Organic Farming

BULLETIN - I

Relevance of Organic Approach in Tea Physiology as a C_3 Plant & Suggestive Recommendations for Effective Organic Tea Cultivation in Assam & Darjeeling Plantations

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&

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Based on the findings from FAO – CFC -TBI Project entitled
'Development, Production & Trade of Organic Tea' at Maud T.E., Assam, India.

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FOREWORD

I am pleased to note that a bulletin on '*Relevance of Organic Approach in Tea Physiology as a C_3 Plant & Suggestive Recommendations for Effective Organic Tea Cultivation in Assam & Darjeeling Plantations'* is being published jointly by Visva – Bharati University and Inhana Biosciences.

I note that this bulletin is the first one out of the series of bulletins being brought out based on the research findings emanating from the model farm laid out to evolve scientific package of practices for organic tea farming under the ongoing project *'Development, Production and Trade of Organic Tea'* being implemented with financial support from Common Fund for Commodities and Tea Board of India with scientific backup from tea research institutes and overall supervision and guidance from IFOAM and FAO

I am sure the bulletin will be of immense use for organic tea producers particularly as an useful field guide for those switching over to organic tea cultivation .

I wish to place on record my sincere appreciations to the authors for bringing out this bulletin.

Kolkata
Dated 28 Jan 2013

M G V K Bhanu
Chairman, Tea Board of India

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Visva-Bharati Act XXIX of 1951
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दिनांक/Date. 20.12.2012

From
Professor Sushanta Dattagupta
Upacharya (Vice –Chancellor)
Visva-Bharati, santiniketan

MESSAGE

I am extremely happy to know that a bulletin on "Relevence of organic approach in Physiology of Tea, a C3 Plant and suggestive recommendation for effective tea cultivation in Assam and Darjeeling Plantation", the findings from FAO-CFC-TBI project entitled 'Development, production and trade of organic tea" at Maud tea estate, Assam, India, is going to be published jointly by Department of ASEPAN, Palli Siksha Bhavana, Visva-Bharati and Inhana Biosciences, a research organization, Kolkata. Professor A.K. Chatterjee, Professor G.C.De and Dr. A. K. Barik have acted as member of the advisory committee of the project.

I hope that the bulletin will provide guidelines and pathway for effective organic tea cultivation.

I wish every success of this endeavour.

(Sushanta Dattagupta)

संस्थापक
रवीन्द्रनाथ ठाकुर
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PROF. SUSHANTA DATTAGUPTA

Date 21.12.2012

From :
Prof. G.C. De
Principal (Dean)

MESSAGE

It gives me an immense pleasure that a Bulletin on "Relevence of organic approach in Physiology of Tea, a C3 Plant and suggestive recommendation for effective tea cultivation in Assam and Darjeeling Plantation", the findings from FAO-CFC-TBI project entitled 'Development, production and trade of organic tea" at Maud tea estate, Assam, India, is going to be published jointly by Department of ASEPAN, Palli Siksha Bhavana, Visva-Bharati and Inhana Biosciences, a research organization, Kolkata.

I think that this bulletin will provide guidelines and pathway for effective organic tea cultivation in eastern India in particular and the country and the globes as a whole.

21.12.12

(G.C. De)
Principal (Dean)

From the Desk of Advisory Board

The FAO-CFC-TBI Project for finding out 'An Effective Road Map for Organic Tea Cultivation' at Maud Tea Estate gave us the opportunity to observe, examine and interpret the application of Organic Science towards practical utility at large scale in the experiments designed and conducted by Inhana Biosciences, the R&D Institute engaged in organic research for more than one decade.

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. This project has conclusively showed the pathway that can be conveniently adopted for large scale organic tea cultivation in an Economically Sustainable manner through attending to all related components.

Being the Professors of Agricultural Science, we are glad that the outcome of the project besides stimulating the tea growers for natural conversion to organic or for gradual shedding of chemical inputs in an effective manner, shall on the other hand also help to formulate effective pathway for organic cultivation in various other agricultural crops.

Prof. A. K. Chatterjee
(*on behalf of Advisory Board*)

VISVA BHARATI UNIVERSITY

PalliSikshaBhavana (Institute of Agriculture), Visva – Bharati, Sriniketan, West Bengal, was established on 1st Sept, 1963 with the ideals of Gurudeva Rabindranath Tagore, with the mission and vision of teaching, research and extension in the field of agriculture and above all rural development. The Institute comprises four Departments and has been running courses in UG and PG in five disciplines like Agronomy, Soil Science and Agril. Chemistry, Horticulture, Agricultural Extension and Plant Protection under Course and Credit system following Syllabi as stipulated by the ICAR. Ph.D. Courses are going on simultaneously.

Admission in UG is through Visva – Bharati Common Admission Test (VBCAT) for 85% and ICAR for 15% seats and in PG courses is through Departmental Admission Test for 75% and ICAR for 25% seats. Admission in Ph.D. programme is either through National Eligibility Test (NET) or Visva – Bharati Research Eligibility Test (VBRET).

The Institute owns three Farms (Agriculture, Horticulture and Dairy and Poultry) and an engineering workshop, a soil Testing Laboratory, a KrishiVigyan Kendra, a Centre for Weed Science Research, a library, a Placement Cell four hostels – all are in walking distance. Pass outs of the last 50 years are absorbed both in the country and overseas.

A good number of collaborative researches with national and international organizations are going on. The concepts of Gurudeva in rural reconstruction through agricultural development are coming into reality by the devotion of each individual of students, teachers and researchers.

INHANA BIOSCIENCES – Science In Harmony with Nature

Inhana Biosciences, a Research Organization based in Kolkata (India) started its journey about 12 years ago, with organic formulations for selected unresolved problems of agriculture like disease management, efficient potash uptake etc. However, it was eventually realized that for effective and sustainable organic management, the input substitution theory has to be transformed to a comprehensive approach linking the finite & infinite components of the ecosystem.

Hence, the organization developed a 'Complete Package of Organic Practice' (Inhana Rational Farming Technology), to enable organic crop production in a sustainable manner. About 1.8 million kg Organic Tea is being produced for the last 9 years under Inhana Rational Farming from 1200 hec. in Assam, which is perhaps the largest organic tea production under any single method/ technology. Five Darjeeling gardens of Chamong Group are also under this technology for the last four years. Rational Farming Tecgnology has been successfully evaluated in wide range of crop trial through experimental projects in the State Agricultural University and State Horticultural Farms.

The organization was outsourced by Maud Tea & Seed Company Ltd. for designing the module and protocol of the FAO-CFC-TBI project at Maud Tea Estate (Assam), conducting the experiment, documentation and interpretation of the research findings.

'INHANA-ADVISORY BOARD' for Project Supervision & Guidance

'Inhana Advisory Board' comprises Professors from different Agricultural Universities, acclaimed stalwatrs in their respective fields and at the same time having right analytical bent of mind to accept and study the Science behind Organic Practices. They are associated with Inhana Biosciences right from the formulation, guidance and evaluation of the research findings and their intricate relationships.

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CONTENT

CONTENT

INTRODUCTION

Chemical fertilization was deemed necessary and therefore practiced rigorously to increase crop productivity for achieving self-sufficiency in food production. However, this was achieved at a great cost to the Nation, both economic and social; and now, after five decades of chemical practice the present depletion of soil and surrounding ecology is reflective in the progressively declining crop productivity. Continuous chemicalization has weakened the plant system (Chaboussou *et al., 1985*), which have slowly but steadily lost their capacity of effective nutrient absorption and their proper assimilation, leading to further deactivation of their natural resistance against pests/ diseases. On the biophysical level, the negative impact had led to organic carbon depletion, increased soil salinity, drastic change in soil-water regimes as well as chemical pollution due to pesticide and fertilizer application.

The negativities were further aggravated in tea plantations, considering long period (even up to hundred years) of mono cropping practice which left little scope for soil rejuvenation (except at the time of re-planting or heavy pruning) along with recurrent, resistant and persistent pest and disease problems. The resultant decline in crop productivity along with rising stringency in the export arena regarding the minimum limit of pesticide residue in made tea, has been plaguing the tea planters for a while.

In this scenario going back to the origin seemed to be the ultimate choice; however, it never daunted that such natural process of cultivation shall now have to be functional in a far more lixiviated environment than what it was prior to the inception of the so-called 'Green Revolution'.

ORGANIC – THE MOST SCIENTIFIC APPROACH

Organic agriculture has become quintessential solution for reverting the cycle of depletion propelled by chemical farming practices. However, the practice is to ensure sustainable and subsequently higher productivity and economic returns from the present soil and plant system that have been lixiviated following few decades of chemicalization. Hence, it does not come as a surprise that the present organic practices fail to achieve the much desired soil rejuvenation or crop sustenance even after few years of adoption. Moreover, the associated huge crop loss and simultaneous cost hike occurring under simple substitution of synthetic fertilizers/ agro-chemicals by organic formulations has led to the belief that organic agriculture is better option but perhaps not sustainable and certainly not a choice for increasing productivity.

However, success in such a depleted environment calls for an increasingly sophisticated approach to the evaluation of resources, to the understanding of environmental issues and to the management of highly complex farming system. The term "organic" is not directly related to the type of inputs used, but refers to the concept of the farm as an organism (Steiner, 1924), in which all the components of farming – soil minerals, organic matter, microbes, insects, plants, animals, and humans – interact to create a coherent whole. Understandably the objectivity cannot be achieved by mere non-chemicalization but through adoption of a production management system that is not focused on the 'Input Substitution Theory' or Compartmental Approach of chemical practice. The system should provide comprehensive guidelines for effective soil management, enable activation of plant physiology and provide measures for composite pest/ disease control i.e. enable sustainable organic crop production through effective utilization of finite and infinite resources. Sustained soil and crop productivity today can form the future foundation for continued higher productivity in future.

ORGANIC IS NECESSARY- ***An FAO Outlook***

FAO reiterates that Organic Agriculture should be supported, at National and International levels, as it has the potential to meet Food Security Challenges.

'International Conference on Organic Agriculture and Food Security' at FAO (Rome) in May, 2007; suggested that Large-scale Shift to Organic Agriculture could Help Fight World Hunger while Improving the Environment.

Simultaneously efforts have been initiated by the organization to promote and accentuate organic crop production and in this respect the FAO-CFC-TBI Project 'Development, Production & Trade of Organic Tea was laid down with the following objectives :

- ✓ *To develop technology, skills and systems of organic tea production.*

- ✓ *To develop appropriate technology for the establishment of new and conversion of existing, tea areas to organic tea farms.*

THE DESIRED OUTCOME :

- Increase number of farmers engaged in organic tea production.
- Increase the production of organic tea.

ORGANIC APPROACH

A Difficult but Most Scientific Proposition for Tea as a C_3 Plant

In tea cultivation sustainable organic crop production has remained elusive. Age old bushes, continuous stress on plants due to multiple vegetative propagation, limited scope for soil rejuvenation, soil acidity/ improper nutrient dynamics along with unresolved pest and disease infestation; lead to complex problems; which are much different and difficult to address as compared to other crops. The critical pest/ disease problems become unmanageable under application of herbal/ biological formulations, which are weaker substitutes of chemical pesticides. Organic soil management to ensure restoration of the soil-plant-nutrient dynamics is a critical issue but there has been no comprehensive and scientific guideline for identification of the right quality organic soil input or regarding their dosage of application depending on qualitative variations.

Moreover, the fertilizer sensitive tea clones, comprising major portion of tea plantation suffer from depressed physiological functioning under application of ordinary compost and slow reacting organic inputs. Thereafter improvement in soil status often does not reflect in the green leaf yield due to depressed soil-plant relationship. Good crop performance or better agronomic efficiency of the plants is not only dependant on the availability of nutrients in soil but also on their effective utilization, which is solely regulated by physiological efficiency of the plant system. This is because higher physiological efficiency entails effective translocation, assimilation and redistribution of nutrients for use in crop growth (Kanampiu *et al.*, 1997).

The FAO-CFC-TBI Project (2009-2011) 'Development, Production and Trade of Organic Tea' was taken up at Maud tea estate (Assam; India) to find out an effective pathway for sustainable organic tea production, through evaluation of the different organic methods/

'Packages of Practice' in terms of crop performance (both yield and agronomic efficiency), soil development as well as economics.

HISTORY OF TEA- THE MOST POPULAR BEVERAGE

Tea has been consumed for over 5,000 years and is the second most popular beverage in the world, playing second fiddle only to water. Tea is nearly 5,000 years old and was discovered, as legend has it, in 2737 BC by a Chinese emperor when some tealeaves accidentally blew in a pot of boiling water. In the 1600s tea became popular throughout Europe and the American colonies.

According to legend, the Shen Nong, an early emperor was a skilled ruler, creative scientist and a patron of the arts. His wise edicts required, among other things, that all drinking water be boiled for hygienic reasons. One summer day while visiting a distant region of his realm, he and the court stopped to rest. In accordance with his ruling, the servants began to boil water for the court to drink. Dried leaves from a near by bush fell into the boiling water, and a brown liquid was created. As a scientist, the Emperor was interested in the new liquid, drank some and found it very refreshing. And so, according to legend, tea was created.

The discovery of the Assam tea plant is attributed to Robert Bruce who is supposed to have seen the plant growing wild in some hills near Rangpur (near present Sibsagar), 1823. According to some sources (Baildon, 1877, Tea in Assam, Calcutta) the tea plant of Assam was discovered by a local Assamese nobleman Maniram Dewan, who later worked in the Assam Company for some time. It is possible that Maniram Dewan brought the plant to the notice of Robert Bruce during his visit to Rangpur in 1823. Maniram Dewan, who belonged to Ahom royal family and also a known freedom fighter, was the first Assamese tea planter. He planted tea in various parts of Assam led by Robert Bruce in 1823. After that the British took initiatives and tea was planted all over Assam and many tea gardens were established. Many workers from various part of India like Bihar, Orissa were imported to Assam. Slowly Assam grew as the highest tea producinghj state in the world. Assam still continues to be the highest producer of tea sharing more than 50% of India's total prodcution.

The Assam Company – the world's first tea company – came into being on February 12, 1839. Dwarakanath Tagore, grandfather of Nobel Laureate Rabindranath Tagore, was one of the directors. On January 10, 1839 the first consignment of Indian tea from Assam consisting of eight chests was put under the hammer at the Commercial rooms in Mincing Lane, London.

PROBLEMS FACED BY THE INDIAN TEA INDUSTRY

The tea Industry in India has a 170 years old history. The credit for creating India's vast tea empire goes to the British, who discovered tea in India. India is one of the world's largest producers and consumer of tea, which accounting for 28.0 percent of the world production and around 14.0 percent of the world tea exports (Basu Majumdar *et al*., 2012). Tea ranks as the fourth-largest agro export item from India. The industry employs around 1.27 million at the plantation work and 2 million people indirectly of which 50 percent are women workers (2nd largest employer in the organized sector after Indian Railway).

In spite of its importance, tea industry of India is going through a crisis phase since 1990's. The industry has faced serious competition in the international and national market which has lead to the present crisis. The major factors related to tea cultivation practice is increase in cost of production and decreasing quality which has been uncompetitive with respect to other global players such as Sri Lanka, Kenya, and that has resulted in our losing out export markets as well as domestic market. This is primarily due to :

1. Productivity of tea plantation stagnated/declined due to poor agricultural practice leading to depletion in soil productivity, increasing stress towards bush health, higher incidence of pest and diseases, age of the tea bush, change in climate etc. According to Das (2009) productivity declined in India from 1996 to 2005 in the large gardens.

2. Current trend of over-reliance on the use of synthetic pesticides in tea crop protection programs around the North-East India has resulted in disturbances to the environment, pest resurgence and variation in susceptibility. (Gurusubramanian *et al.*, 2005; Borthakur *et al.*, 2005; Bora *et al.*, 2007a,b).

   Where the average usage of pesticide in India is mere 0.5 kg ha^{-1}, Indian tea industry was among highest users of pesticide in the world. The average use pattern of chemical pesticides was estimated to be 11.5 kg ha^{-1} in the Assam valley and Cachar, 16.75 kg ha^{-1} in Dooars and Terai and 7.35 kg ha^{-1} in Darjeeling (Barbora and Biswas, 1996) compared to 7.0 kg ha^{-1} in USA, 2.5 kg ha^{-1} in Europe, 12 kg ha^{-1} in Japan and 6.6 kg ha^{-1} in Korea (Anonymous, 2003a).

3. Price realization as well as rate of increase in price realization of per kg tea export of Indian tea is lowest among major tea export countries. The major reason for lower increase in price realization of Indian tea is primarily due to inferior quality (Anonymous, 2003a).

4. In the recent years, it has become a major concern to the tea industry as the importing countries are imposing stringent restrictions for acceptability of the made tea due to pesticide residues. Europe especially the EU, is a major export destination for high value Indian tea. However pesticide residue regulations in the EU could possibly have a curtailing effect on export of Indian Tea to Europe (Gurusubramanian *et al.*, 2008).

5. Increasing usage of chemical fertilizers and pesticides to sustain the crop productivity as well as sharp increase of these input prices (Rahman *et al.*, 2005b) also increase the cost of production.

LIMITATION OF TEA GROWING SOIL.

1. **Acid soils have natural limitation of microflora and also nutrient availability.**

   Plant availability of nutrients in soil solution is greatly influenced by soil pH. Especially in acid soil, availability and /or toxicity of the nutrients varies sharply with minor decrease in soil pH. At the same time microbial diversity and population decreases with increase in soil pH. Fukushi *et al.* (1984) showed that microbes in acidic tea field soil had a high denitrification activity. Nioh *et al.* (1993) showed that the microbial characteristics of acidic tea field soil were qualitatively different from those of cultivated soil with natural pH. Hayatsu (1993) showed that soil acidification reduced the population of microbes in tea field soil, and lowered both the cellulose degradation rate and the nitrification activity of the soil.

