of CO_2 taken by photosynthesis goes back to atmosphere through respiration. 90% of the rest also returns to atmosphere through microbial activities in the soil and other disturbances like fire.

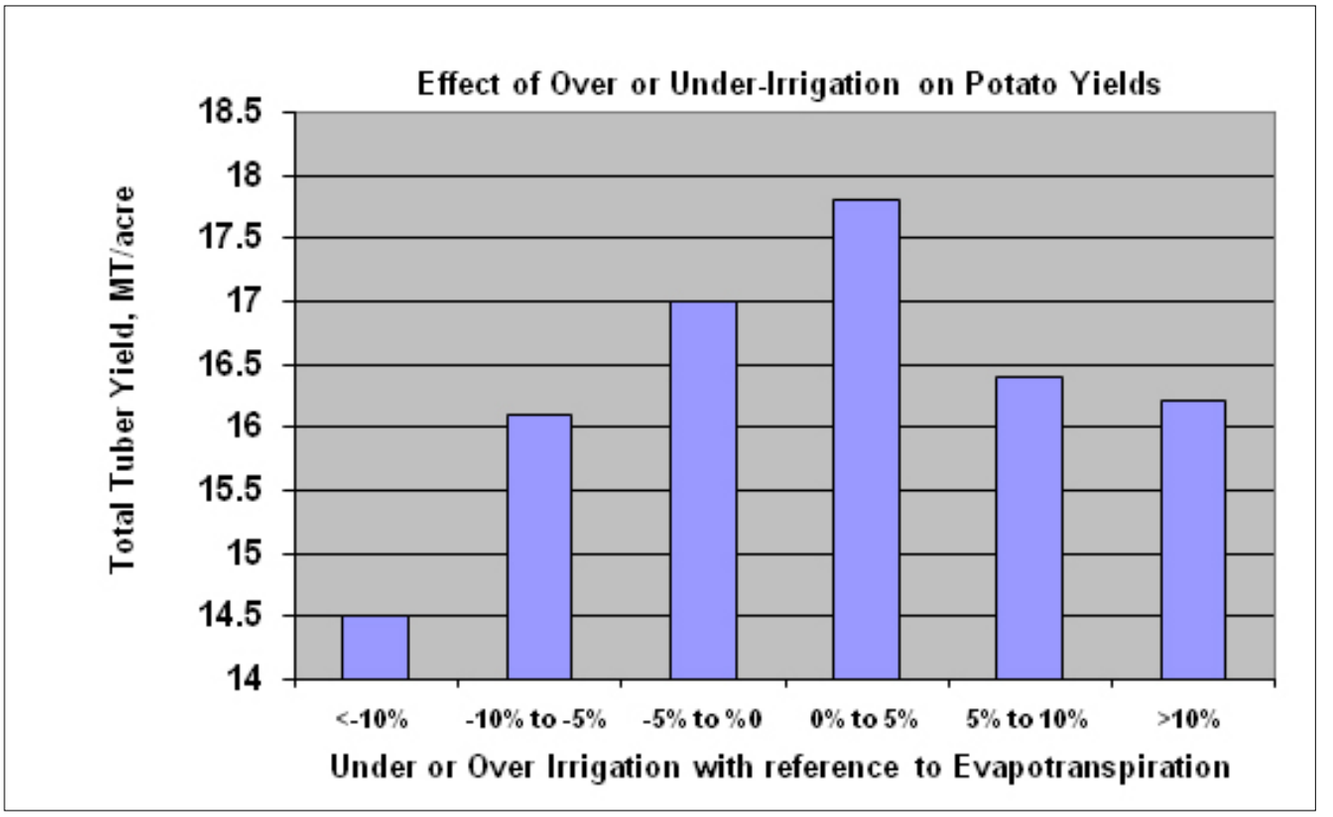
A tree can absorb up to 21.8 kg CO_2 per year by the time it reaches 40 years. Teak has the highest rate of Sequestration of CO_2. Among crops, Sugarcane is one of the highest CO_2 Sequester - 0.66 ton /ha/yr.

Precision farming (PF)

PF is a management strategy which identifies, analyses and manages within-field variability for increased Productivity and reduced Environmental impact. Site specific management, Prescription farming and Precise Input management are the major

Soil Preparation	Humus level, microbial load, aeration &drainage, fertility restoration, mulching.
Land preparation	Ensure chemical and physical uniformity of top soil
Nursery	Physically, physiologically uniform seedlings with intact roots
Crop geometry	Single, double, triple and tetra rows (straight and alternate)
Drip-Fertigation	Water and Nutrients matching with the physiological demand
Growth management	Regulation of flowering, training the canopy, frost protection.
Plant protection	Monitoring System, IPM
Protected cultivation	Adopt Green house, Shade house and Low tunnels
Field Level PHM	Harvest, handling, sorting, grading and labeling
Cluster Approach	Registered Precision Farmer's Associations at Cluster level
Market linkage	Collective marketing, Market information through IT.
Empowerment	Cluster Farmers'Co-operative or Company

Fig. 2. Precision irrigation produces highest yield. More water less yield



drivers of PF. Open field PF is more efficient in terms of retarding Climate change by reducing the GHG emission.

In Developed Countries PF implementation is at a higher level than in developing countries because of application of technologies like;

- GIS and Sub cubic cm soil grid level studies
- Maintenance of uniform Nature of Soil by Sensor based diagnostics and application of inputs
- Adoption of Single Crop Cycle system And highly mechanized Farming system where variation due to human intervention is kept to the minimum.

In countries like India,Prohibitive GIS Cost, Diverse nature of the Soil Multi -cropping system And Manual Farming system (low mechanization) makes PF adoption more difficult. But still there are very successful cases where PF is practiced and productivity enhancement is noticed along with reduction in GHG emission.

The following interventions are done for PF adoption in India and the results are found to be excellent.

Optimum and timely inputs are applied and Higher yields and incomes achieved. The precision interventions/ management steps are in the following factors.

- Improved Seeds
- Soil and seed bed management
- Space management (GEOMETRY)
- Sunlight
- Water
- Fertilizer
- Pests
- Mechanization of operations
- Harvest and Post-harvest

Practicing PF

Monitor the soil and plant physicochemical parameters: by analysis and placing sensors (electrical conductivity, nitrates, temperature, evapotranspiration, radiation, leaf and soil moisture, etc.)and the optimal conditions for plant growth can be achieved. Obtain data in real time: the application of sensing devices in the fields will allow a continuous monitoring of the chosen parameters and will offer real time data ensuring an updated status of the field and plant parameters at all time. Provide better information for management decisions.

Adopt micro irrigation and fertigation with scientifically prepared schedules of water and fertilizer application to manage inputs-irrigation water

Table 1 . Actual water need of rice

CROP WATER REQUIREMENTS OF PADDY CROP	WR mm	m3/ha
Coastal Peninsular region North (West Godavari/AP) October planting	574.8	5748.3
Interior Peninsular region (Kurnool/AP) October planting	584.1	5841.0
Southern Coastal Peninsular (Tirunelveli) January planting	478.4	4783.5
South-Eastern Coastal peninsular (Thiruvarur-Tanjore/TN) Summer planting (April planting)	555.7	5556.6
Central Semi -Arid region (Medak/Telengana) July Planting	616.6	6165.9
North temperate region (Kurukshetra/ Haryana) June planting	388.1	3880.8
North temperate region (Patiala/ Punjab) June planting	369.4	3693.9

Table 2. Benefits of PF in Paddy cultivation- Very low Methane(GHG) emission.

Summary of first results of drip for rice	Flood	Drip	Saving	%
Average irrigation water consumption (000 l/ha)	6'325	3'084	3'241	51%
Transplanted rice (000 l/ha)	6'850	3'434	3'416	50%
Direct seeding (000 l)/ ha	6'384	2'969	3'415	53%
Water productivity (kg/m3 water)	0.300	0.800	0.500	63%
	flood	aerobic		
Methane emissions (CO_2 eq tons/ha/120 days)	3.7	1.9	1.8	49%
Estimated savings with drip (CO_2 eq tons/ha/120 days)	3.7	1.5	2.2	60%

and fertilizers most precisely in quantity and time. This would save time and costs; reduce fertilizer and chemical application costs, reduce pollution through lesser use of chemicals and lower doses of application.

Provide better farm records essential for sale and succession and monitor the history of agricultural land. These can be integrated with any farm management software, to make all activities on-farm easier and to improve farm productivity. This precision will also reduce the GHG emission.

Objective of PF is to achieve two contrasting goals- to increase crop productivity and to reduce the potential environmental risk by optimizing inputs.

For example , see the figure below. When irrigation volume applied was equivalent to the Evapotranspiration of Potato crop, the yields recorded were the highest. The commonly held erroneous belief that more water more yield is proved wrong. Precision irrigation results in highest yield.

Precision farming technologies, like implementing an irrigation schedule based on crop evapo-transpiration and fertigation schedule where nutrient application rate and time matches the crops' physiological need for nutrients, type and rate.

How Much water do I need for Rice crop?

