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CARBON SEQUESTRATION IN BIOCHAR AMENDED SOILS

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Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures. Eleven years from 1995-2006 rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The 100-year linear trend (1906-2005) of 0.74 [0.56 to 0.92] °C is larger than the corresponding trend of 0.6 [0.4 to 0.8] °C (1901-2000) and over the 21st century average temperature of earth surface is likely to go up by an additional of 1.8- 4^{o}C (IPCC, 2007). This temperature increase can be attributed to the altered energy balance of the climate system resulting from changes in atmospheric concentrations of the greenhouse gases (GHGs) (Fig. 1).

The dynamics of terrestrial ecosystems depend on interactions between a number of biogeochemical cycles, particularly the carbon cycle, nutrient cycles, and the hydrological cycle, all of which may be modified by human actions. Terrestrial ecological systems, in which carbon is retained in live biomass, decomposing organic matter, and soil, play an important role in the global carbon cycle. The combined anthropogenic radiative forcing is estimated to be +1.6 [–1.0, +0.8] W m^{-2}, indicating that, since 1750, it is extremely likely that humans have exerted a substantial warming influence on climate.

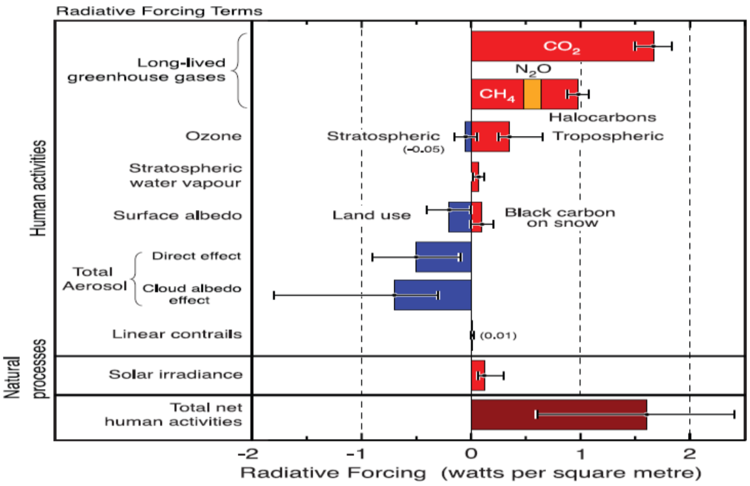

Fig.1-Summary of the principal components of the radiative forcing of climate change (IPCC, 2007)

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Climate change has not come alone; it has brought with it a number of threats to the environment, ecosystem and entire mankind. Some of these include the reduction in the terrestrial and arctic snow cover (Post *et al.*, 2009), rise in sea level (IPCC, 2007), decline in crop yield, reduction in ecosystem services (Walker *et al.*, 2009), increase in frequency of extreme events (e.g. the hurricane Katrina in 2007) especially drought (e.g. monsoon failure in India in 2009), change in biodiversity (IPCC, 2007) because of pole-ward shift of principal biomes, and increase in global hunger and food insecurity. There is a strong link between food insecurity, soil degradation, and climate change (Fig.2), because of a strong positive feedback among the underpinning processes.

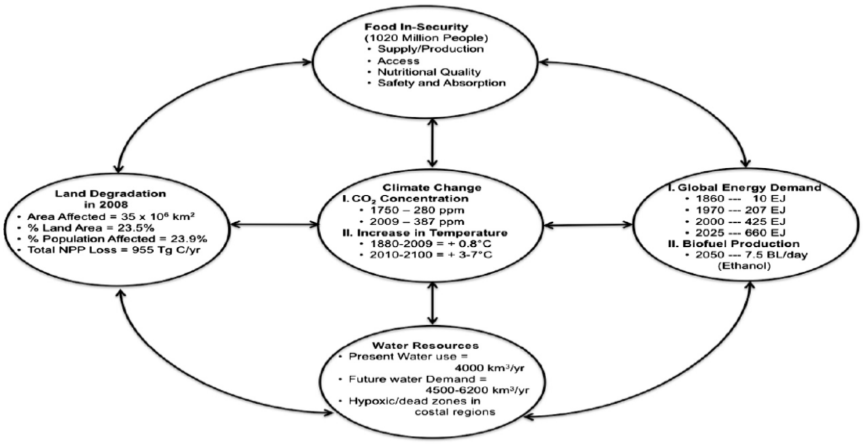

Fig.2- Inter-twined global scale challenges related to climate change

The twin crisis of climate change and food insecurity can be addressed by restoring soil organic carbon pool through carbon sequestration in agro-ecosystems, especially in agricultural soils. The global potential of C sequestration in soils of agro-ecosystems is about 2.1 billion tons C/yr (Lal, 2010). If the SOC pool in world soils can be increased by 10% (+250 billion tons) over the 21st century, it implies a drawdown of about 110 ppm of atmospheric CO_2 (1 billion tons of soil C = 0.47 ppm of atmospheric CO_2).

Carbon sequestration

Carbon sequestration is the capture and secure storage of carbon that would, otherwise, be emitted or remain in the atmosphere. Carbon sequestration in the agriculture sector refers to the capacity of agriculture lands and forests to remove carbon dioxide from the atmosphere. Carbon dioxide is absorbed by trees, plants and crops through photosynthesis and stored as carbon in biomass in tree trunks, branches, foliage and roots and soils (EPA, 2008) (Fig.3).

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Forests and stable grasslands are referred to as carbon sinks because they can store large amounts of carbon in their vegetation and root systems for long periods of time. Soils are the largest terrestrial sink for carbon on the planet. The ability of agriculture lands to store or sequester carbon depends on several factors, including climate, soil type, type of crop or vegetation cover and management practices.

Soil application of biochar, charcoal created by low-temperature pyrolysis of biomass under anaerobic conditions, is now a day's considered as an option to increase the SOC pool (Roberts et al., 2010). The potential of biochar application for SOC sequestration may be 1 billion tons C/yr or more (Sohi et al., 2010).

Biochar

Biochar is the carbon-rich product obtained when biomass, such as wood, manure or leaves, is heated in a closed container with little or no available air. In more technical terms, biochar is produced by so-called thermal decomposition of organic material under limited supply of oxygen (O2), and at relatively low temperatures (<700°C). These charred organic matters are applied to soil in a deliberate manner, with the intent to improve soil properties.

Conceptually, biochar is the "charcoal (biomass that has been pyrolysed in a zero or low oxygen environment) for which, owing to its inherent properties, scientific consensus exists that application to soil at a specific site is expected to sustainably sequester carbon and concurrently improve soil functions (under current and future management), while avoiding short- and long-term detrimental effects to the wider environment as well as human and animal health" (Verheijen et al., 2010).

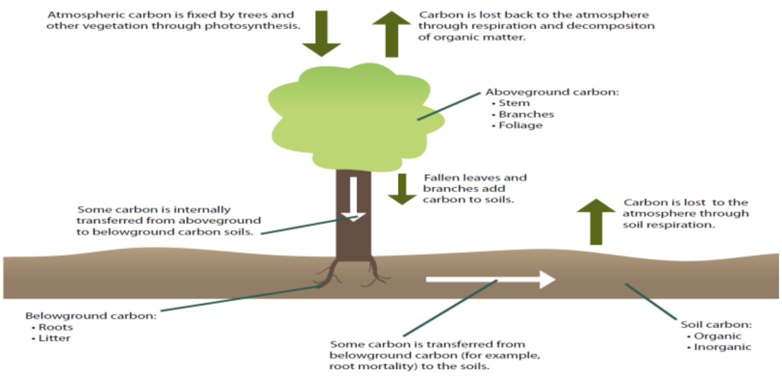

Fig.3- Processes of carbon gain and loss for trees and soils

There are a number of options for carbon sequestration in agro-ecosystems (Fig.4) (Lal, 2011).

Land application of biochar is not a new concept. It traces its roots to observations made by 19th century naturalists. In the recent past, terra preta soils in the Amazonian Basin have been linked to the ability to sequester carbon, as well as improve agricultural production. These terra preta soils have received large amounts of charred materials, the residues from biomass burning (Sombroek *et al.* 2003).

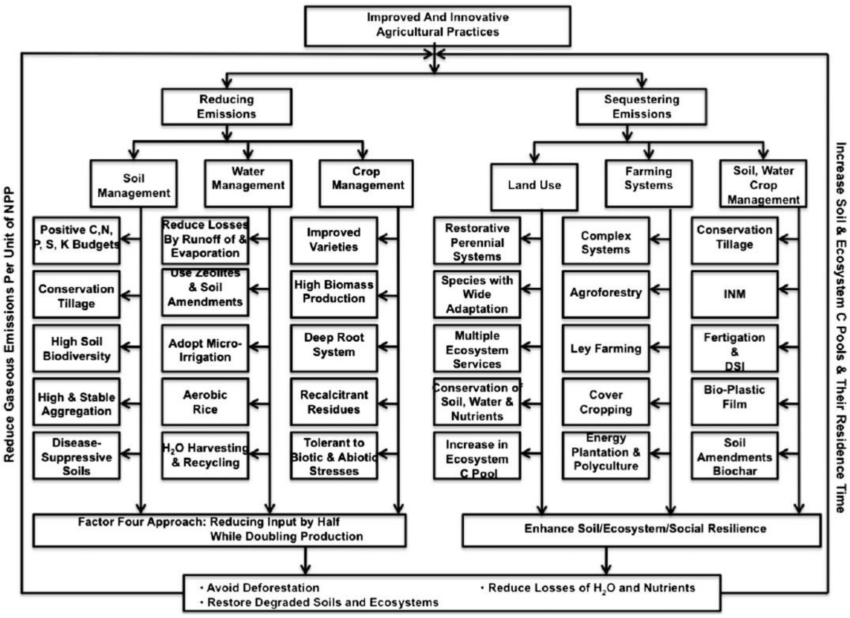

Fig.4- Technological options to reducing emissions and sequestering emissions from agricultural ecosystems

Biochar Stability and Stabilization

The stability of biochar is of fundamental importance in the framework of biochar use for environmental management. There are two reasons why stability is important; first, stability determines how long C applied to soil as biochar willremain sequestered in soil and how long it may influence emissions of greenhouse gas from the pedosphere and contribute to the mitigation of climate change. Second, stability will determine how long biochar can provide benefits to soil and water quality.

