FAO-CFC-TBI PROJECT (2008 – 2013)

Need for a Comprehensive Approach to Ensure Sustainable and Cost- effective Organic Tea Cultivation

- An Experience from Model Farm Maud T.E. (Assam), under FAO-CFC-TBI Project.

Evaluated by

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Sustainable organic production has always remained elusive especially for tea plantations, with its wide variety of associated problems, which are difficult to address under organic management as compared to other crops. Even the present organic practices fail to sustain because they have not diverted from the compartmental approach of chemical farming and follow the same input substitution theory, only the chemicals being replaced by organic formulations. At the same time, India being the largest tea producer in the world with a fair share of exports, sustainable organic production of the crop is slowly becoming a compulsion.

In India, a CFC funded Organic development project entitled **'Development, Production & Trade of Organic Tea'** was commenced in the year 2008 aimed at **'Finding out an Effective Pathway for Sustainable Organic Tea Production'.**

GOAL FOR FAO-CFC-TBI ORGANIC TEA DEVELOPMENT PROJECT AS LAID DOWN BY IFOAM

- Developing the Technology, Skills And Systems Of Organic Tea Production.
- Developing Appropriate Technologies for establishing new Organic Tea Plantations, and the Methodologies for conversion of existing, conventional tea areas into Organic Tea Farms.

With the desired Objectives,

- Increase no. of farmers engaged in Organic Tea Production.
- Increase in the production of Organic Tea.

The Project was initiated in three 'Tea Growing Zones' of India i.e. Assam, Darjeeling & South India. Research was initiated at the existing tea research organization in these zones i.e. TRA, DTRDC & UPASI along with actual field validation in 100 hectare 'Model Farm' in each area. Maud Tea Estate (Dibrugarh) was selected for the Assam chapter and Inhana was outsourced by Maud Tea & Seed Company Ltd for designing the Module and Protocol for experimentation, conducting the project, documentation and interpretation of the research findings.

FAO has reiterated that Organic Farming is the ONLY PATHWAY to enhance food security, resume environmental integrity, ensure sustainable livelihoods and bring about rural development But in present day organic farming, even quantitative application of compost/ manure has not ensured the soil development and mere cessation of Chemical Inputs & their Substitution by Organic Formulations (which are relatively Weaker Options) FAIL to Manage the Ever Increasing Pest Virulence leading to crop support that are requisite for economic sustenance which reflects in the current share of Organic Tea in total tea production which is only about 1%.

Conventional Organic Challenges – face by Indian Organic Agriculture

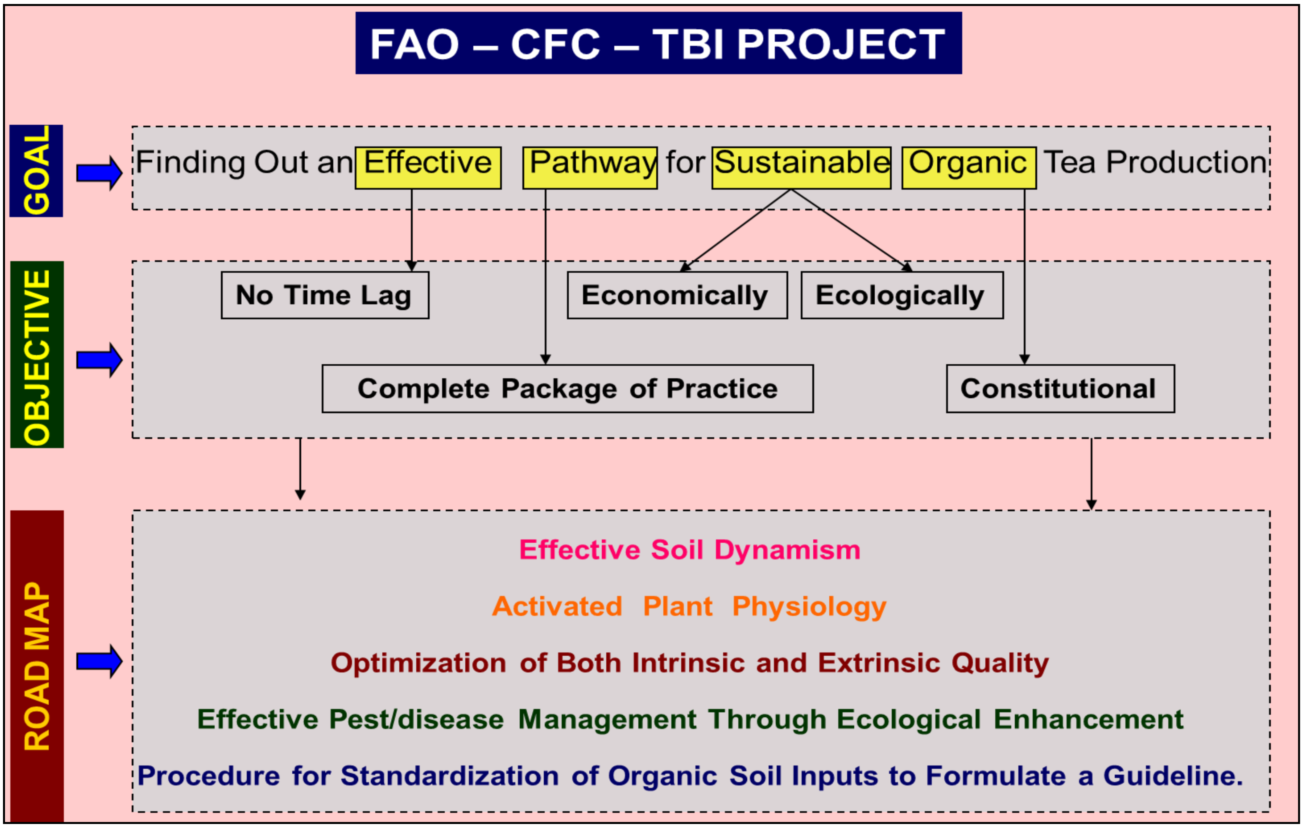
- No assurance in Crop Sustainability.
- Huge Off-farm Organic Soil Inputs further increases COP.
- No technological support for sustaining crop productivity & farm waste recycling in a cost effective manner.
- No comprehensive & scientific guideline for organic pest/disease management.
- No assurance in end product quality.

Then WHAT should be the Pathway???

Shift from the Principle of Input Evaluation to Evaluation of 'Packages of Practice'

As the objectivity of the project was to bring forth A SUSTAINABLE ORGANIC PATHWAY, it was understood from the guiding principle of Organic Science that the objectivity cannot be met through evaluation of individual organic inputs. Even scientifically, individual inputs with its single specific objectivity cannot provide composite benefits and neither their individual evaluation can bring forth the desired pathway. Hence, the concept of Comprehensive Organic Method/ 'Package of Practice' was introduced for the first time, because in organic the soil-plant-ecology work in an integrated, interrelated and cohesive manner i.e. Organic means organized or systematic as an 'Organic Whole', where sustainability cannot be obtained by a fragmental approach. Thus, while laying out experiments, concept of evaluation of different organic 'Package of Practice' was introduced.

'Sustainable Organic Production' is a function of Sustainable Organic Method/ Technology/ System and compartmental evaluation of individual input cannot bring forth such Method/ Technology/ System.



Logic behind Formulation of Treatments (Organic packages of Practice) for Different Experiments

When 'Package of Practice' concept was decided, the next question comes that how the treatments will be selected? To bring forth the 'Effective Organic Pathway' only the two available organic methods viz. Biodynamic Farming (BD) and Inhana Rational Farming (IRF), which are practiced in organic tea gardens in India in a sizeable area, were taken up for evaluation and at the same time different commonly used organic Plant & Soil inputs viz. vermicompost, bio-fertilizers, bio-pesticides, herbal formulations, etc., were also taken up for study.