Because paddy is the most unscientifically irrigated crop in terms irrigation volumes and paddy is the highest GHG emitting crop, let us study the actual crop water requirement (= ETP) of paddy crop in various locations of differing Evaporative demands and different planting seasons

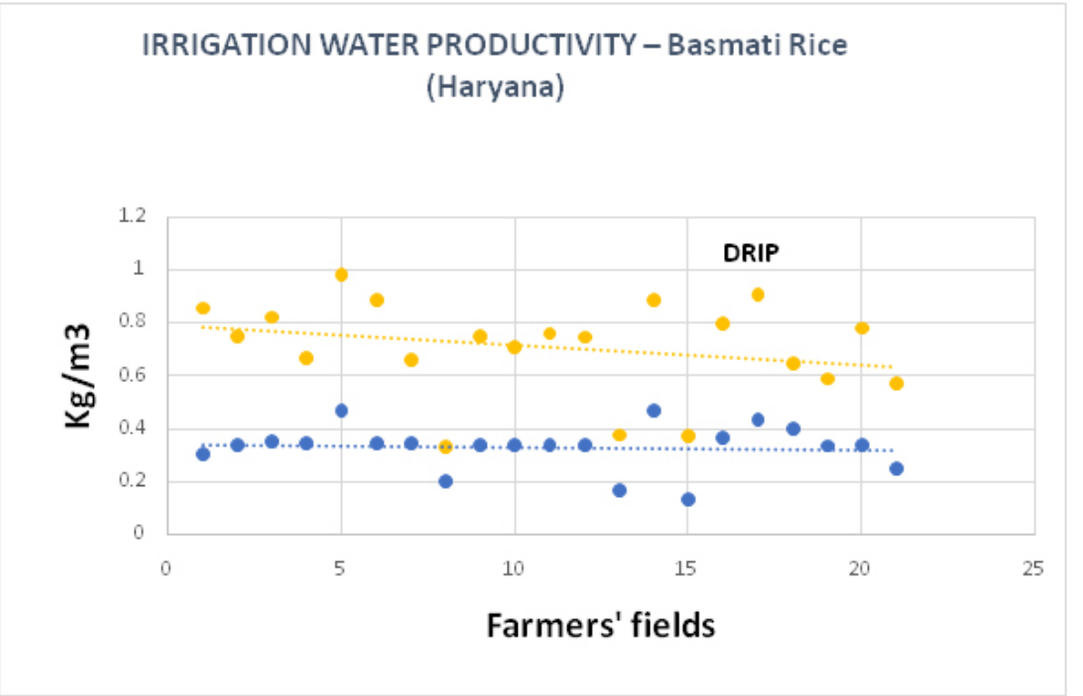
In conventional irrigation of Paddy crop the whole season consumes an average of 23750 M^3 in the above regions and the average productivity recorded ranged from 2.0 - 2.5 t/ha in farmers field.

Excess irrigation results in high Methane emission (GHG). A change to PF would reduce the GHG load into the atmosphere (see Table 2).

Because of the above strict regimen soil is never loaded with excess fertilizer. This alone is adding to lower rate of residual accumulation in the soil and ground water.

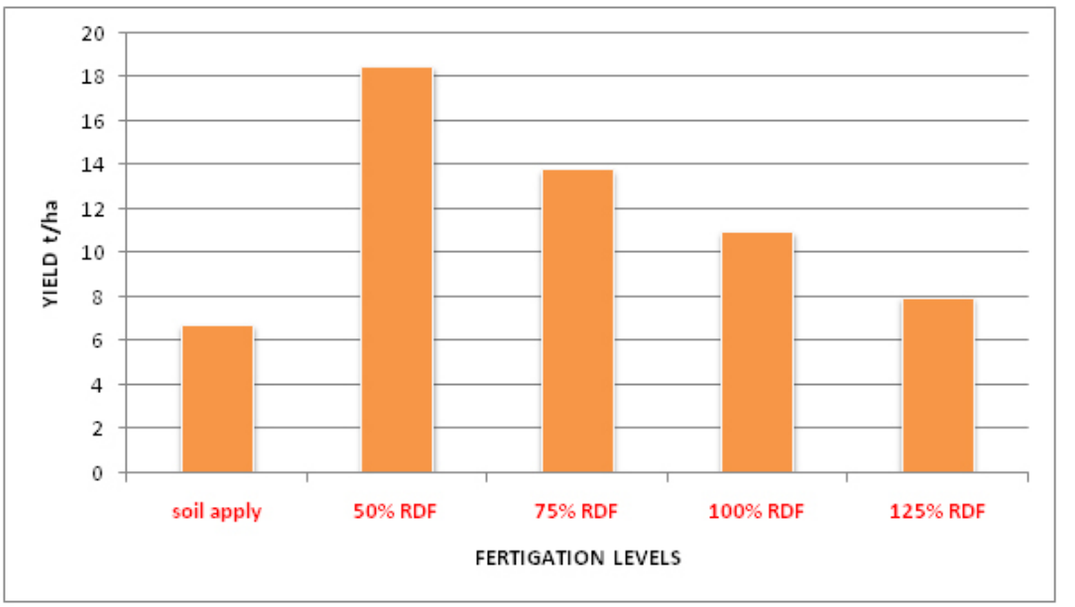
The use of frequent fertigation, combined with improved irrigation scheduling, results in improved fertilizer uptake efficiency, and enhanced water use efficiency, increased residence time of nutrients in the

Fig. 3. Water productivity of paddy crop both in conventional flood and ETP based drip irrigation methods.



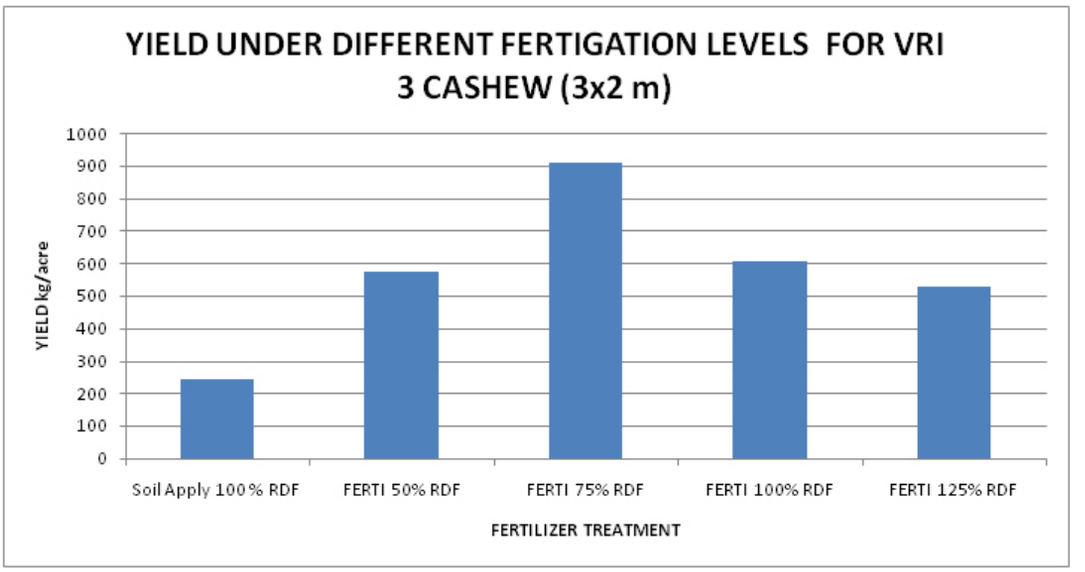
Average Water Productivity under ETP based drip irrigation was around 0.75 kg/m3 while it was 0.36 kg/m3 under conventional flood system. PF method of growing paddy not only reduces water consumption but improves yield also. The GHG emission is reduced by 60 plus %.

Fig. 4 Effect of fertigation in reducing fertilizer use in Pomegranate.



100% recommended dose (RDF) applied to the soil is compared with fertigation at 50% RDF, 75% RDF, and 100 and 125 % RDF. Fertigation at 50% RDF resulted in highest productivity (18 t/ha) making a direct saving of 50% fertilizers. Avoiding direct soil application of solid fertilizers in large quantities reduces GHG emission.

Fig. 5. Effect of fertigation in reducing fertilizer use in Cashew.



100% recommended dose (RDF) applied to the soil is compared with fertigation at 50% RDF, 75% RDF, and 100 and 125 % RDF. Fertigation at 75% RDF resulted in highest productivity (950 kg/acre) making a direct saving of 25 % fertilizers. Avoiding direct soil application of solid fertilizers in large quantities reduces GHG emission.

root zone, and reduced potential for groundwater pollution.

In drip –fertigation, water, fertilizer placement, and application frequency are managed more efficiently compared with a dry fertilization program.

Productivity gains with irrigation and fertigation, using the same fertilizer doses, increased nutrient use efficiency 25%, compared with flood irrigation and solid fertilizer direct to the soil.

For this reason, it is recommended to reduce N and K doses by 20-25% when nutrients are applied through fertigation in relation to the nutrient levels recommended for direct solid fertilizer application to the soil.

Simply by need based (Crop need assessment) fertilizer application through fertigation where very low concentrations (rates) of the fertilizers are applied to the rhizosphere in large number of doses during the crop growing duration. Fertigation schedules prepared by agronomists provides this opportunity. The result is high nutrient use efficiencies and no or nil effect nutrient on the environment. This practice helps in retarding the rapidity of climate change.

The reduced GHG emission resulted from avoidance of high volume flood irrigation and practice of fertigation, both critical input management methods in PF.

Fertigation method of application of chemical fertilizers offers very high FUE (fertilizer use efficiency) and a very high percent reduction in GHG due to extra loading of soil by chemical fertilizer, as it happens in direct application of RDF at one or two split doses. Fertigation is an essential step in PF.

Studies like the above with a number of crops show that the recommended fertilizer doses of these crops always result in over-fertilization leading to GHG formation and lower yields. Fertigation enhances FUE (fertilizer Use efficiency) and reduces GHG load on to the atmosphere.

Additionally, practice of IPM methods for pest management also help in PF by reducing chemical load into the environment.

Use of insect traps, surveillance and application of chemical control measures only afire arriving at Economic Threshold levels (ETL) improves Crop production and reduces its negative impact on climate change.

Legumes for Soil Health Management

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Introduction

Agriculture is the backbone of the developing nations with a prime focus on optimum productivity of crops and efficient use of natural resources in a suitable manner so that it can provide food and nutritional security in an efficient manner.Soil health management is a prime concern to ensure agricultural sustainability. Dwindling soil fertility as well as declining soil health is one of the great challenges of the present time to feed the world population. Injudicious use of chemical fertilizers may negatively affect soil health. Further, chemical fertilizer production is associated with release of greenhouse gases to atmosphere and thus, pollutes the environment. Crop husbandry is a major component of agriculture and it is influenced by both natural

as well as anthropic activities. Human, since the starting of crop husbandry, always seeks to use more and more resources to produce more from the limiting land resource. Cropping system, in its broader sense, is the cropping pattern followed in a farm and its interaction with other farm resources which determine the make-up. Due to productive as well as marketing advantages along with specialization of crop husbandry, farmers kept on cultivating rice and wheat years after years. This practice of sole cropping led to nutrient mining, weed and pest infestation, declining soil fertility and productivity.