2. **Plantation age of more than 100 years cause mono cropping toxicity and hard pan formation.**

   Monocrop production and its associated chemical inputs not only reduce soil biodiversity and soil organic matter, but also compact soils. Researchers have found that tea plantation soil contained between one-third and one-half the number of earthworms per square meter as the nearby natural forest soil. In addition, most earthworms found in tea plantations were not native species to the area (Senapati *et al.,* 2002).

3. **Chemical fertilizer application over decades that too chemical N- fertilizers result in soil toxicity.**

   Chemical fertilizers when used for a long time will deplete soil quality gradually. Chemical fertilizers might be able to give quick result, but the roots are underdeveloped and thus give weaker plants. Use of fertilizers reduces the natural nutrients on the soil surface (Fred, 1991). Moreover, chemical fertilizers are harmful to the environment-especially, on soil fertility because most of the microorganism decrease following increased huse of the chemical fertilizers (Katsunori, 2003). On the other hand, fertilizers are regarded as a non-point-source pollution with severe impact on the environment (LIU Yu, *et al.*, 2009).

   There is a tendency in chemical gardens to use nitrogen fertilizers at high rates with lower emphasize in phosphate and potash. Such imbalanced nutrition leads to decline of productivity. Fertilizer application at high rates causes amide (theanine) toxicity in roots leading to damage of feeder roots, depletion of starch from the roots and even death of plants in extreme cases (Barua, 1990). It will also lead to considerable leaching and runoff loss leading to contamination of nearby water bodies and ground water.

4. **Physical character of the soil is depleted in the form of lesser aeration, poor infiltration and poor water holding capacity.**

   Tea being a perennial plant, there is very little scope for soil rejuvenation resulting in depletion of soil physical characteristics. Ananthacumaraswamy *et al.* (1988) studied some soil properties in a 25-yr-old field experiment with tea and found that the soil cropped to tea alone had a greater bulk density and much lower air-filled porosity and water retention capacity than soils planted with other crops. Long-term tea cultivation also influences soil physical properties such as bulk density, air-filled porosity and water retention (Othieno, 1975; Ananthacumaraswamy *et al*., 1988).

5. **Inherently low soil microflora is further reduced due to chemical fertilizers.**

   Acidic soils inherently have lower microbial population as well as reduced microbial diversity. Continuous application of chemical fertilizer further reduces the population, as higher salt concentration in soil solution is toxic for natural proliferation of microflora. Loss in important soil biota (reduced up to 70%) (Senapati *et al.*, 2002).

6. **Soil dynamism is mostly impaired leading to poor soil-plant relationship.**

   Monocrop toxicity, long term usage of chemical soil inputs, toxic pesticide/weedicide and lack of soil rejuvenation under tea plantation deteriorate soil quality which directly influences both population and diversity of soil microorganisms. As a consequence soil dynamism which is largely controlled by soil micro-organism is impaired leading to disturbed soil-plant relationship and simultaneously poor nutrient management. Depleted plant physiology due to poor nutrient management makes the plantation more venerable towards pest and disease infestation.

7. **Effective soil management programme is not followed in most of the gardens in the absence of any scientific guideline.**

   To achieve higher crop there is indiscriminate and rampant use of chemical fertilizers and pesticides/ weedicides in the plantations. Moreover in the absence of proper guidelines, very little cultural practices like green manuring, mulching, in-situ composting etc. is taken up in the gardens in order to minimize the negative impact of the applied chemicals.

SUCCESSFUL ORGANIC TEA CULTIVATION IS A DIFFICULT PROPOSITION

There are number of inherent and practical bottlenecks in tea plantations which are much different and difficult to address as compared to other crops.

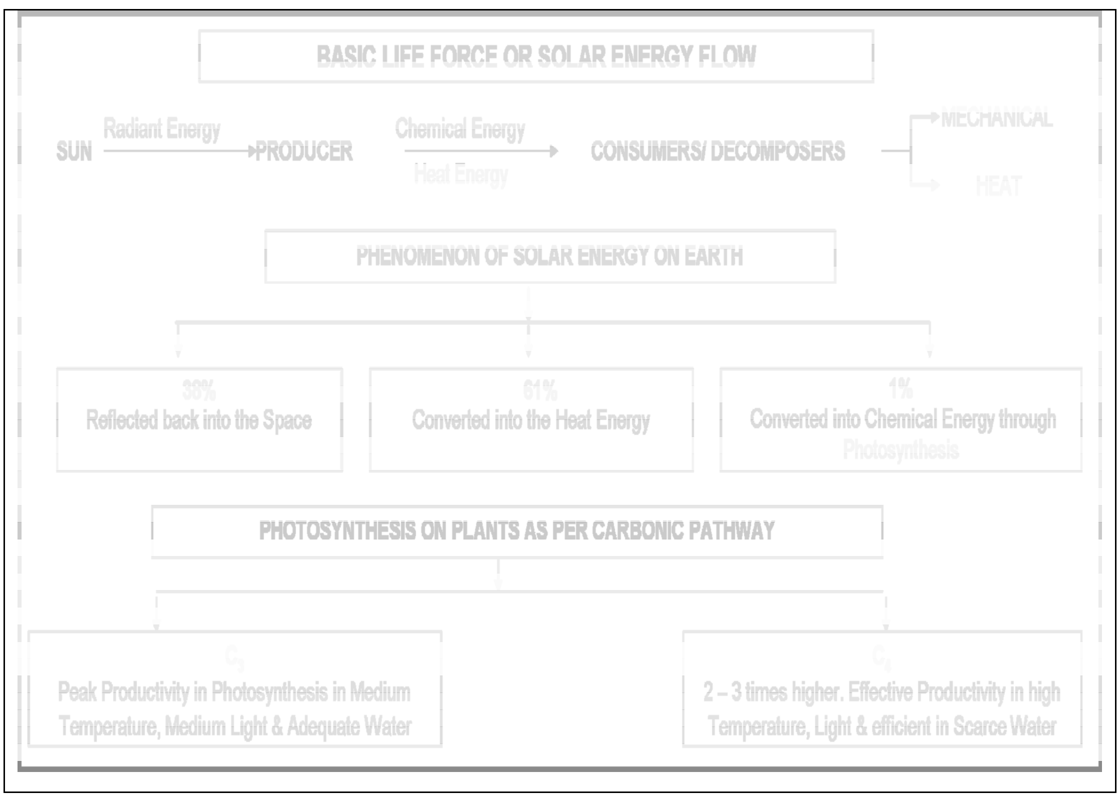
- Acid soil has inherently poor and improper nutrient dynamics.
- Perennial occurrence of resistant pest and diseases.
- Higher need of Nitrogen for vegetative propagation.
- No scope for soil rejuvenation except during replanting and corrective pruning.
- Old bushes may sometimes be more that 100 years of age, especially in Darjeeling.

The negative impact of the above limitations on soil and plant system become further aggravated under chemical farming practices. Organic approach remains the only true solution but mere non- chemicalization and the compartmental approach under present organic practices fail to resolve such major hurdles along the pathway towards sustainability.

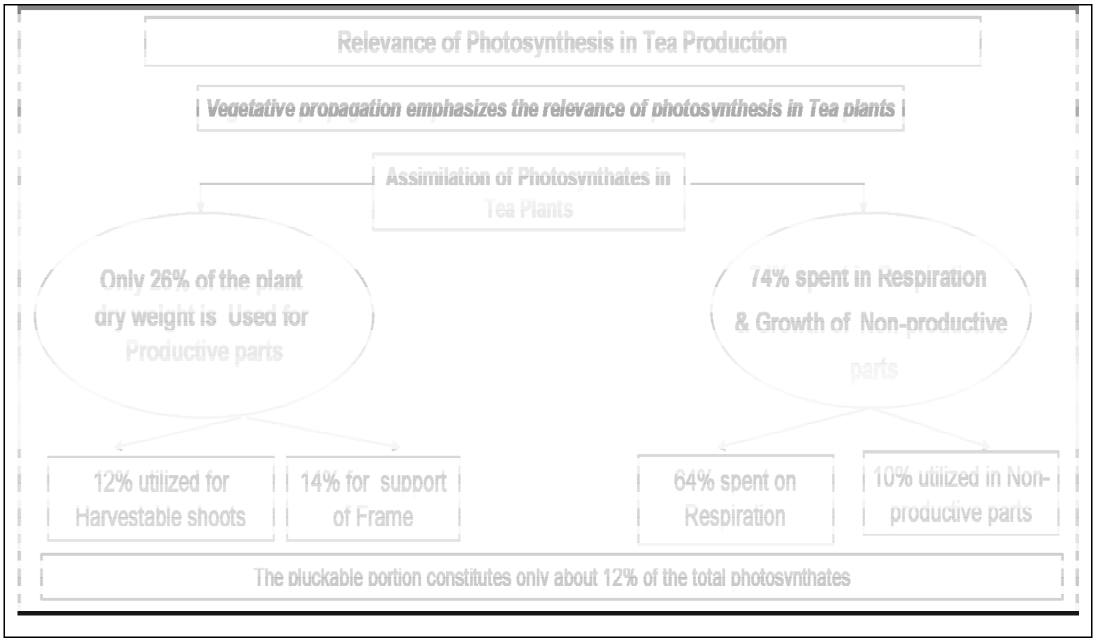
INHERENT LIMITATION OF TEA PLANT PHYSIOLOGY AS A C_3 PLANT

Photosynthesis is the primary function for plant growth. Tea being a C_3 plant is comparatively less efficient in photosynthesis. Rate of photosynthesis in C_3 plants is inherently lower i.e. only 35 to 50 % of that occurring in C_4 plants. Net Photosynthesis in C_4 plants is 40–80 $mgCO_2dm^{-2}h^{-1}$ while in C_3 Plants it is 15–35 $mgCO_2dm^{-2}h^{-1}$. Surprisingly in tea it is even lesser i.e. 13 $mgCO_2dm^{-2}h^{-1}$.

Maximum light saturated photosynthetic rates of tea are below the average for C_3 plants and photo inhibition occurs at high light intensities. The processes restrict the source capacity of tea. At the same time tea yields are sink limited as well, because shoots are harvested before their maximum biomass is reached in order to maintain quality characters of made tea (De Costa *et al.*, 2007).



Net Photosynthesis in C_3 plants occur only in the presence of medium temperature, medium light and adequate water. Moreover only a small portion of the total photosynthates is utilized for productive part of the tea plantation.



Being a vegetative propagated crop, relevance of photosynthesis can be well understood in case of Tea plants, where 95% of the Dry Weight is formed through photosynthesis. However, of the total amount of carbohydrate formed from photosynthesis, 64 percent is spent for respiration, 14 percent to support plant frame, 10 percent on the growth of non-productive parts and only 12 percent for harvestable shoots i.e. the productive portion which determines crop productivity.

More over the pluckable part i.e. two leaves and bud is the strongest sink and harvested regularly, which puts further pressure on tea plant physiology.

RELEVANCE OF PHOTOSYNTHESIS IN TEA

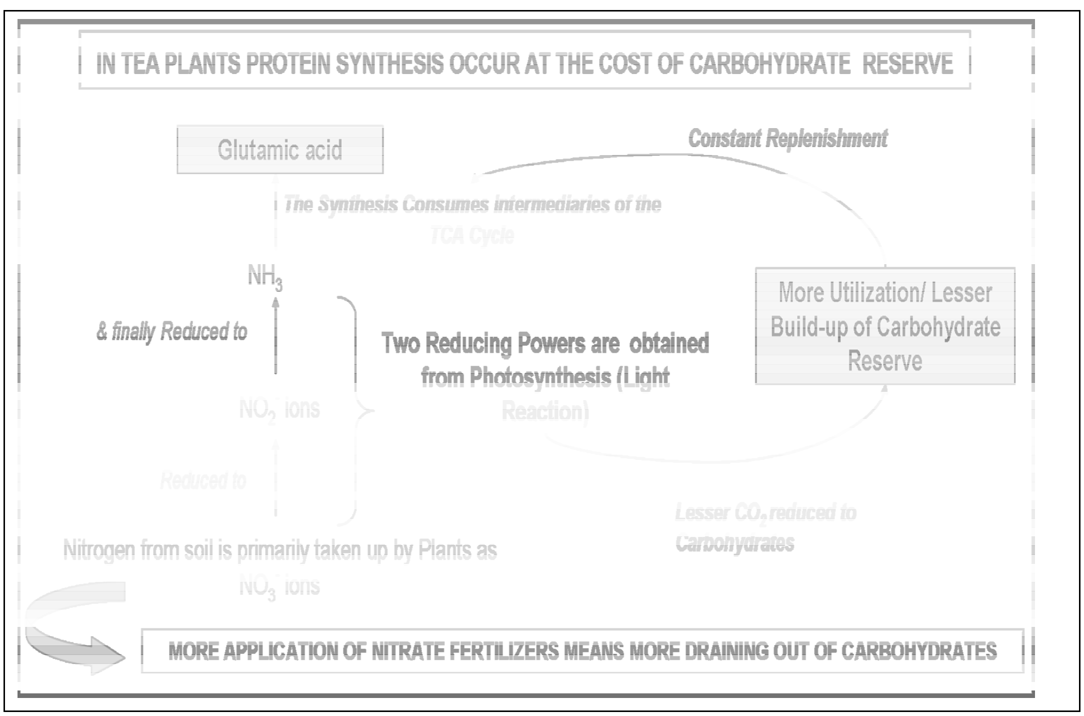
- 95% of Dry weight is formed through Photosynthesis.
- Apical growth is harvested repeatedly in a year.
- Vegetative Growth requires more efficient Photosynthesis.
- Tea as a sink deficient plant depends more on it.
- Pruning causes huge quantity dry matter removal.
- Activated Plant Physiology depends mostly on effective net Photosynthesis.

FATE OF PHOTOSYNTHESIS IN TEA

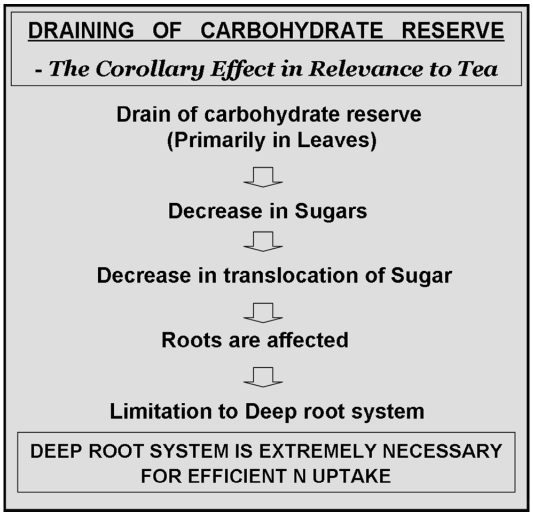
- Less efficient in Photosynthesis due to Photo Respiration
- Less efficient in Partitioning of dry matter.
- Rate of Photosynthesis drops considerably in very high/low temperature.
- Scarcity of adequate water significantly reduces Photosynthesis.
- Harvestable shoots only use 12% of the Photosynthates.

HOW APPLICATION OF CHEMICAL FERTILIZERS FOR BOOSTING LEAF PRODUCTION NEGATIVELY IMPACTS TEA BUSH HEALTH

Carbohydrate, the primary product of photosynthesis is the primary indicator of plant functioning and bush health. However, in Tea, protein synthesis occurs at the cost of this carbohydrate reserve.



The phenomenon gets magnified in case of C_3 plants on application of chemical N- fertilizers. In tea, higher uptake of nitrate ions triggered by its high concentration in soil solution enforces higher



protein synthesis, which occurs at the expense of carbohydrate reserve (drainage of existing and restriction towards build up on new reserve). Hence, chemical fertilizers induced crop growth (pluckable shoots) incurs greater depletion of carbohydrate reserve i.e. bush health.

CHEMICAL FARMING – HOW THE PROBLEM MAGNIFIES ?

Increasing crop productivity for ensuring self- sufficiency in food production was the logic behind our first 'Green Revolution' in 1963, through increased use of chemical fertilizers.

However, the introduction of chemical fertilizers in turn led to the requirement of chemical pesticides and weedicides, thereby propelling the vicious cycle of more and more chemicals due to depressed plant physiology/ fertilizer sensitive clones, deactivated environmental resistance, higher biotic potential, mutagenesis of the pest and killing of non- target organisms.

The phenomenon can be very well understood through the Trophobiosis Theory of Francis Chaboussou, which explained how plant nutrients affected plant health, with what makes the plant susceptible or resistant to disease or pest attack.

Trophobiosis Theory:

Prevailing plant protection practices rest on the postulate, mostly unspoken but almost universally accepted, even among many organic farmers, that pests, pathogenic agents are arbitrary enemies that, when present, will furiously attack our crops and will stop only when there is nothing left. So we have to fight them, eradicate them if possible, or keep them in check with our most efficient and potent weapons. The most aggressive weapons at our disposal are the synthetic chemical poisons, or pesticides, as the chemical industry likes to call them.