All these inputs were taken up for evaluation, but not in a manner to judge their potential for managing individual criteria. These inputs were matched on the basis of scientific rationale to form different **'Packages of Practice'** that can attend both the criteria of **soil and plant and thereby to evaluate their comprehensive effectivity towards crop and ecological sustainability.**

Project Module in Brief

- All available methods/ technologies were taken for evaluation.
- All relevant organic inputs were studied forming Packages using scientific rationale.
- All composting methods were analyzed and documented through On-Farm production.
- All growth stages of tea cultivation were taken for study of the effectivity of Packages.
- Detailed study was done from Soil quality up to Tea Quality.
- Soil input quality were evaluated both in lab & field condition.

Evaluation of Different Organic Soil Inputs Quality and their Post- Soil Application Effectivity in terms of Crop Yield, Soil Quality Development and Economics.

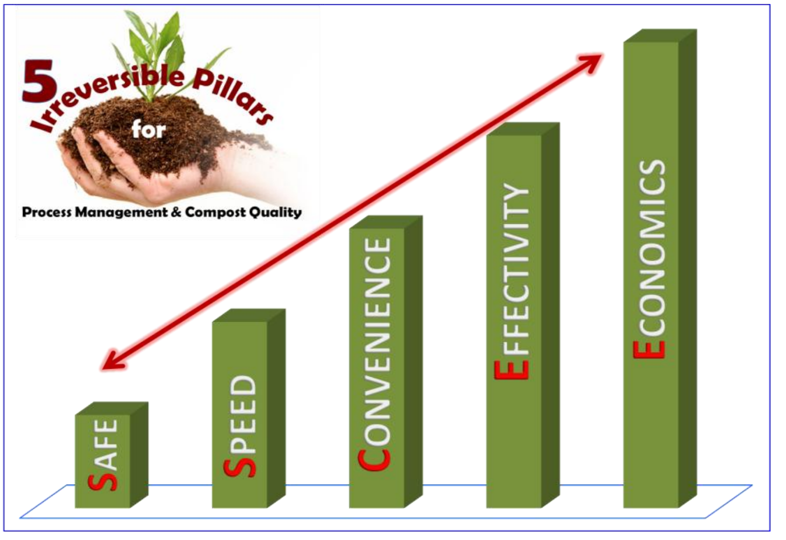
Organic soil amendment is the most limiting criteria for consideration since, it comprises about 60 to 80 percent of the total expenditure made on inputs but at the same time plays the key role both during conversion and for practicing organic agriculture. Application of organic soil amendment/ compost in soil is basically aimed at increasing the proliferation and activity of the indigenous population of soil microbes, which being the prime drivers behind all soil ecological processes serve for restoration of soil quality. However, the major bottleneck towards adoption of organic cultivation practices is the poor quality of organic soil inputs in terms of low nutrient (N, P and K) content, microbial status and stability which, entails their voluminous requirement to suffice for crop nutrient requirement (Rupela, 2009). The problem becomes magnified in case of large organic farms viz. tea/ coffee plantations etc. where the huge requirement of soil inputs often cannot be met by on- farm production hence, outsourcing remains the only option.

The non-uniform quality and high cost of off- farm soil inputs (since on-farm production is most often compromised) are the major limiting factors. Different On-farm composting programme was taken up for production of four different types of compost viz. Vermicompost (VC), Biodynamic Compost (BD), Indigenous Compost (FYM) and Novcom Compost (NOV).

The composting processes were evaluated on- farm in terms of process convenience, N appreciation in final compost, economics of production and end product quality. This was followed by assessment of post- soil application effectivity of the different types of compost in terms of crop performance, soil quality development and finally economics.

HOW TO BE JUDGED THE PATHWAY FOR PRODUCTION OF AN IDEAL ORGANIC AMENDMENT?

Only a process based on the five irreversible pillars can enable the production of such high quality compost/ organic amendment. All the Compost Must comply FIVE IMPORTANT CRITERIA.



'NOVCOM COMPOSTING METHOD' under IRF Technology based on the 5 INVINCIBLE PILLARS

SAFE

There is a belief that compost cannot harm soil, plant or water ecosystem but modern research confirms, 'Immature Compost' can cause N-immobilization, starve roots of oxygen, create high levels of organic acids and support growth of pathogens viz. Salmonella and Pythium in soils (Inbar et al., 1990).

Temperature of the compost heap need to be more than 62.8^{0}C for continuous 3 or more days for complete destruction of pathogens and weed seeds within compost heap. Rapid and intense generation of high temperature (up to 75^{0}C) during 'Novcom Composting' ensures total destruction of weed seeds and any harmful pathogens thereby ensuring absolute safety of Novcom Compost. This has been scientifically proved by the **'Stability/ Maturity & Phytotoxicity'** evaluation of any compost as per 'National & International Protocol'

SPEEDY

Most of the presently available composting methods require huge time period (minimum 80-90 days) for production, hence it becomes difficult to maintain a constant supply for satisfying crop requirements during the growth period. Longer composting time also increases the risk of higher nutrient loss from compost heap.

However, a speedy process of composting can not only satisfy the demand but also optimize the production capacity of composting units. **Novcom composting Method completes with 21 days - The speediest composting method in the world.**

CONVENIENT

Soil health rejuvenation is becoming a compulsion, but the infrastructural requirement and raw material specificity of different composting methods do not appeal to the planters/ farmers; who have become habituated to the ‘Switch Button System’ of fertilizers.

Keeping in view the rising scarcity of green matter resources, a convenient system that allows a wider choice of raw material along with the least need for infrastructural development shall certainly prove to be a convincing solution.

EFFECTIVITY

Today when the ever increasing food demand necessitates not only soil health regeneration but insists a progressive soil potential for stepping up agricultural production; success of compost without any time lag is a compulsion. Most of presently available composts cannot assure the exact time period required for soil health restoration and bio- fertilizers too have their own limitations.

Novcom compost contains huge population (of order 1016) of naturally generated microbes along with sufficient energy resources for their natural proliferation. On soil application, prolific activities of these microbes create favourable environment for restoration and enhancement of native soil microflora – ‘Major Drivers’ for a dynamic soil.

ECONOMICAL

Most important factor remains the economics because even a high quality but costly compost becomes economically unviable.

The cost of compost under Novcom method comes within Rs. 1.0/ kg, as against Rs. 4 – 6 /kg in case of any other presently available organic supplements. It is only the economics rather than the awareness, which restrains the number of buyers as well as the usage.

too wet

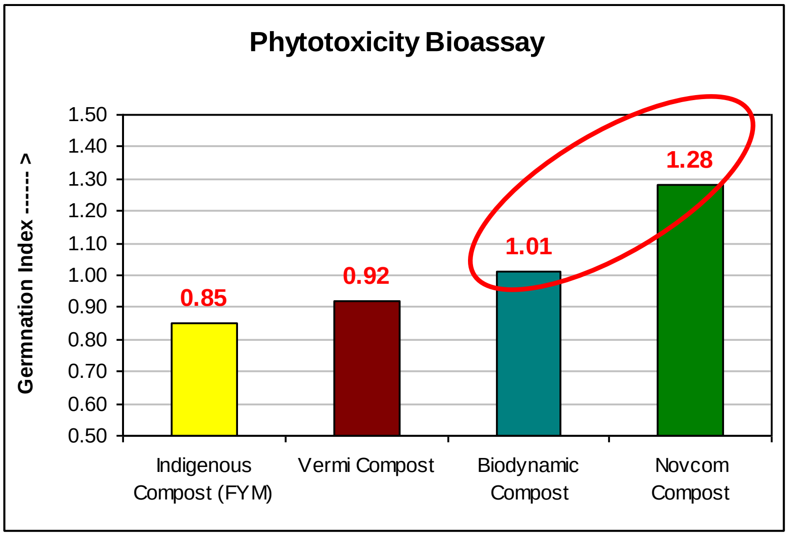
optimal

too dry

Quality Assessment of Different Organic Soil Inputs and Evaluation of their Post- Soil Application Effectivity in terms of Crop Yield, Soil Quality Development and Economics

Soil health rejuvenation is becoming a compulsion, but the infrastructural requirement and raw material specificity of different composting methods do not appeal to the planters/ farmers; who have become habituated to the 'Switch Button System' of fertilizers.