Legumes description

Pulses, because of their quality protein profile, is considered as the "poor man's meat" and occupy a special place in Indian diet. Global population is going to hit 8.6 billion by 2030 and 9.6 billion by 2050 and along with this population explosion, biotic and abiotic influences of climate change on global food production can't be neglected. Therefore, agriculture is under huge pressure to maintain food as well as nutritional security, mitigate adverse effect of climatic aberrations and to recover soil health and improvement of other resource bases.

Legume inclusion in cropping systems replacing the existing cereal-cereal cropping systems can register a vital role in sustaining the agricultural production system because of their multirole services, i.e., source of nutritious food for both human and animals, atmospheric N fixation, mitigation of greenhouse gas emission, breaking of weed and pest cycle, etc. Hence, legume inclusion in cropping systems is the need of the hour with high priority to sustain the agricultural activity and to maintain the food as well as nutritional security. In India, pulses are generally cultivated in resource constraint areas and more emphasis is being given to the cereals. A significant population in India are malnourished. India constitutes nearly 70% of world vegetarian population, so to fulfil this nutritional security there is a scope to increase area as well as the productivity of pulses using different agro-techniques. Along with nutritional advantages, pulses have ability to enhance soil nutrient status, as they can fix atmospheric nitrogen (N), can sequester carbon in soil and indirectly enrich micro and macro- nutrient status of soil on their incorporation.

Being the third largest family among flowering plants after the families of Asteraceae and Orchidaceae in the plant kingdom, the Leguminosae comprises of 800 genera and 20,000 species. Nutritionally, legumes are far superior to many other food sources containing 126-660 g carbohydrates, 180-430 g protein, 7-400 g fat, 0.9-2.4 g calcium, 28-115

mg iron, 13-39 mg riboflavin, 3-99 mg thiamine and 7- 64g dietic fibers in a kg of dry grain. Legumes are broadly grouped into warm-season legumes (i.e., soybean, groundnut, pigeon pea, etc.) and temperate legumes (i.e., pea, lupin, French bean, lentil, vetch, etc.), among which soybean is most widely cultivated legume crop in the world. But, due to more intensive and specialized production system, cultivation and expansion of major cereals are way more extensive than pulses.

Legumes and biological nitrogen fixation (BNF)

Nitrogen is a primary essential nutrient for crop production and is the vital factor for crops after solar radiation and water. Except legumes, almost all crop plants depend on soil N for their requirement, even(even though)the Earth's atmosphere is rich in N gas. Legumes have the capability to fix the atmospheric nitrogen through legume-rhizobia symbiotic association. This biological nitrogen fixation (BNF) not only help the legume to fulfil its nitrogen need, but also enrich the soil nitrogen status to improve the succeeding crop yield. Plants can get nitrogen from soil either through decomposition of legume residue or from atmospheric nitrogen fixation by leguminous plants. Those leguminous plants which fix and add atmospheric nitrogen to soil(are) called "N-donor" plants and those which receive this soil nitrogen (are)called "N-receiving" plants. The extent of this biological nitrogen fixation varies from zero to several hundred-kilogram nitrogen per hectare

Inclusion of legumes in cropping system

Sequential cropping

Crop rotation is considered to be incomplete if legumes are not included in a cropping system. The amount of nitrogen addition (added)to soil through legume inclusion depends on the legume crop taken for the system. Crop rotation through suitable legume inclusion not only improves biomass production but also enhance soil carbon and nitrogen status.

Inter cropping

Intercropping is the cultivation of two or more than two crops on the same land as they coexist for some period of their life cycle. It is practiced to achieve some ecological goals,i.e., reducing risks of farmers from complete crop failure against climate abnormalities, increasing resource use efficiency, increasing diversity of the farm promoting species interaction and cybernetics. Generally,

the main crop or base crop of intercropping should be the dominant crop of the locality and the second or component crop is grown for additional output using the left-out resources.

Crop rotation

Crop rotation is also an intensive strategy with recurrent succession of crops to enhance the output of the system in terms of crop productivity through inclusion of suitable crops. Inclusion of legume in the system is mostly encouraged knowing their multifaceted advantages, i.e., BNF, nutrient recycling, increase soil carbon and nitrogen stock, etc.

Green and Brown manuring

Green manuring is the incorporation of green crop residues, preferably legume in-situ or ex-situ to make the crop residue decompose and supply nutrient to the succeeding crops. Legume are preferred for green manuring as they fix atmospheric nitrogen in soil, produce more biomass within short time period, rich in nutrients and low in C:N ratio.

Green manuring can partially or completely fulfil the N need of succeeding crop. Green manure play a vital role by bringing positive effects on soil physio-chemical and biological properties and thus improves soil health. Further, it replaces fallowness and restricts soil erosion and nutrient loss from the top soil. Amelioration of degraded soils can easily be done by addition of green foliage into the soil.

Cover crop

Legumes are close growing crops and hence serves as cover crop. Also, the dense foliage of most legumes reduces the erosive action of rainfall to a large extent. Legumes release many root exudates such as organic acids to the soil which acts as a binding agent and reduces soil erodibility by improving aggregate stability. As legumes are capable of being grown in relatively resource poor areas, they can act as both a fertility restorer and a measure of erosion control in such areas. Legumes can also be grown in alternate strips along with some erosion susceptible crops to keep the soil loss below acceptable threshold.

The benefits of using legume as cover crop is due to the fact that it ensures food and nutritional security while protecting the soil from erosive agents and improving the soil health (Blanchart et al., 2006; Doane et al., 2009).

Bio-mulching

After the pods are picked, the residues of legume can be added to soil, which can improve the organic matter content and nutrient status of soil. As the residues of legume have low C:N ratio, they can easily decompose and supply nutrients more quickly as compared to residues of cereals.

Legumes and Soil Health Improvement

Modern, intensive agriculture system is mainly agrochemical dependent directing towards consistent degradation of soil health, i.e., physical, chemical and biological quality of soil. Due to intensive cultivation and faulty soil management practices, severe constraints like increase in soil compaction and erosion, reduction in soil productive potential and reduction in soil microbial activity have been well recognized. Legume inclusion in the soil improves the physicochemical and biological properties by totalling organic substances and root exudates to the soil.

It was reported that legume can accumulate about 2.6 kg N/ha/day, and their incorporation can be equivalent to 50-100 kg N ha-1 application of chemical nitrogenous fertilizer. However, Dhaincha(Sesbania sp.) at 45-60DAS can accumulate 5.5 kg N/ha/day) and can fix about 300 kg N/ha.

Conclusion

Legumes are short duration crop, grown world-wide in resource limited conditions. Inclusion of legume in cropping systems has several advantages such as food as well as nutritional security, ecological soundness and creation of an efficient agro-ecosystem, reduction of soil erosion, enhancement of water and nutrient use efficiency, sustained soil function, biological nitrogen fixation and improvement of soil health, increase in soil organic carbon and nitrogen stock, soil carbon sequestration, and thus, increase in agricultural productivity.

Post-Harvest Storage of

Rice Straw

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Introduction and Background

Rice straw is defined as a byproduct of the rice production process at harvest. Rice straw/ paddy straw is removed with the paddy (rice grains covered with husk) during harvest. In general, rice straw bundles are formed after collection from the field using machines or they are spread in the field if harvested manually. Post-harvest management of rice / paddy straw is still a challenge in the rice straw supply chain. Globally, annual rice straw production is 800 – 1000 million tons/ year, with about 600 – 800 million tons/year in Asia, and the straw:grain ratio is 0.7–1.4 depending on rice variety and growth factors (IRRI). According to IRRI, for every 4 tons of rice harvested, 6 tons of rice straw is left in the field. It is estimated that 97.19 million tons of rice straw residue is produced in India among which 23% of the produce is surplus which is left in the field as uncollected or burnt (Gadde et al., 2009). The prevalent burning of rice straw in India is a primary contributor to a high level of air pollution that leads to various health issues. To address such problems, different alternatives/

applications are reported, for example, non-energy uses: biochar, animal feed, building material, erosion control, and mushroom production as well as energy production: generate fuel, heat, or electricity (via thermal, chemical, or bioprocesses). The heating value of rice straw is 16.28 MJ/kg (Phayom, 2012) that indicating its potential use as a fuel. In India, around 0.12 t/ year of rice straw are collected to add 12 megawatts of electricity to the local power grid (Hegazy and Sandro, 2016). For such applications, the availability of rice straw should be throughout the year that requires appropriate storage and transportation.

Storage of Baled Rice Straw

The rice straw bundles, formed after collection from the field, are compressed into bales such that transportation cost is reduced. The bulk density of a round rice straw bale (70 cm length; 50 cm diameter) is 60–90 kg/m^3 in dry matter; whereas, 13–18 kg/m^3 in dry matter for loose rice straw (Van-Hung et al., 2020). After transportation, the bales are stored or processed as per the need.

The moisture content of straw/bales is an important parameter considered while processing and its final use (Van-Hung, 2020). Further, for reduction of the straw volume, 12–17% moisture level should be maintained before compression. The traditional methods of storage in Indian villages include building rectangular or circular stacks in the open air over a platform made of locally available materials, for example, bamboo, bricks, jute sticks, wood, and others. Improper storage condition results in fungal and mold (microbial) attack in baled rice straw (Dobie and Haq, 1980). Reddy et al. (2009), reported a 29–41% dry basis moisture content range as a threshold below which microbial activity would not occur in rice straw. The method and duration of storage can highly vary the moisture level of bales; thus, affecting their storage life, quality, processing, and overall cost of utilization (Singh et al., 1995; Blunk et al., 2003).