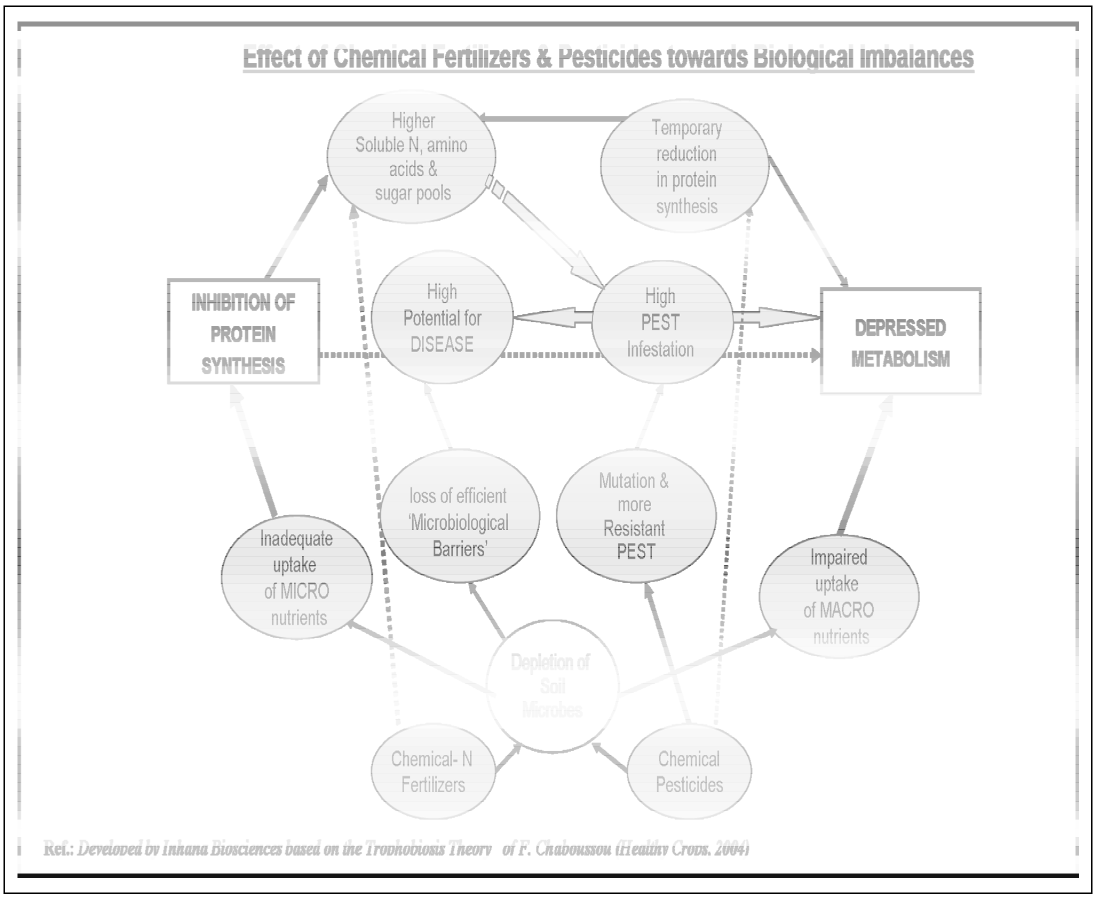
But these creatures are not arbitrary in the way they harm our plantation and gardens and the more poisons we apply, the more diseases and pests we get. Pests can only cause damage on plants that are somehow unbalanced, in their metabolism. Most pest & disease organisms depend for their growth on free amino acids and reducing sugars in solutions in the plant cell sap.

Francis Chaboussou gave a working explanation of the related biochemical mechanism. His Trophobiosis theory is a revolution in plant pathology and is a mortal law to Agri-chemistry as commonly practiced in modern Agriculture. Increase in free amino acids and reducing sugars in plants is a common phenomenon under chemical faming practice :

Heavy Application of Soluble Nitrogen Fertilizers – Increase in cellular amount of nitrate ammonia and amino acids faster that can be used for the synthesis of proteins.
Herbicides – Temporary reduction in protein synthesis – the most sensitive of metabolic processes.
Pesticides & Fungicides – Same effect.

REDUCTIONS IN THE RATE OF PROTEIN SYNTHESIS RESULT IN TEMPORARY ACCUMULATION OF AMINO ACIDS

Therefore, while the immediate attack by a pest may be reduced by a pesticide, the susceptibility of the crop is increased. When offered soluble free nutrients; pests grow better and multiply faster. In this sense, therefore, agro-chemicals and poisons are primarily responsible for inducing pests and diseases.



The basic conclusion is that the relation between plant and parasite as shown above, are nutritional in nature.

- The abundance of phenolic compounds and the paucity of amino acids appear to inhibit the growth or proliferation of pathogenic microorganisms.

In contrast, an abundance of soluble sugars and amino acids guarantees their growth and proliferation. – Dufrenoy (1936). Plants vulnerability to its parasites is a function of the abundance of amino acids and sugar in its vacuolar solutions. This is because of a nutritional imbalance or is the result of the protein breakdown or amylolysis brought about by the parasites.

- Maximum protein synthesis correlates with maximum resistance, and that a plant's susceptibility is linked with a physiological state in which protein breakdown predominates.

- The delayed impacts of different parasites or the side effects are noticed at the end of certain period. This makes it difficult to asses the relationship.
  Pesticide→ effects on the plant physiology→ susceptibility to parasite attack.

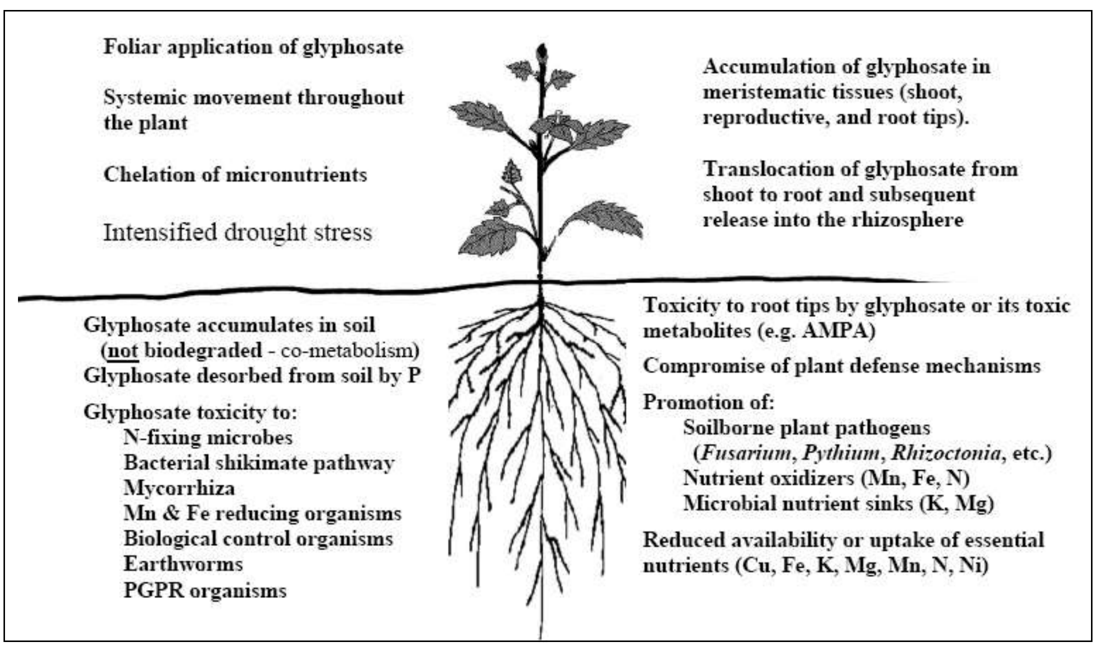
- The confusion often occurs regarding parasite proliferation, due to positive effect on the parasites' biotic potential, and the supposed 'Resistance' of the pathogenic agent to the pesticide (when the resistance manifests only under field condition).

Spraying activity in Tea Estate

Effect of Weedicides:

Weedicide reaching the soil in significant quantities have direct effect on soil microbiological factors that strongly influences plant growth. Some of the most important effects caused by pesticides are : alterations in ecological balance of the soil microflora, inhibition of N_2 fixing soil microorganisms such as *Rhizobium, Azotobacter, Azospirillum* etc. and cellulolytic and phosphate solubilizing microorganisms, suppression of nitrifying bacteria, alterations in nitrogen balance of the soil, interference with ammonification in soil, adverse effect on mycorrhizal symbioses in plants and nodulation in legumes and alterations in the rhizosphere microflora, both quantitatively and qualitatively.

As an example Glyphosate is a strong, broad-spectrum nutrient chelator that inhibits plant enzymes responsible for disease resistance so that plants succumb from pathogenic attack. The various interactions of glyphosate with nutrition are represented in the following schematic diagram.



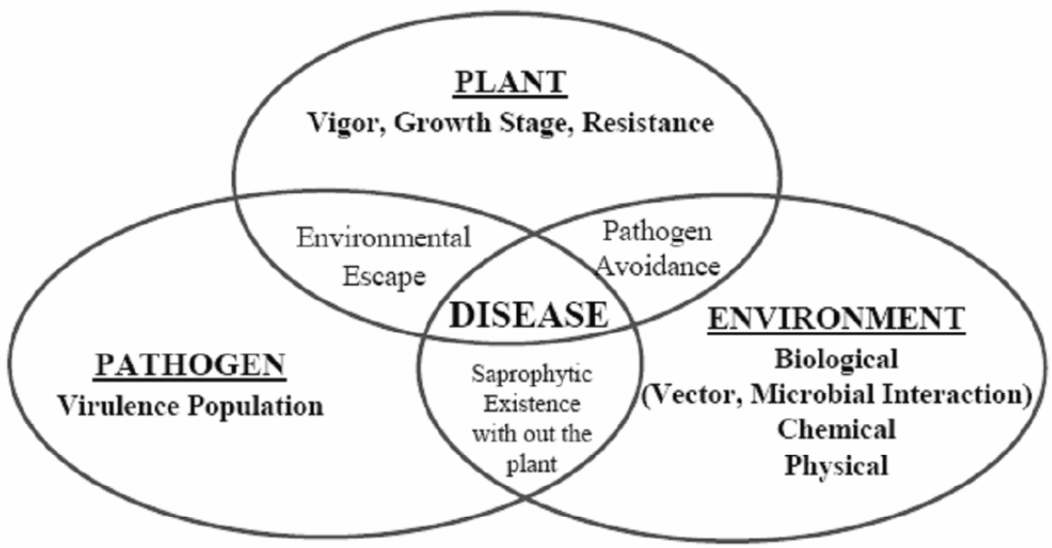
Source : ***Agri- Chemical &Crop Nutrient Interactions – Current Update*** *by Don M. Huber, Emeritus Professor, Purdue University*

BALANCED NUTRIENT MANAGEMENT TO CURB DISEASE & PEST PROBLEM.

"Pest and disease attacks are true reflection of the fertility status of soil in which the crop is growing and the quality of seeds used" (Jerome, 2013). Basically a healthy fertile soil can only ensure good plant health. Plants growing in poor soil with nutritional deficiency will be very susceptible to pest and disease attacks. Healthy fertile soil will impart power to plants to resist pest and disease attacks. Hence, vitalising and improving the soil by suitable organic agricultural methods is very important.

Many researchers have suggested that increasing insect pest and disease pressure in agro-ecosystems is due to changes that have occurred in agricultural practices since World War II. For example, the usage of fertilizers and pesticides has increased rapidly during this period and evidence suggests that such excessive use of agrochemicals in conjunction with expanding monocultures has exacerbated pest problems (Conway and Pretty, 1991). On the other hand, proponents of alternative agricultural methods contend that crop losses to insects and diseases are reduced with organic farming (Merrill, 1983; Oelhaf, 1978). Although this view is widespread, there have been surprisingly few attempts to test its validity. The few conducted studies suggest that lower pest pressure in organic systems could result from the greater use of crop rotation and/or preservation of beneficial insects in the absence of pesticides (Lampkin, 1990). Alternatively, reduced susceptibility to pests may be a reflection of differences in plant health, as mediated by soil fertility management (Phelan *et al.*, 1995). Many researchers and also practicing farmers have observed that fertility practices that replenish and maintain high soil organic matter and that enhance the level and diversity of soil macro and micro biota provide an environment that through various processes enhances plant health

(McGuiness, 1993). Plant resistance is linked directly to the physiology of the plant and thus any factor that affects the physiology of the plant may lead to changes in resistance to insect pests (Altieri and Nicholls, 2003).



Source : *Huber D. M. and. Haneklaus S (2007). Managing Nutrition to Control Plant Disease Landbauforschung Völkenrode. (57):313-322*

Plant nutrients may affect disease susceptibility through plant metabolic changes, thereby creating a more favorable environment for disease development. When a pathogen infects a plant, it alters the plant's physiology, particularly with regard to mineral nutrient uptake, assimilation, translocation, and utilization. Pathogens may immobilize nutrients in the soil or in infected tissues. They may also interfere with translocation or utilization of nutrients, inducing nutrient deficiencies or toxicities. Still other pathogens may themselves utilize nutrients, reducing their availability to the plant and thereby increasing the plant's susceptibility to infection. Soil borne pathogens commonly infect plant roots, reducing the plant's ability to take up water and nutrients. The resulting deficiencies may lead to secondary infections by other pathogens. Plant diseases can also infect the plant's vascular system and impair nutrient or water translocation. Such infections can cause root starvation, wilting, and plant decline or death, even though the pathogen itself may not be toxic.

Thinner, weaker cell walls leak nutrients from within the cell to the apoplast (the space between plant cells). This can create a fertile environment that stimulates the germination of fungal spores on leaf and root surfaces. Mineral nutrient levels directly influence the amount of leakage as well as the composition of what is leaked. For instance, potassium (K) is essential for the synthesis of proteins, starch, and cellulose in plants. Cellulose is a primary component of cell walls, and K deficiency causes cell walls to become leaky, resulting in high sugar (starch precursor) and amino acid (protein building blocks) concentrations in the leaf apoplast. Calcium (Ca) and boron (B) deficiencies also cause a buildup of sugars and amino acids in both leaf and stem tissues. Nitrogen (N) is a key component of amino acids; therefore, an excessive supply of N can bring about higher amounts of amino acids and other N-containing compounds in plant tissues. These mineral imbalances low;er resistance to fungal diseases by creating a more favorable environment for pathogens.

Mineral nutrition affects susceptibility to bacterial infections in much the same way that it affects fungal infections. K and Ca play key roles in forming an effective barrier to infections. When K, Ca, and, often, N levels are deficient, plants are more susceptible to bacterial attacks (Spann and Schumann, 2012).

Pests are organisms such as insects, mites, and nematodes that are harmful to cultivated plants. In contrast to fungal and bacterial pathogens, visual factors such as leaf color are important factors in pest susceptibility. Nutritional deficiencies discolor leaf surfaces and increase susceptibility to pests. The Asian citrus psyllid, *Diaphorina citri*, for example, tends to settle on yellow reflecting surfaces (i.e., surfaces that appear yellow in color to the human eye).

Three primary pest defenses of plants are:

1. Physical surface properties: color, surface properties, hairs
2. Mechanical barriers: tough fibers, silicon crystals, lignification
3. Chemical/biochemical: content of attractants, toxins, repellents.

Mineral nutrition affects all three defense systems. Generally, young or rapidly growing plants are more likely to suffer attack by pests than older, slower-growing plants. Therefore, there is often a correlation between N applications (stimulation of growth) and pest attack. Boron deficiency reduces the resistance to pest attack in the same ways it reduces resistance to fungal infections. It is used in the synthesis of flavanoids and phenolic compounds, which are a part of the plant's biochemical defense system.

Nutrition influences all of the interacting components affecting disease severity. As part of the “environment,” nutrients influence plant, pathogen, and microbial growth to remain an important factor in disease control. The interaction of nutrition in these components is dynamic and all essential nutrients are reported to influence the incidence or severity of some diseases. A particular element may decrease the severity of some diseases, but increase others, and some have an opposite effect in different environments. Some forms of biological disease control and suppressive soils are manifestations of microbial activity that influence nutrient availability (Huber, 1989; Huber and Graham 1999). In general, the greatest benefit to the plant is provided when full nutrient sufficiency is provided.

ORGANIC SOIL MANAGEMENT – THE RIGHT STEP FOR CROP SUSTAINABILITY.

Low efficiency in the uptake of fertilizer is a major factor that aggravates the negative environmental effects (Barlog and Grzebisz, 2004). Over 50% of the applied N can be lost from agricultural systems as N_2, trace gases, or leached nitrate (Vitousek *et al*. 1997; Tilman 1998), and the impacts are usually long term and global in scope (Vitousek *et al*. 1997; Rabalais *et al*. 1998). Similarly, when P, another growth-limiting nutrient, is applied in high quantity, sometimes up to 90% is precipitated by metal complexes in the soil (Rodriguez and Fraga 1999; Gyaneshwar *et al*. 2002) and can later lead to P pollution (Rodriguez and Fraga 1999; Sharpley *et al*. 2003).