SAFETY



Compost maturity and phytotoxicity rating are the most important criteria for ensuring soil safety on compost application.

Most significantly value >1.0 as obtained in case of Novcom compost indicated not only the absence of phytotoxicity (Tiquia et al., 1996) in the compost but moreover, it confirmed that the compost enhanced germination and radical growth (Trautmann & Krasny, 1997).

SPEED

Novcom composting Method completes with 21 days - The speediest composting method in the world.

Parameters	Vermi compost	Biodynamic Compost	Indigenous Compost	Novcom compost
Biodegradation period	60 to 75 days	80 to 90 days	80 to 90 days	21 to 30 days

Shorter biodegradation period curtails the criteria of nutrient losses leading to higher compost quality.

CONVENIENCE

Composting method need to be most convenient in terms of Infrastructural requirement and wider selectivity of raw materials for easy and large scale adoption by the Industry.

Moreover, when raw materials for On-farm Compost production is scarce, as in most of the Tea Estates, then every Extra ton is Counted.

Parameters	Vermi compost	Biodynamic Compost	Indigenous Compost	Novcom compost
Requirement of infrastructure	Yes	Partly Yes	No	No
Selectivity of raw materials	Yes	No	No	No
Monitoring requirement	Yes	Minimum	No	Minimum
Simplicity in composting process	Complex	Moderate	Simple	Simple
Sensitivity to external factors	Yes	No	No	No
Recovery Percent	67.0	61.0	57.0	69.4
Raw materials to achieve 1500 kg Made Tea (tons.)	15.7	19.2	24.0	11.5

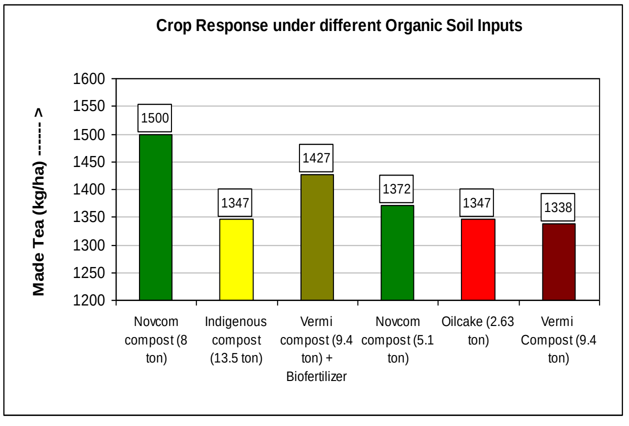
Under this project IORF whished to evaluate the impact of all the available soil inputs (i.e. compost/concentrated organic manure) quality towards their application dose, crop efficiency, relative cost and soil rejuvenation. Quantity of various soil inputs were calculated on Crop–N requirement basis.

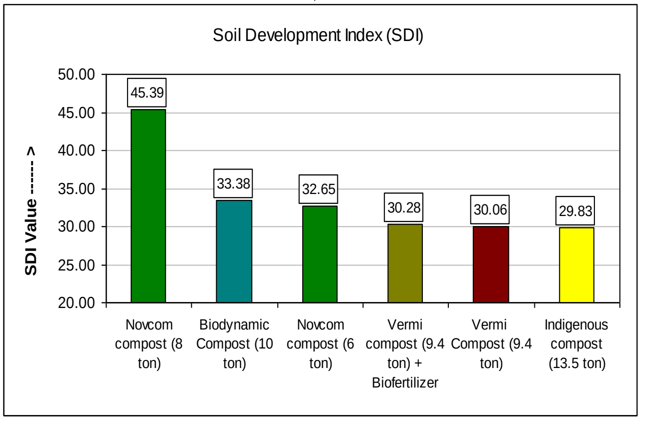
As, scientifically oil cakes have no role towards soil quality development and can't made on-farm, it was taken for Soil Input Quality Experiment and not taken under POP.

EFFECTIVITY

Post Soil Application Effectivity of different Organic Soil Inputs in terms of Crop Response and Soil Quality Development.

Crop Response **Soil Development**





ECONOMICS & QUALITY

Quality Evaluation of different Compost and their Related Economics

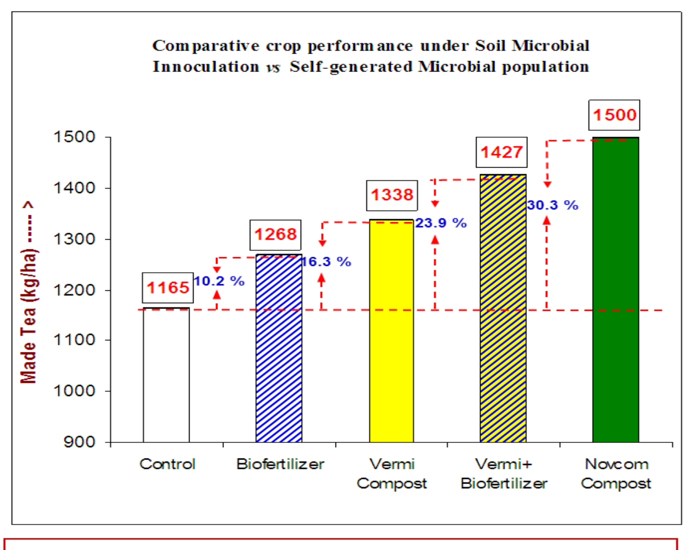
Evaluation of the different composting methods as well as quality assessment of their end products [viz. vermicompost (VC), Indigenous (FYM) compost, Biodynamic compost (BD) and Novcom compost (NOV)], indicated **Novcom composting method as the speediest process completing within 21 to 30 days** and **NOVCOM containing high nutrient status (4.05 in terms total N+P+K), very high microbial population in the order of 10^{16} c.f.u. (atleast 10,000 to 1,00,000 times higher than compost) and lowest production cost of Rs. 860/- per ton, when compared with all others.**

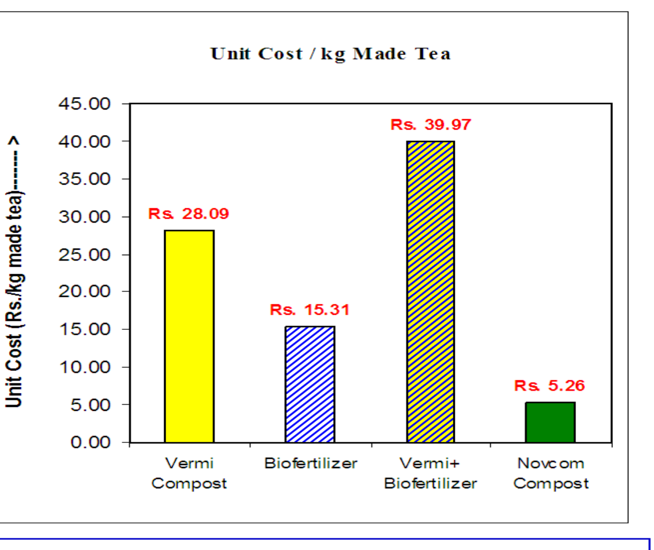
Quality Evaluation of different Compost and their Related Economics

Assessment of post application effectivity revealed highest crop response (dose: 8.0 ton/ ha, yield 1500 kg/ha) and soil rejuvenation (SDI: 45.39) under NOV. Other than NOV, FYM (dose: 13.5 ton/ha; yield 1479 kg/ ha) and VCBF (VC @ 9.4 ton/ ha+ bio-fertilizers as per recommendation, yield 1427 kg/ ha) also influenced good crop response. In terms of SDI, VCBF followed the above trend, but FYM failed to do so.