Therefore, the storage method and duration should be decided based on the use of rice straw, for example, moisture content < 20% is desirable

for most potential uses for rice straw and high moisture straw can be used for ensiling or for anaerobic digestion to produce methane (Dobie and Haq, 1980). In this study, outside storage of round bales rice straw was conducted in USA during bailing and storage, and reported a significant change in the central temperature, energy, crude protein, fiber, and silica concentration with the variation in moisture level (20–50%). Spontaneous heating was also reported in bales with straw moisture contents exceeding 20% wet basis (wb), and straw baled at moistures between 40-50% reached maximum temperatures around 65 °C within the first 4 days of the experiment. Individual rice straw bales commonly exhibit self-heating within a few days of baling but eventually cool towards ambient temperature. Bale temperatures also respond to the addition of moisture, for example as rainfall. Blunk et al., (2003) reported each subsequent precipitation event led to additional heating in all bales having exposed upper surfaces. In contrast, bales stored indoors or under permanent cover remained near the mean daily ambient temperature after cooling from the initial heating following baling. Accordingly, bales exposed at the top of stacks suffered large losses in physico-chemical and heating value. Al-Mamun et al., (2002) reported a study on the influence on nutritive quality and mycotoxin contaminant of rice straw in the selected village of Bangladesh. Based on the results, the improved storehouse (22.5 ft length, 9ft height, and 13ft width) having gable type tin shed with raised slate about 1.5 ft height from the ground was suggested for storage of rice straw. Phayam et al., (2012) conducted a laboratory study (in the incubator) of nearly five months of rice straw storage at a temperature of 10^0C, 20^0C and 30^0C to develop a predictive model.

The model for the higher heating value of rice straw was based on carbon, nitrogen, ash, and moisture concentration that provided accurate predictions. Further, with the increase in storage period and storage temperature, a reduction in carbon, nitrogen, moisture, and ash concentrations was reported.

The Way Forward

The study on long-term storage under different storage conditions in multi-locations of India is needed to recommend storage norms for baled rice straw.

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Water Harvesting Structure

Farm pond for Food and Livelihood Security in Rainfed Regions of Karnataka

Introduction

Karnataka is an agrarian state wherein more than 60 percent of cultivable land is under arid conditions next only to the state of Rajasthan. In Karnataka, more than 50 percent of food grains and 75 percent of oilseeds are produced in the rainfed region. The scope for enhancing the irrigation potential in the state is limited in view of its geographical position as an upper riparian state.The vast majority of dryland area in the state received rainfall of about 450 to700 mm, which

Fig. 1: Dugout farm pond with field crops in farmer field

Table 1: Subsidy components under Krishi Bhagya Scheme

Sl.No.	Unit	Subsidies (%)	
		General Category	SC/ST
1	Farm ponds with polythene cover	80	90
2	Diesel pump sets for lifting water (5HP)	50	90
3	Solar pump sets	50	50
4	Sprinklers for irrigation (7 no per farmer)	90	90
5	Plastic sheets	50	50
6	Plastic pipes (30 no per farmer)	50	90

Source: Karnataka State Department of Agriculture, Govt. of Karnataka.

is highly erratic and unevenly distributed in cropping seasons. In addition to this, reduced rainy days, increased rainfall intensity as result of changing climate has created undesirable condition for sustainability of rainfed ecosystem in the state. In this milieu, Government of Karnataka brought out Kriishi Bhagya Scheme as pilot scheme during 2014-15 to achieve sustainable growth and development in agriculture. The major interventions of the scheme was to construct water harvesting structure-farm ponds for harvesting excess runoff and used it for critical life saving irrigation. This intervention has helped the farming communities to conserve and harvest surplus rainwater through dugout ponds and later used for life saving irrigation thereby enhancing crop productivity.Water harvesting is one of the key components of successful rainfed/dryland farming in rainfed region. There is an abundant scope and opportunity for harvesting excess runoff in the rainfed region in different states of the country (Wani et al., 2003). Thus, it is imperative to harvest excess rainwater through dugout farm ponds for improving the productivity of rainfed crops and income of the region (Dupdal et al., 2020).

Water harvesting structure under Krishi Bhagya Scheme

This scheme is implemented in the form of package for sustaining the income and livelihood of the dryland farmers in the state. Under the scheme, Government is supporting the dryland farmers for construction of farmponds along with polythene lining, installation of diesel/solar pump set with sprinkler irrigation system with 80 to 90% of subsidies. In addition to this, scheme provides shade nets and polyhouses to farmers for promoting high value commercial crops particularly horticultural and vegetable crops. The farmers contribution under the scheme was merely 10 to 20 percent depending upon the type of activities and vulnerable category to which beneficiary belongs. The farmer's contribution was mainly to inculcate a sense of ownership and to ensure sustainability of the created infrastructure. The different size and dimensions of ponds were constructed under the scheme which is depend on catchment area of farm for providing protective life saving

irrigation at critical growth stages of crops. The dimension of farm ponds usually depend on various factors such as land holding size, soil type, type of crop grown and requirement of farmers etc. Altogether, the scheme helps to integrate different farming system such as agriculture, horticulture, fisheries and dairying for creating employment opportunities, reduction of out-migration and enhance the on-farm and off-farm income of farming communities in dryland areas. At present 1.93 lakh farm ponds were constructed with total expenditure of Rs. 1920 crores mainly to benefit the critical irrigation needs of 4.13 lakh hectares of area through conservation of excess runoff water used as lifesaving irrigation. In addition, for promoting farmers to grow more high value produces such as flowers and vegetables nearly 2546 polyhouses have been constructed under the scheme.

Importance of water harvesting structure-farm ponds

Water harvesting structure has critical role to play for enhancing crop productivity and farm income for resource poor dryland farmers.

Apart from life saving irrigation to crops, farm ponds help for recharge of groundwater, reduction of soil erosion and drinking water for livestock. Farm ponds enhance the risk taking ability of farmers thereby help in diversifying their cropping system and income (Dupdal at el., 2019). Besides conserving soil and water required for crop production, it play crucial role in tiding over droughts that occurs in recent days. Therefore, rainwater management though farm ponds was an important part of strategy for enhancing crop productivity of rainfed agriculture.

Conclusion

Water harvesting structures constructed under KrishiBhagya Scheme has huge impact on dryland agriculture as more than 60 percent of cultivated area is under arid condition in the state of Karnataka.The sustained food and livelihood security of farmers can be assured with water harvesting structures through mixed farming and crop diversification strategies in rainfed regions. Farm ponds constructed under the scheme has able to provide one to two life saving irrigations for five acres of land area on critical crop growth stage thereby increases crop productivity up to 25 to 30 percent. Hence, dugout farm ponds are crucial for enhancing crop productivity and income in rainfed areas under changing climatic situations.

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CLIMATE RESILIENT AGRICULTURE

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According to the Food and Agricultural Organisation guidelines on Climate Resilient practices (2021), Climate Resilient Agriculture (CRA) refers to the ability of the agricultural system to anticipate and prepare for, to adapt, absorb and to recover from impacts of climate change and extreme weather. Resilience can be enhanced by implementing short and long term climate mitigation and adaptation strategies, ensuring transparent and inclusive participation of multiple stakeholders in the decision making and management process.

Climate change and agriculture creates a vicious circle. The burgeoning global population demands more food, attainable through intensive farming and livestock enterprises. Subsequently increased greenhouse gas (GHGs) emissions elevate the atmospheric temperature, attune global warming, which raises sea level due to melting up of ice cover. Over exploitation of limited natural resources like water and land aggravate ecological imbalances leading to wildfires, droughts, torrential rainfall, floods and cyclones wreak havoc. Unscrupulous agricultural practices like overdose of chemicals and fertilisers induce pest and disease incidence, soil degradation, destruction of soil microorganisms that play a key role in nutrient cycling. The non judicious utilisation of forest resources and timber logging led to biodiversity threats, habitat loss and enraged human - animal conflicts.

Climate mitigation strategies like adopting climate resilient crops and modified farm management practices, should be undertaken by the farmers. The management practices include adjusting planting time, irrigation facilitation, use of resilient crops, adoption of conservation agriculture, intercropping, crop

rotation, long term and short term crop and seed storage infrastructure (Acevedo et.al., 2020). Early maturing varieties of cereals, salt tolerant and drought tolerant crops, heat tolerant tubers and legumes all help farmers to increase crop yield in a sustainable manner. These climate resilient crops and varieties offer endurance due to abiotic stress conditions like salinity, drought, floods, heat or chilling injury and busts biotic stress factors like physiological disorders or pest and disease incidences. Hence they protect the farmers from the risk of declined crop yield or production even in unfavourable environments. Adoption is not the mere acceptance of a practice, instead selecting and using it for a sustained period by an individual or organisation and thereby making the innovation a common practice in their socio-ecological system.

Conservation agriculture refers to enhancement of biodiversity through diversification of plant species, minimum soil disturbance or zero tillage. Climate change adaptation includes planned or autonomous activities that may lower the risks of climate change, either by reducing exposure to such hazards or enhancing capacities to respond to them. Adaptation also refers to making use of beneficial outcomes that may arise due to climate change. The Notre Dame Global Adaptation Initiative (ND-GAIN) index depicts the list of countries according to their vulnerability to climate change (https://gain.nd.edu/our-work/country-index/rankings/). Adoption of climate resilient crops and practices among small holding farmers (less than 2 hectares of land holding) in these vulnerable countries are not so promising. The major reasons are lack of efficient agricultural extension services and outreach, low education level of the head of family, pitfalls in awareness regarding climate change hazards, non availability of good quality resilient crops and seeds, agricultural inputs like fertilisers on time.

During February 2011, Indian Council of Agricultural Research (ICAR), launched National Innovations in Climate Resilient Agriculture (NICRA) funded by the Ministry of Agriculture, Government of India. NICRA aims at making farmers self-reliant through four modules of natural resource management, improving soil health, crop production and livestock. The components of the scheme are strategic research in adaptation and mitigation, technology transfer in combating climate change to 100 vulnerable districts (2011-2013), capacity building through extension services and sponsored competitive research to fill critical gaps. Strategic research is functional in 21 ICAR institutes on the above mentioned modules.

Technology transfers are carried out through Krishi Vigyan Kendras in collaboration with state agricultural universities. Engaging focus group discussion with the community, the location specific critical gaps were identified. Interventions were finalised as an integrated framework for climate resilient practices covering four modules. Farmers were given support in multiple component interventions rather than single aspects.