Conversion of biomass to biochar followed by application of biochar to the soil increases the residence time of carbon (C) in the soil relative to the application of the same biomass directly to the soil, and therefore can be considered over particular timescales to result in a net withdrawal of atmospheric CO_2 (Lehmann, 2007).

Mean Residence Time

Biochar found in high proportions in the so-called ‘Terra Preta’ soils of the Amazon region have been radiocarbon dated and found to originate from 500 up to 7000 years BP (Liang *et al.*, 2008).They provide a visually compelling proof for the longevity of biochar.By matching annual production of char by savannah fires to measured char stocks for various soils in Northern Australian woodlands, mean residence times of 718 to 9259 years were obtained. But, the most likely and conservative scenarios suggested mean residence times of 1300 to 2600 years under the dry-land conditions of Northern Australia (Lehmann *et al.*, 2008).

Biochar Stability Framework

The available scientific evidence clearly demonstrates that biochar is the most stable form of organic matter that can be added to soil. However, some types of biochar can be mineralized to a significant extent in the short term and all types of biochar eventually decompose, with a complex interplay of stabilization, destabilization and transport processes that change over time. It is therefore important to quantify the extent of short-term decomposition both for the calculation of C credits as well as for its effects on soil.

The generally slow decay of biochar poses challenges to quantifying its longevity. Decomposition rates of plant litter have often been established experimentally by adding litter to soil and measuring its disappearance. Since the turnover time of litter ranges between weeks and years, the organizational and financial commitment to such efforts is feasible. In contrast, direct measures of turnover times for biochar may require centuries to millennia, and are therefore not experimentally accessible by such an approach.

Schematically, this challenge can be depicted for a hypothetical data set in Figure 5 (Lehmann *et al.* 2006). The calculated MRT increases if data are available for longer periods of time. If data were only available for two years, the MRT obtained by a double-exponential model is merely 57 years.

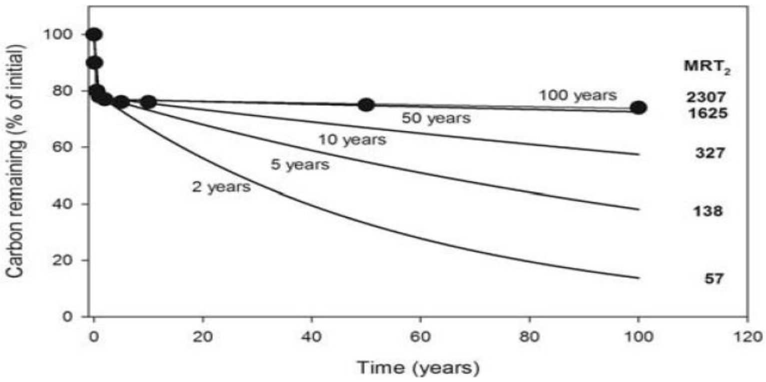

Fig.5- Double-exponential model ($C_{remaining} = C_1e^{-k_1t} + C_2e^{-k_2t}$, with 1 and 2 being a labile and stable pool, respectively) fitted to hypothetical data of biochar decay after 0.1, 0.5, 2, 5, 10, 50 or 100 years, assuming data availability for either the first 2, 5, 10, 50 or 100

years.MRT_2 is the mean residence time of the stable pool 2, calculated from the rate k_2, and is given in years.

Mechanisms of Biochar Stability and Stabilization

The principal mechanisms operating in soils through which biochar entering the soil is stabilized and significantly increase its residence time in soil are intrinsic recalcitrance, spatial separation of decomposers and substrate, and formation of interactions between mineral surfaces.The relatively stable nature of organic matter protected within aggregates or through the formation of organo-mineral interactions may also be of relevance to the stability and longevity of biochar in soil.

Recalcitrance

The conversion of organic matter to biochar by pyrolysis significantly increases the recalcitrance of C in the biomass. The composition changes through a complete destruction of cellulose and lignin and the appearance of aromatic structures (Paris and Zickler, 2005) with furan-like compounds. These changes in the composition of organic bonds by pyrolysis have a significant effect on the stability of biochar.

Carbon Stability in Soils

To assess the biochemical stability of black carbon (BC) in soils, a chronosequence of ancient BC rich anthrosols (Terra Preta de Indio) and their adjacent soils were taken from four sites namely Hatahara (HAT), Lago Grande (LG), Acutuba (ACU) and Dona Stella (DS) (central Amazon, Brazil) in a study carried out by Liang and co-workers (2008). The properties and age of the soils are given in table 1.

Table 1-Properties of BC-rich Anthrosols and adjacent soils in the central Amazon

Site	Type	Depth (cm)	Age (years BP)	pH		Organic C ($mg\ g^{-1}$)	Total N ($mg\ g^{-1}$)	C/N ratio	Sand (%)	Silt	Clay
				1:2.5 (H_2O)	1:2.5 (KCl)						
HAT	Anthrosol	43–69	500–1000	6.4	5.5	22.0	1.0	23	51.3	21.7	27.0
	Adjacent soil	0–10		4.6	3.8	21.8	1.6	14	60.4	3.8	35.9
LG	Anthrosol	0–16	900–1100	5.9	4.9	31.5	1.8	18	47.9	29.6	22.6
	Adjacent soil	0–8		4.2	3.5	17.5	1.3	14	69.4	3.9	26.7
ACU	Anthrosol	48–83	2500–3000	5.6	4.2	15.7	1.0	16	81.9	7.7	10.4
	Adjacent soil	0–30		4.7	3.9	15.4	0.8	20	87.9	3.6	8.5
DS	Anthrosol	Buried (190–210)	6700–7000	5.0	4.1	16.5	1.1	15	96.8	2.9	0.3
	Adjacent soil	0–12		3.9	2.6	10.2	0.4	27	91.1	8.6	0.3

Table 2-The turnover time of total SOC

Sites	Type	Turnover time(years)	BC fraction(% of totalC)	Aromatic Carbon (%)
Hatahara	Anthrosol Adjacent soil	50 18	79.4 20.2	41.5 23.6
Acutuba	Anthrosol Adjacent soil	52 20	73.1 44.3	32.6 26.3
Dona Stella	Anthrosol Adjacent soil	44 9	75.1 10.6	35.5 21.3

This higher stability of organic carbon in anthrosols can be attributed to the presence of significantly higher BC fraction with more aromatic-C forms (Table 2).

Effect of Temperature on Biochar Stability

Baldock and Smernick (2002) showed that thermal alteration decreases bioavilability of wood. In their experiment *Pinus resinosa* sapwood were heated at different temperatures (70, 150, 200, 250, 300 and 350°C) and incubated separately in a sand medium to which nutrient solution and microbial inoculum derived from decomposing *Pinus resinosa* wood were added (Fig. 6).

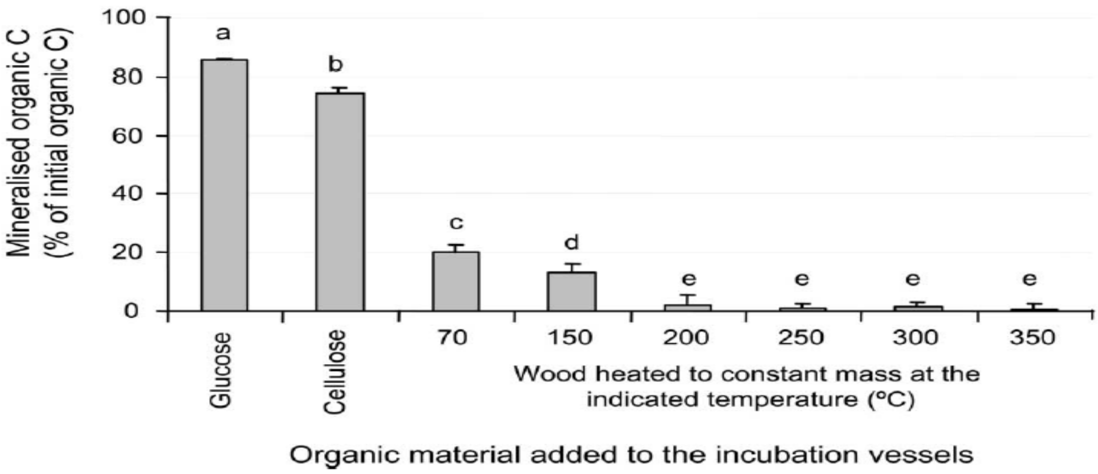

Fig. 6 -Mineralisation of organic carbon contained in glucose, cellulose, and Pinus resinosa sapwood heated to thermal equilibrium at increasing temperatures

This higher stability of thermally altered woods can be attributed to increase the aromaticity as indicated by progressive decrease in H/C and O/C ratios (Table 3) and conversion of O-alkyl to aryl and O-aryl groups with increasing temperature (Fig.7).