Parameter	Vermi compost	Biodynamic compost	Indigenous (FYM) compost	Novcom compost
Moisture percent (%)	54.3	48.5	46.5	56.7
pH_{water} (1 : 5)	6.56	7.23	7.03	7.61
Organic carbon (%)	25.5	26.3	23.7	27.9
Total nutrient (N+P+K) content (%)	3.26	3.73	2.69	4.05
N enrichment (% increase over initial value in raw material)	142.88	172.1	107.41	207.75
Total Microbial Count (c.f.u / gm moist sample)	67×10^{16}	43×10^{12}	21×10^{12}	17×10^{12}
Compost Quality Index (CQI)	2.82	3.59	2.24	7.28
Cost of Production (Rs./ ton final compost)	4000/-	920/-	770/-	860/-
Cost/ kg made tea (Rs.)	26.90	7.19	7.18	5.16
Crop efficiency (%) (w.r.t. target yield of 1500 kg made tea/ ha)	89	85	88	100

Organic Soil Management - Self generated or Microbial inoculation ?





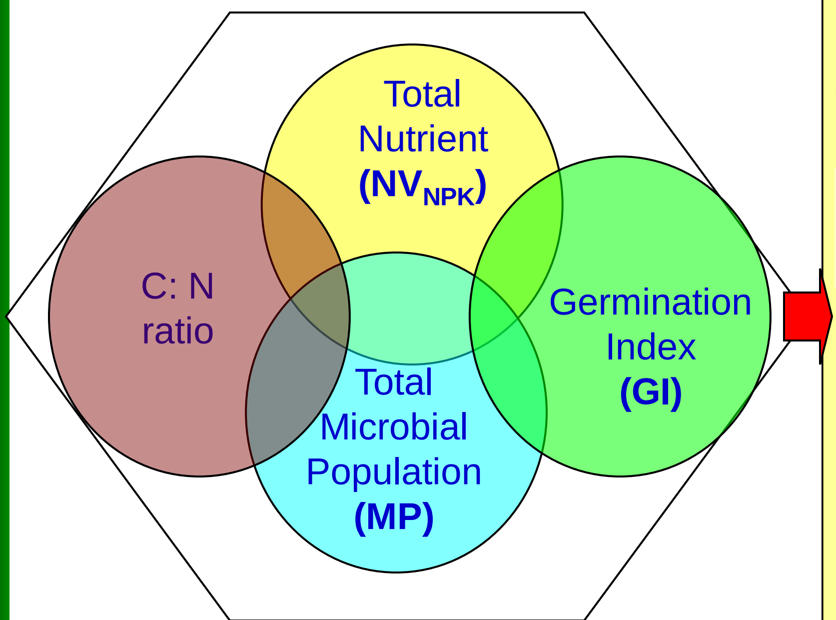
Comparative crop performance under organic soil inputs with limited microbial population, bio-fertilizer, bio-fertilizer combination & Self generated high microbial population.

Addition of bio-fertilizer caused the cost/kg made tea to increase significantly i.e., by 42 % but it did not reflect proportionately in terms of crop response

Formulation of Compost Quality Index (CQI)

Compost Quality Index (CQI) was formulated to grade organic soil input quality for easy understanding at end-users level.

Compost quality value corroborates with crop response and soil quality development supports the Hypothesis that ‘**Quality of Organic Inputs is the key factor behind Successful Organic Soil Management**’.



COMPOST QUALITY INDEX’ (CQI)

$$\text{Compost Quality Index (CQI)} : \frac{NV_{NPK} \times MP \times GI}{C/N \text{ ratio}}$$

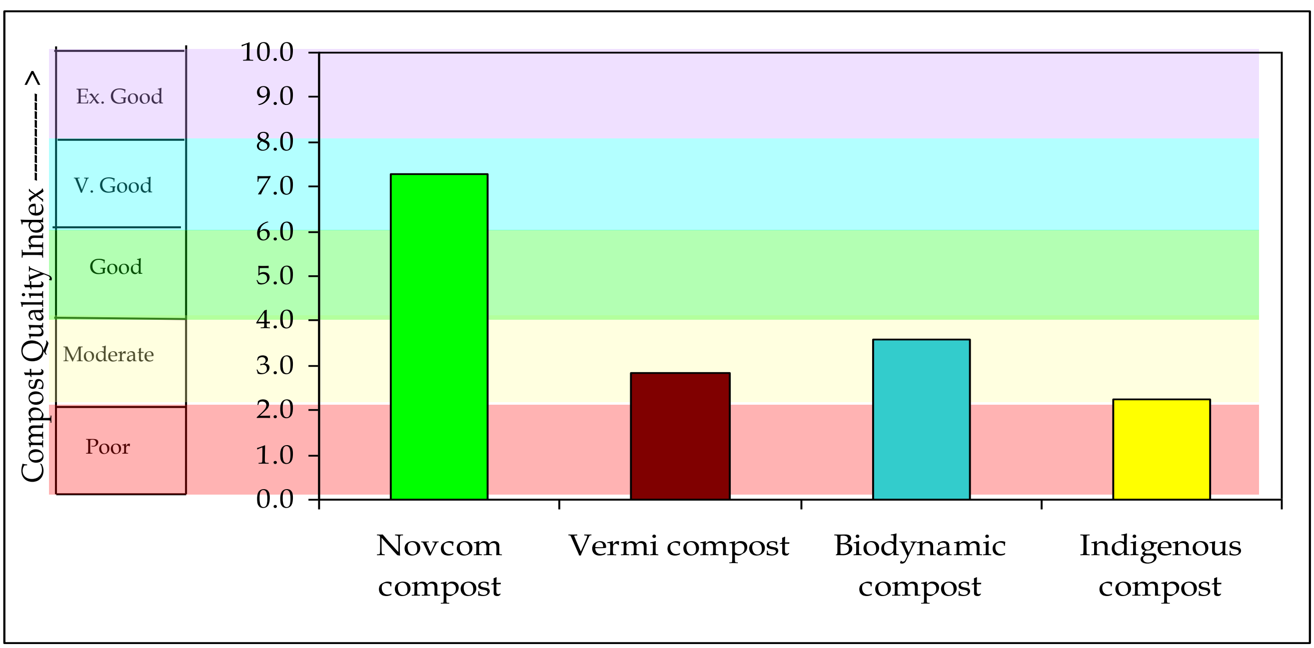
Where NV_{NPK} = Total nutrient N+P+K (%)

MP = $\log_{10}$ value of total microbial population

GI = Germination Index

<u>Classification of compost as per Compost Quality Index</u>

Compost Quality Index (CQI)		Compost Quality Classification
> 2.00	:	Poor
2.00 – 4.00	:	Moderate
4.00 – 6.00	:	Good
6.00 – 8.00	:	Very Good
8.00 – 10.00	:	Extremely Good



Organic as a practice is most scientifically and aptly suited for Tea, which as a C_3 plant inherently suffers from impaired photosynthesis and ineffective partitioning. But the threat of Crop Loss is the major deterrent towards Conventional Organic Conversion.

As from the scientific point of view any alternative crop production technology/ methods/ POP must be ecologically and economically viable with complete scientific understanding of each components and steps. Our main objective was to bring forth the most effective organic method/ 'Package of Practice' that can ensure sustainable organic tea production along with scope for soil quality rejuvenation, but most importantly at an affordable cost. Hence, the POPs were judged on the basis of the **EECCS MODEL** comprises of **'Five Irreversible & Irreplaceable Pillars'** that are the determinant criteria for successful organic cultivation.

From the principle of Organic Farming it was considered hypothetically that any sustainable pathway should exhibit all round effectivity hence, experiments were laid out in a manner so that potential of individual packages could be judged under all stages of tea growth i.e. **Nursery, New Plantation, Young Tea and Mature Tea.**

Steps of Evaluation In Order Of Importance

EFFECTIVITY (With respect to Target Yield and Control and in all Stages of Tea Cultivation.)