Offering insurance coverage against vermin species and early weather forecast systems help the farming community in adopting CRA. Besides, ensuring timely supply of inputs like resilient crop seeds, advisory support and policy intervention in improving education, health, finance and land availability of small scale producers increases opportunities for income generation.

Extension services should be evolved towards participatory, information and communication technology, enhanced partnering with multiple stakeholders belonging to diverse socioeconomic backgrounds like womens groups, NGOs, public institutions, individuals varying in age groups. In short, climate resiliency at farm level plays a crucial role in achieving food security and improved livelihood in rural communities solely depending on agricultural production.

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Curry leaf a wonder crop

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India is popularly known as the "spice bowl of the world" for production of variety of spices and condiments with superior quality of taste and aromatic fragrance. Spices and condiments can be broadly classified into six groups, based upon the plant parts used like root and rhizomes, barks, leaves, flowers, fruits and seed spices. Among that curry leaf comes under leafy spices.

Curry leaf *(Murraya koenigii L.Spreng)* is a perennial leafy vegetable. It belongs to the family Rutaceae and native of India, Sri Lanka, Bangladesh and the Andaman Islands. Curry leaf is an aromatic pubescent shrub or small tree commonly known as kariveppallai in tamil.

Curry leaf plays an important role as a condiment in the culinary preparation of South Indian dishes. It is widely cultivated in some parts of Tamil nadu and Karnataka like, Coimbatore, Erode, Madurai, Salem and Trichy districts of Tamil Nadu and in Dharwad, Belgaum and Uttara Kannada of Karnataka State.

Curry leaf is well grown under tropical and sub-tropical

climatic condition. It is a small tree or shrub and they typically grow 6-15 feet tall. The leaf is shiny, dark green in colour which grow pinnately along with stem, and each branch can hold up to twenty, tightly clustered leaves. Curry leaves are extremely aromatic and have a strong flavor that has been compared to citrus, asafoetida, anise, and lemongrass. Curry leaves is also known as Karivepallai in Tamil, or Kariveppu in Malayalam, Kadi Patta or Meetha Neem in Hindi are known by many vernacular names as this tree is indigenous to India, Srilanka, and many Southeast Asian countries.

Curry leaf is a valuable plant for its characteristic aroma and medicinal value. It is an important export commodity from India as it fetches good foreign revenue. A number of chemical constituents from every part of the plant have been extracted. The most important chemical constituents responsible for its intense characteristic aroma are P-gurjunene, P-caryophyllene, P-elemene and O-phellandrene. The plant is rich source for carbazole alkaloids.

Curry leaf is widely used in Indian cookery from centuries and have a versatile role to play in traditional medicine. The plant is credited with tonic and stomachic properties. Bark and roots are used as stimulant and externally to cure eruptions and bites of poisonous animals. Green leaves are eaten raw for cure of dysentery, diarrhoea and vomiting. Leaves and roots are also used traditionally as bitter, anthelmintic, analgesic, curing piles, inflammation, itching and are useful in leucoderma and blood disorders.

Nutritional, Vitamins and Minerals	Per 0.5 g
Calories	0.1
Potassium	1.5 Mg
Vitamin A	0.50 %
Calcium	0.001
Vitamin C	0.10 %
Vitamin B-6	0.10 %

Curry leaf contains a number of chemical constituents that interact in a complex way to elicit their pharmaco dynamic response. A number of active constituents responsible for the medicinal properties have been isolated and characterized. This plant has been reported to have anti-oxidative, cytotoxic, antimicrobial, antibacterial, anti ulcer, positive isotropic and cholesterol reducing activities.

Curry Leaves and its Nutrients

Consumption of curry leaves is considered beneficial to the body. The International Journal of Environmental & Agricultural Research, in an article published in January 2017, says curry leaf has anti-carcinogenic properties due to the presence of carbazole alkaloids. Curry leaf can be used as an anti-oxidant as it contains the anti-oxidants tocopherol, b-carotene, and lutein, according to the journal. These high-speed deciduous shrubs are a compulsory part of Indian cooking where all the dishes for seasoning or garnishing start and end with it. Curry leaves are very rich in copper, minerals, calcium, phosphorous, fiber, carbohydrates, magnesium, and iron, which are important nutrients.

Besides, curry leaves often contain different kinds of vitamins and amino acids. Depending on the intended use, the leaves can be dried or fried, and the fresh form is very common as well.

Health Benefits of Curry Leaves:

Helps in Lowers Cholesterol Level:

Curry leaves have properties that help to lower one's blood cholesterol levels. These shrubs, packed with antioxidants prevent cholesterol oxidation that produces LDL cholesterol (bad cholesterol). This raises the amount of good cholesterol (HDL) and protects from atherosclerosis and heart disease.

Aids Digestion:

The mild laxative properties present in curry leaf help the stomach to get rid of unnecessary waste and aids in Digestion.

Curry Leaves for Liver:

Curry leaf research suggested that there were strong hepato-protective properties of the tannins and carbazole alkaloids present in the leaves. Also, when combined with vitamin A and vitamin C, it has highly powerful anti-oxidative property which will not only prevent but also activates the organ to function more effectively.

Curry Leaves Hastens hair growth:

It will help in preventing greying of the hair. It is also very effective in treating damaged hair, adding bounce to limp hair, strengthening the shaft of thin hair, hair fall and treats dandruff. The leaf extract has demonstrated antifungal activity against fungal scalp infection which is why it can be used to treat dandruff.

Curry Leaves for Eye Health:

Curry leaves are rich in carotenoid-containing vitamin A, thereby reducing the possibility of damage to the cornea. Deficiency of vitamin A can cause eye disorders, including night blindness, vision loss, and cloud formation. Thus, the leaves keep the retina safe and protect against loss of vision.

Curry Leaves Eradicates Bacteria:

Every second disease is caused by infections or includes damage to oxidative cells. In today's world, where the occurrence of antibiotic-resistant strains is rising rapidly, alternative infection therapies are a necessity. This is where the promise is demonstrated by curry leaves.

Carbazole alkaloids, compounds that contain antioxidant, antibacterial, and anti-inflammatory properties, are laden with curry leaves. Also capable of destroying bacteria and cell-damaging free radicals are the compound linalool, responsible for the flowery smell of these shrubs.

Controls side effects:

Curry leaf intake decreases the effects of chemotherapy and radiotherapy and also protects against chromosomal damage and bone marrow protection.

Curry Leaves for Blood Circulation:

It helps to resolve menstrual issues, gonorrhea, diarrhea and alleviate aches by integrating curry leaves into one's regular diet.

Anti Diabetic Properties in Curry Leaves

One of curry leaves' greatest health benefits is that it has the potential to regulate diabetes. Through using curry leaves in one's diet, insulin-producing pancreatic cells can be stimulated and covered.

Curry Leaves helps to Treats Wounds

Applying the paste of curry leaves has curative effects on wounds, rashes, boils, and mild burns. A paste of the leaves also helps prevent and eliminate any type of harmful infection.

Curry leaves for weight Loss

When it comes to losing weight, curry leaf is a good herb. It is one of the best remedies to get rid of the body's assembled fat. Studies show that curry leaves can help reduce the number of triglycerides and cholesterol, which helps to prevent obesity. Curry leaves aid weight loss, Carbazole alkaloids work against weight gain and help to control the body's levels of cholesterol. To help weight loss, curry leaves can thus be eaten. You can munch on dried curry leaves to increase their consumption, or add fresh or dried curry leaves to your meals. Also, you can add it to your salad. Consume curry leaves regularly for faster weight loss along with a balanced diet and exercise.

Dosage of curry leaves:

Curry leaves Powder – ¼-½ teaspoon twice a day.

Curry leaves Capsule – 1-2 capsules twice a day.

Curry Leaves Allergies & Side-Effects:

If one is allergic to it, curry leaves must be avoided. Before use by pregnant, breastfeeding women and toddlers, a qualified medical practitioner should be consulted.

Cultivation of curry leaf (Bushy type)

In recent days, the use of curry leaf is increasing not only in culinary purpose but also in pharmaceutical activities. The curry leaf is the very rich source of vitamin E which is mainly responsible for maintenance of skin texture and skin health. Because of urbanization use of curry leaf powder instead of fresh leaves is also increased and it is in great demand for export also. Hence, commercial cultivation of curry leaf with more emphasis on vegetative production is the main concern of the farmers to get the sustainable income. Therefore bush cultivation of curry leaf is to be popularized among the farming community of Tamil Nadu and other southern parts of the country.

METHODOLOGY

Curry leaf varieties:

Sen Kaampa, Suwasini

Spacing: 3 m x 0.75 m

Pit size: 2 feet x 2 feet x 2 feet

Manuring: FYM, sand gravel and leaf mould 50 kg/ pit

Sowing:

Rooted seedling has to be placed in the centre of the pit in the second fortnight of October by following all good

Agricultural practices.

Pruning:

Allow the plant to grow up to 6-8 months period and when the plant attains the height of 60cm, cut the tip portion to encourage the lateral branches. Allow the 4-6 lateral branches up to a height of 1.5 m and again cut it, mainly to encourage the secondary and tertiary branches (This will take 10-12 months under good condition).

Irrigation:

Drip irrigation has to be provided

Nutrient Management:

The recommended dose of fertilizer is 150:25:50 g/ plant/year. Good amount of nitrogenous fertilizers is to be supplied at least 100-150 g/ plant and 2nd year 600-800 g in four equal doses on quarterly basis.

Harvest:

When the plant is grown to its fullest capacity after 12 – 14 months, 1st harvesting may be taken up by clipping branches, which are grown up to 90cm when the leaves turn form light green to dark green colour.

Matured twigs are to be clipped. This can be attended by following either alternate plants or alternate rows once in a weeks' time, so that the farmer will be having regular income. Immediately after pruning the plants has to be provided with sufficient quantity of nitrogen to encourage new flush which will be ready for harvesting in 90-100 days (4 harvests per year). Yield: 20-25 tonnes of fresh leaf /year and Profit is Rs. 10,000 lakh /year.