Table 3- Molar elemental ratios calculated for Pinus resinosa sapwood heated to the indicated temperatures

Heating temperature (°C)	Molar elemental ratios ($n = 3$)	
	H/C	O/C
70	1.52[a] (0.02)	0.72[a] (0.01)
150	1.45[a] (0.03)	0.70[a] (0.02)
200	1.02[b] (0.02)	0.61[b] (0.00)
250	0.51[cd] (0.03)	0.44[c] (0.01)
300	0.46[d] (0.02)	0.40[d] (0.00)
350	0.54[c] (0.03)	0.32[e] (0.01)
ANOVA P-value	<0.0001	<0.0001

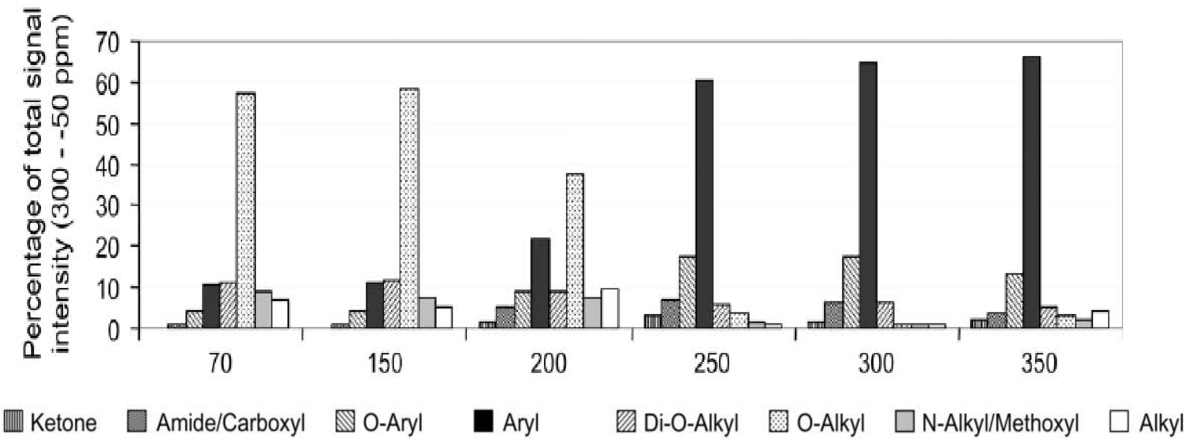

Fig. 7-Distribution of total ^{13}C NMR signal intensity into chemical shift regions

Another study by Bruun and co-workers (2010) also supported the fact that increasing production temperature increases the stability of biochar (Fig. 8).

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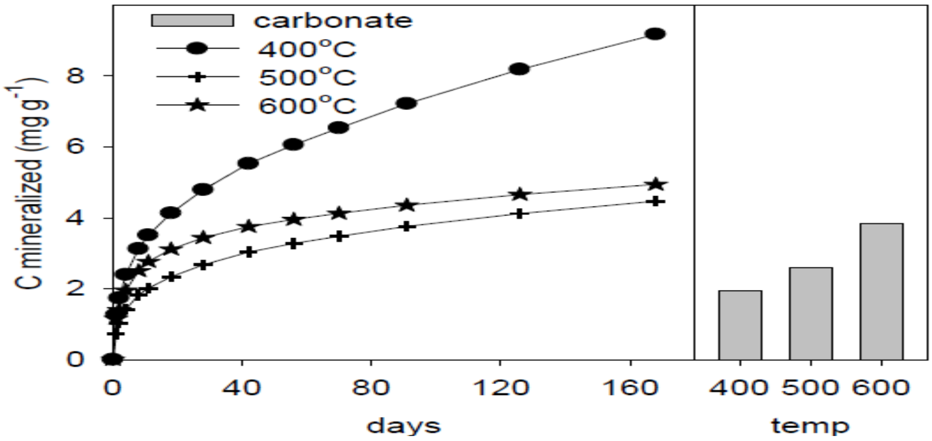

Fig. 8-Mineralization of C and C in carbonates of biochars produced at 400°C, 500°C and 600°C

They studied the mineralization of ^{14}C labelled biochar produced at different temperatures in the range from 400°C to 600°C, and incubated in different soils at the same water potential. Mineralization decreased considerably as production temperature increased from 400 to 500°C, reduced at 600°C (Fig. 8).

Influence of biochar on native organic carbon

Biochar can promote rapid loss of forest humus and below ground carbon during the first decade after its formation (Wardle *et al.*, 2008). In their experiment, mesh bags filled with pure humus collected from the forest, pure charcoal created in the laboratory, or a 50:50 mixture of humus plus charcoal were left in the field and harvested over 10 years. It was found that over the 10-year period, loss of mass and C from the bags containing mixtures of charcoal and humus was substantially greater than what was expected on the basis of the components considered separately (Fig.9A & C).

Substrate (i.e., glucose)-induced respiration (SIR), a relative measure of active microbial biomass, was always significantly greater in the mixture bags than the value predicted on the basis of the charcoal and humus components considered separately (Fig. 9B).

On the contrary, to the above finding, Bruun *et al.* (2010) reported slower mineralization of SOM with more biochar added (Fig. 10). However, the effect of biochar on plant litter decomposition was very small (Table 4).

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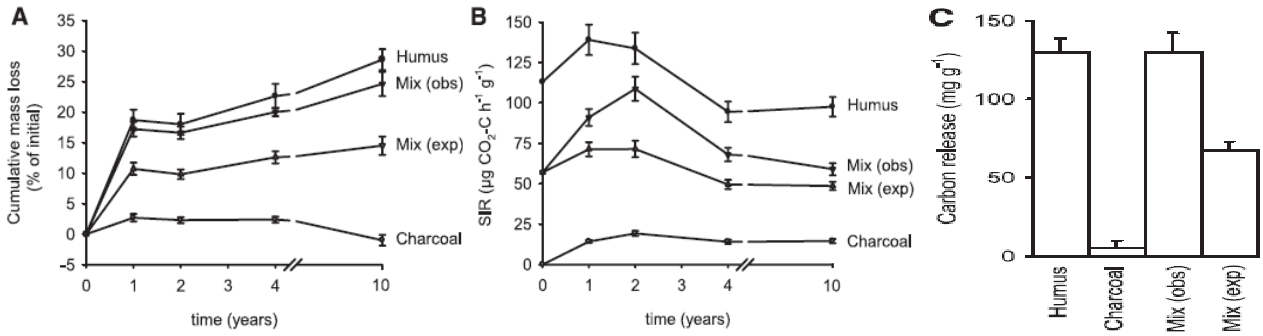

Fig. 9- Changes in litterbag properties over a 10-year period: (A) Total mass loss; (B) SIR;

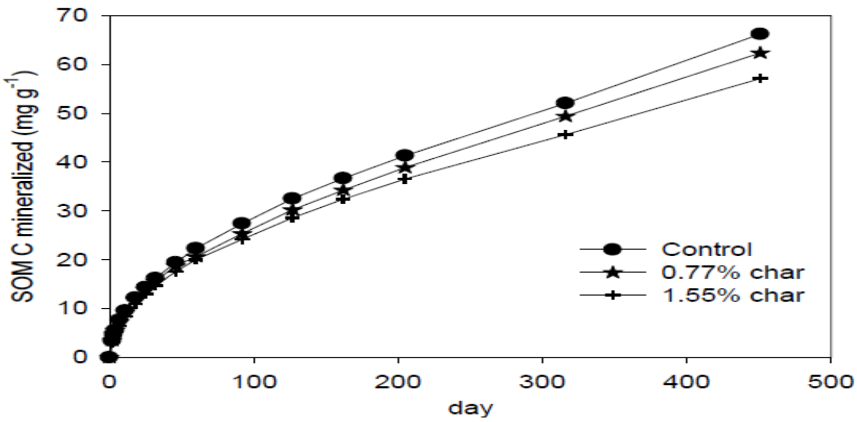

Fig.10- Mineralization of SOM C from a control soil and soils amended with different amounts of biochar

Table 4-Mineralization of plant litter with and without addition of biochar

Amount of Biochar applied (%)	Litter C mineralized (%)
0	48±0.2
0.15	45±1.6

The reason for decreased mineralization of SOM and litter upon addition of biochar can be manifold. First, the addition of biochar may change water availability by absorption. Secondly, microorganisms degrading biochar may immobilize N and impose N limitation on SOM decomposition.

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Carbon sequestration potential of biochar

Biochar is recalcitrant nature, so the release of the biochar-C is a very slow process, resulting in a long-term removal of C from the atmosphere. In addition, pyrolysis of biomass generates a bio-oil and a syngas, which can be used to replace fossil fuels e.g. by using the bio-oil as fuel in power plants and the gas to provide heat for the pyrolysis process. Combining these three pyrolysis outputs renders the whole process not only carbon neutral, which is very often the vision for bioenergy solutions, but actually carbon-negative (Bruun *et al.*, 2011) (Fig. 11).

Mitigation of carbon emissions is obtained not only from biochar soil application, but also from substitution of fossil fuel by the produced bio-oil. The quantity of fossil fuel replaced depends on a range of parameters such as the efficiency of the technology used to convert bio-oil into the desired energy form, the kind of fossil fuel it substitutes, and the handling and transportation of biomass and bio-oil.

In the assessment of the different biochars' sequestration potentials, the stability and quantity of produced biochar are the two main parameters to assess. As discussed, the stability can be increased by raising the pyrolysis temperature, but this will be at the expense of the quantity produced (Fig. 11).

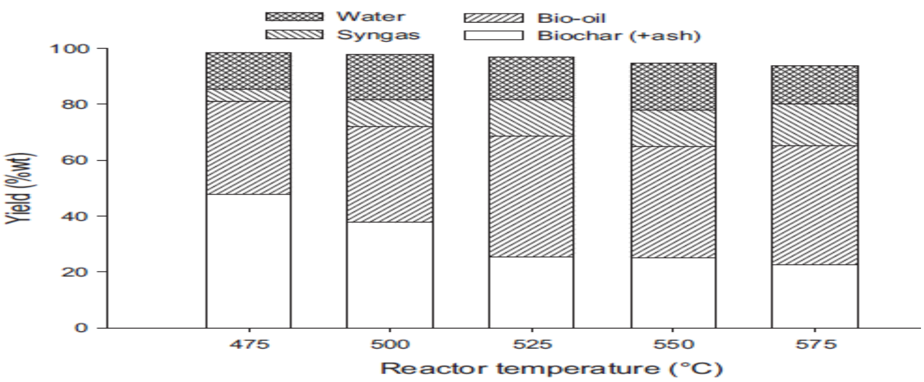

Fig. 11- Mass balance of pyrolysis products as a function of increasing reactor temperature

This inverse relation makes it possible to determine the pyrolysis temperature that gives the highest C sequestration. Based on the assumption that all biochar carbohydrates will be mineralized to CO_2 within a relatively short timeframe, the original feedstock sequestration potentials is calculated and shown in Table 5.