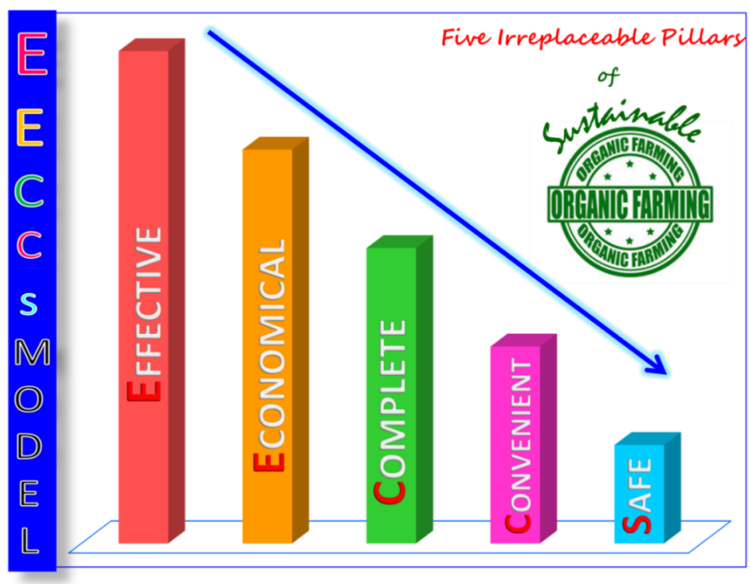
↓

ECONOMICS (Comprising of Soil Input, Plant Growth, Pest Management & Plant Physiology)

↓

COMPLETENESS (In terms of Solution/answer for all Existing/Emerged Problems) → **CONVENIENCE** (In terms of Procurement, Production, and Application) → **SAFETY** (In terms of Principle, Usage and Harvested End Product)

The package which did not exhibit any significant performance in the effectivity or it has been achieved at a very high cost were not considered for the evaluation in the following steps.



Five essential pillars that are inevitable for the viability of any ***ORGANIC FARMING*** *method to be successful*

The 'Packages of Practice' were evaluated in terms of Meeting the Target Yield, their Crop Efficiency over Control, Soil Quality Development and finally Economics.

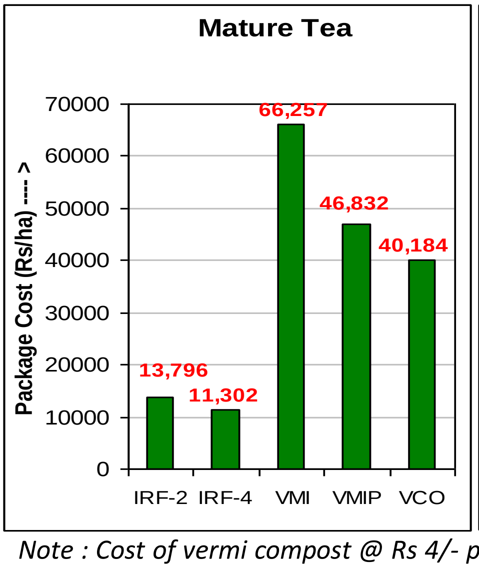
A sustainable pathway should exhibit all round effectivity, hence the experiments were laid out in a manner so that potential of individual packages could be judged under all stages of tea growth i.e. **Nursery, New Plantation, Young Tea and Mature Tea.**

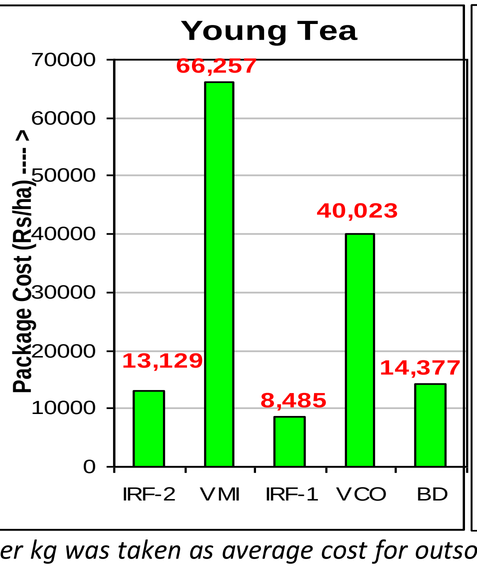
Crop Performance under different Package of Practice (1st Five Ranking) in in Different Tea Growth Stage Experiment

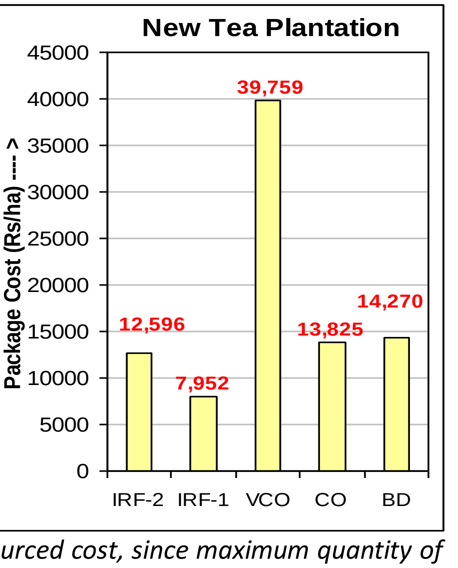
MATURE TEA			YOUNG TEA			NEW TEA PLANTATION			NURSERY	
Package of Practice	Yield (kg/ha)	Yield (% over control)	Package of Practice	Yield (kg/ha)	Yield (% over control)	Package of Practice	Yield (kg/ha)	Yield (% over control)	Package of Practice	Plant Dev. Index (PDI)
IRF-2	1374	45.2	IRF-2	807	55.2	IRF-2	956	48.1	IRF	42.2
IRF-4	1369	44.8	VMI	653	25.6	IRF-1	870	34.7	MI	32.7
VMI	1299	37.3	IRF-1	619	19.0	VCO	868	34.4	CO	23.3
VMIP	1235	30.5	VCO	618	18.0	CO	760	17.7	BD	20.5
VCO	1158	22.4	BD	593	14.1	BD	695	7.7	VCO	17.5

Inhana Rational Farming (especially IRF-2 i.e. Novcom compost @ 100 % of the N req.) influenced highest and consistent crop yield under all the tea growth phases.

Economics under the same 1st Five Ranking *(in terms of Crop Yield)* Package of Practice in Different Tea Growth Stage Experiment







Note : Cost of vermi compost @ Rs 4/- per kg was taken as average cost for outsourced cost, since maximum quantity of the total requirement was outsourced. If the required quantity of vermi compost can be produced on-farm then the cost under VMI, VMIP & VCO will be reduced to Rs. 50,371/- , Rs. 30,946 and Rs. 24,298 per ha; however the cost still remains considerably higher than that incurred under other treatments.