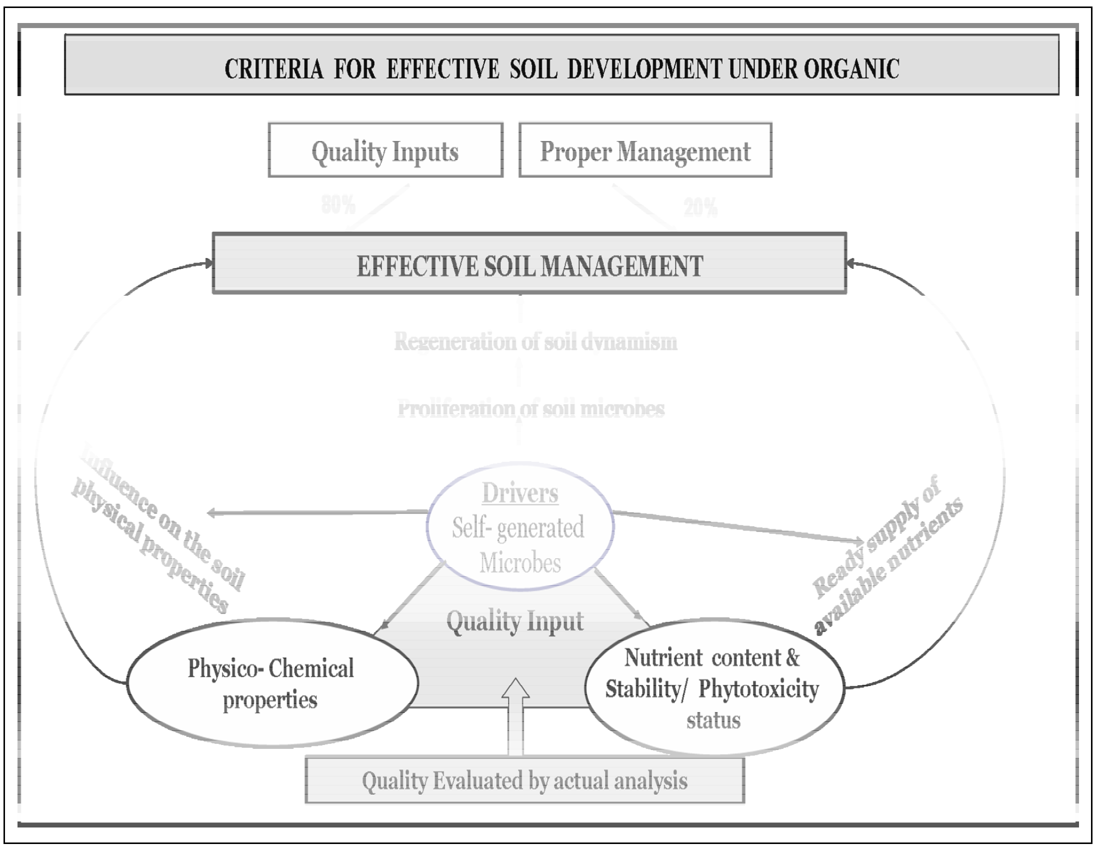
The changes in microbial activity of the soil based on the application of the organic materials are important. In this respect compost was shown to increase the uptake of some nutrients into the leaf. It was suggested that compost application to agricultural soil should provide better long-term fertility and lower off-site impacts (Adesemoye & Kloepper, 2009).

ORGANIC SOIL MANAGEMENT TO RESTORE THE SOIL-PLANT-NUTRIENT DYNAMICS

Organic soil amendment has been understood as the best option available to restore and enhance soil potential in order to restrict the continuous decline of productivity. 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 ultimately restore soil quality. However, the major bottleneck especially under organic crop production is the low quality of organic soil inputs in terms of nutrient (N, P and K) content, microbial status and stability, so that sustainability remains hard to achieve even after quantitative application of organic soil inputs over a period of time.

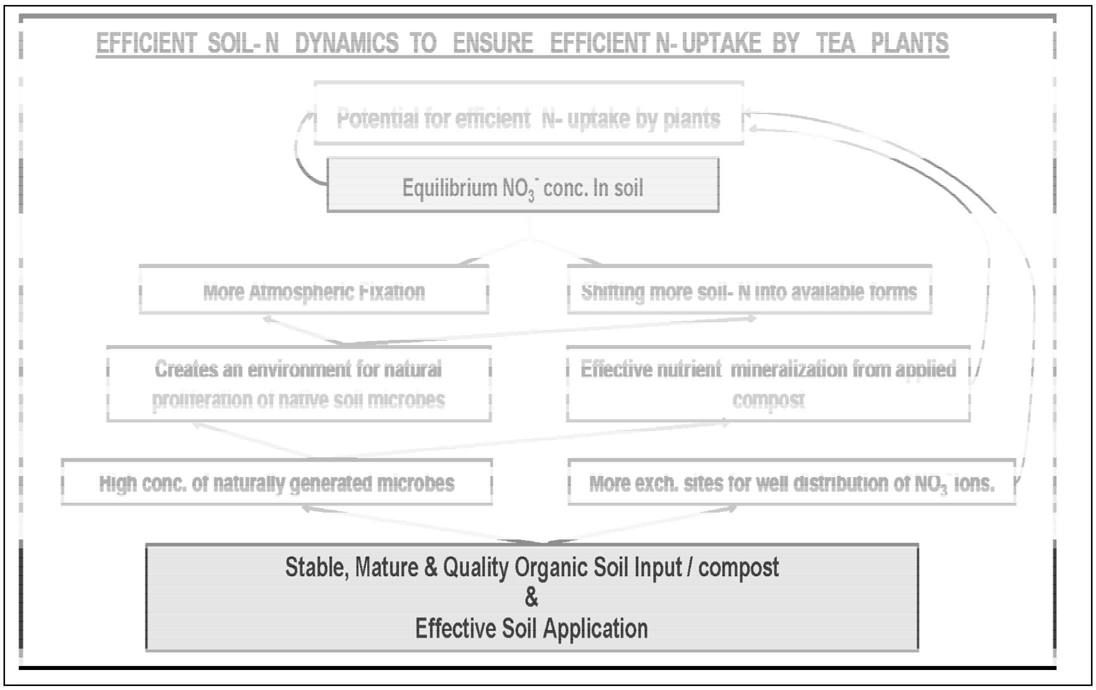
To ensure speedy restoration of soil potential and sustained productivity without triggering soil nutrient mining; application of good quality, stable and mature compost is necessary. At the same time their method of application in soil is important because effectivity of organic manure post soil application is greatly influenced by the application method.

Criteria for Effective Soil Development under Organic Management.



EFFICIENT SOIL- N DYNAMICS TO ENSURE EFFICIENT N-UPTAKE BY TEA PLANTS

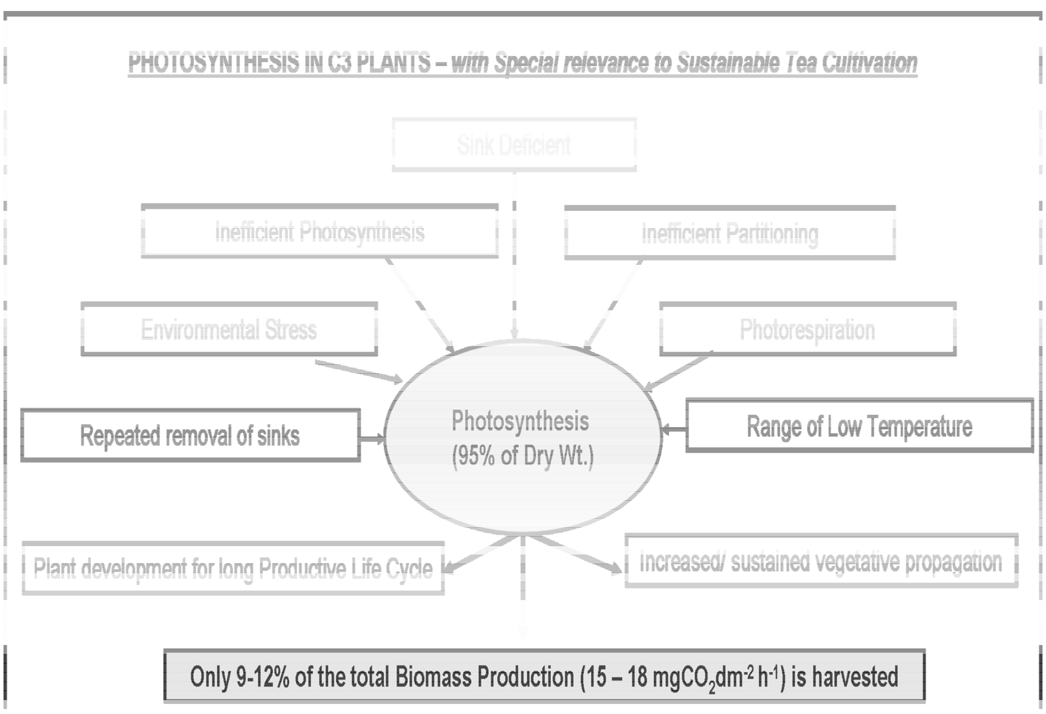
N-dynamics in soil primarily guides the pathway (beside other contributory factors) for N mineralization and its subsequent uptake by plants, where soil micro flora act as the major driving force. However, application of chemical fertilizers especially nitrogenous ones over a period of time has led to severe depletion of microbes due to toxicity generated by high nitrate concentration in soil solution.



To ensure equilibrium soil- N concentration leading to its efficient uptake and utilization by plants restoration of soil microflora is the ultimate solution, which can be only achieved through application of high quality, stable and mature compost. Shifting more nitrogen into available form, increasing more uptake sites and enhancing the efficiency of nitrate uptake could meet the requirement of N in the desired manner. This in the soil can achieved by the efficient soil - N dynamics which is the cohesive effect and relationship of the various forms of N and N converters i.e. ammonifier and nitrifier population. Presence of naturally generated, intensive population and diversity of microbes within compost will enable effective nutrient mineralization and serve to create a favourable environment for natural growth and proliferation of the native soil microbes in a speedy manner for restoration of the natural soil-plant-nutrient dynamics. Application method of compost also plays a determinant role towards its post application effectivity.

RELEVANCE OF ORGANIC MANAGEMENT TOWARDS ACTIVATION OF PLANT PHYSIOLOGY.

Tea although being photosynthetically less efficient has to derive 95% of its dry weight from photosynthesis. About 12% of assimilates are utilized for harvestable shoots, 14% for frame and balance 74% for respiration and non- productive part. At the same time it is sink- limited, the unopened bud constituting the strongest sink; simultaneously repeated plucking creates artificial limitation towards growth. Therefore more requirement of vegetative growth, which on the other hand demands enhanced net photosynthesis.

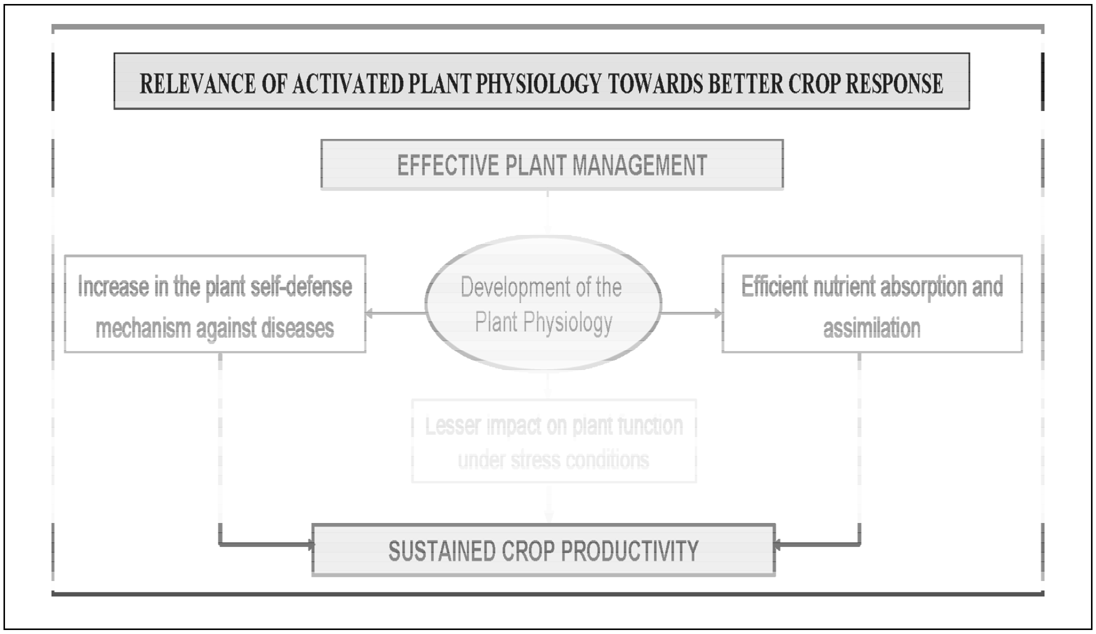


Hence, increase in photosynthesis and more efficient partitioning is the most logical step for increasing productivity. Now rate of photosynthesis where on one hand will depend on the plant physiological efficiency, the other regulating factors will be the environmental conditions and some basic plant constituents' *viz.* chlorophyll.

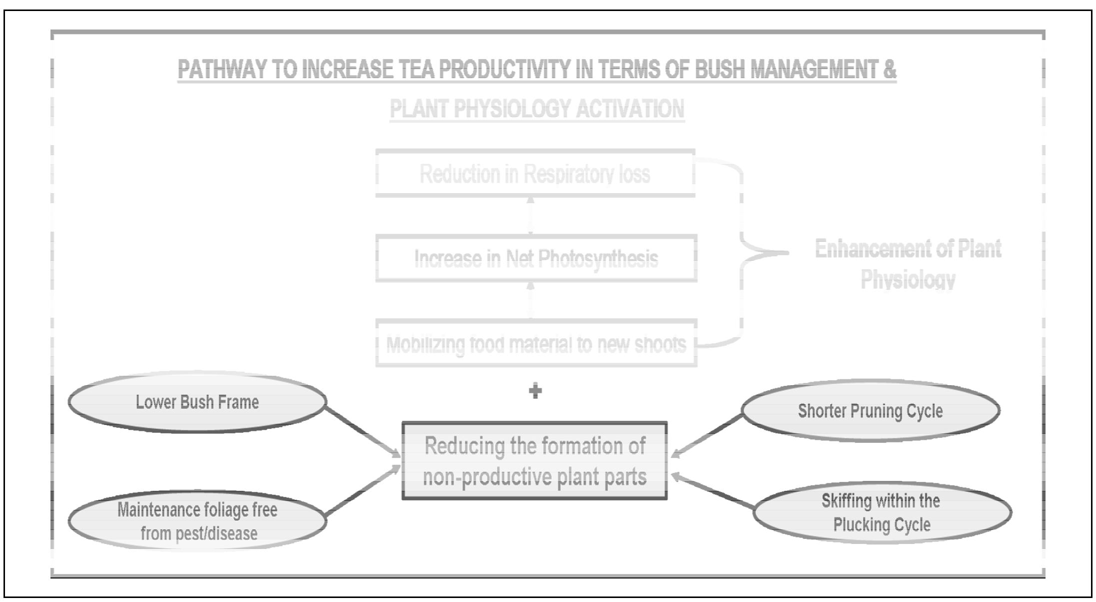
Nitrogen is the most important element required by tea and accounts for percent of the dry weight of the shoots. At the same time, higher concentration of nitrates in soil is toxic to tea plants. Furthermore, photosynthetic energy is used twice to convert nitrate to amino acids or leaf protein synthesis. Photosynthesis and translocation of photosynthates being the limiting factor, this process get hampered. Hence, increasing the rate and efficiency of net photosynthesis is one way to enhance the synthesis of amino acids. This can be achieved through activation or energization of plant physiology, which is possible only under an effective organic plant management programme.

Activation of plant physiology through adoption of comprehensive organic management can enable better plant functioning leading to efficient carbohydrate dynamics/ better bush health or in other words better crop performance even under stressful environmental conditions.

Hence, an effective plant management programme that can enable enhancement of plant physiological efficiency is of utmost importance. Activated plant physiology shall not only ensure better uptake, utilization and assimilation of plant nutrients but also serve to curtail the limitations suffered by tea as a C_3 plant towards enhanced net photosynthesis.

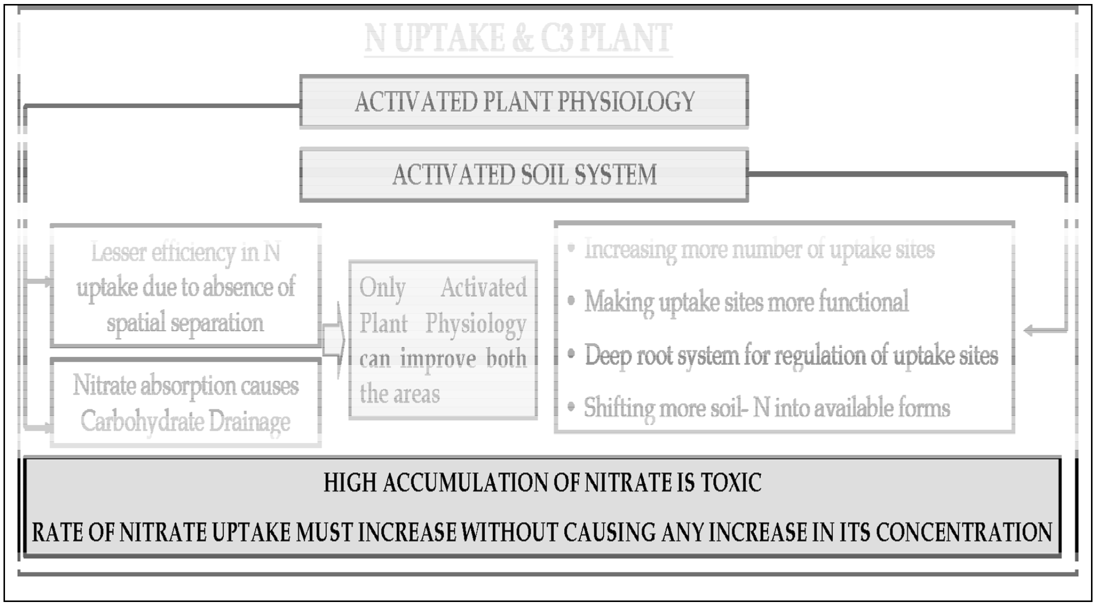


This coupled with practices to ensure better bush management in terms of shorter pruning cycle, better control of pest/ diseases etc. that can enable reduction of non- productive plant parts shall ensure better yield performance.