Table 5-Overall mitigation of carbon emissions in relation to initial straw-C, when combining biochar-C sequestration and bio-oil fossil fuel C substitution

Temperature (°C)	Yield[a] (g C kg^{-1} C)	Stability[b] (% of wt)	Yield[c] (g kg^{-1})	Substitute (g kg^{-1})	Substitute (g C kg^{-1})	Biochar[d] (g C kg^{-1} C)	Bio-oil (g C kg^{-1} C)	Total (g C kg^{-1} C)
475	550	65.6	463	190	161	360	410	770
500	464	82.7	505	207	176	380	450	830
525	329	92.4	584	239	204	300	520	820
550	316	95	570	234	199	300	500	800
575	291	97	560	230	195	280	500	780

Assumptions- Heating value of bio-oil: 16.4 MJ kg^{-1}, Heating value of fuel oil: 40 MJ kg^{-1}, C content of fuel oil: 85% (w/w), C content of wheat straw: 39.4% (w/w)

a- Feedstock-C that ends up in biochar, b- Total biochar cellulosic-C þ hemicellulosic-C percentage subtracted from 100%, c- Yield of bio-oil per kg feedstock, d- Biochar-C sequestration per kg feedstock-C pyrolyzed. Calculated as biochar 'Yield' multiplied by 'Stability'

Biochar is highly stable against microbial decomposition and applying this to farmland has the potential to mitigate GHG emissions. However, CO_2 is emitted throughout the biochar life cycle (Fig.12), including pyrolysis, transportation, and farmland application.

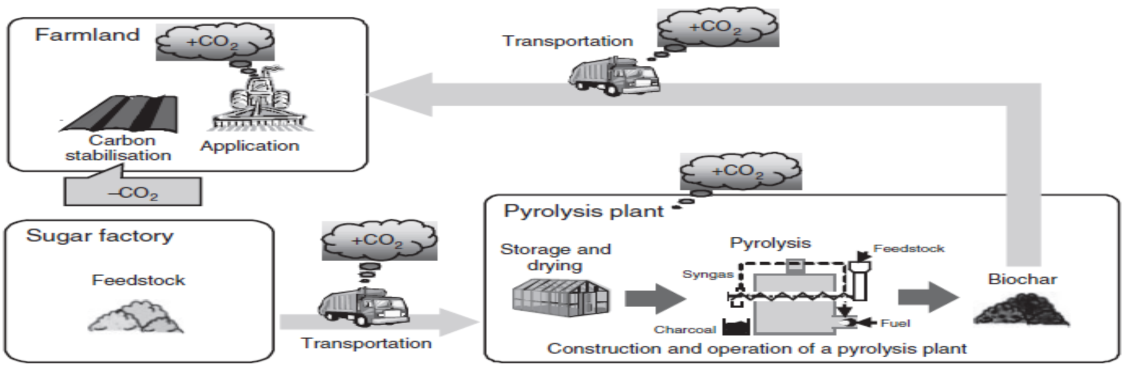

Fig.12- Biochar life cycle (e.g. sugarcane bagasse)

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Therefore, estimating the net carbon sequestration potential by considering these CO_2 emissions is important. Kameyama *et al.* (2010) carried out a study on Miyako island (Japan) to estimate the net carbon sequestration potential of farmland application of bagasse charcoal produced by the pilot plant. To this end, the operational properties of the carbonisation device were examined, and CO_2 emissions and carbon stabilised as charcoal within the life cycle of bagasse charcoal were calculated. Furthermore, the CO_2 mitigation potential was estimated on the basis of inventory data from the pilot plant.

Conclusions

- Stability of biochar-C increases with production temperature making it more suitable for the purpose of carbon sequestration in soil.
- To derive the maximum possible benefit of carbon sequestration by soil application, both yield and stability of the biochar should be optimized.
- Carbon sequestration by biochar is likely to be less in soils relatively higher in native-C than in soils relatively lower in native-C due to stimulation of native carbon loss by biochar application.
- Biochar technology can be a promising approach for soil carbon sequestration when the capacity of biochar-C to remain sequestered in soil is combined with the capacity of bio-oil to reduce CO_2 emission by substituting fossil fuel use.

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INDUCTION OF PARTURITION IN CATTLE

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The induction of parturition is a very useful tool for managing the time of calving. For both the natural and induced parturitions, the stages of labour, pelvic relaxation, calf viability, colostral transfer and milk production are similar in healthy animals, but the knowledge of proper breeding dates and high incidences of retention of the placenta are main constraints. The induction of parturition is indicated to save the viability of the fetus as well as that of the cow. Since the fetus gains about 0.5 kg/day during the last weeks of normal gestation, induction of parturition can be a useful tool to prevent dystocia from an oversized fetus. Induction of parturition is also beneficial when the gestation is prolonged which allows the cows extra time to resume reproductive cyclicity to breed again. Potentially, parturition induction can be used to schedule calving to occur during daylight hours on known dates, so that it can be managed by the adequate number of personnel.

Indications

- Advancing the time of calving to coincide with the availability of suitable pasture for enhancing milk production.
- To ensure that the cow parturate at a pre-determined time when skilled personnel is available so that proper attention can be given to the cows.
- To reduce the birth weight of the calf so as to reduce the occurrence of dystocia by shortening the length of gestation.
- Also indicated in diseased or injured cows for the treatment of cardiac failure, uterine hydropsy or other critical conditions to save the life of fetus and cow.
- To prevent udder edema and distension that predisposes difficulty in milking which may lead to mastitis.

Various protocols of induction of parturition

A number of studies have been carried out for the induction of parturition using different types and combinations of hormonal treatments along with their efficacy and safety. They are described below.

Short-acting corticosteroids

The most widely used corticosteroid for induction of parturition is Dexamethasone (20 to 30 mg) or Flumethasone (8 to 10 mg) given as a single intramuscular injection. The efficacy of induction of parturition is 80 – 90% when it is administered within 2 weeks of the normal term. The parturition commences within 24 to 72 hours of administration of an injection. The average duration is 48 hours. Retreatment is often recommended if the parturition does not commence within 72 hours of injection.

Long and intermediate-acting corticosteroids

Long-acting corticosteroids are used when the lactation is to be synchronized with the grazing season and the viability of the calf is not important. It includes Dexamethasone trimethyl acetate (20 mg) or Triamcinolone acetonide (4 to 8 mg) (medium acting). The single intramuscular injection is to be administered one month before the due date of calving. The calving occurs over 4 to 26 days of administration of the injection. The udders of the treated cows get engorged with milk about one week after injection. Milking can be done in these animals before parturition if the udder is already full to prevent the regression of secondary tissue.

The occurrence of retained placenta is quite less (9-22%) compared to short-acting corticosteroids. However, the incidence of calf mortality is more (7% to 45%) due to premature placental separation and also the birth of the premature calf.

Prostaglandins

Prostaglandins give similar results to induction of parturition as short-acting corticosteroids with a range of 24 -72 hours (average of 45 hours)from treatment to calving. There is also a high chance of retained placenta and failure of induction when administered within 2 weeks of the normal term.

Prostaglandin and corticosteroid combination

Hormones generally used for induction of parturition initiate endocrine events that are triggered by fetal cortisol. Corticosteroids remove the placental source of progesterone by converting placental progesterone into estrogen. Failure to induce parturition may occur due to the non-removal of the ovarian source of progesterone. On the other hand, prostaglandins remove the ovarian source of progesterone. But they may fail in the induction of parturition due to remaining placental progesterone. So, a combination of two hormones can remove both the sources of progesterone and can efficiently induce parturition.

A combination of both prostaglandin and dexamethasone induces parturition within 25 to 42 hours of treatment and the interval from injection to calving is also less variable.

Combination of long-acting corticosteroid, dexamethasone, and cloprostenol

This combination is used to induce calving during daylight and a low incidence of retention of the placenta. Long-acting corticosteroids lead to the lowest incidence of retained placenta but there is high variability in the interval from treatment to calving, whereas, dexamethasone and cloprostenol combination has the least variability in the interval from treatment to calving. So, the combination of long-acting corticosteroid, dexamethasone and cloprostenol induce parturition in daylight hours with a low incidence of retained placenta.

Summary of treatments for induction of parturition in cattle

For early induction (250-275 days of gestation): Long-acting corticosteroid followed by short-acting corticosteroid or $PGF_{2\alpha}$after 8 days if the calving has not occurred. The calving occurs after 48 hours of the last injection.

For late induction (after 275 days of gestation): $PGF_{2\alpha}$ or short-acting corticosteroid

Some disadvantages of induction of parturition

- It is not always effective.
- The birth weight of the calf in induced parturition is lower than that of normal parturition.
- High incidence of retention of fetal membranes when the short-acting corticosteroids are used.
- Milk yield is initially affected. There is a delay in reaching peak lactation.

Conclusion

Induction of parturition plays an important role in managing to calve, synchronizing the calving with the availability of pasture to maximize the milk production, in reducing the chances of post-partum health problems of the cow. But the treatment protocols are also having some undesired consequences like retention of the placenta which is harmful to the reproductive health of the cow. So, an effective treatment regimen at the proper time of the gestation period may give a successful induction of parturition.

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INTEGRATED FARMING SYSTEM

Article Id: AL201930

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Nowadays, farmers are subjected to a high degree of uncertainty in their income due to their dependence majorly on a single enterprise. India needs to adopt a "well designed" Integrated Farming System (IFS) to overcome this problem. So, farmers have to diversify their farming to get a more sustainable income as if one fails, another one can provide income. The integration of various agricultural enterprises such as cropping, animal husbandry, fishery, poultry, etc. have great potential in the farming economy. This also helps in reducing wastage of output from one enterprise as it can be used as an input for another one.