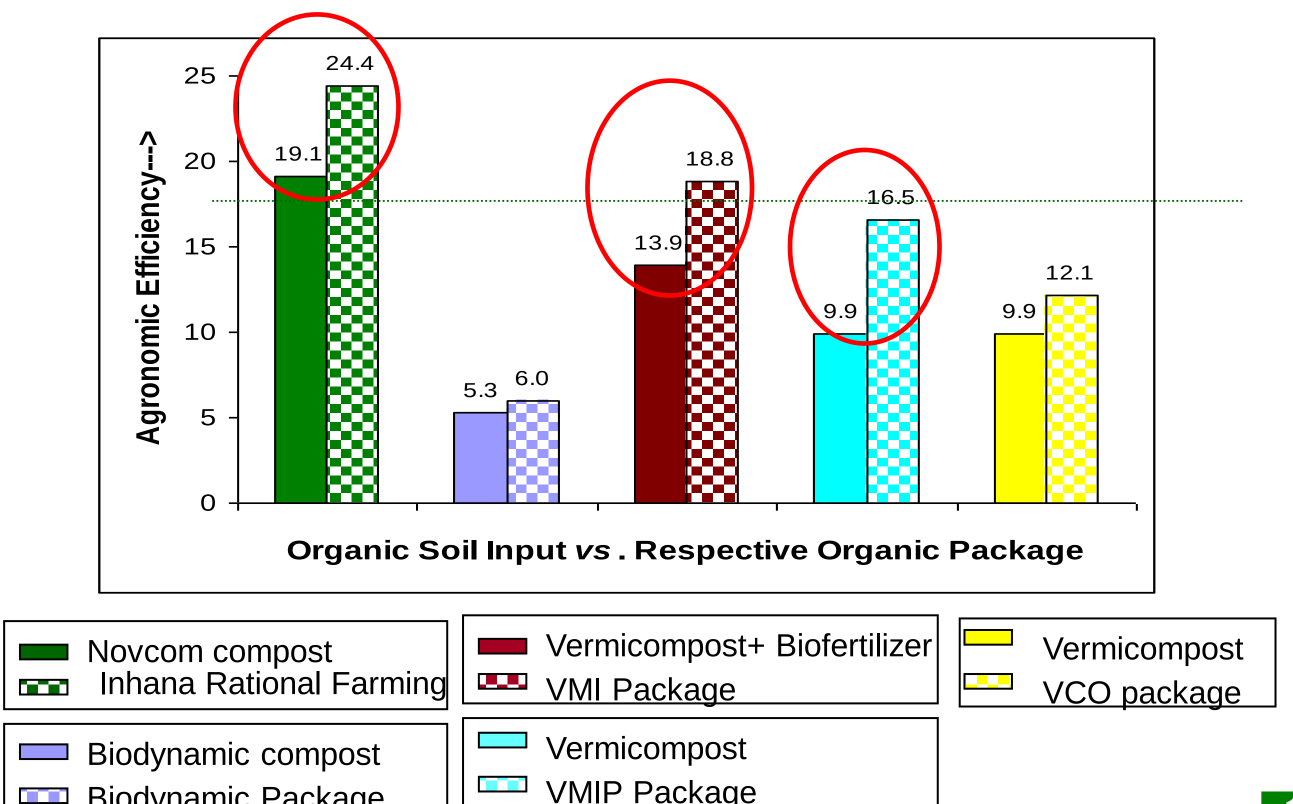
Relevance of a Composite Approach In Organic Cultivation

A healthy plant with activated physiological efficiency is known to have higher nutrient utilization efficiency (both in terms of their uptake and utilization) especially nitrogen (i.e., NUE, as assessed through agronomic and relative agronomic efficiency) which serves to improve crop yield and also plays an essential role in cutting down the production costs.

Other than IRF Technology no other available method/practice/technology has the concept of Plant Health Management. Hence, to assess scientifically the relevance of a composite approach in organic cultivation, agronomic efficiency of plants (AECN) and crop recovery efficiency of applied compost N (RECN) was ascertained under different organic packages (i.e., Package of Practice Experiment) vis-à-vis under only organic soil management i.e. Soil Input Experiment' where same organic soil input with same dose as used in Package of Practice Experiment' were taken.

Any increase in the value of AECN under any Organic Package as compared to that obtained under application of only Organic Soil Input of the respective Package indicates the positive Influence of Plant Health Management towards Activation of Plant Physiology.

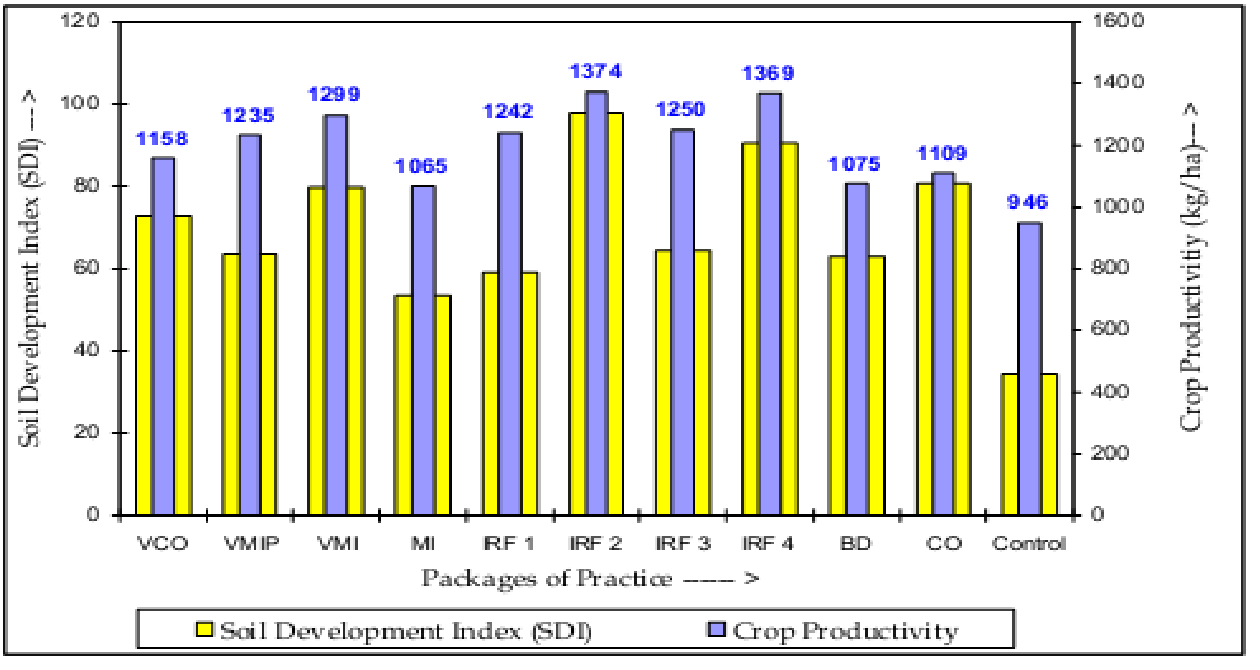
Higher AECN was obtained under the organic packages as compared to organic soil management alone but the highest value was noted under Inhana Plant Health Management .



Evaluation of different Organic 'Packages of Practice in terms of Soil Development

One of the primary objectives of any Organic Production System is to rejuvenate the soil by creating a favourable soil–plant–microbial environment or in other words, make the Soil System Live For Healthy Plant Growth & better Soil Biological Barrier.

Comparative Study of Soil Development under different organic Packages of Practice over a period of 3 years.



Development of Organic Tea Nursery under Different Packages of Practice

Nursery is the backbone of any good tea garden; however successful development of Nursery under organic management is still considered as a challenging job. The study under this project was taken up to find out an effective pathway for successful establishment of nursery in the shortest possible time period with ensured quality of planting material.

Plant growth under different packages was assessed in terms of different morphological characteristics viz. shoot height, stem diameter, root mass, and shoot/ root ratio as well as seedling quality in terms of Dickson Quality Index (DQI).

Parameters	Different Organic Packages of Practice					
	CO	BD	IRF	MI	VCO	C
Shoot Length (cm)	62.18[c]	63.14[bc]	68.76[a]	63.71[b]	61.39[d]	52.38[e]
Root Length (cm)	39.17[b]	39.15[b]	42.64[a]	37.59[c]	37.45[c]	35.09[d]
Leaf (No.)	27.40[cd]	28.10[b]	30.30[a]	26.40[d]	23.70[e]	19.10[f]
Total Leaf area (cm^2)	623.6[b]	633.1[b]	698.1[a]	599.8[c]	544.4[d]	421.0[e]
Girth (cm)	2.00[b]	1.98[bc]	2.18[a]	2.11[ab]	1.89[c]	1.62[d]
Branch (No.)	2.10[c]	2.20[b]	2.40[a]	2.40[a]	1.70[d]	1.50[e]
Stem wt. (dry)(g)	4.53[cd]	4.56[cd]	5.47[a]	4.91[b]	4.23[d]	3.11[e]
Root wt. (dry)(g)	5.46[b]	5.41[b]	6.48[a]	5.53[b]	4.94[c]	3.96[d]
Shoot/ Root ratio	1.50[bc]	1.53[c]	1.47[b]	1.52[c]	1.49[b]	1.43[a]
Leaf wt. (dry)(g)	3.64[b]	3.74[b]	4.04[a]	3.51[bc]	3.15[c]	2.54[d]
Total wt. (dry)(g)	13.63[b]	13.71[b]	15.99[a]	13.95[b]	12.32[c]	9.61[d]