IMPORTANCE OF SOIL-N DYNAMICS STUDY IN TEA

Nitrogen is the most important element required by tea and accounts for 4-5 percent of dry weight of the shoots. Only a small



part of soil N is readily available to the plant and majority remains unavailable. At the same time, higher concentration of nitrates in the soil is toxic to tea plants. Furthermore, photosynthetic energy is used twice to convert nitrate to amino acids or leaf protein synthesis. Photosynthesis and translocation of photosynthates being the limiting factor, this process get hampered.

Increasing the rate and efficiency of net photosynthesis is one way to enhance the synthesis of amino acids, which can be achieved through activation or energization of plant physiology. Shifting more nitrogen into available form, increasing more uptake sites and enhancing the efficiency of nitrate uptake could meet N-requirement of plants in the desired manner. This in soil can be achieved through efficient soil- N dynamics i.e. a cohesive relationship of the various forms of N and N converters i.e. ammonifier and nitrifier population.

ORGANIC MANAGEMENT IS THE ONLY CHOICE FOR ACTIVATION OF PLANT PHYSIOLOGY – CONFIRMATION FROM FAO-CFC-TBI PROJECT.

The project was conducted at Maud T.E. (Assam) during 2009 to 2011 for 'Finding out an Effective Pathway for Sustainable Organic Tea Cultivation'.

Organic methods viz. Biodynamic Farming (BD) and Inhana Rational Farming (IRF), which are practiced in organic tea gardens in India on large scale, were taken up for evaluation. Different inputs viz. vermicompost, bio-fertilizers, bio-pesticides, herbal formulations, etc., which are used in Indian tea industry or Indian agriculture (for attending their respective criteria) were also taken up for study. However, these inputs were not studied individually but combined to form different 'Packages of Practice (POP)' based on scientific rationale.

Impact of Plant Management Practice under Different Organic Packages of Practice, towards Agronomic Efficiency of Tea Plant

Agronomic efficiency (AE), which indicates the relative increase in yield per unit of N applied, depends upon two processes: i) uptake efficiency or ability of the plant to remove N from the soil as NO_3^- and NH_4^+ and ii) utilization efficiency i.e. ability to use N to produce grain yield. Hence, improvement in these two processes entails better utilization of the applied N from compost leading to improvement of yield and decrease in environmental pollution (Olsen and Sommers, 1982). While increase in compost N use efficiency can be brought about by increasing compost quality as well as cultural practices like compost application method, post application management, changing application time/ dose etc.; these only serve as the supportive criteria for enhancing the agronomic efficiency of plants, which primarily depends on their physiological efficiency.

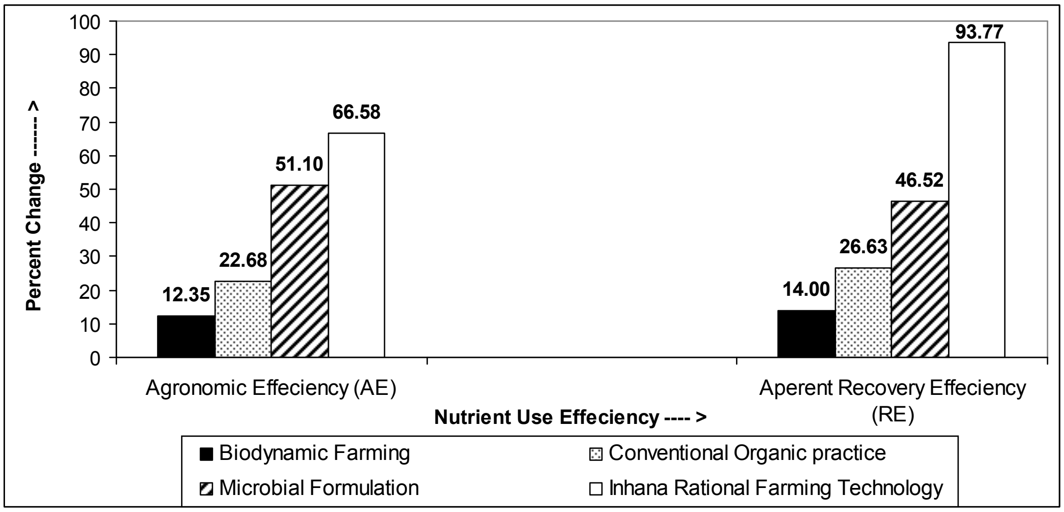
Comparative assessment of agronomic efficiency (AE_{CN}) and apparent recovery efficiency (RE_{CN} i.e. amount of nutrient in the crop as a ratio of the amount applied or available) of mature tea plants under different organic packages of practice (i.e. both soil and plant management) *vis-à-vis* under only soil management (using same organic soil input and dosage in both cases) was done under the project.

Impact of plant management on agronomic efficiency of tea plant.

Impact of plant management	Treatments	Nutrient Use Efficiency		% change in Nutrient Use Efficiency	
		(AE_{CN})	(RE_{CN})	(AE_{CN})	(RE_{CN})
Inhana Rational Farming (IRF)	Novcom compost-1 (NOV-1) (@ 8 ton/ha)	19.13	12.69	27.74	28.86
	Inhana Rational Farming with 8 ton Novcom Compost (IRF 2)	24.44	16.36		
	Novcom compost-3 (NOV-3) (@ 5.1 ton/ha)	22.99	12.18	105.42	158.67
	Inhana Rational Farming with 5.1 ton Novcom Compost (IRF 4)	47.22	31.50		
Biodynamic Farming (BD)	Biodynamic compost (BDS) (@ 10 ton/ha)	5.31	3.86	12.35	14.00
	Biodynamic Package of Practice (BD)	5.97	4.40		
Microbial Formulation	Vermicompost+ Biofertilizer (VCBF)	13.92	9.77	35.29	35.61
	Vermicompost+ Microbial Formulation for both Soil & Plant (VMI)	18.83	13.24		
	Vermi compost (VC) (@ 9.4 ton/ha)	9.90	7.16	66.91	57.42
	Vermicompost + Microbial Formulation for Plant (VMIP)	16.52	11.27		
Conventional Organic Practice	Indigenous compost-2 (FYM-2) (@13.5ton/ha)	11.05	8.36	-48.04	-51.34
	Indigenous compost + Conventional Organic Practice (CO)	5.74	4.07		
	Vermi compost (VC) (@ 9.4 ton/ha)	9.90	7.16	22.68	26.63
	Vermicompost + Conventional Organic Practice (VCO)	12.14	9.07		

Any increase in the value of AE_{CN} and RE_{CN} under organic package as compared to that obtained under only soil management indicated the positive influence of plant management towards activation of the physiological efficiency of plant. In general AE_{CN} was found to increase under comprehensive approach (i.e. application of both plant management and soil management practice as done under organic packages of practice) as compared to sole application of different soil inputs. The highest increase of AE_{CN} was influenced by Inhana plant management practice under IRF packages (105.42) followed by bio-pesticides and microbial growth promoter as applied under MI package (66.91). Increase of agronomic efficiency under application of microbial formulations indicated, that they were more suited for plant management as compared to soil quality development.

Higher value of AE_{CN} under IRF packages indicated most economic expense of compost- N for crop production. Agronomic efficiency of N can be increased by increasing plant uptake and decreasing N losses from the soil-plant system (Amanullah and Lal, 2009). Hence, the results obtained in these plots might be due to (i) improvement in soil-nutrient dynamics due to enhanced microbial proliferation and activity in these plots as influenced by the high self- generated microbial population within Novcom compost and (ii) activation of plant physiology due to application of energized and potentized botanical solutions under Inhana plant management practice.



**(-)ve observation in one set under conventional organic practice was omitted for average calculation.*

Fig.: Impact of plant management on nutrient use efficiency of mature tea under different organic packages.

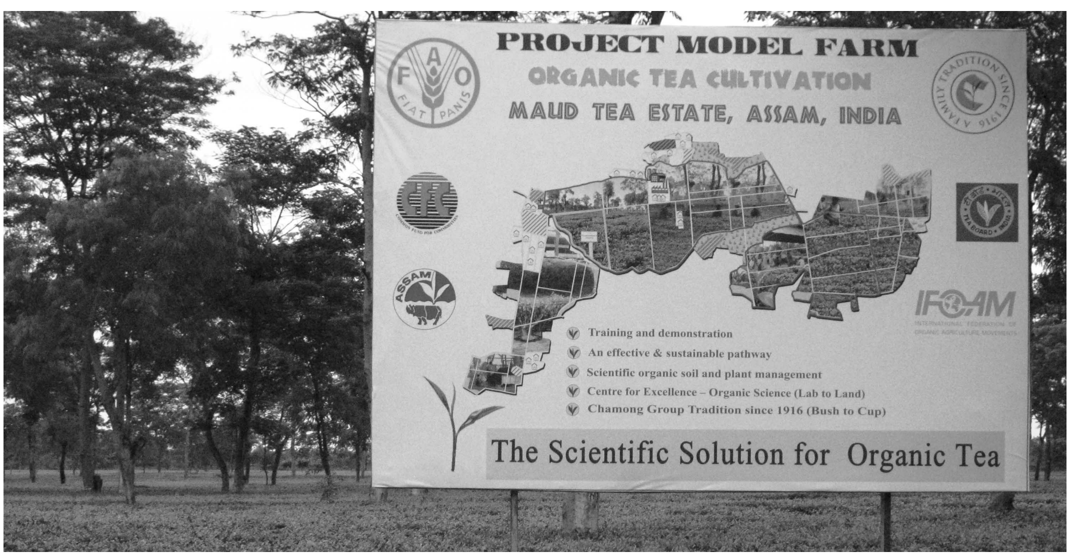
Apparent recovery efficiency (RE_{CN}) of applied compost N is defined as the amount of nutrient in crop as a ratio of the amount applied or available. The value depends largely on the degree of congruence between plant N demand and the available supply of N from applied fertilizer or organic N sources.

Consequently, optimizing the timing, quantity, and availability of applied N as well as activation of plant physiology is the key towards achieving high RE (Dobermann, 2005). RE_{CN} was also highest in case of IRF packages, which once again indicated an effective plant management programme leading to efficient soil-plant-nutrient dynamics.

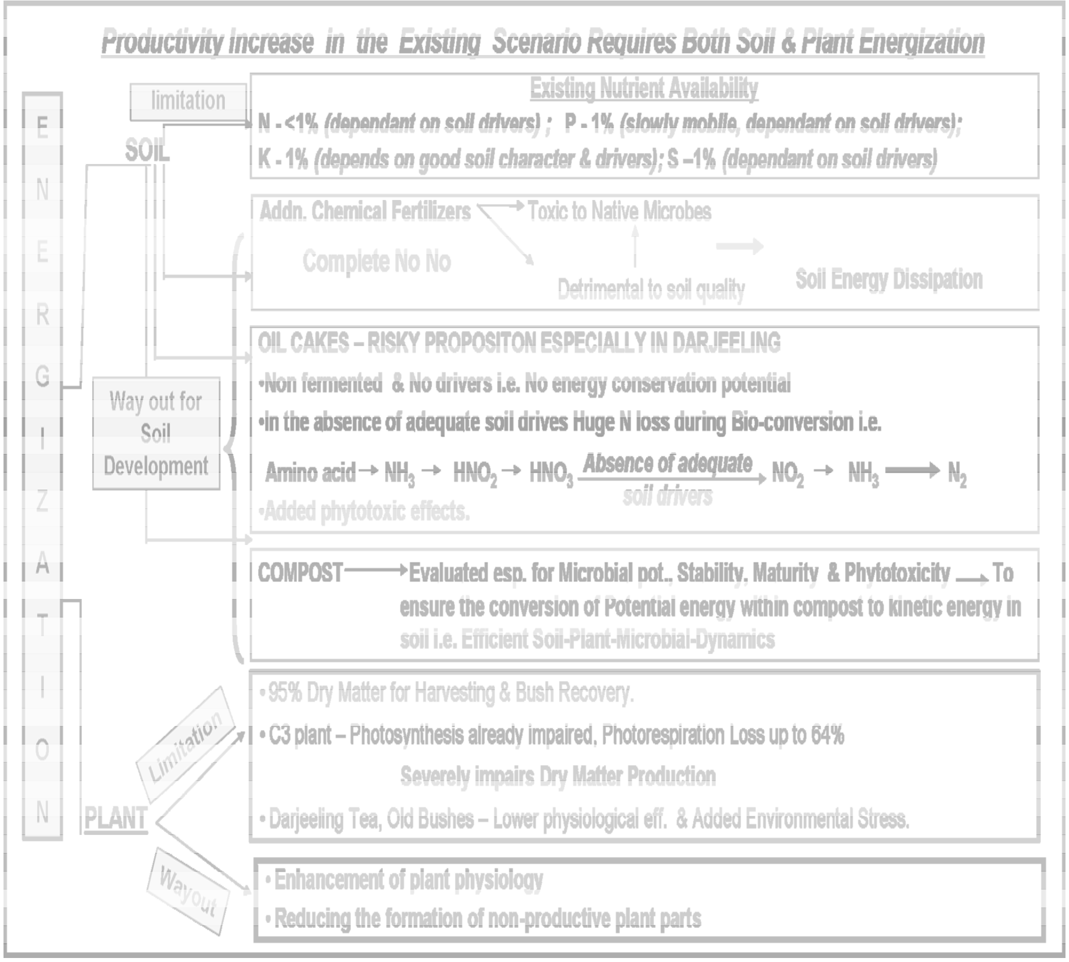
PATHWAY FOR SUSTAINABLE ORGANIC TEA PRODUCTION

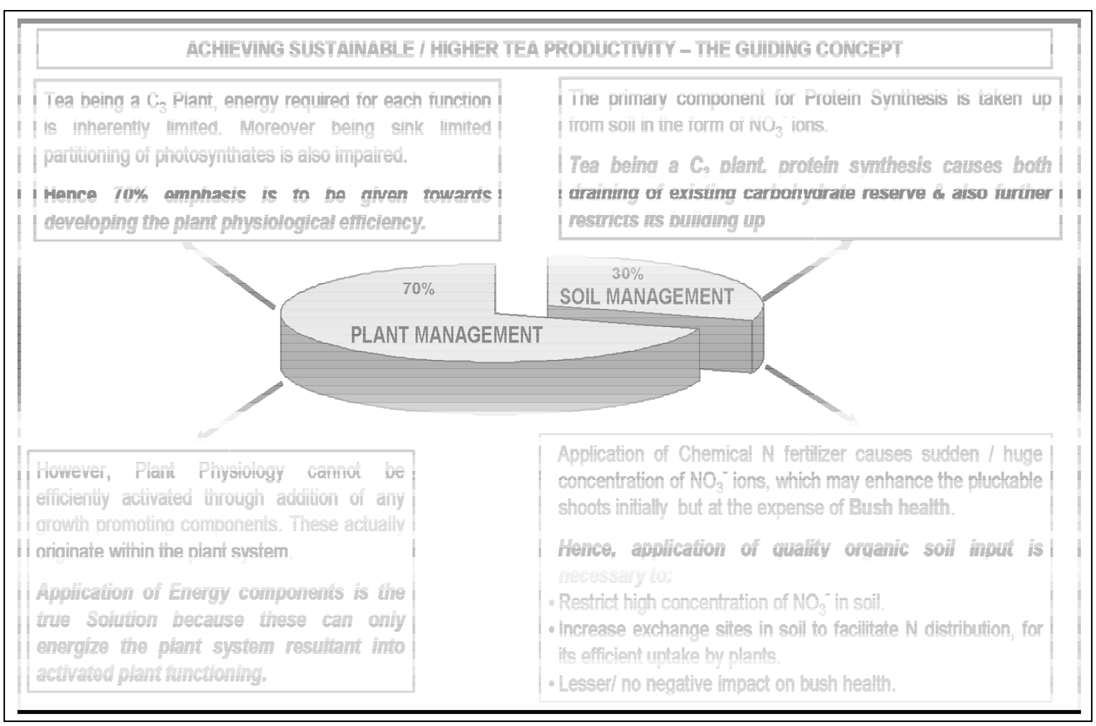
Hence, only a comprehensive approach in terms of effective soil management, activation of plant physiology and composite pest/ disease control can enable sustainable organic crop production. It is to be understood that the resources are not deficient; they have only become deactivated following few decades of harsh chemicalization. Hence, to re-activate the resources energization of the soil and plant system through a scientific organic approach is of prime requisition.