Problems of present-day agriculture systems

- The decline in agriculture growth rate
- Decline in productivity
- Shrinkage in the net cultivable area
- Increasing environmental pollution
- Depleting groundwater table
- The increasing cost of production
- Low farm income
- Problems of farm labours due to large scale migration
- Climate change and decrease in average rainfall

Integrated Farming System

In recent years, food security, livelihood security, water security as well as natural resources conservation and environmental protection have emerged as major issues

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worldwide. Developing countries are struggling to deal with the dual burden of climate change and globalization. It has been accepted that sustainable development is the only way to promote proper utilization of resources and environmental protection without affecting economic growth. Developing countries around the world are promoting sustainable development through newer agricultural practices which will help them in addressing socio-economic as well as environmental issues simultaneously. Within the broad concept of sustainable agriculture "Integrated Farming System" hold a special position.

It refers to an agriculture system that integrates livestock and crop production. Moreover, the system will help poor small farmers, who have very small landholding for crop production and few heads of livestock to diversify farm production, increase cash income, improve the quality and quantity of food produced and exploitation of unutilized resources.

Elements of Integrated farming system

- Farm ponds
- Bio-pesticides
- Bio-gas
- Bio-fertilizers
- Solar energy
- Vermicompost making
- Green manuring
- Rainwater harvesting
- Watershed management

Advantages of Integrated farming system

1. Increase in crop production to supply the exploding population of our country.
2. Increase in farm income due to proper utilization and recycling of residues and byproducts.
3. Organic farming can be practiced for sustainable soil fertility and productivity.
4. Environmental pollution can be reduced by the effective recycling of wastes from animal activities like dairy, piggery, poultry etc.
5. Decreased input cost through recycling from the byproducts of allied activities.
6. Stable income can be obtained through products like eggs, meat, milk, vegetables, silkworm cocoons from integrated farming.
7. Cultivation of fodder crops such as intercropping, and border cropping will result in the availability of nutritious fodder for animals.

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8. Generation of consistent employment for labours depending on farming.

Types of Integrated farming system

- Crop - livestock - farming system
- Crop - livestock - fishery farming system
- Crop - livestock - poultry - fishery farming system
- Crop - poultry - fishery - mushroom farming system
- Crop - fishery - duckery farming system
- Crop - livestock - fishery - vermicomposting farming system

Limitations of the integrated farming system

1. Lack of awareness about sustainable farming systems.
2. Unavailability of varied farming system models.
3. Lack of credit facilities at easy and reasonable interest rates.
4. Non-availability of ensured marketing facilities especially for perishable products.
5. Lack of deep freezing and storage facilities.
6. Lack of timely availabilities of inputs.
7. Lack of education/knowledge among farming community especially of rural youth.

Fig 1: Goat-Fish Integration

Fig 2: Biogas plant

Fig 3: Chicken-Fish Integration

Fig 4: Tree Intercropping

What to improve?

- ❖ There is a need to create a database related to the farming system in relation to the type of farming, infrastructure, economics, sustainability etc. under different farming conditions.
- ❖ The assessment and refinement of the technologies developed at the research station at the cultivator's field.
- ❖ Need to prepare contingent planning to counteract the weather/climate threats under different farming conditions.
- ❖ Need to prepare research models for different holding sizes and various types of farming system.

Conclusion

Sustainable development is the only way to promote rational utilization of resources and environmental protection without affecting economic growth and Integrated Farming Systems hold a special position as in this system nothing is wasted, the by-product of one system becomes the input for others. India has considerable livestock, poultry and crop wastes. IFS is a promising approach for increasing overall productivity and profitability through recycling the farm by-products and efficient utilization of available resources. About 95% of the nutritional requirement of the system is self-sustained through resource recycling. As the number of enterprises is increased, the profit margin also increases. It could further generate employment opportunities to the farming communities round the year and provide better economic and nutritional security. This can go a long way uplift rural life through increased income.

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IMPORTANCE AND ROLE HYDROPONICS FEEDING IN LIVESTOCK AS SOURCE OF GREEN FODDER

Article Id: AL201931

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India is an agriculture-based country and having highest livestock population in the world. Total livestock population is 535.82 million in the country showing an increase of 4.64 % over (20th Livestock census 2019). There was decreasing 6 % in the total Indigenous cattle population. Productive performance of Indigenous cattle (2.93 kg/day) is very less compared to Exotic / crossbred cow (7.71 kg /day). The demand for milk and milk products in India is creating new potential in the profitability of dairy farming as an occupation. At the same time, there is a substantial decline in fodder availability. In addition, the area under food crops is also declining owing to urbanization and industrialization. The shortage of fodder due to ever decreasing area under cereals and fodder crops is getting compensated with increased use of commercial cattle feed, resulting in increased costs of milk production. Several attempts have been made to find alternate sources of cattle feed. Hydroponics is considered as the most economic and efficient feed substitute and a sustainable feed for livestock. Green fodder is an important feed component of the dairy animals ration; otherwise the productive and reproductive performance of the dairy animals is adversely affected. Hydroponics is a method of growing plants without soil. Only moisture and nutrients are provided to the growing plants. Hydroponic growing systems produce a greater yield of fodder over a shorter period of time in a less area than others traditionally grown fodder crops. Although the methods of hydroponic fodder production date back to the 1930's, there is renewed interest in hydroponic fodder as a feed-stuff for Cattle, sheep, goats, and other livestock. Hydroponically grown fodder is an extremely economical feed supplement for cattle. With hay, grain, corn and soybean prices reaching record highs, dairymen need a better feed option. This leads to total control over meat or milk production and operational costs. There is also reduction of pesticides and herbicides because the plants are growing fully protected environment. Hydroponics is a year-round growing system that produces a consistent quality and quantity of fodder for animals, regardless of outside

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weather. With sprouting, there is a reduction in total energy. The increase in protein percentage is due to the dry matter loss. In fact, the downside to hydroponic fodder is its high water content. According to various forage analysis reports, the dry matter content of hydroponic fodder is only 12 to 15 per cent, compared to almost 90 percent in (unspotted) grains and hays. Even corn silage and haylage have considerably more dry matter than sprouts. Sprouting changes the nutritive characteristics of the grain. There is an increase in fibre and some vitamins and a decrease in toxic and an anti-nutritional factor. This method is fully utilized for fulfil demand of feeds and fodder in the country.

Chemical composition of maize hydroponics

S./No.	Parameters	One % DM Basis
1.	DM (Dry matter)	18.54
2.	CP (Crude Protein)	14.01
3.	EE (Ether extract)	3.56
4.	CF (Crude Fibre)	6.59
5.	NFE (Nitrogen free extract)	75.23
6.	Ash	1.58
7.	AIA (Acid insoluble ash)	0.65

Source of feed for meat animals

Hydroponic fodder may be must suited to meat animals (horses, rabbits, pigs, and poultry) who would benefit more from the changes in the feed due to sprouting (e.g. less starch, more sugars) as compared to ruminants (sheep, goats, and cows) that are less efficient at digesting high quality feed. It is good source of feeds to rabbits and mature chickens; to feed them on the form of mash and pellets makes from maize germ, whole maize, soya beans, canola, sunflower and coccodiostat, among others, in the morning and evening. Chicks, on the other hand, are fed on commercial mash for seven weeks before they are weaned on the homemade feeds.

Indigenous chicken can be fed on hydroponic fodder as three quarters of their daily feed requirement while layers and broilers (exotic) can be fed on hydroponic fodder as a third of their meal. The farmer also uses hydroponics to plant strawberries, tomatoes and lettuce. It needs less labour to cultivate hydroponics fodder for animals. If farmer can fed chicken on hydroponic fodder exclusively. First of all, 2kg of seed produces 10kg of fodder in just 7 to 8 days. If each chicken eats 150g of fodder, that would mean we could feed up to 66 chickens. 7 day old fodder is just a bit too tough to be digested by poultry. This is because the fibre content is so high and poultry have a real problem digesting this fodder. Thus it is best to feed your chicken with 4 day old fodder. If fodder fed after 7 days, the farmer fed to chicken with any dry commercial feed in flour form is good. Usually mix it up at a ratio of 100g of hydroponic fodder to 30g of commercial feed. The chicken has responded well to this, with a faster weight gain, larger eggs and certainly no constipation. All this with the added advantage of reducing the feeding cost.

As feed for livestock

Fodder sprouts are tender and young, the equivalent of fresh green grass. As such, they are more palatable and nutritious to all types and classes of livestock. On a dry matter basis, hydroponic fodder compares favourably with other nutritious feed-stuffs.

Advantages of hydroponic fodder

There is less waste water, as animals consume the recirculation water along with the feed. Since production is hydroponic, there is no leaching of nutrients into the environment. Hydroponic fodder production requires considerably less land and labour to produce feed for livestock. While hydroponic fodder is not likely to become a major source of feed for commercial livestock, it could be feasible under certain circumstances.

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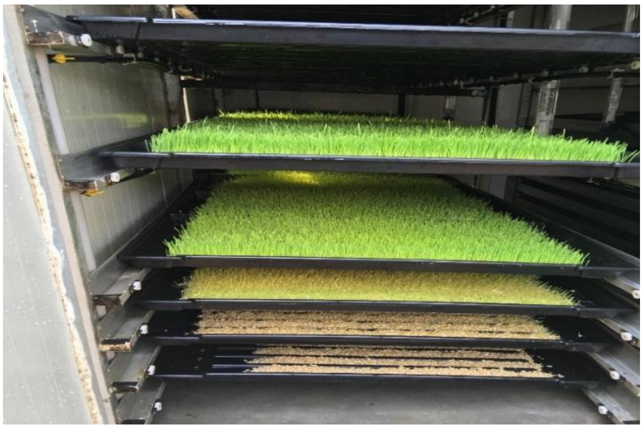
Dry and drought-prone regions



Hydroponic fodder production is probably best-suited to semi-arid, arid, and drought-prone areas of the country. By growing fodder indoors, crop failures would no longer be a risk. Good quality forage could be produced year-round. Feed supplies would be insured. Lack of water resources could be allocated more efficiently.