Duncan MRT $_{(p < 0.05)}$

Seedling were high under IRF (68.76 cm) followed by MI (63.14 cm) and BD (63.14 cm). Stem diameter, which has been considered the best single predictor of field survival and growth was highest under IRF management indicating better growth potential as compared to other packages of practice. **Dickson quality index was highest (1.41) in case of IRF treated seedlings followed by MI (1.27) and CO (1.21) packages which indicated that comparatively higher quality tea seedlings with better survival chances and speedier post field transplanted growth; can be obtained under Inhana Rational Farming (IRF) as compared to the rest other packages.**

Parameters	Unit	Different Organic Packages of Practice					
		CO	BD	IRF	MI	VCO	C
Growth Indices							
Leaf Area Index (LAI)	unitless	3.42	3.47	3.83	3.29	2.98	2.31
Specific Leaf Area (SLA)	cm^2/mg	0.171	0.169	0.173	0.171	0.173	0.166
Leaf Area Ratio (LAR)	cm^2/g	45.75	46.18	43.66	43.00	44.19	43.80
Specific root length (SRL)	(m/g)	0.072	0.072	0.066	0.068	0.076	0.089
Root length to leaf area ratio(RLA)	cm/cm^2	0.063	0.062	0.061	0.063	0.069	0.083
Leaf Nitrogen content	mmol N/g	3.97	4.13	4.52	3.89	3.47	2.68
Plant Nitrogen uptake	g/plant	0.319	0.319	0.377	0.316	0.284	0.210
Seedling Quality Index							
Plant Strength	mg/cm	0.22	0.22	0.23	0.22	0.20	0.18
Dickson Quality Index	unitless	1.21	1.19	1.41	1.27	1.05	0.83
Plant Development Index	unitless	33.68	35.13	51.25	36.69	20.95	-

Large Scale Effectivity Assessment of the Different Organic Packages of Practice, under Minimal Microclimatic Influences.

Assessment of 'Large Scale Adoptability Potential' or in other words their lab to land potential, of any Organic Package/ Method that is exhibiting potential in the small experimental plots should be mandatory in tea cultivation. This is because the tea gardens mostly spread over few hundred hectare area and also various zones, where the organic package/method has to deliver under micro-climatic influences as well as wider heterogeneity.

The experiment was initiated in 2nd year with selected Five 'Packages of Practice' based on their potentials in Mature Tea Expt. after one Project year and also their individual relevance in organic tea cultivation. No specific design was followed for experimental lay out and bigger plot size varying from 1.31 to 2.12 ha was taken for the different treatments.

Performance of IRF-2 followed a consistent pattern as also observed under all the other experiments covering different growth stages of tea i.e. during 2009 to 2011.

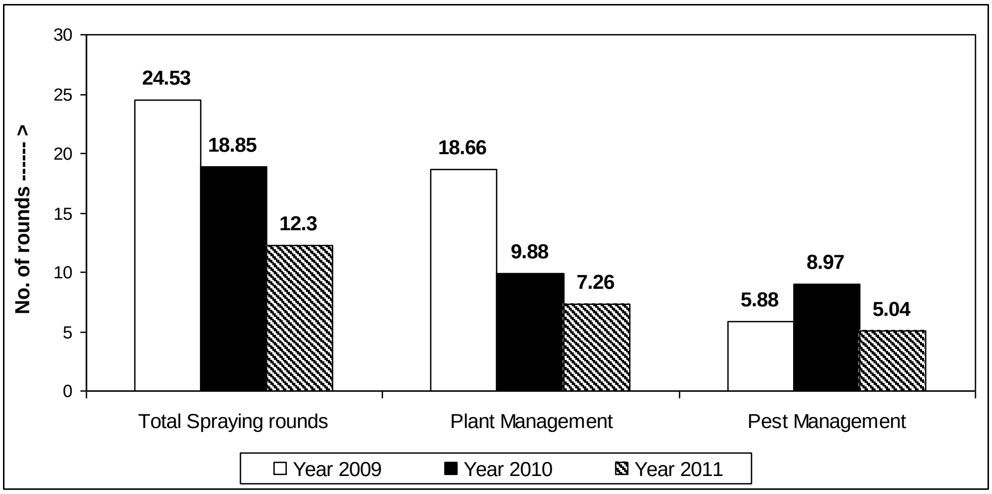
Package of Practice	Crop Efficiency				Economics of packages of practice (Average of 2010 & 2011)		
	Year 2010 (Unprune)		Year 2011 (Deep skiff)				
	Yield (kg/ha)	Over control	Yield (kg/ha)	Over control	Cost / ha	Cost/kg made tea	VCR[1]
T_1 : C	1045	-	574	-	-	-	-
T_2 : VMI	1089	4.21 %	598	4.18 %	Rs. 66,466/-	Rs. 78.80/-	0.10
T_3 : IRF-1	1168	11.77 %	731	27.35 %	Rs. 9,152/-	Rs. 9.64/-	3.05
T_4 : VCO	1366	30.72 %	805	40.24 %	Rs. 40,233/-	Rs. 37.06/-	1.37
T_5 : IRF-2	1928	84.50 %	1200	109.06 %	Rs. 13,796/-	Rs. 8.82/-	10.93
T_6 : BD	1878	79.71 %	1321	130.14 %	Rs. 15,236/-	Rs. 9.53/-	10.36

Evaluation of the Practice followed in General garden Area of Maud T.E.

Total area of Maud T.E. About 155 ha. Approx. 20 ha. Area was under different experimental areas comprising 'Package of Practice' Evaluation in Mature Tea, Young Tea, New Tea Plantation, Nursery and Large scale adoption as well as Soil Input Experiment. In the balance 135 ha. Area organic tea production was done using Inhana Rational Farming i.e., IRF Technology. Hence, an opportunity was provided to evaluate the package's potential in small experimental area vis-à-vis on wider scale under lesser microclimatic influences.

Considering average crop productivity of the garden (in case all the sections were left unpruned), the yield obtained in 2009, 2010 and 2011 indicated attainment of 87.9, 77.9 and 79.7 percent (respectively) of its total productive potential, during the project period.

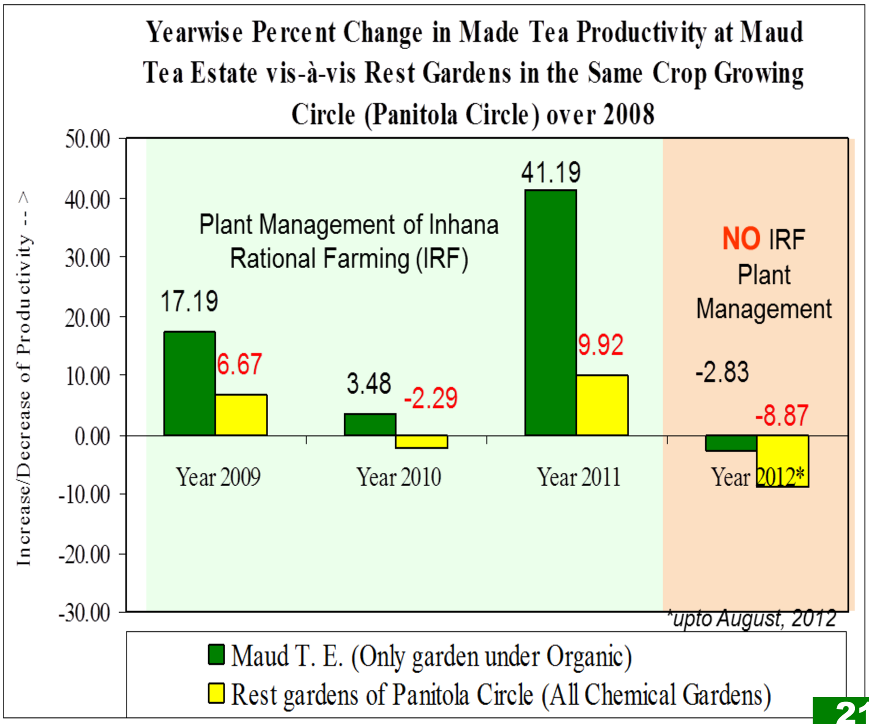
An ideal Organic Practice should minimize dependability on External Inputs with its progress following overall development of surrounding ecology, which restores the natural pest and predator relationship. Also restoration of self-nourishment and self-protection quality of plant system under organic plant management schedule plays a complimentary role in reducing the usage of off-farm inputs.