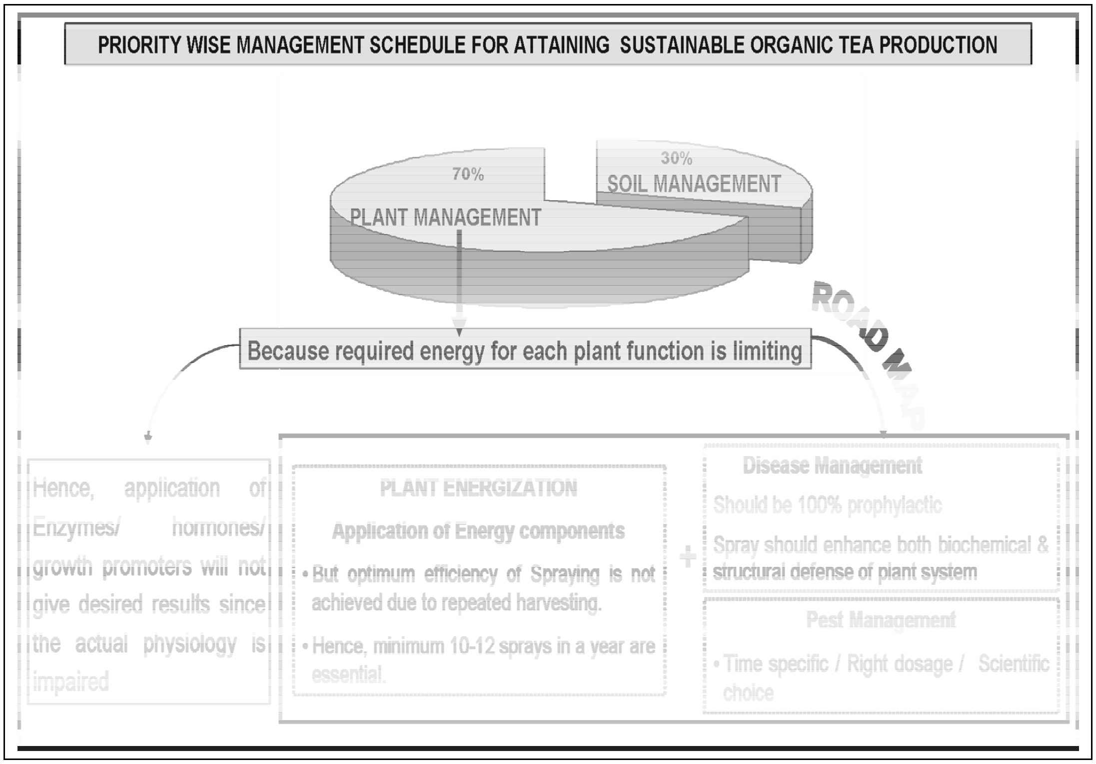
Effective organic soil management through application of good quality (with high nutrient and microbial status) stable, mature, non- phytotoxic organic amendment to ensure proper mineralization of nutrients, speedy soil rejuvenation and eventually an effective soil- plant- nutrient dynamics. Basic cultural practices like green manuring, mulching, in-situ composting, hand weeding etc. should also be essential components of an organic soil management programme.



FAO –CFC-TBI project was conducted at Maud T.E., Assam to find out a n effective pathway for Sustainable Organic Tea Production.


Productivity increase in the Existing Scenario Requires Both Soil & Plant Energization
ENERGIZATION
limitation
SOIL
Existing Nutrient Availability
N - <1% (dependant on soil drivers) ; P - 1% (slowly mobile, dependant on soil drivers);
K - 1% (depends on good soil character & drivers); S –1% (dependant on soil drivers)
Addn. Chemical Fertilizers
Toxic to Native Microbes
Complete No No
Detrimental to soil quality
Soil Energy Dissipation
OIL CAKES – RISKY PROPOSITON ESPECIALLY IN DARJEELING
•Non fermented & No drivers i.e. No energy conservation potential
•in the absence of adequate soil drives Huge N loss during Bio-conversion i.e.
Amino acid → NH_3 → HNO_2 → HNO_3 $\xrightarrow[\text{soil drivers}]{\text{Absence of adequate}}$ NO_2 → NH_3 → N_2
•Added phytotoxic effects.
Way out for Soil Development
COMPOST → Evaluated esp. for Microbial pot., Stability, Maturity & Phytotoxicity → To ensure the conversion of Potential energy within compost to kinetic energy in soil i.e. Efficient Soil-Plant-Microbial-Dynamics
• 95% Dry Matter for Harvesting & Bush Recovery.
• C3 plant – Photosynthesis already impaired, Photorespiration Loss up to 64%
Severely impairs Dry Matter Production
• Darjeeling Tea, Old Bushes – Lower physiological eff. & Added Environmental Stress.
Limitation
PLANT
Wayout
• Enhancement of plant physiology
• Reducing the formation of non-productive plant parts


ACHIEVING SUSTAINABLE / HIGHER TEA PRODUCTIVITY – THE GUIDING CONCEPT
Tea being a C_3 Plant, energy required for each function is inherently limited. Moreover being sink limited partitioning of photosynthates is also impaired.
Hence 70% emphasis is to be given towards developing the plant physiological efficiency.
The primary component for Protein Synthesis is taken up from soil in the form of NO_3 ions.
Tea being a C_3 plant, protein synthesis causes both draining of existing carbohydrate reserve & also further restricts its building up
70%
PLANT MANAGEMENT
30%
SOIL MANAGEMENT
However, Plant Physiology cannot be efficiently activated through addition of any growth promoting components. These actually originate within the plant system.
Application of Energy components is the true Solution because these can only energize the plant system resultant into activated plant functioning.
Application of Chemical N fertilizer causes sudden / huge concentration of NO_3^- ions, which may enhance the pluckable shoots initially but at the expense of Bush health.
Hence, application of quality organic soil input is necessary to:
• Restrict high concentration of NO_3^- in soil.
• Increase exchange sites in soil to facilitate N distribution, for its efficient uptake by plants.
• Lesser/ no negative impact on bush health.



At the same time plant management protocol towards enhancement of plant physiological efficiency should also be stressed at. This will not only ensure better nutrient assimilation and enhanced net photosynthesis leading to better bush health but also serve towards re-activation of natural host-defense mechanism of plants for better resistance against disease/pest incidence. A composite protocol for rejuvenation of plant system along with time specific control of pests with scientific choice of inputs shall ensure better bush health towards sustained and higher crop productivity.

EXPERIENCE FROM FAO-CFC-TBI PROJECT (2009 - 2011)

FAO-CFC-TBI Project (Period: 2009 to 2011, at Maud T.E., Assam) entitled 'Development, Production & Trade of Organic Tea' was an Endeavour to 'Find Out an Effective Pathway for Sustainable Organic Tea Production'

PROLOGUE

The experimentation taken up under FAO-CFC-TBI Project at Maud T.E. (Assam) is perhaps the most detailed, elaborate and exhaustive in nature where all available organic methods and organic inputs were evaluated (in the form of 'Packages of Practice') in terms of crop and soil sustainability and cost effectiveness.

Such unique documentation regarding different On-Farm Composting methods, preparation of Herbal Concoctions as well as all other practices related to organic tea production has been made for the very first time in the organic scenario.

In this project, the concept of Comprehensive Organic Method/ 'Package of Practice' was Introduced for the first time, because Organic means organized or systematic as an 'Organic Whole', where sustainability cannot be obtained by a fragmental approach.

To bring forth the 'Effective Organic Pathway' Organic Methods viz. Biodynamic farming & Inhana Rational Farming Technology, which are presently adopted and practiced in sizeable organic tea plantations, were taken up for scientific evaluation.

Although there are no other popular methods, a large number of organic Inputs viz. vermicompost, bio-fertilizer/ pesticides, herbal formulations etc. are also in wide use.

However, individually these inputs do not provide composite benefits and neither their individual evaluation can bring forth the desired pathway, hence they were combined to form different 'Packages of Practice' (based on scientific rationale) before taking up for effectivity assessment .

These Methods/ Packages were Evaluated for Comprehensive Effectivity under All Tea Growth Stages i.e. Nursery, New Plantation, Young Tea & Mature Tea.

The Project Findings shall ably provide the required answers related to organic tea cultivation.

BACKGROUND BEHIND SET UP OF EXPERIMENTAL PROTOCOL

Careful consideration of the project objectivity and the decade long experience in organic led Inhana Biosciences to perceive that to bring forth an effective organic pathway, the evaluation method has to be shifted from reductionist approach of conventional agriculture to the true science of more intuitive understanding of interrelatedness.

Conventional organic agriculture is viewed as just the absenteeism of chemical inputs and their replacement by their organic counterparts. But the principle being the same, there has been no interrelated functioning.

Due to such compartmental experiments and observation, till date despite elaborate assessment of organic inputs and formulation of newer ones, effective management of individual problems/ criteria in organic agriculture still remains unaccomplished. Thus there has hardly been any provision of a specific guideline or Road map, which can ensure sustainability of crop, soil and ecology.

Hence, the Concept of Comprehensive Organic Method/ 'Package of Practice' was Introduced for the first time, in the experimental protocol because Organic means organized or systematic as an 'Organic Whole'.

LOGIC BEHIND SELECTION OF TREATMENTS FOR EXPERIMENTATION

All the available organic methods were sourced, however; only the ones (i.e. Biodynamic Farming & Inhana Rational Farming Technology) that are presently used in a sizeable area or in a considerable number of organic tea plantations were taken up for evaluation.

The presently available organic inputs can be segregated into two criteria i) for soil application ii) for foliar application.

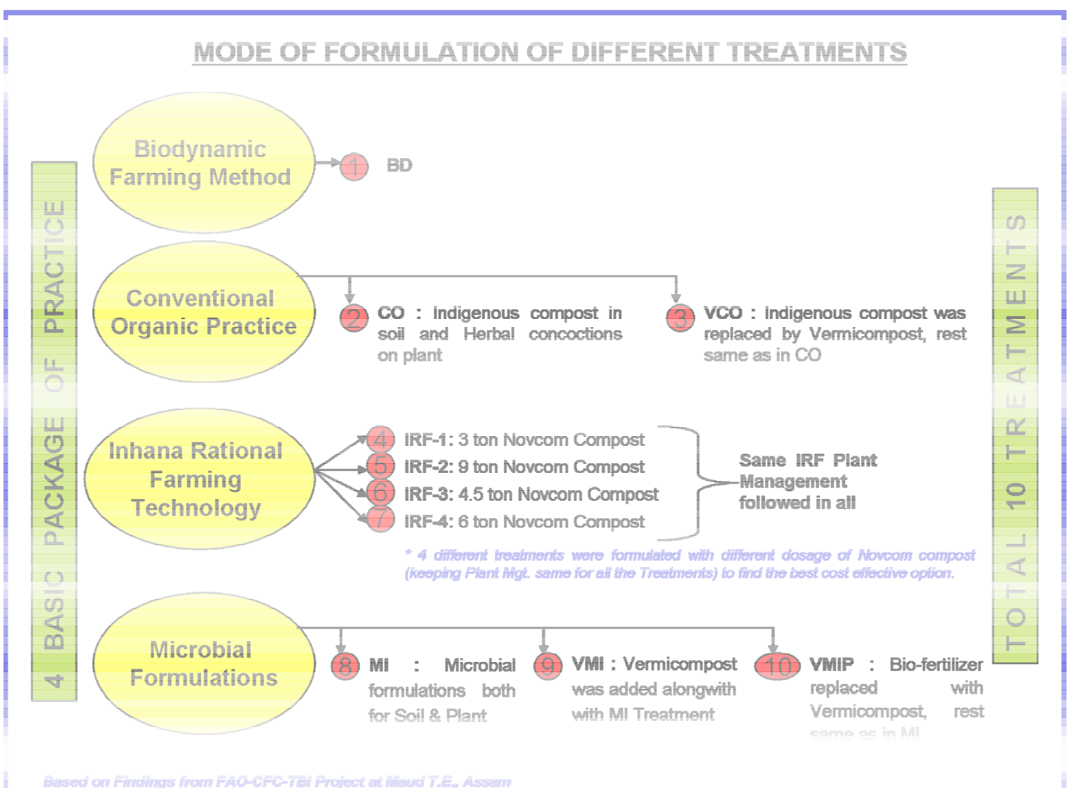
In the 1st category once again there are only three relevant options *viz.* vermicompost, Indigenous compost/ FYM and Bio-fertilizers. While the second category basically serves for pest and disease control through the use of various herbal concoctions and bio-pesticides.

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.

Finally all the methods/ 'Packages of Practice' were judged for their economic viability because a package even if effective, cannot be adopted on a large scale if the relative cost is very high.

The declined soil sustainability has invited the attention for organic soil management. Most interestingly, a healthy soil is most often thought the road map for agricultural sustainability. However, effective management of soil at a convenient cost in a time bound manner is still found to be unachievable through use of available organic soil inputs. The non-uniform quality and high cost especially in case of off- farm soil inputs (since on-farm production is most often compromised) are the major deterrent factors.

On- farm composting is undoubtedly the most appropriate option for organic soil management. At the same time, enough reports are not available regarding the quality and cost effectiveness of on-farm composting methods. Hence, different composting methods were taken up under the project for evaluation of their effectiveness towards convenience to adopt, bio-degradation period, CMI, -N appreciation potential and maturity (based on analysis), their effect on crop performance and impact on economics.



The objectivity of the experiment was to evaluate :

i) How quality of different organic soil inputs influences crop yield and soil quality.

ii) Whether better quality compost (based on analysis) in lower dosage can support crop yield without any soil mining; through rejuvenation of soil microbial population.

Soil samples were also collected from all Treatment plots and analyzed for physicochemical, fertility and microbial properties during each year before and 60, 90 and 150 days post application of soil inputs (i.e. total 10 times during 3 years project period).

Personnel from CFC-TBI visit the Organic model farm, Maud T.E. under FAO-CFC-TBI Project.

PERFORMANCE APPRAISAL OF THE ORIGINAL AVAILABLE PACKAGES i.e. BIODYNAMIC FARMING & INHANA RATIONAL FARMING

Two Original Packages available i.e. Biodynamic Farming (B.D) & Inhana Rational Farming (IRF) were taken for the study.

Comparative Performance of Original Packages under Different Stages of Tea Cultivation

Different Stages of Tea Cultivation	Original Package	
	B.D (With 10 tons of BD Compost)	IRF-2 (With 8 tons of Novcom Compost)
Nursery (Total 5 Treatments)	4th	1st
New Plantation (Total 7 Treatments)	5th	1st
Young Tea (Total 7 Treatments)	5th	1st
Mature Tea (Total 10 Treatments)	7th	1st
Soil Input (Total 10 Treatments)	9th	1st

- Though cost of BD Package is 3rd lowest but the poor crop performance in all stages of tea cultivation has resulted in very low Cost/ Effectivity Ratio.

- Since this performance has been achieved in the experimental area even after strict adherence to the guidelines, it is unlikely that this Package will show any improvement in large scale adoption.

- Most importantly, very poor result (only 85.2% Crop efficiency) of BD Compost in the Soil Input Experiment points out furthermore the limitation of this 'Package'.

- Inhana Rational Farming Technology (IRF) showed consistently best performance in all stages of tea cultivation, along with lowest cost. Novcom Compost also exhibited highest crop performance amongst all organic soil inputs in the most cost effective manner.

- Inhana Rational Farming Technology has also been evaluated in Maud T.E. in large scale adoption (i.e. approximately 130 ha area) for 3 years with 3 different types of soil inputs in each year, keeping IRF Plant Management common in all three years.

- After adoption of IRF, yield went up by 36 percent in 2011 (w.r.t. 2008). Whereas, Agronomic- N Efficiency (AEN in terms of 'Partial Factor Productivity') showed highest value in 2009 (62.6 kg made tea per kg N applied), under application of Novcom compost.

	2009		2010 & 2011	
	Crop gain over 2008 (kg)	Revenue Generated*	Net Crop Gain/ loss w.r.t. 2009	Revenue Generated
Maud T.E.	27,535	(+) Rs. 55.07 lakh	(+) 9,424	(+) Rs. 18.85 lakh
Sister Organic Garden	53,912	(+)Rs. 107.82 lakh	(-) 22,352	(-) Rs. 44.70 lakh

** Price of Made Tea @ Rs. 200/- per kg*

- Relevance of plant physiology was also clearly proved in the crop performance of Maud and another sister organic garden. Same soil input at the same rate were applied in the Maud T.E. and sister garden for 3 years, but while IRF plant management package was applied in Maud T.E for all 3 years, the same was adopted in sister garden in the 1st year (i.e. 2009) only.

Agronomic N Efficiency (AEN) decreased on replacing Novcom compost by Press mud compost and oil cake in 2010 and 2011 respectively. However, as compared to sister organic garden, the rate of decrease in AEN was much lower In case of Maud T.E., due to better plant N uptake efficiency under IRF plant management package.

EVALUATION OF PACKAGES BASED ON MICROBIAL FORMULATIONS WITH/ WITHOUT VERMICOMPOST

Three Packages were taken for evaluation with Microbial Formulations comprising of bio-fertilizers, bio- pesticides and plant growth promoters. These formulations are gaining importance both for agro-chemical companies and organic tea plantersk, but their effectivity have never been scientifically evaluated either singly or in combination.

While one treatment was with only Microbial Formulations for soil, plant & pest management (MI), two other treatments were formulated.

The second treatment was formulated by adding Vermi Compost (full dose) with Package of Microbial Formulation (MI) thereby naming it VMI. The objective was to observe additive effect on crop performance and to find out soil-plant relationship potential through combination of soil converters with Vermi Compost.

The third treatment was formulated to observe the crop performance potential with only vermi compost for Soil Management & Microbial Formulations for plant growth & particularly pest management, thus named as VMIP.

Comparative Performance of Formulated Packages under Different Stages of Tea Cultivation

Different Stages of Tea Cultivation	Formulated Package MI	VMI	VMIP
Nursery (Total 5 Treatments)	2nd	5th	N.T*
New Plantation (Total 7 Treatments)	7th	6th	N.T
Young Tea (Total 7 Treatments)	7th	2nd	N.T
Mature Tea (Total 10 Treatments)	8th	3rd	4th
Soil Input (Total 10 Treatments)	10th	3rd	N.T

*N.T : No Treatment

The possible cost increase in this full or part addition was purposefully over looked at the beginning with the intension to observe only their crop efficiency potential.

The table clearly signifies that Microbial Formulations (MI) as a Package can't be adopted/ recommended as an effective pathway for sustainable organic tea cultivation, as it appeared lowest amongst all packages, in all stages of experiments.

Role of microflora in soil development is well endorsed by science, but they must be self- generated because addition of selective strains shall not be desirably effective. Similarly, natural predators have role in pest or disease control but that again happens best when they occur naturally in the surrounding ecosystem.

Researches have revealed that artificially cultured microorganisms most often can't sustain fully in the newer environment due to nonacclimatization and thereafter whatever sustain can't multiply or take longer time to reach to the desired level. This has no relationship with crop harvest cycle and pest or disease cycle.

- VMI Package though performed much better among all the treatments with microbial formulations (except in Nursery & New Plantation), the cost per hectare being exorbitant can't be commercially recommended.