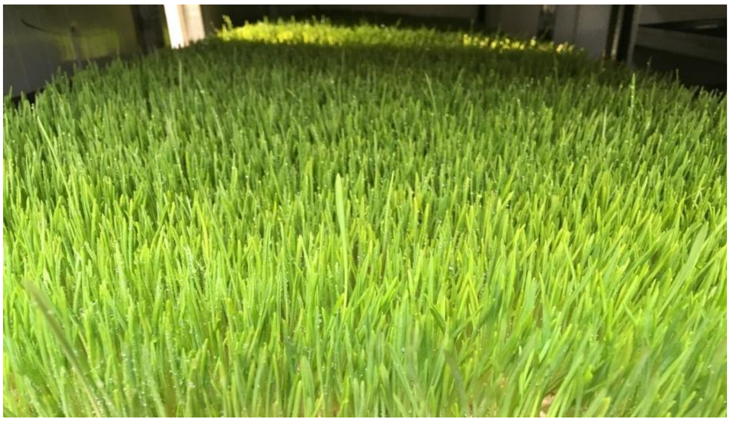
Limited land

In places where less land for agriculture are extremely high or land is simply not readily available, hydroponic fodder has obvious advantages, as it can be produced in a small footprint. Because the fodder is produced continuously, there is no need for long-term feed storage and no nutrient losses that can be associated with feed storage.

High alternative feed costs

Hydroponic fodder is considerably more expensive than conventional feedstuffs, it assumes that conventional feedstuffs are available and priced competitively. There are many locations in which this is not the case and hydroponic fodder could be more competitively priced.

Small-scale producers



Requiring smaller amounts of fodder, small-scale producers may be able to build their own fodder systems for a few thousands. When the investment is low and labour is unpaid, the cost of hydroponic fodder is considerably less.

Organic

Hydroponic fodder production seems particularly well-suited to organic producers, who already pay high prices for feed or have difficulty to grow organic feedstuffs. Cereal grains can easily be sprouted in accordance with Certified Organic Programs.

In the future

Due to scarce of land and water increases and feed prices continue to rise, hydroponic fodder could become a better option for more livestock producers.

Conclusion

Hydroponics can be used as an ideal green fodder substitute for livestock, fish and poultry, this technology will be taken up in a big way by the dairy and poultry farmers, especially, by those who have less land as well as scarce conditions for fodder production. It can be concluded that hydroponics is a promising source of feed for chicken and other meat animals effective in improving, Growth performance, Digestibility, Milk production, Reduces the feeding cost.

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ZERO HUNGER INDEX: INDIA'S INFAMOUS CONDITION

Article Id: AL201932

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In a diversified world where we harvest enough food to feed everyone, 821 million people – one in nine – still go to bed on an unfilled stomach each night (FAO, 2015). By keeping this viewpoint, in 2015 the global community adopted the 17 Global Goals for Sustainable Development to improve people's lives by 2030. Among the 17 Goals, Goal 2 – Zero Hunger – pledges to end hunger, achieve food security, improve nutrition and promote sustainable agriculture, and is the priority of the World Food Programme. According to the UNICEF (2019) recently published, India reported the most number of deaths of children below five years in 2018. Approximately 8.8 Lakh Children under 5 years died in 2018 in India which is highest in the world. Nigeria recorded the highest number of deaths (8,66,000) followed by Pakistan (4,09,000). The report titled "State of the World's Children 2019", 69 percent of deaths of children are caused due to malnutrition. Every second child in the country affected by some form of malnutrition. This includes stunting 35 percent, wasting 17 percent, and overweight 2 percent. Only 42 percent of children age group between 6 to 23 months are fed an adequate frequency, whereas only 21 percent receive a proper diet. However, 53 percent of infants aged 6-8 months are complementary fed timely. As per the micronutrient deficiencies among the children under 5 years in the country is concerned, every fifth child is deficient of Vitamin A, whereas one in every third child has Vitamin B12 deficiency, and two out of every five children are anaemic. However, the Government of India initiated many related programme such as National Nutrition Mission, Anaemia Mukt Bharat, MDM but not reached the children effectively.

What is ZERO HUNGER?

'Zero Hunger' is defined as the access and ensure of sufficient, safe, nutritious food to all people round the year, in particular, the poor and people in vulnerable situations, including infants. Factually, ZERO HUNGER' was adopted by the United Nations on 25 September

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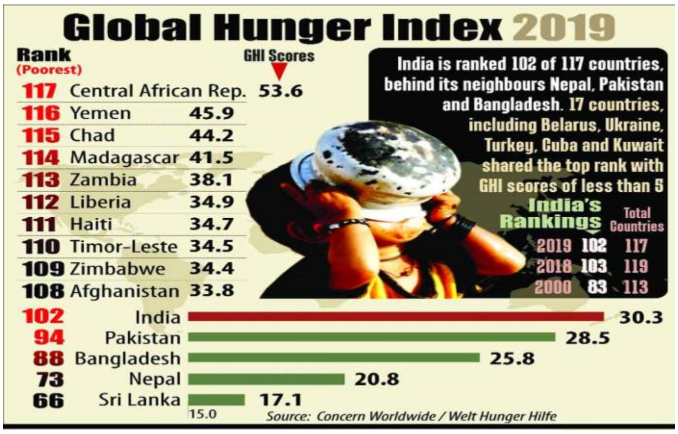
2015 as one of the 'Sustainable Development Goal'. In light of this, The Global Hunger Index was developed and jointly published annually by Concern Worldwide and Welt Hunger Hilfe, to comprehensively measure and track hunger at the global, regional, and country levels. The GHI aims to trigger action to reduce hunger around the world. The Global Hunger Index was categorized based on score. The five-category mentioned in HGI was Extremely alarming ≥ 50.0, Alarming 35.0–49.9, Serious 20.0–34.9, Moderate 10.0–19.9 and Low ≤ 9.9.

Indian Scenario on Global Hunger Index

As per the recent survey on Global Hunger Index (2019), the India stood in 102nd position, because of its large population, India's GHI indicator values have an outsized impact on the indicator values for the region. India's child wasting rate is extremely high at 20.8 percent—the highest wasting rate of any country in this report for which data or estimates were available. Its child stunting rate, 37.9 percent, is also categorized as very high in terms of its public health significance (de Onis et al. 2019). In India, just 9.6 percent of all children between 6 and 23 months of age are fed a minimum acceptable diet. Similarly, as of 2015–2016, 90 percent of Indian households used an improved drinking water source while 39 percent of households had no sanitation facilities (IIPS and ICF 2017). In 2014, the prime minister instituted the "Clean India" campaign to end open defecation and ensure that all households had latrines. Even with new latrine construction, however, open defecation is still practiced. This situation jeopardizes the population's health and consequently, children's growth and development as their ability to absorb nutrients is compromised (Ngure et al. 2014; Caruso et al. 2019). Further, in comparison with the previous statistic related to GHI, it spell out something different, in the year 1992, the India's GHI rank was 76th, then in 2000, it was 83rd, Again in 2008, it was 102nd position. Subsequently, in 2016, it was 97th rank, in 2017, it was 100th rank. Similarly, in 2018, it was 103rd rank.



However, the Government of India has taken up some initiative to improve the standard of living, poverty alleviation, affordable house, property sanitation such as National Nutrition Mission (NNM), Mid-Day Meal (MDM), Ayushman Bharat, Pradhan Mantri Awas Yojana-Gramin etc.but due tolack of proper implementation of programme; only present in

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black and white, corruption, lack of follow up, illiteracy, and primitive perception, the failure to improve Indian condition can be observed.

Conclusion

The condition seems like getting worst due to the human factor. To improve India's GHI, proper policy and implementation at the grass-root level should be installed followed by repeated follow up of the programme. The coordination with all the related organizations and stakeholders is highly advisable and appreciable for inclusive growth and development.

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ADVANCED CITRICULTURE IN VIDHARBHA REGION OF MAHARASHTRA: A CASE STUDY OF SUCCESSFUL ADOPTION OF TECHNOLOGIES

Article Id: AL201933

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Citrus is one of the major fruit crops in India. The citrus group includes Mandarins like Nagpur Mandarin, Kinnow, Darjeeling and Coorg Mandarin; Sweet Orange like Mosambi; Acid Limes and Lemons like Assam and Baramasi Lemons. According to the Horticulture Statistics Division of Ministry of Agriculture and Farmers' Welfare (2016-17), India produced 12.04 million tons of citrus in 0.94 Mha area with a yield of 12.75 tons/ha (GoI, 2017). Central India has ideal growing conditions for citrus and Vidharbha region produces bulk of the fruit. To provide impetus to the citrus cultivation of Central India, ICAR-CCRI was established (formerly NRCC) in 1985 in Nagpur and till date, this premiere institute is functioning with the motto of increasing the overall citrus production and productivity through high tech citriculture in the country (http://www.ccringp.org.in/ccringp/). The scientists through their rigorous research have developed revolutionary technologies which have changed the scenario of citrus cultivation in India over the years. The improved rootstocks, disease free planting material, high yielding and early maturing varieties, disease resistant rootstocks, microbial consortiums, recommended dosages of nutrient, protective chemicals and irrigation, nursery management and post harvest handling techniques have been standardized by the institute and disseminated to farmers who have immensely benefitted. Often the technologies developed by research institutes remain confined to experimental farms and laboratories. These technologies are not adopted by farmers and over the time, tend to lose significance. But the technologies which make their way to a farmers' field and generate remunerative income for them, bring pride and glory not only to the farmer but also to the research institute. One

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such case of successful adoption of CCRI technologies have been done by a progressive citrus grower of Kandli village of Achalpur taluka of Amravati district of Maharashtra, named Shri Pramod Jagannath Washankar.

Progressive Farmer: Shri Pramod Jagannath Washankar

Shri Washankar is a progressive farmer of 58 years of age who owns and manages citrus orchard of around 60 acres located near the Satpuda Hill region. With an experience of more than 19 years in citrus farming, he expresses his heartfelt thanks to CCRI whose technologies have helped him to improve his farming in scientific manner and fetch better income. He works in his orchard everyday for 8-9 hours, assisted with 5 labourers, taking care of about 6000 trees. His primary occupation is farming which has been his family occupation since ages. His father established citrus orchard in 1985 which had been handed over to him from year 2001.