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Kachri

(*Cucumis melo var. callosus*)

An Untapped Cucurbit Vegetable

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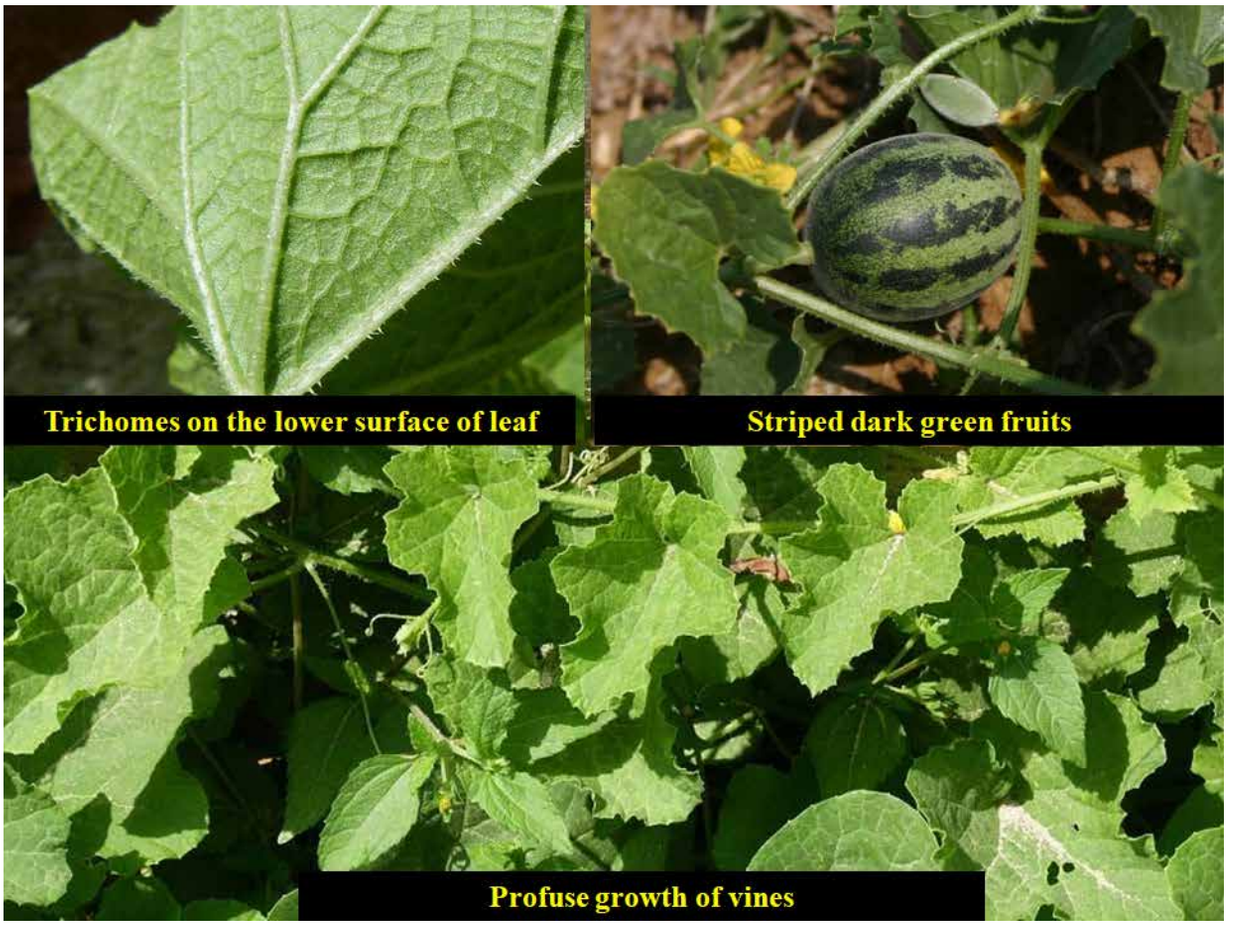
Cucumis melo var. callosus (Kachri) is also known as wild melon, native gooseberry, and Ulcardo melon. It is a member of the Cucurbitaceae family and has chromosome number 2n=24. It is said to have originated in India's dry, arid zone (south western Rajasthan). It is restricted to desert soil and water stress conditions (hot, dry), and it is susceptible to water logging circumstances. It is often found in India in its wild form among the field bunds and agricultural borders of the Deccan plateau and the Indo-Gangetic plains (Tamilnadu, Karnataka, Madya Pradesh, Uttar Pradesh, Jharkhand and Chhattisgarh, Assam). Kachri is one of the underutilized crop species; it is not produced economically as a solitary crop, but it may be planted in conjunction with Bajra, mung bean, and moth bean. Kachri is used as a vegetable (raw, boiled, or pickled) that is high in protein, Vitamin C and antioxidants and is mostly utilised in Rajasthan regions to produce recipes such as Panchcuttakisabzi. It also imparts an aromatic sour flavour to dishes. Chakla and kokla are two dried forms of kachri in which the fruit is cut into slices with or without skin and then dried and used as a souring agent to prepare chutney, curries and other dishes. Mrugakshi is another name for this in Ayurveda because of its importance in the preparation of various medicines, acting as a tonic, coolant, and stimulant. Some tribal people in Madhya Pradesh utilise the leaves, blossom, fruit, and root to cure a variety of diseases.



Kachri Origin and Distribution

Kachri is indigenous to India (Rajasthan), although it may also be found in North Australia, Afghanistan, North Africa, West Asia and Indo-Malaya. Kachri is native to India's hot, dry, arid southwest (South-western Rajasthan), where it is limited to desert soil, water stress conditions, and susceptibility to water logging, making it inconspicuous in high-humidity, high-rainfall environments. It is often found in India in its wild form around field bunds and agricultural borders of the Deccan plateau and Indo-Gangetic plains, which include the states of Tamilnadu, Karnataka, Maharashtra, Madhya Pradesh, Uttar Pradesh, Jharkhand, Chhattisgarh, Odisha, West Bengal, and Haryana. These flowers, leaves, and roots are utilised by tribal people (Gonda and Baiga populations-Annuppur, Dindori, Shadool and Umaria districts of Madhya Pradesh) to cure different diseases. Kachri has been identified as a wild muskmelon progenitor.

Cucumis ambigua Fenzl. and *Cucumis cognata Fenzl*. from Sudan; *Cucumis callosus* (Rott.), *C. trigonus* wild, *C. pubescens* from India; and *C. jucundus F. Muell*, *C. picrocarpus F.Muell* from Australia

Wild melons were described by Charles Naudin in 1859, and they were distinguished from cultivated melons. Wild melons from India were known as 'melon sauvage de l'Inde,' while wild melons from Africa were known as 'melon sauvaged 'Afrique.' Ferdinand Muller described the wild melons of Australia.

Finally, they are classified into the 'Agrestis' group, which comprises *Cucumis melo subsp. melo f. agrestis* (India), *Cucumis callosus* (Rott.), *Cucumis pubescens; Cucumis melo subsp. agrestis* (Australia), *Cucumis picrocarpus*, *Cucumis jucundus;* and African Agrestis, which contains *C. melo subsp. meloi*.

Botanical features

The plant is a hardy, perennial vine with a tuberous tap


Female flower


Female flower inflorescence


Fruit from female flower


Fruit bearing on the vine

root. It has drooping branches and strongly lobed (5-7lobed) light green upwardly curled leaves. The female flower has a beautiful yellow corolla and an ovary coated in thick white hairs. Mature fruit is brownish yellow, round or oblong. Looks like a little melon with 10 noticeable white or greenish longitudinal stripes and a thick glossy epicarp (Tarachand et al.) and contains 150-180 tasteless seeds within. The pericarp of the fruit tastes bitterer than the endocarp (Cucurbitacin B). Fruit tastes bitter at first, then sweetens with sourness (tangy) as it ripens. The fruit resembles a micro watermelon.

Uses

Cucumis callosus is high in vitamin C, protein, and iron and calcium. It contains 1.28 g of fat, 1.21 g of fibre, and 29.81 mg of vitamin C per 100 g of fresh fruit. Fresh Kachri is also high in Omega-3 fatty acids. Since Kachri exists in its natural state, it serves as a repository for valuable genes such as resistance to biotic and abiotic challenges such as leaf eating caterpillars, Fusarium wilt, Downey mildew (pest and disease) and drought. As a result, muskmelon melon breeders are fascinated to this plant and exploit it for crop improvement.

Kachri as a Medicine

In Ayurveda, kachri is known as "Mrugakshi" due to its usefulness in the preparation of numerous remedies. Cucumis callosus is rich in antioxidants and may help enhance immunity, decrease cholesterol, and relieve stomach problems. It also serves as a tonic, a cooling, and a stimulant, providing triple benefits. The tribal people of Madhya Pradesh (Gonda and Baiga groups - Anuppur, Dindori, Shadool, and Umaria Districts) used to cure numerous ailments using these flowers, leaves, roots, and fruits of kachri, and they still do.

AHK-119 and AHK-200 Kachri Varieties:

The CIAH has released two enhanced kachri *(Cucumis Spp.)* varieties, AHK-119 and AHK–200. Commercially, several types, particularly AHK-119, are grown as rainy and

summer crops. Farmers in the Bikaner district and surrounding regions have polled regarding the performance of the following kinds. AHK-119 is superior to AHK-200, according to the farmers who raise both cultivars. Farmers as well as customers in local communities / cities have a strong demand for this kind. This cultivar is well-suited to thriving in hot, dry climates. Farmers get an average net revenue of Rs.36,000-42,000 per hectare every season by producing this variety, depending on management and environmental circumstances. The fruits of AHK-119 are one-of-a-kind in terms of shape, size, flavour, and colour, and they have a very appealing appearance. According to farmers and consumers, it is ideal for making chutney, dry powder, pickle, sauce, and blending with other vegetables for an acidic taste. Furthermore, the farmers stated that planting these types on barren ground can prevent soil erosion and boost organic matter in the soil. Farmers, on the other hand, stated that the inability to obtain seeds of this variety (AHK-119) in a timely manner is the main impediment to expanding the area and increasing output of this variety.