- More specifically it reveals that to achieve this crop performance, cost incurred was the highest, thus resultant into highest Cost/ Efficiency ratio.

- Moreover, the experiment showed that while the difference in crop performance between VMI & VMIP was only about 5% more, the difference in Package cost went about 44% higher.

- Hence, VMIP can be considered for its relatively better Cost/ Efficiency ratio but again that is also second highest package cost.

EVALUATION OF PACKAGES WITH ON-FARM PRODUCED HERBAL FORMULATIONS WITH FYM & VERMICOMPOST

Majority of the Organic Gardens use various herbal concoctions against pests & diseases. Indigenous compost (FYM) is often prepared on-farm in a scattered manner. But perhaps not a single organic garden solely depend on FYM for soil management or use only these herbal concoctions for pest/ disease control.

Thus, planters or tea community give their opinion on individual items based on their observational findings, but none have ever been evaluated in the proper scientific manner.

On the other hand, these concoctions mostly can be made on-farm with the commonly available herbs or plants, easy to prepare and low cost.

Hence, a Package on conventional organic (CO) with Indigenous Compost (FYM) for soil management and only herbal concoctions for pest/ disease control was taken as treatment.

Again, another Package was formulated by replacing FYM with Vermi Compost for soil management and herbal concoctions for pest & disease management (VCO), for the comparative evaluation of the effectivity of Vermi Compost over FYM.

Comparative Performance of Formulated Packages under Different Stages of Tea Cultivation

Different Stages of Tea Cultivation	Original Package	
	CO	VCO
Nursery (Total 5 Treatments)	3rd	5th
New Plantation (Total 7 Treatments)	3rd	2nd
Young Tea (Total 7 Treatments)	6th	4th
Mature Tea (Total 10 Treatments)	6th	5th
Soil Input (Total 10 Treatments)	7th	6th

- The experiments reveal that the package where Indigenous Compost was replaced by Vermi Compost (i.e. VCO) has performed comparatively better but insignificantly. For example in Mature Tea Experiment, VCO has shown only 4.4% higher crop efficiency but with 210% cost escalation.

- Therefore, the Cost/ Efficiency ratio of VCO became 36.5 as against only 12.9 of CO, i.e. almost two times higher. Since both the Packages could not meet the target crop with 92.8% & 89.2% crop efficiency, this increase in the cost has exhibited strong limitation of VCO Package for recommendation at large scale.

- Similarly, Conventional Organic Package (CO) also recommends about 13 tons of Indigenous Compost for three years average, with 20 tons in 1st year for meeting 1500 kg crop cycle, and even thereafter registered less than 90% crop efficiency.

- This seriously focuses the limitedness for adoption of Conventional Organic Package (CO) in spite of being low cost and convenient to adopt. Moreover, huge requirement of Indigenous Compost and 24 rounds of spray of different concoctions in a year also may be a point to note.

Dr. A. Seal with Ms. Joelle Kato, Programme Manager, IFOAM, Germany, inspecting Novcom Coompost Heap prepared at Maud T.E., Assam under FAO-CFC-TBI Project 'Development Production and Trade of Organic Tea' in November 2009.

PERFORMANCE & ECONOMICS OF THE TOP FIVE ORGANIC 'PACKAGES OF PRACTICE' UNDER DIFFERENT GROWTH STAGES OF TEA

MATURE TEA : Highest crop performance (in terms of made tea) was obtained in case of IRF- 2 (1374 kg/ ha) followed by IRF-4 (1369 kg/ ha), VMI (1299 kg/ ha), VMIP (1235 kg/ ha) and VCO (1158 kg/ ha) respectively. Among all the treatments only the first three

Rank	Package of Practice	Yield (kg/ha)	Crop Efficiency (%)		Cost / ha (Rs.)
			Over TY#	Over control	
1	Inhana Rational Farming with 9 ton Novcom Compost (IRF-2)	1374	113.3	45.20	13,796/-
2	Inhana Rational Farming with 6 ton Novcom Compost (IRF-4)	1369	110.0	44.80	11,302/-
3	Vermicompost + Microbial Formul. for Soil & Plant (VMI) *	1299	103.5	37.30	66,257/-
4	Vermicompost + Microbial Formulation for Plant (VMIP)	1235	98.9	30.50	46,832/-
5	Vermicompost + Conventional Organic Practice (VCO)	1158	92.8	22.40	40,184/-

 # TY : Target (1220 kg/ha)

viz. IRF-2, IRF-4 and VMI accomplished the target yield (crop efficiency: 113.3 %, 110.0 % & 103.5 % respectively) while VMIP performed just close to the target (98.9 %).

YOUNG TEA : IRF-2 showed the most promising results in terms of crop yield (made tea: 807 kgha^{-1}), which was 55.2 percent higher than

Rank	Packages of Practice	Yield (kg/ha)	% over control	Cost/ ha (Rs.)
1	Inhana Rational Farming with 9 ton Novcom Compost (IRF 2)	807	55.2	13,129
2	Vermicompost + Microbial Formulation for both Soil & Plant (VMI)	653	25.6	66,257
3	Inhana Rational Farming with 3 ton Novcom Compost (IRF 1)	619	19	8,485
4	Vermicompost + Conventional Organic Practice (VCO)	618	18.8	40,023
5	Biodynamic Package of Practice (BD)	593	14.1	14,377

control and about 25.6 percent higher than the next best performing package of practice i.e. VMI (made tea: 653 $kgha^{-1}$). Cost incurred per ha followed the same trend as in mature tea experiment, being lowest in case of IRF-1 (Rs. 8,485/ ha) followed by CO (Rs. 12,792/ ha), IRF-2 (Rs. 13,129/ ha) and BD (Rs. 14,377/ ha).

NEW TEA PLANTATION : Crop yield was 48 percent higher than control in case of IRF with 9 ton Novcom compost (IRF2), followed by VCO and IRF-1 both recording about 34 percent higher crop than

Rank	Packages of Practice	Yield (kg/ha)	% over control	Cost/ ha (Rs.)
1.	Inhana Rational Farming with 9 ton Novcom Compost (IRF 2)	956	48.1	12,596
2.	Inhana Rational Farming with 3 ton Novcom Compost (IRF 1)	870	34.7	7,952
3.	Vermicompost + Conventional Organic Practice (VCO)	868	34.4	39,759
4.	Indigenous compost + Conventional Organic Practice (CO)	760	17.7	13,825
5.	Biodynamic Package of Practice (BD)	695	7.7	14,270

control respectively. Another significant finding is that although crop performance under IRF-2 was only about 13 percent higher than VCO, it was obtained at a comparatively lower cost (lower by 68 percent).

NOTE : *Cost of vermicompost was taken as Rs. 4.0/- per kg. On-farm Vermicomposting programme was taken up at Maud T.E. for the production of quality compost, in order not to compromise the yield or soil development results, under the project. The cost of on-farm vermicompost varied between Rs. 2.40/- and Rs. 2.60/-per kg. However, large scale vermicompost production could not be carried out due to the huge infrastructure requirement, which was beyond the scope of the project. This forms a practical limitation in case of tea plantation where even a small garden of about 100 ha shall be requiring a minimum quantity of 250 to 300 ton even when applied in combination with other available organic soil inputs . Hence, off-farm vermicompost was sourced and quality was ensured through random quality analysis of the samples. Good quality compost as used under thr project came at a cost of Rs. 4.0/- per kg.*

KEY FINDINGS FROM FAO- CFC- TBI PROJECT, MAUD T.E.

- Activated plant physiology is the key for sustainable organic tea cultivation.
- Activated Plant Physiology & Energized Soil System complements each other in optimum resource management, towards sustainable crop performance.
- Here, Quantitative increase of soil inputs only jack up the cost but never provide similar incremental benefit on crop productivity.
- In case, Off-Farm soil input is concentrated organic manure (oil cake); it has to be necessarily added with quality compost to minimize its harmful effect and increase its nutrient utilization efficiency.
- An effective plant management package should be complimented with Off– Farm soil inputs for lowering the risk, avoiding losses & increasing the revenue by enhancing plant physiological efficiency.

The findings Corroborate that Only an Organic Pathway that Works Towards Activation of Plant Physiology and Enables Restoration/ Proliferation of Native Soil Microflora can Ensure Sustainable Organic Tea production

WHAT SHOULD BE THE OBJECTIVITY OF ORGANIC SOIL & PLANT MANAGEMENT

Objectivity of Soil Management : *A dynamic soil system with adequate nutrition towards effective soil-plant relationship. This can be readily achieved by increasing the Soil Microbial Status to 10^7 c.f.u. or higher.*

Objectivity of Plant Management : *Activation of plant physiology leading to restoration of two lost qualities of plant system i.e. Sense of Self-Nourishment & Self- Protection.*

RECOMMENDATIONS BASED ON FINDINGS FROM FAO-CFC-TBI PROJECT AT MAUD T.E. (ASSAM)

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.

Inhana Biosciences being the research organization dedicated in organic for more than one decade developed Rational Farming Technology to unveil the true science of organic, not just for commercial reasons. Hence, the organization wants to share its technology only with the tea gardens dedicated to organic.

Two more packages i.e. VMIP and VCO also have potentials, but they are to be re- formulated eliminating the limitations and thereby enhancing their crop and cost effectiveness.

Evaluation of their performance reveals that if their soil management component can be improved in terms of post soil application effectivity with lower cost, then they can be recommended for organic tea cultivation.

Thus, vermicompost may be replaced by Novcom compost in VMIP & VCO packages keeping the respective plant management protocol unchanged. Hence these packages coined as NMIP and NCO respectively will cost approx. Rs. 18,293/- and Rs. 11,854/- per hectare i.e. 60% and 70% lower than VMIP & VCO packages respectively.

At the same time it is presumed from interpreting the experiments that the newly formulated packages will certainly maintain their performance, if not higher. But a multi-centric trial can conclusively prove this.

ASSAM TEA PLANTATIONS – EXISTING ORGANIC OR FOR ORGANIC CONVERSION - Choice I

Inhana Rational Farming (IRF) as found to be the best Cost-Effective Package (113% crop efficiency with Lowest Cost) under FAO-CFC-TBI Project

YEAR I

Considering 1500 kg Made Tea (or 6521 kg green leaf)/ha in Unpruned, as Yield Target

SOIL MANAGEMENT:

Criteria : Ideally Soil Resource Map and Crop requirement should be considered for the fixation of soil input dose. However, this is not possible in the 1st year. Hence……

Considering the importance of Nitrogen for Tea plants, the compost/ soil input dose shall be calculated on the basis of Garden Target Yield. This can be determined by the difference between highest and lowest Crop yield of the garden during last 5 years. As for example if highest yield of a garden is 1500 kg/ha, the lowest yield will be not less than 20% i.e. 1200 kg/ ha.

N requirement = [Difference of yield (300kg)/ 0.23 (made tea recovery %)]/ Agronomic Efficiency of Applied N

Since the cost of soil input comprises 2/5th to 4/5th of the total cost of production, to achieve the desired cost effectivity soil input is the most crucial factor. Hence, Soil Management can be done using:

i) On-Farm Produced Novcom Compost *[Also found to be best cost-effective as compared to vermicompost, Biodynamic compost and Indigenous (FYM) compost; in 'Soil Input Expt.' under the Project]*

ii) Conc. organic manure (oil cake) + On-Farm Novcom compost [*Addn. of compost provide the enrichment of microflora, which is nil in oil cake & to counteract any toxicity generated from oil cake*]

PLANT MANAGEMENT:

Spraying Schedule of various Inhana Solutions (10 to 12 rounds in a calendar year) for activation of plant physiology and host defense mechanism.

PEST/ DISEASE MANAGEMENT:

Pest management primarily through neem and karanj products/ oils/ concoctions.

Agronomic Efficiency of Applied N (AE_N)- Formula & Value under Different Treatments

AE_N = (Yield treatment - Yield control)/ Applied N treatment

AE_N under Novcom compost = 21 (*as found from 'Soil Input Expt.' in Mature Tea under the Project*)

AE_N under Inhana Rational Farming (IRF) = 36 (*as found from 'Packages of Practice.' Expt. under the Project*)

AE_N under Oil Cake = 10.4 (*as found from 'Soil Input Expt.' in Mature Tea under the Project*)

Basis for Calculation of Compost/ Soil Input Dose

Considering 1500 kg/ha as highest yield of a garden, the lowest yield will be minimum < 20% i.e. 1200 kg/ha.

I. In case of adoption of IRF along with On-Farm produced Novcom Compost

N requirement = [Yield Difference/ 0.23 (made tea recovery %)]/ Agronomic Efficiency of Applied N under Novcom compost

= (300/ 0.23)/21 = 62 kg N

Therefore Novcom compost Dose = 8 ton (approx.) considering 2% N & 60% moisture in compost

Adoption of IRF Package i.e. Novcom Compost for soil application along with IRF Plant Management Package as per recommendation can enable the lowering of compost dose after a period of 3 to 4 years, as indicated by the higher (36) AE_N under complete IRF Package.

Hence N requirement will be (300/ 0.23)/36 = 36 kg N

Therefore Novcom compost dose can be reduced to only 4.5 ton approx. i.e. by almost 50 percent

II. <u>Adoption of IRF in case without Sufficient Resources for required Novcom compost</u>

In case of insufficient resources for required Novcom compost production Oil cake can be applied, considering that they are mostly available with high N content. Moreover, due to negligible moisture content it is a relatively less freight intensive product.

<u>In case of Oil cake</u> :

N requirement = [Yield Difference/ 0.23 (made tea recovery %)]/ Agronomic Efficiency of Applied N under Oil cake

= (300/ 0.23)/10.4 = 125 kg N

Therefore Oil Cake Dose = 3 ton (approx.) considering 4% N in oil cake, with negligible moisture

However, Sole Application of Oil Cake is Not At All recommended due to following limitations:

i) Having no microbial population, oil cake has no role in soil rejuvenation, which is considered to be the primary objective behind application of an organic soil input.

ii) Being a high source of N, with no inherent microbial potential, post soil application it causes an initial N robbing from soil.

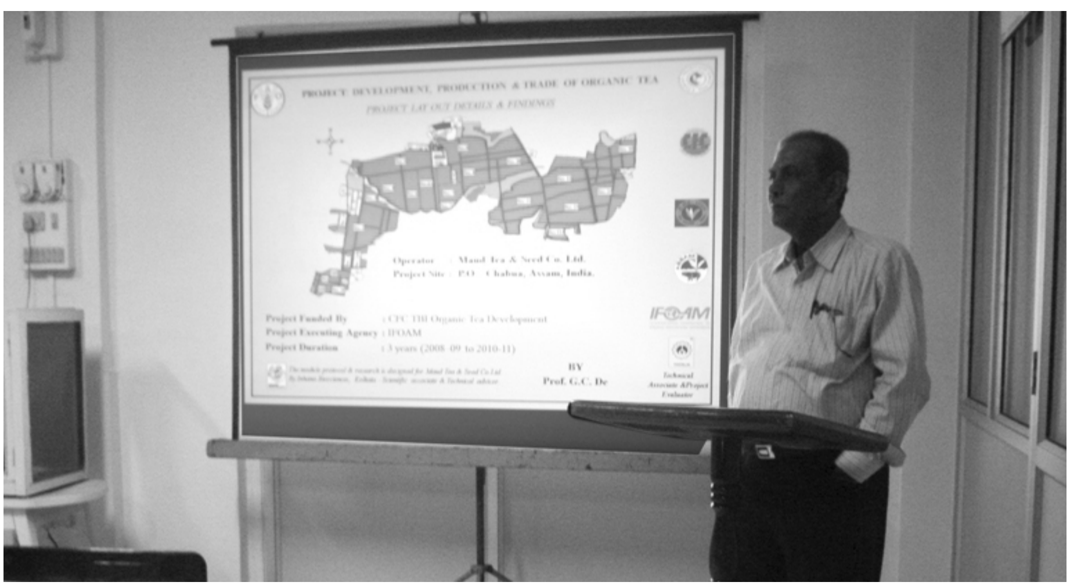
iii) Being a non-composted product, initiation of its biodegradation post soil application releases various inorganic acids and NH_4^+ compounds, which can be phytotoxic.

Hence, Novcom Compost is suggested for addition with Oil Cake at a ratio of 2 : 2.

2 ton Oil cake + 2 ton Novcom compost will enable more or less even mixing, in order to ensure :

i) Immediate Initiation of nutrient mineralization from oil cake in the presence of adequate moisture and huge self- generated microbes within compost.
ii) Minimize the potential for nutrient loss from oil cake during its intense mineralization process.
iii) Mitigate any toxicity generated from oil cake.

Moreover, Reduction of Oil Cake dose from 3 to 2 ton will enable to cut down the expense on soil input by 22%, even after addition of 2 ton Novcom compost.



Prof. G.C. De, member of Advisory team & Co-editor presented the progress of the Project under FAO-CFC-TBI Project at Maud T.E.

Approximate Cost of Inputs for Organic Crop Production under Inhana Rational Farming (IRF)

Example : Considering Highest yield of a Garden is 1500 kg/ha & Lowest yield is 1200 kg/ ha, considering that difference between highest & lowest yield will be not less than 20%

Management Schedule	Cost / ha
1st OPTION : Rational Farming along with 100% On-Farm Novcom Compost	
8.0 ton Novcom compost + 40 kg Elemental- S + 80 kg Rock Phosphate per ha Various Inhana Solutions for plant management. Pest/ disease mgt. on actual basis (based on FAO project Exp.). This may reduce gradually.	Rs.9,000/- Rs.2,500/- Rs.2600/- to 3400/- (approx.)
Total Cost : Rs. 14,100/- to 14,900/- (approx.) Dose of Novcom compost can be reduced upto 50% under adoption of complete IRF package after 3-4 years	
In Case of insufficient resources for Required On-Farm Compost Production **2nd OPTION:** Rational Farming Technology (Plant Mgt.) along with conc. organic manure (@ Rs. 6.0/kg) + On-Farm Novcom compost @ 2:2 ratio	
2 ton Oil cake + 2 ton Novcom compost/ ha Various Inhana Solutions for plant management. Pest/ disease management on actual basis	Rs.14,000/- Rs.2,500/- Rs.2600/- to 3400/- (approx.)
Total Cost : Rs. 19,100/- to 19,900/- (approx.)	