Fig. 1: Mr. Washankar: the progressive citrus grower

Contact with CCRI

Way back in 2001 when Mr. Washankar involved himself in citrus farming, he came to know about CCRI and its activities through an acquaintance at Punjab Rao Deshmukh Krishi Vidyapeeth. From then there was no turning back. He improved his orchard's production and productivity by adopting the institute's technologies. To solve any major problem, he consults the scientists of CCRI. Most of the scientists of this institute are frequent visitors to his orchard. His orchards are an excellent showcase of improved technologies of CCRI.

Technologies Adopted

Shri Washankar has adopted several improved technologies of CCRI with great enthusiasm and has been receiving positive results.

- **Rootstocks and Nursery Management:** Shri Washankar prepares his own plants in his net house nursery in an area of 1 to 1.5 acres. He has adopted several types of rootstocks like Rough lemon, Sekhwasha, Trifoliate, Rangpur Lime and Alemow for cultivation of Nagpur Mandarin. Alemow is a promising rootstock which has been developed by CCRI through years of rigorous research. He has also grafted Mosambi and Acid Lime on Alemow. Mr. Washankar prepares his planting materials in plastic bags with growing media composed of soil, FYM and sand.

- **Cultivars and Varieties:** Most of the cultivars and varieties developed by CCRI are being cultivated with success by Mr. Washankar. They include NRCC-7, NRCC-4, Grape fruit, Pummelo, Blood Red, Cutter Valencia. Brazilian sweet orange varieties like Hamlin, Pera, Natal and Indian varieties like Jaffa and Katol Gold are also to be seen in his orchard.
- **Orchard Management:** Mr. Washankar maintains hygiene in his orchard by discarding fallen and infected fruits, barks etc. He removes the dead wood every year which is very essential to prevent citrus decline. He does pruning every alternate year in his trees, in November-December for *Ambia* flush and in March for *Mrig*. While planting of saplings from nursery to orchard, he treats the roots of saplings with fungicide. He maintains proper spacing while planting (about 5mx5m). He also practices high density planting of Nagpur Mandarin with about 240 trees per acre.
- **Irrigation management:** Shri Washankar's orchards are irrigated through drip irrigation method. Compared to traditional method of irrigation in citrus crop, drip saves 61 per cent water and gives an increase of about 50 per cent in yield. For inducing flowering, Mr. Washankar maintains in his orchards, a water stress period of about 30 days from mid Dec to mid Jan in *Ambia* flush of Nagpur Mandarin and again of 30 days from 2nd week of May to 2nd week of June in *Mrig* flush.
- **Nutrient Management:** Mr. Washankar follows the CCRI recommended doses of nutrient fertilizer 4 times a year to *Ambia* and *Mrig* flush trees. For *Ambia* he applies in Jan, April, June and end of August. For *Mrig* flush he applies in Sept, Oct, Nov, Jan, June. Depending on the quantity of bearing he keeps on changing the fertilizer doses but it basically consists of 1.75 kg DAP, 750 gm 10-26-26, 1 kg potash and 1kg ammonium. He also nourishes his trees with micro nutrients consisting of Zn, Fe and Borax.
- **Plant Protection:** Mr. Washankar follows CCRI recommended doses of fungicides for prevention of gummosis in citrus. For management of insect pests, he follows

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the same for insecticides. He has also installed fruit fly traps and sticky traps in his orchard mainly for reducing the application of chemicals. Once in 2004 due to *Kolshi* (Black Fly) attack in his orchard, he had suffered huge economic loss. He was able to recover his orchard back with the expert consultation of eminent entomologists of CCRI.

- **Harvest and Marketing:** When the fruits reach their maturity standards, Mr. Washankar handpicks them with utmost care. The fruits are graded and packed in cartons and loaded on trucks which take them to Paratwada waxing plant. The charges for waxing are Rs. 20 per carton. Thereafter agents from different states and even abroad purchase his fruits. Mr. Washankar supplies Mandarins to markets in Ahmedabad, Delhi, Pune and Kerala. His fruits also fetch good prices in markets of Bangladesh.

Production and Profits after contact with CCRI

Mr. Washankar at present makes a profit of around Rs. 10 lakhs annually. He expresses his sincere thanks to the highly productive and disease resistant rootstocks of CCRI like Alemow and improved cultivars which have helped him to achieve this target. Before his contact with CCRI he states that his income was merely around 1 lakh with trees having very poor bearing and infected by diseases.

Farmer led Innovation

By farmer led innovation we mean innovations done by the farmer in his own level to tackle a problem situation in his field. Mr. Washankar is no less in that. When he found a Nagpur mandarin tree was in its dying stage, he side grafted it with Alemow plant and now the Mandarin plant stands tall and sturdy bearing fruits by virtue of the healthy Alemow rootstock. It was inevitable a mastery of horticultural practice which Mr. Washankar had attained through his years of experience.

Constraints

When asked about the constraints which Mr. Washankar faces as a citrus grower, he says that the major constraint is attack of *Wayvar* in citrus fruits of the region. It causes decline in citrus production. The second main constraint is of depletion of ground water level. Even borewells as deep as 175 ft does not fetch water in the region of Satpuda Hills.

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Fig 2: Mr. Washankar inspecting the quality of fruits

Awards and Recognitions

In spite of natural constraints like erratic weather, insect or disease attack resulting in production fluctuations, Mr. Washankar has managed to prove his excellence as a progressive citrus farmer of Amravati district. He says that his contact with CCRI has helped him to achieve it. He was felicitated in Maharashtra State level Farmers' Meet organized by State Department of Agriculture and Animal Husbandry in Akola in June, 2004. He was also felicitated in National Citrus Meet organized by CCRI (then NRCC) in Nagpur in August, 2013 for his enormous contribution in citriculture. He had also attended the National Meet of innovative Horticultural Farmers organized by IIHR, Bangalore in 2014. He is also a member of the Farmer Producer Company in his Taluka which has about 250 registrations from farmers. He is also the Chairman of *Seva Sahkari* Society in his village which is funded by Amravati District Cooperative Bank and grants loans to farmers.

Future Aspirations

Mr. Washankar is enterprising and curious learner even at this age. He says that if given opportunity and required facilitation, he would like to venture into the world of citrus processing and export. Along with that he also wants to try new varieties and rootstocks tested and approved by CCRI.

Fig 3: Mr. Washankar with ICAR-CCRI Scientist Dr. R.K. Sonkar visiting his orchard

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Farm Family

Apart from being a citrus grower, Mr. Washankar is a loving and caring father who has always given equal opportunities to his daughter and son without any gender discrimination. His daughter is a mechanical engineer working in Oman and his son is preparing for NEET examination as a medical aspirant. His wife is involved in vegetable farming which she takes care herself and the produce is sold in the market. All the decisions regarding the seasonal vegetable to be grown and in how much area, all are taken by his wife. This reflects the individual roles which each family member in this particular farm family has.

Conclusion

Both Mr. and Mrs. Washankar are trying their best to contribute towards the food and nutritional security of the nation. About 58 per cent of India's population is dependent on agriculture as an occupation and whole of the nation of 1.2 billion is dependent on farmers for food security. Agricultural scientists are working rigorously to provide better technologies and livelihood opportunities to farmers. The Hon'ble Prime Minister of India has already declared Doubling Farmers' Income by 2022 as a target to be achieved. And the success story of Mr. Washankar increasing his income by adopting CCRI technologies is a reality. So it is now time that farmers and research institutes work in close coordination to identify research problem from field, solve it in laboratories and take the solution back to farmer through a Farmer Back to Farmer Model. Meanwhile research institutes through their encouragement to enthusiastic farmers like Mr. Washankar will continue creating new success stories.

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SULA: MAKING WINE INDUSTRY A NEW DESTINATION FOR YOUNG AGRIPRENEURS IN INDIA

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Indian agriculture is witnessing a growing disinterest of youth in agriculture sector. In the contrary, the present situation of this sector especially demands the innovativeness, creativity and enthusiasm of youths of the nation. Realizing and utilizing the vast range of opportunities in primary and secondary agriculture can combat the present challenge of youth disinterest in agriculture and youth unemployment simultaneously, by absorbing the massive demographic force into this sector. This would benefit Indian agriculture in turn by giving it a chance to modernize and revitalize. Grapes (*Vitis*sp.) cultivation is one of the most remunerative farming enterprises in India. India has the distinction of achieving the highest productivity in grapes in the world, with an average yield of 21.8 Metric tonnes/hectare (MT/ha). Maharashtra is the leading state in production of grapes in the whole country with around 88 per cent of total production. Area under grapes in Maharashtra is 86 thousand ha and production is around 2050 thousand MT of grapes annually (NHB, 2016). There is a phenomenal rise in export of grapes from India from 54,049.87 tonnes during 2005-2006 to1,07,257.85 MT in 2014-2015 valuing Rs. 1,086.51 crores(APEDA, 2016), out of which nearly 99 per cent is exported from Maharashtra. With regard to both grapes production and export, Nashik district is at forefront in the state. The exports from Nashik were 48,465 metric tonnes in 2013 contributing around 70 per cent of Maharashtra's total grapes export (APEDA, 2016). In the transitional phase of Indian agriculture from subsistence farming to commercialization this crop certainly offers tremendous opportunity for Indian farmers and

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agri-preneurs. However, there is still enormous gap in awareness and motivation among Indian educated youth to take up agro based industries as their profession. Fortunately, there are some exceptions that are setting examples for youth of the nations to engage in agri-preneurship. One such pioneering endeavor is taken upby Mr. Rajeev Suresh Samant, the founder and Chief Executive Officer (CEO) of Sula Vineyards which is presently, one of Asia's largest wineries.