Pharmacological importance

The hypoglycaemic, antioxidant, and anti-ulcer properties of methanol extracts from fruits have been reported. The bitterness of the pericarp of kachri outweighs that of the endocarp. Cucurbitacin B, a bioactive tetracyclic triterpene with high oxygen content, is responsible for the bitterness. It contains anticancer properties (inhibits leukaemia cell activity in the body) as well as hypoglycaemic properties (lowers blood sugar levels)

1. The root paste may be used to treat scorpion stings and skin eruptions, and the root decoction can be used to treat dyspepsia and dropsy.
2. Breast inflammation, ulcers, stomach enlargement, cough, and asthma are all treated with root.
3. Drink lukewarm milk with kachri root powder (shade dried roots are then pulverised) before going to bed if you have a fever.
4. The leaf extract is applied on wounds to help them recover.
5. Apply the crushed fruit juice for rheumatic and joint problems.
6. Soak the flowers in water for 1-2 hours and using twice a day to avoid heat strokes.
7. The fruit is used to prevent insanity, cure jaundice, and relieve cerebral congestion; the fruit pulp is abortifacient
8. Kachri seeds contain hepatoprotective properties (aids in the treatment of bilious disorders) Powdered seeds are used to lower blood sugar levels
9. *Cucumis callosus* seed oil has a laxative effect (easy bowel movement)

Conclusion

Cucumis callosus is a natural medicinal herb that grows wild. It contains numerous medical qualities such as hypoglycaemic, hepatoprotective, antioxidant, laxative, and so on. It is also a good source of beneficial genes (pest and disease resistance genes), which leads breeders to use this crop for agricultural development. Unfortunately, it is a lesser-known and underutilised crop. However, in tribal areas, people are still utilising it as medicine to treat a variety of health concerns, and it is being over-exploited.

Before this crop becomes extinct, ex situ conservation of this valuable genetic resource, as well as more pharmacological investigations, are required to assist utilise the medicinal and economic potential of the Kachri plant.

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NFT HYDROPONICS: AN OVERVIEW

Hydroponics in simple words is soiless cultivation. As the word indicates, it is growing of plant by providing the required nutrients through water. Hydroponics is not a new concept, it has been practiced for many years. In recent times it is gaining more importance and recognition.

Advantages of Hydroponics:

- More yield and faster growth than conventional farming
- Precise use of nutrients as per the plant need
- Irradiate soil-borne diseases
- Less land needs

Types of Hydroponics system

- NFT system
- Dutch bucket system
- Trough system

NFT system

NFT stands for Nutrient Film Technique, which means, a layer of nutrients is maintained near the root of plants without any other substrate.

This is a circulatory type of system where water is reused and results in the usage of only a small amount.

The system comprises of an NFT channel with slots for keeping the plants, a reservoir tank and a pump. There is an inlet pipe through which the water is circulated to the channel and an outlet pipe, thus the water is continuously circulating.

The required amount of nutrients is added to the water in the reservoir tank so that the plants will get the adequate and sufficient amount of nutrients which indeed, helps in its growth and development. Nutrient deficiency and toxicity can be prevented by this way as we can easily identify the amount of




nutrients we are adding.

Nutrients

In hydroponics,the nutrients are usually measured in terms of TDS value,(Total Dissolved Solids) The TDS value of the reservoir tank give us an idea about the quantity of nutrients in the solution. Each plant have a specific range of TDS values for its effective growth. By knowing the required TDS value of a particular crop, we could ensure maximum growth and yield from each plant.

For the plants to absorb the nutrients effectively, optimum range of pH is necessary, usually the range is 5.5-6.5.We need to adjust the pH of the water for effective absorption. If the pH is low a pH UP solution is used to raise the pH. Similarly if the pH is high, a pH DOWN solution is used. The commonly used pH DOWN solution is ortho phosphoric acid.

Plants grown

Mainly leafy vegetables are grown in NFT system, namely Spinach, Lettuce, Kale, Mint, Coriander, Parsley, etc. Two plants can be grown in 1 sqft area.

Unlike traditional farming, these requires much less time and attention. An average range of TDS values for leafy greens are 800-1200.

Relevance of NFT system

- In this system Water usage is minimum as water is reused, so this system is highly recommended to water scarce area.
- Planting as well as after care in NFT system is much easier than conventional way of farming.
- We all know about the importance of having a healthy diet. Leafy greens are highly rich in vitamins and minerals as well as other nutrients which are necessary for good health. Now a days it's hard to get chemical free greens from market. So starting a small NFT unit within the premises of your home can bring you healthy benefits.

Hydroponics is the new face for sustainable farming.Its a new way of urban farming for a healthy and better tomorrow. Spare a little time and gain lifetime benefits.

Nutritional importance and value-addition of Palmyra ***(Borassus flabellifer)*** Sprouts

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Introduction:

Since ancient times, many fruits and vegetables have been consumed by the humans. Present scientific evidences increased their consumption due to their potential health and disease preventing benefits. Fruits and vegetables are the good source of various nutrients like vitamins, minerals, proteins, polyphenols and so their recommendation in the diet helps in the prevention of various types of cancers, atherosclerosis and other chronic diseases (Sahni et al., 2014).

Borassus flabellifer L. is commonly called as Palmyra pam. The tree is called as miracle tree due innumerable health benefits of almost each and every part of the tree. The tree belongs to Arecaceae family. *Borassus flabellifer* got its

Palmyra (Borassus flabellifer) **Fruits**

Taxonomical classification:

Kingdom	Plantae
Sub-Kingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Liliopsida
Subclass	Arecidae
Order	Arecales
Family	Arecaceae
Genus	Borassus L
Species	Borassus flabellifer L.

Vernacular names	
Bengali	Taala
English	Toddy palm
Hindi	Taad
Kannada	Olegari
Tamil	Talam
Telugu	Tatichettu
Malayalam	Karimpana
Sanskrit	Taalah

Ref: Saravanya and Kavitha, 2017)

Nutritional composition of Borassus flabellifer Sprouts

Moisture (g 100 g -1 FW)	62.38	Mineral elements in	B.flabelliferroots(ppm)
Ash (g 100 g -1 DM)	4.95	Iron	1.38
Protein (g 100 g -1 DM)	8.54	Strontium	0.14
Fat (g 100 g -1 DM): (Fresh, dried)	0.6	Copper	0.09
Crude fiber (g 100 g -1 DM)	7.29	Manganese	0.11
Carbohydrates (g 100 g -1 DM)	23.53	Zinc	0.08
Food energy (Kcal)	118.42	Aluminium	0.48

***Palmyra (Borassus flabellifer)* Sprouts**

name from Greek roots namely *'Borassus'* and *'flabellifer'* which means fruit with leather covering and fan-bearer respectively. The tree is widely found in India, Sri Lanka and other tropical countries. The tree can best grow in arid and semi-arid conditions and can withstand averse climatic conditions. The tree can live for more than 100 years (Krishnaveni et al., 2020).

Botanical description

The tree is tall, erect with fan shaped leaves, a large trunk resembling that of a coconut tree. Furnitures and handicrafts can also be made from the trunk and dried flexible leaves of the tree. Nectar of the plant is brewed for the preparation of vinegar, wine and to make sugar. Husk can be used to extract natural colouring substance. The seeds sown on top of mounds and watered regularly for 45 days for germinating. The embryonic axis grows downward within a long apical tube into the soil and strikes roots. Growing upward from the roots is a bladeless first leaf within which accumulated food material translocate from the endosperm, thereby forming the starchy tuber (Saravanya and Kavitha, 2017).In some states like Tamil Nadu, Andhra Pradesh, Telangana and in Jaffna Sri Lanka, the seeds are planted and germinated. The fleshy stems below the surface are consumed in boiled or roasted form.

Uses of sprouts:

Young roots have diuretic and anthelmintic activity. The decoction of the roots is given in certain respiratory diseases. The roots of the plants are cooling, curative and diuretic (Jery, 2018).

Value added products from *Borassus flabellifer* Sprouts

As it is the good source of energy, protein and fiber, sprouts of the plant are dried, powdered and incorporated to various food products.

Niththiya et al. (2014) developed instant soup mix

with incorporation of uncooked Palmyrah *(Borassus flabellifer)* tuber flour.

Flour developed from Palmyra sprouts was analysed for nutritional composition and compared with wheat flour. The total ash and fiber content of the Palmyra sprouts was very high when compared to wheat flour. Value addition of the developed flour in muffins significantly improved the nutritive value of the muffins (Khatri et al., 2020).

Conclusion

Palmyra tree is one of natural medicine that every part of the tree can be used for treatment of various health problems. Palmyra trees are unique in providing us both food and non-food products. Promotion of FPO based approach, encourage more research on developing advanced varieties, production and processing technologies.