Evaluation of Crop Performance in Maud T.E. vis-a-vis Same Crop Growing Circle (Panitola Circle)

Panitola circle comprised of gardens all under conventional chemical practice. Hence, a comparative study was done between Maud T.E. i.e. Organic and Chemical gardens.

Year wise percent change (over 2008) in made tea indicated better crop response in Maud T.E. as compared to other gardens of Panitola Circle. Especially in 2010 under huge helopeltis infestation and unfavourable weather conditions in terms of intensive rainfall, less sunshine hours etc., higher yield (although very small hike) over 2008, indicated better pest control and better crop performance in Maud T.E., even under stressed conditions.



Perhaps the most Scientific Evaluation in Organic Tea Cultivation done so far - Field & Lab Analysis

Inhana from its experiences in organic research understood that there is a need to apply scientific principle in the formulation of an effective organic pathway for which the academicians and the Universities can take the most important role. Hence, it formulated an 'Inhana Advisory Board' comprising of Professors from different Agricultural Universities, acclaimed stalwarts in their respective fields and at the same time having right analytical bent of mind to accept and study the Science behind Organic Practices.

Two Ph.D Programmes. Enrolled under this project at Model Farm Maud T.E. from 2009 to 2011.

4 M.Sc. Thesis. & about 15 Research Publications in National & International Journals.

Generation of Huge Analytical Data base

Soil, Organic Soil Input Samples/ Compost, Plant and Made Tea Samples were collected on periodical basis to analyze their respective quality parameters.

Total 2,682 soil samples were analyzed during the 3 years project period, in a periodical manner i.e. total 10 times. Soil samples were collected from each experimental plot before the initiation of experiment and periodically at 60, 150 and 240 days post soil input application.

Total 247 compost/ organic soil inputs were analyzed during the 3 year project period. Among these 132 samples were analyzed in detail as per 32 quality parameters, while the rest were tested for physicochemical, fertility status and microbial potential.

Total 198 green leaf samples were analyzed during the 3 year project period. Green leaves were collected from experimental plots (package of practice experiment in mature tea and soil input experiment) 3 times in a year to study their nutrient content.

Total 84 made tea samples were analyzed during the project period. Different grades (CD, PD, PF, BOP etc) of made tea samples were collected from the garden to analyze various quality parameter viz. pH, TSS, TDS, total polyphenol, total flavanoid etc.

ANALYTICAL PARAMETERS OF SOIL SAMPLES (Total 30 parameters)

The Organic Soil Inputs are being evaluated as per 32 Qualitative Parameters following the Protocol of U.S Composting Council (2002) & Australian Stds. (1999)

Soil Physical Parameters

1. Sand %
2. Silt %
3. Clay %
4. Bulk density
5. % pore space
6. WHC
7. Particle density
8. Volume Expn.

Soil Chemical & Fertility Parameters

1. pH (H_2O)
2. EC
3. Org. C
4. CEC
5. Available N
6. Available P
7. Available K
8. Available S

Soil Biological Parameters

1. Total Bacteria
2. Total Fungi
3. Total Actinomycetes
4. Total Ammonifiers
5. Total Nitrosomonas
6. Total Nitrobacter
7. Total PSB
8. Soil respiration

Nitrogen Dynamics

1. Readily Av. - N
2. Total Min. - N
3. Total NH_4^+
4. Exch. NH_4^+
5. Fixed NH_4^+
6. Exch. (NO_2 + NO_3)

Physical Properties

1. Moisture percent (%)
2. Bulk density (g/cc)
3. Porosity (%)
4. WHC (%)

Chemical Properties

1. pH_{water} (1 : 5)
2. EC (1 :5) dS/m
3. Total volatile solids (%)
4. Total Ash Content (%)
5. Organic carbon (%)
6. CEC (cmol(p
7. CMI
8. Sorption Cap
9. Humification

Microbial Potential

1. Total Bacteria
2. Total Fungi
5. Total Actino
6. Microbial bio

Fertility Parameters

1. Total nitrogen (%)
2. Total phosphorus (%)
3. Total potassi
4. C/N ratio

Water Extract Components

1. Water soluble Org. C (%)
2. Water soluble Org. N(%)
3. Water solubl
4. Organic C/N

Stability, Maturity & Phytotoxic

1. CO_2 evolution rate
2. NH_4^+ - Nitrogen (%)
3. NO_3^- - Nitrogen (mgkg^{-1})
4. Nitrification Index
5. Seedling em
6. Root elonga
7. Germination (phytotoxicity

Key Findings from FAO-CFC-TBI Project (2008 - 2013)

- **For Ecologically and Economically Sustainable Tea production in is necessary to shift from the input based approach to a Complete Package of Practice.**
- Inhana Rational Farming (IRF) Technology showed consistently best performance under all stages of tea cultivation, at lowest COP. **Novcom Compost also exhibited highest crop performance amongst all organic soil inputs with cost effectiveness.**
- **Enhancement of native micro flora in soil is the key behind effective organic soil management. But in this respect self- generated micro flora are the best fit because laboratory cultured microbes are less diversified and most often fail to acclimatize in the un-favourable soil environment.**
- Plant Health Management has a definite role **in inducing higher crop productivity due to Due to Better Bush Health as well as, Lesser Incidence and Better Management of Pest & Disease Problems.**
- **Plant health management helps to increase the nutrient uptake, utilization efficiency and its assimilation for complete protein synthesis leading to better vegetative growth.**
- **Besides ensuring efficient Protein synthesis, activation of Plant Physiology, also enables improved metabolism leading to efficient secretion of phenolic compounds that are responsible for bio-chemical defense as well as higher intrinsic quality.**

"The outcome of this project is perhaps the first of it's kind that has delivered the concept of 'Packages of Practice', hence shifting from the input- based approach or component research".

Prof. A. K. Chatterjee
Head, Dept. of Agricultural Chemistry & Soil Science,
Viswa Bharati University, Santiniketan, W.B., India
(***on behalf of Advisory Board***)

Conclusion

- ✓ The role of a comprehensive package as pre-requisite factor for sustained tea cultivation was conclusively proven, considering that inputs for various problems when combined together failed to provide that comprehensiveness.

- ✓ The findings also brought forth the fact that as soil management comprises more than 2/3rd to 4/5th cost of production under any Package, quality of soil input is one of the determinant factor for sustainable organic tea production. In that case, On- Farm composting proved to be the most Cost- Effective option.

- ✓ **Inhana has done Scientific & Perhaps the most exhaustive Research and Documentation under Organic taking all the relevant & important inputs/components for the evaluation.** Inhana Rational Farming Technology (IRF) which is being used for the production of about 2 million kg organic tea for the last one decade in the most cost- effective manner has also been scientifically evaluated as the best, most consistent as well as cost effective option among all other organic packages, in all the experiments.

- ✓ IORF being the research organization dedicated in organic for more than one decade developed Inhana Rational Farming (IRF) Technology to unveil the true science of organic, not just for commercial reasons. Hence, the organization wants to share its technological benefits with the existing organic tea gardens as well as for the organic conversion.

- ✓ Effectivity of best five POPs found under FAO-CFC-TBI project at Maud T.E. can be taken for other Agricultural Crops also.