Rise of Sula

After receiving degrees in economics and engineering management from Stanford University, USA, Mr. Samant joined the Oracle Corporation which he left after couple of years only to come back to his roots in Nashik in India.Initially he started with mango cultivation in his family’s 20 acres plot. However, it did not take him long to realize that climatic condition in Nashik is perfect for growing wine grapes. He immediately pursued the idea and met Kerry Damskey, a master winemaker from California.In 1997, the duo took the revolutionary step of setting up the first ever winery in the region which is situated 180 km northeast of Mumbai in Nashik. They started cultivation of such grapes varieties which were never grown in India before like French variety like Sauvignon Blanc and Californian variety like Chenin Blanc. In 1998, Sula Vineyard was established which launched their first wines in 2000 and soon got acclaimed for producing India’s best white wines.The name of the company was inspired by Samant’s mother's name "Sulabha" that symbolizes the rich Indian heritage. They are the first in the country to use an Indian logo for wines.

Paving the way for Indian wine industry

Wine making in India is a sunrise industry. However, some historians claim that wine has been prevalent in India for many thousands of years, in fact 5,000 years according to some Vedic scriptures. Unfortunately India has neither realized nor considered the potential of this industry in both domestic as well as export market. In spite of having favourable agro-climatic conditions to grow wine grapes in certain parts of the country, India has never taken any initiative to produce enough quantity of wineuntil recently. Only one per cent of around 123,000 acres of vineyards across India are used for growing wine grapes. Out of total grapes production, more than 80 per cent is destined for fresh consumption and the rest for wine and raisin making (ILO, 2015).In this regard, Sula Winery has definitely taken a path breaking step by realizing that agro-climatic conditions of Nashik is naturally blessed with characteristics in favour of setting up winery. Situated at an altitude of 600 metres above sea

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level in the Western Ghats, Nashik's soil is of volcanic origin, ranging from weathered basalt to red laterite to heavy clay. The heavier soils are closer to the Godavari river beds while the lighter crumbly weathered red soils are closer to the northern hilly part of the region. Vineyards in proximity to hills or rivers have remarkably suitable microclimate for cultivation of wine grapes. The best example is the Dindori region which is particularly famous for growing wine grapes. This region is mostly known for producing Sula's premium red grapes like the Cabernet Sauvignon, Shiraz, Zinfandel, Malbec and Tempranillo. Sula has a significant portion of owned and contracted land in Dindori. The cool nights of Nashik ensure high level of acid in the grapes while warm days ensure optimum ripeness of the grapes, resulting in perfect growing conditions for premium wine grapes. Today, Sula Vineyards is not only the first winery at Nashik but it also paved the way for the emergence of India's Wine Capital, with almost 35 other wineries following their footsteps in the region. Presently, 80 per cent of India's wine is produced in Nashik alone.

Growth of Sula

Presently, Sula is India's leading wine company with a market share of 65 per cent in this industry. Starting with Rs. 3-4 crores as seed capital on the 20 acres offamily plot,today, Sula owns three factories worth Rs. 1,000 crores and buys grapes from 3,000 acres of vineyard. It is home to some of India's latest viticulture innovations and technologies, 25 of the world’s finest wine grape varieties that get blended into 28 marvelous flavours of wine and Sula holds capacity of producing 7 million liters of wine annually. One of the major reasons for success of Sula winery is their smart price mechanisms. They have their wines in the range of Rs.750 to 3000 which makes it quite affordable for Indian customers. It has succeeded in drawing consumers from imported wine market to the domestic one which has certainly inspired many entrepreneurs to endorse this industry further in India.It has magnificently prevailed over not only Indian market but also made its way into the World wine market as well. Significant portion of their produce is exported to several countries especially, UK and Japan. Some of their flavours are considered best all across the Asia and not only India.

In 2005, they took Sula one step further by making the winery and vineyards open to the public for educational tours, and also launching their beautiful tasting room which invites visitors to enjoy their wines in the midst of overwhelming views of the vineyards and surrounding Gangapur dam water and Goverdhan hills which are naturally gifted to

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landscapes of Nashik. Therefore, Sula has not restricted its scopes to processing and manufacturing but smartly used its location to supplement its business activities with agro-tourism ventures. Today, Sula has the biggest non-religious tourist site in Maharashtra.

Sustainable wine making

Sula is not only a business house that is growing extraordinarily in terms of profitability, but it also takes pride in contributing to a sustainable production and business system. It is one of the most eco-friendly companies in India, with a significant amount of its resources committed to sustainable wine making practices. For instance, it has started using solar power to run the machineries in the firm. Almost 50 per cent of their energy requirements are supplied through solar panels established in the firm. They also contribute to water conservation by meeting 25 per cent of their annual water requirement through rainwater collected during the year at reservoirs, check dams and bore wells. The total storage capacity of their water-harvesting reservoirs is around 30 million liters of water annually. To add on to this, they have also come up with state-of-the-art waste water treatment plants where the runoff water from cleaning and other operations gets treated and used back to irrigate the surrounding vineyards, resulting in 45 per cent reduction in water consumption. They have also set example by utilizing drip irrigation systems to cut down irrigation requirements by 50 per cent compared to the traditional flood irrigation. Sula also manufactures homemade organic compost and farmyard manure through vermiculture which meets 40 per cent of the fertilizer needs. In addition to that, they also use the food waste from their hospitality outlets and byproducts of wine manufacturing unit like grape skins, seeds and stems which constitutes almost 30 to 40 per cent of the harvest yield to generate manures for their vineyards. Recently they have also launched their grape seed oil and grape seed cookies which is another pioneering initiative in India to utilize by products of wine industry. This way, they have adapted a remarkable waste management system and they claim almost nothing goes waste in their firm. They have even taken the initiative to avoid chemical pesticides wherever possible and trained farmers to apply chemicals with due safety measures.

Social responsibility

Sula is also well aware of its responsibility towards the farming community who makes it possible for them to serve the desired wine to their customers from farm to glass. They have their owned as well as contracted vineyards where thousands of farmers from the

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nearby villages are engaged in producing grapes. This not only secures employment opportunity forthem but also assures them a fixed income on regular basis. The farmers are also provided with on-ground training and support on the latest sustainable package of practices of wine grapes. This contract farming system also guarantees secure supply of raw materials to the winery. Therefore, Sula promotes a win-win scenario where both the winery and the farmers are benefitted and grow hand in hand. With their contract farming strategy they have been able to support a number of small farms in Maharashtra and Karnataka by contributing to their sustainable economic development and as well as ensuring them fair livelihoods. A large number of Sula's workers come from disadvantaged communities and have seen a significant change in their standard of living through their tie up with the company. This has been a revolutionary phenomenon in the surrounding villages. Sula employs around 600 employees other than farmers in various sectors like production, manufacturing, hospitality management, public relations and export with two third of them falling in the youth category. Sula’s founder, Mr. Rajiv Samant is also a leading advocate for India's wine industry and actively represents the interests of India's wine grapes producers and wine manufacturers to national and state Governments. Besides, it also takes part in developing community infrastructure, conducting educational and training programmes and other social activities.

Open learning culture at Sula

Sula has always maintained an organizational culture that is supportive and promotes open learning at every level. Over the year they have developed a proficientand as well as diverse team with experiences in sales and marketing, management, consulting, finance, hotel management, viticulture, winemaking, design, non-profit and people management. This has been possible only because of their strong commitment towards continuous growth and development. They also provide opportunity for excellent on-the-job training and internship for those who are looking forward to build a career not only in winemaking but also the food and beverage industry as a whole.

Why is Sula important for Indian agriculture sector?

The story of Sula is significant for agriculture sector of India from a number of perspectives. Firstly, it is an extraordinary example of agro-processing industry which is really important in today’s agricultural scenario in the country. In spite of being the second largest producer of fruits in the world, India is yet to realize its full potential in terms of utilizing this production boom. According to Ministry of Food Processing Industries (MoFPI,

2016) around 20 to 22 per cent of fruits and vegetables are wasted in the country annually and only 4 per cent of the production is commercially processed. This is in sharp contrast to the extent of processing of fruits in several other developing countries such as Brazil (70%), Malaysia (83%), Philippines (78%) and Thailand (30%).In this circumstance, endeavours taken up by firms like Sula are definitely a shaft of light. Another facet is potential of agriculture sector to grow as agri-business sector. This is the right time for Indian agriculture sector to turn its farmers into agripreneurs and farms into business units. Grapes being one of the most remunerative fruit crops in India have lot of potentials for the agripreneurs to launch their ventures with this crop. This would also create employment opportunities for many people who are in sheer need of it in the areas of production, processing and distribution. Sula has also smartly exemplified the idea of contract farming, eco-friendly agriculture and agro-tourism at their production site. Though wine industry is new to India and requires high initial investment it can be a smart choice for young agripreneurs for its high profitability. For producing 1 litre of wine that sells at the price of at least Rs. 750, approximately only 1 kg of grapes are required that costs Rs. 60 to 80 in domestic market. Even after excluding the manufacturing and packaging costs there is approximately, Rs. 300 to 400of profit per liter of wine. The profitability increases even more when the produce is exported and this commodity has tremendous scope in export market indeed. Sula can be a pioneering example for young educated youth of the country who have the intelligence and potential to invest in the agribusiness sector. Mr. Rajiv Samant, the founder of Sula winery started his journey at a very young age as well leaving behind his well-paid job as Software engineer in the USA. For attracting youth in agro-based industries, it needs to be intellectually satisfying and economically rewarding. Wine industry promises to meet these demands provided, it is taken up with profound business planning and support.

Conclusion

Sula is one of the premier wine companies in India today that has piloted many other wineries to grow over last decade in the country. It takes pride in turning the Nashik region of Maharashtra into the wine capital of India and making Indian wine prominent in international market. Starting up his enterprise in an industry which was never explored before in India was a bold step for Mr. Rajiv Samant, the founder of Sula. However, his passion and courage paid him back rightly as Sula grew out to be India's largest winery. Sula has set example not only in terms of being a profitable business venture but also by contributing to environmental conservation and social sustainability. It is a business house that grows together with its

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farmers by securing a sound livelihood option for them. It has opened a new door for young agripreneurs for realizing the potential of food processing sector of the country. These types of ventures are severely required in the present context of Indian agriculture.

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