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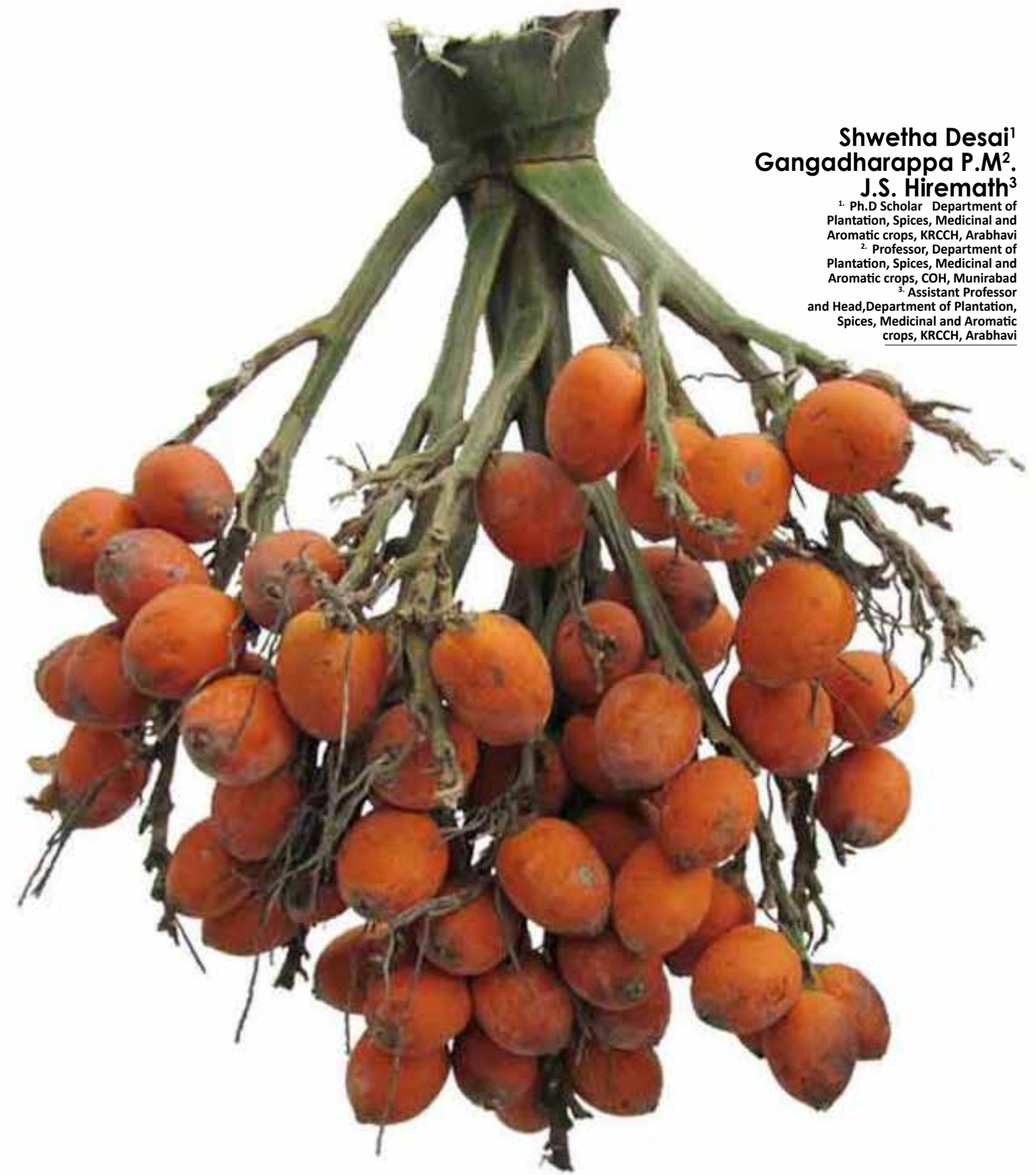

ARECA NUT

Beyond mastication

Areca nut (*Areca catechu*) is an important commercial plantation crop of India. The industry forms the economic backbone of a substantial number of farm families. India is the world's largest producer of areca nut contributing nearly 49 % area and 50 % towards world production (Mitra and Devi, 2018). It is generally used for mastication by millions of people in different parts of world as it is believed to have many medicinal properties. It is chewed mainly along with other ingredients such as betel leaf, lime, fennel etc., It has also very important place in religious functions in many Asian and Oceanic countries. Karnataka leads in area and production which accounts for 63% of total share in production followed by Kerala and Assam (Anon., 2019). It is widely grown as cash crop in Malnad belt of Karnataka by providing income and livelihood security. It is being mainly used for chewing in tender, ripe or processed forms which leads to limited export potential and often cursed for its association with pan masala and gutka. Liberal import policies have reduced the price, which are uneconomical for farmers. Hence, areca nut growers are presently facing lot of problems like price fluctuation, middlemen involvements etc.,With dropping prices and wide spread worries about the ill effects of areca nut chewing, growers are shifting to cultivation of other crops like rubber and oil palm (Varmudy, 2012). Therefore, developing alternative uses of areca nut is the need of the hour to stabilize the market and ensure healthy prices for the growers.

Alternative uses of areca nut

1. Health benefits

- The medicinal properties were described by Vagbhata (in 4th Century AD) as effective against leucoderma, leprosy, cough, fits, worms, anemia and obesity.
- Recent studies have shown that arecanut has pharmacological uses viz., hypoglycemeic effect, mitotic activity, antihelminthic activity, cholinomimetic activity etc.
- In the metabolic system it acts as a digestive, carminative and anti-diabetic (Research from Hyderabad Medical College).
- The ethanolic extract of Areca root, has prominent antimicrobrial activity against the human pathogenic bacteria
- Used against certain skin diseases
- Used as aphrodisiac
- Improves eyesight when used as Thamboola seva
- Helps in relieving asthma
- CFTRI Mysore has developed a soft drink concentrate called Pan Supari Nectar
- Lowers Blood Pressure level (Old Arecanut)

Anti-diabetic formulations from areca nut

Dia Areca: Liquid formulation

It was invented by ARS, Navile Campus (UAHS, Shimoga), is manufactured and marketed by Dia Enterprises, Bengaluru

Pooga Trim:

Powder formulation. It is manufactured and marketed by SDM College of Ayurveda and

Dia Areca

Pooga Trim

Hospital, Udupi, Karnataka

Dia catechu:

Tablet formulation. It is manufactured and marketed by Jeddu Ayurveda Pharmacy, Alike, Dakshina Kannada, Karnataka

2. Industrial applications

- Arecanut husk finds use in preparations of hard boards, paperboards, cushions and non-woven fabrics besides being a good source of furfural.
- Tannins are obtained as a by-product from the process of preparing immature betel nuts for masticatory purposes. It was found that tannic acid from the nut, when mixed with ferrous sulphate in warm distilled water gave black writing ink of acceptable quality.
- Tannins are also used as adhesive in plywood industries and as a textile dye.
- Arecanut husk acts as a potential bio-adsorbent for remediation of chromium and can be used as a corrosion inhibitor for Al metal in a cost effective and eco-friendly manner.
- The areca nut slurry can be effectively utilized for printing of cotton fabric which is having excellent protection against uv rays.

3. Waste utilization

- On an average about 5.5-6 tonnes of organic wastes/ha/year is available from areca nut growing gardens. It leaves behind enormous quantity of areca nut husk(1404 kg/ha/year), leaf sheath(375 kg/ha/year), areca nut leaf(7015). Thus, the disposal of areca nut waste is becoming a problem.
- At present majority of areca nut waste is disposed of by burning which resulted into a loss of potential source of organic matter and valuable plant nutrients.

The areca tea is including 5 different flavours

- Areca husk and leaf can be effectively converted to valuable compost by using native microbial inoculants like *Phanerochaete chrysosporium* and *Pleurotous sajar caju*.
- In Sagara and Shikaripura taluks of Shimoga, Areca nut growers are started the composting of areca nut husk by using bioinoculants and getting the benefits from that. The compost prepared from areca nut husk contain more nutrients(C:N ratio: 20:1, OC: 25.85, NPK: 0.86: 0.58: 1.85, pH: 7.2) than Farm Yard Manure (C:N ratio: 20:1, OC: 10.8, NPK: 0.56: 0.25: 0.37, pH: 7.8).

4. Value added products of areca nut

1. Areca Tea

- Areca tea is the brand new product invented by Mr. Nivedan Nempe in 2015 from Mystic Aromatics Company which was selected for the Make In India Excellence Award by AITMC as the innovative product of the year 2014-15
- It consists of processed areca granules along with secret Ayurvedic herbs and is approved by FSSAI.

Health benefits of Areca tea

Appetizer and digestive: It increases the flow of saliva and aids in digestion.

Lowers cholesterol: It has strong inhibitory action on pancreatic cholesterol esterase which lowers the cholesterol absorption.

Antioxidant: It has a potential source of natural antioxidant.

Detains wrinkling: It improves skin hydration, skin elasticity and decreases skin wrinkles.

Supports diabetic therapy: Pancreas which plays an active role in diabetes is found to be protected by Areca tea.

The areca tea is including 5 different flavours

1. Areca Tea Regular
2. Areca Tea Lemon
3. Areca Tea Ginger
4. Areca Tea Mint
5. Areca Tea Tulsi

Air fresheners made from the husk of areca nut

2. Icy Areca

- After a great hit of Areca tea in national and international markets, Mystic Aromatics company came up with non-carbonated cool drink Icy Areca.
- It is a ready-to-drink product available in lemon and chocolate flavours.

3. Air fresheners made from the husk of areca nut

Areca nut husk is converted into a material that is similar to a board, added natural growth promoters and perfume to it to make air fresheners.

- Completely biodegradable
- Act as a fertiliser once thrown away
- Increase the water retention capacity of the soil

4. Areca Milk Mix

- It was invented by a engineering student Nikhil M C from Shivamogga, manufactured and marketed by Malenadu Agri-Research & Development, Malali, Shivamogga.
- It can be consumed in the form of hot milk or cold milk shake.
- Health benefits: Energy booster Control diabetes Beneficial for brain

4. Areca leaf plates

Traditionally, areca leaf sheaths were treated as agricultural waste and burned. Their transformation into durable dinnerware for export is a relatively recent phenomenon. Karnataka has a thriving cottage industry of areca ware and there are reportedly 6,000 large and small "bioplate" factories in the

Areca Milk Mix

areca leaf plates

state.

- Areca nuts tree leaf plate is made of completely organic material which is a fallen leaf collected from areca palm trees.
- The manufacturing of areca leaf plates is done using single mechanized machine designed by CFTRI Mysore
- The areca leaf plates are good biodegradable natural products

Characteristics of areca leaf plates

- Hygienic & Odourless
- Do not alter taste of the food on the plate
- Freezer, Microwave & Oven Safe
- Leak Proof
- The strongest and most heat tolerant disposable plate
- Economical & Commercially Viable
- Biodegradable, Compostable & Sustainable
- 100% Natural, Non-Toxic & Organic
- Naturally biodegrade within 6-8 weeks
- After use, it can be utilized as cow fodder

Conclusion

- Areca nut being a palm species has multiple uses.
- Seeing the crop growing pattern and longevity in the state, it should be utilized to its fullest potential so that the farmers can get more incomeby utilizing the areca nut and its by products.
- Adding value to the areca nut can expand the market, moreover the demand of eco-friendly products are gaining importance in global market.

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