Recommendation	Year II	Year III
Soil Management :	Recommendation will be given only on the basis of Soil Analysis Data + Ist year crop performance	Required Dose of Input should decrease. But will be recommended only on the basis Ist & 2nd year crop performance
Plant Management :	Same as Year I	Same as Year I
Pest/ Disease Management :	On Actual Basis	On Actual Basis

Though Inhana Rational Farming Technology exhibited Consistent and Best Performance in the most Cost Effective manner but its success depends on Strict Adherence of the Guidelines. Hence, for practical consideration, Inhana Biosciences wishes to offer Two Other Organic Packages

ASSAM TEA PLANTATIONS – EXISTING ORGANIC OR FOR ORGANIC CONVERSION - Choice II

Novcom compost for Soil + Microbial formulations for Plant Management (NMIP)

LOGIC for NMIP : VMIP (Vermicompost + Microbial Formulations for Plant Management) was found to be 2nd best (i.e. after IRF packages) with 99% crop efficiency (w.r.t. Target Yield) under FAO-CFC-TBI Project. Soil input cost using vermicompost was Rs. 37,600/-, while cost for plant & pest disease management was approx. Rs. 9,232/- ; **Total Cost being Rs. 46,832/- per hectare**. Moreover agronomic N efficiency (AE_N) under vermicompost (AE_N : 10) is only about 50% of AE_N of Novcom compost.

Approximate Cost of Inputs for Organic Crop Production under NMIP Packagel of Practice.

Management Schedule	Cost / ha
Ist OPTION : Novcom Compost + Microbial formulations for Plant Management	
8.0 ton Novcom compost + 40 kg Elemental- S + 80 kg Rock Phosphate per ha	Rs. 9,000/-
Microbial formulations for Plant Management, which comprise growth promoter and bio-pesticides.	Rs. 9,293/- (approx.) (Might increase in case of higher infestation)
Total Cost : Rs. 18,293/- (approx.)	
In Case of insufficient resources for Required On-Farm Compost production **2nd OPTION:** Conc. organic manure (Oil cake @ Rs.6.0/kg) + On-Farm Novcom compost @ 2:2 ratio with Microbial formulations for Plant Management.	
2 ton Oil cake + 2 ton Novcom compost/ ha	Rs.14,000/-
Microbial formulations for Plant Management, which comprise growth promoter and bio-pesticides.	Rs. 9,293/- (approx.) Might increase in case more rounds of bio-pesticides is required for higher infestation
Total Cost : Rs. 23,293/- (approx.) **CROP EFFICIENCY CANNOT BE ENSURED & COST MAY FURTHER INCREASE in case of Higher Infestation**	

In this respect data generated from 'Soil Input Experiment' under the Project; revealed 12% more crop efficiency under Novcom compost, at almost 5 times lower cost than vermicompost (even when considered at lowest price of Rs. 4/- per kg). Hence, logically **if vermicompost in VMIP package is replaced by Novcom compost, it will certainly not lower the relative crop efficiency, if not more.**

Recommendation	Year II	Year III
Soil Management :	Recommendation will be given only on the basis of Soil Analysis Data + Ist year crop performance	Required Dose of Input should decrease. But will be recommended only on the basis Ist & 2nd year crop performance
Plant Management :	Fixed rounds of Growth promoter & Bio-pesticides both as per Fixed Rounds + On Actual Basis	Fixed rounds of Growth promoter & Bio-pesticides both as per Fixed Rounds + On Actual Basis

On the other hand total package cost will come down 3 times lower, i.e. approx. Rs. 17,187/-.

Hence, NMIP though not tested as a Package; but is recommended based on individual findings from 'Packages of Practice' & 'Soil Input Experiment' under the Project. Moreover, VMIP was a formulated Package, to observe the combined effectivity of vermicompost with microbial formulations for plant. Hence, vermicompost can be certainly replaced by Novcom compost.

NOTE :

To Ensure the Crop Efficiency at an Affordable Cost On-Farm produced Novcom Compost shall be the Best Option.

Novcom compost for Soil + Conventional Organic Package for Plant Management (NCO)

LOGIC for NCO : VCO (Vermicompost + Conventional Organic Package for Plant Management) was found to be 3rd best (i.e. after IRF packages) in terms of 93% crop efficiency (w.r.t. Target Yield) under FAO-CFC-TBI Project. But the soil input being vermicompost, incurred a cost of Rs. 37,600/- while cost for plant & pest disease management was approx. Rs. 2,584/- ; Total Cost being Rs. 40,184/-. Moreover agronomic N efficiency (AEN) under vermicompost (AEN :10) is only about 50% of AEN of Novcom compost.

Data generated from 'Soil Input Experiment' under the Project; revealed 12% more crop efficiency under Novcom compost at almost 5 times lower cost when compared with vermicompost (considered @ Rs. 4/- per kg). Hence, logically **if vermicompost in VCO package is replaced by Novcom compost, certainly it will not lower the respective crop efficiency, if not more.**

Moreover, total package cost will come down approx. 4 times lower i.e. approx. Rs. 10,478/-.

Hence, NCO though not tested as a Package but is recommended based on individual findings from 'Packages of Practice' & 'Soil Input Expt.' under the Project; and also because suggested concoctions (under CO) use commonly available herbs & are easy to prepare on- farm.

However, it is to be noted that only 93% crop efficiency was obtained under VCO treatment (as exhibited in the Project), and that too under 26 rounds of recommended sprays. **Since, there is**

only 78% effectivity against pest, hence extra caution to be taken while adopting the package.

Approximate Cost of Inputs for Organic Crop Production under NCO Packaes of Practice

<table>
<tr><th>Management Schedule</th><th>Cost / ha</th></tr>
<tr><td colspan="2">1st OPTION : Novcom Compost + Conventional Organic Package for Plant Management</td></tr>
<tr><td>8.0 ton Novcom compost + 40 kg Elemental- S + 80 kg Rock Phosphate per ha
Conventional Organic Package for Plant Management, which comprise concoctions for pest & disease control.</td><td>Rs. 9,000/-
Rs. 2,584/- (approx.) (Might increase in case of higher infestation.)</td></tr>
<tr><td colspan="2">Total Cost : Rs. 11,584/- (approx.)</td></tr>
<tr><td colspan="2">In Case of insufficient resources for Required On-Farm Compost production
2nd OPTION: Concentrated organic manure (Oil cake @ Rs.6.0/kg) + On-Farm Novcom compost @ 2:2 ratio with Conventional Organic Package for Plant Management.</td></tr>
<tr><td>2 ton Oil cake + 2 ton Novcom compost/ ha
Conventional organic package for Plant Management, which comprise concoctions for pest & disease control.</td><td>Rs.14,000/-
Rs. 2,584/- (approx.) (Might increase in case of higher infestation.)</td></tr>
<tr><td colspan="2">Total Cost : Rs. 16,584/- (approx.)
CROP EFFICIENCY CANNOT BE ENSURED & Cost may Increase in case of Higher Infestation</td></tr>
</table>

Recommendation		Year II	Year III
Soil Management	:	Recommendation will be given only on the basis of Soil Analysis Data + Ist year crop performance	Required Dose of Input should decrease. But will be recommended only on the basis Ist & 2nd year crop performance
Plant Management	:	Both as per Fixed Rounds + On Actual Basis	Both as per Fixed Rounds + On Actual Basis

NOTE : Ensure the Crop Efficiency at an Adaptable Cost On-Farm produced Novcom Compost shall be the Best Option.

DARJEELING TEA PLANTATIONS – Existing Organic or for Organic Conversion

Darjeeling tea plantations suffer from added limitations of very low soil depth, fertile top soil loss due to soil erosion, low soil microbial activity as well as adverse weather conditions in terms of temperature, light etc.

Moreover in organic gardens long term application of organic matter of varied nature along with slow soil microbial activity has increased the Bulkiness of Soil leading to Very Slow Nutrient Dynamics.

Even under existing limitations more than 50 percent of the Darjeeling gardens are organic and ultimately the rest 50 percent will also go for organic conversion due to increasing compulsion.

Hence, the downhill going productivity in these organic gardens comes as no surprise, because compartmental approach of the present organic methods fail to attend the inherent and specific problems of the Darjeeling plantations, which further aggravates the limitations suffered by Tea as a C_3 plant. **In the absence of specific guidelines, Yield and Economic Sustainability remains a far fetched objective.**

Hence, Sustainable organic Tea Production in Darjeeling can be achieved only through Activation of Plant Physiology, which should be given prime Emphasis along with restoration of Soil Dynamism, primarily through application of good Quality compost.

While Biodynamic package and Microbial formulations provide plant growth promoting agents, none of the organic method/ Packages of Practice work towards enhancement of plant physiological efficiency, except Inhana Rational Farming (IRF).

Hence, existing organic gardens or the ones willing to go for Organic Conversion can Adopt Inhana Rational Farming (IRF) as found to be the best Cost- Effective Package (113% crop efficiency with Lowest Cost) under FAO-CFC-TBI Project

Recommendation for 500 kg Made Tea/ ha as Yield Target

YEAR I

SOIL MANAGEMENT:

Criteria : Soil analysis followed by assessment of Soil Quality Index (SQI) and finally Soil Resource Map should be considered along with the Crop nutrient requirement towards fixation of soil input dose. However, this is not possible in the 1st year. *Hence* Considering the importance of Nitrogen for Tea plants, the compost/ soil input dose shall be calculated on the basis of 5% N of Garden Target Yield.

As for example for Target Yield of 500 kg/ha; N requirement = 25 kg/ ha

Due to slow nutrient dynamics, which calls for reconstitution of the native soil microflora, application of good quality compost is of prime consideration. At the same time cost of soil input comprises 2/5th to 4/5th of the total cost of inputs. Hence, to achieve soil rejuvenation along with desired cost effectivity, soil input is the most crucial factor. Thus, Soil Management can be done using:

i. **On-Farm Produced Novcom Compost** *[Also found to be best cost-effective as compared to vermicompost, Biodynamic compost and Indigenous (FYM) compost; in Soil Input Experiment Under the Project]*

ii. **Conc. organic manure (oil cake) + On-Farm Novcom compost @ 1:2** [*Addn. of compost is important to provide the enrichment of microflora, which is practically nil in oil cake + to counteract any toxicity generated from oil cake*]

PLANT MANAGEMENT:

Spraying Schedule of various Inhana Solutions (minimum 10 to 12 rounds in a calendar year) for the activation of plant physiology and host- defense mechanism.

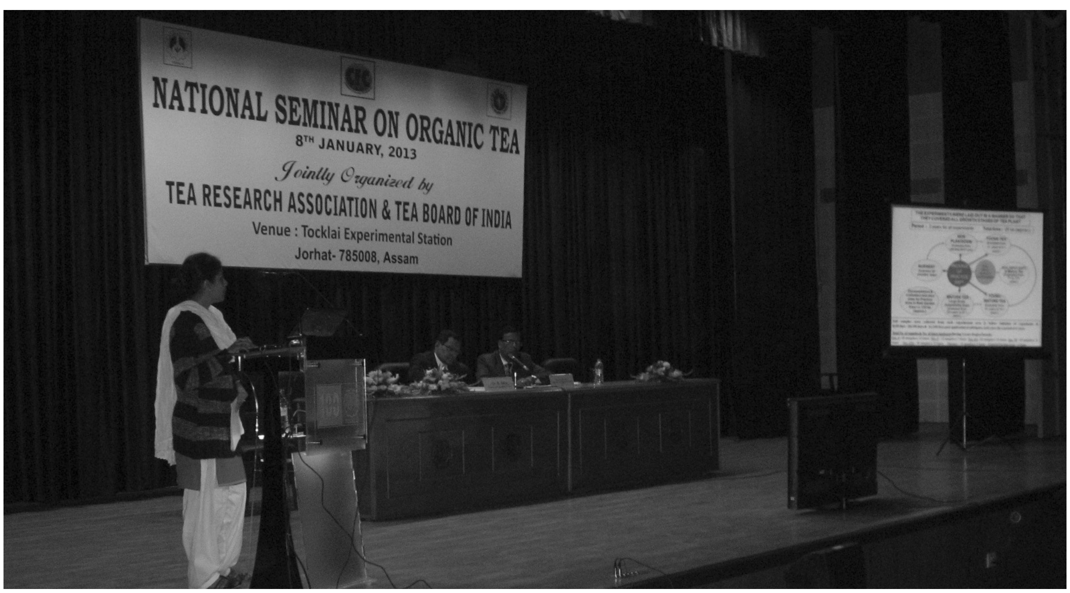
PEST/ DISEASE MANAGEMENT:

Pest management primarily through neem and karanj products/ oils/ concoctions.

Approximate Cost of Inputs for Organic Crop Production under Inhana Rational Farming (IRF).

Yield Target (Made tea)	Management Schedule	Cost / ha
1st OPTION : Rational Farming along with On-Farm Novcom Compost		
500 kg/ ha	**4.0 ton Novcom compost/ ha** for supplying 25 kg N/ ha **+ 40 kg Elemental- S + 80 kg Rock Phosphate per ha**	Rs.5,000/-
	Spraying of various Inhana Solutions for plant management.	Rs.2,500/-
	Pest/ disease management on actual basis (based on FAO project Exp.). This may reduce gradually.	Rs.2,600/- to 3,400/-(approx.)
	Total Cost : Rs. 10,100/- to 10,900/- (approx.)	
In Case of insufficient resources for Required On-Farm Compost production		
2nd OPTION: Rational Farming Technology (Plant Management) along with concentrated organic manure (@ Rs.6.0/kg) + On-Farm Novcom compost @ 1:2 ratio		
500 kg/ ha	**1 ton Oil cake + 2 ton Novcom compost/ ha**	Rs.8,000/-
	Spraying of various Inhana Solutions for plant management.	Rs.2,500/-
	Pest/ disease management on actual basis	Rs.2600/- to 3400/- (approx.)
	Total Cost : Rs. 13,100/- to 13,900/- (approx.)	

Recommendation		Year II	Year III
Soil Management	:	Recommendation will be given only on the basis of Soil Analysis Data + Ist year crop performance	Required Dose of Input should decrease. But will be recommended on the basis Ist & 2nd year crop performance + Soil Resource map/ Soil Quality Index.
Plant Management	:	Same as Year I	Same as Year I
Pest/ Disease Management		On Actual Basis	On Actual Basis



Dr. A. Seal Presented the research findings of FAO-CFC-TBI project at Maud T.E. in National Seminar on Organic Tea at Jorhat.

BIBLIOGRAPHY

Adesemoye A. O. & Kloepper J. W. (2009). Plant–microbes interactions in enhanced fertilizer-use Efficiency, Appl Microbiol Biotechnol (2009) 85:1–12

Altieri, M. A. and Nicholls C. I. (2003). Soil fertility management and insect pests: harmonizing soil and plant health in agroecosystems. Soil & Tillage Research 72 (2003) 203–211

Amanullah and Lal K.A. 2009. Partial Factor Productivity, Agronomic Efficiency, and Economic Analyses of Maize in Wheat-Maize Cropping System in Pakistan. presentation at the Southern AgriculturalEconomics Association Annual Meetings, Atlanta, Georgia,January31- February 3 , 2009.Page1-26. Available in http:// ageconsearch. umn.edu/bitstream/ 46747/2/amansaea09a.pdf

Ananthacumaraswamy, A., M.S.D. Lakshmie and P.A.N. Punyasiri. (1988). Effect of inter-planting dadaps (Erythrina lithosperma) in tea (Camellia sinensis) on soil physical properties of an Ultisol. Sri-Lanka J. Tea Sci. 57(1): 11-15.

Baildon (1877). Pamphlet written by Samuel Baildon, and published by W.Newman and Co. of Calcutta (Original not seen).Cross reference: Tea. Available in http://wikipedia.atpedia.com/en/articles/t/e/a/Tea.html (dated 31.01.2013)

Barbora, B.C. and A.K. Biswas (1996). Use pattern of pesticides in tea estates of North East India. Two and A Bud, 43, 4-14.

Barlog P, Grzebisz W (2004) Effect of timing and nitrogen fertilizer application on winter oilseed rape (Brassica napus L.). II. Nitrogen uptake dynamics and fertilizer efficiency. J Agron Crop Sci 190:314–323

Barua, D. (1990). Effect of long term application of Nitrogen Fertiliser on yield of tea. Two Bud, **37(1)** : 1-3.

Basu Majumder A., Bera B. and Rajan, A. (2010) Tea Statistics: Global Scenario. *Inc. J. Tea Sci.* **8** (1): 121-124

Bora, S., A. Rahman, M. Sarmah and G. Gurusubramanian (2007a). Relative toxicity of some commonly used insecticides against tea looper caterpillar, Buzura suppressaria Guen (Geometridae : Lepidoptera) and its effect on food consumption and utilization. Int. J. Trop. Agric., 25, 257-265.

Bora, S., M. Sarmah, A.Rahman and G. Gurusubramanian (2007b) Relative toxicity of pyrethroid and non-pyrethroid insecticides against male and female tea mosquito bug, Helopeltis theivora Waterhouse (Darjeeling strain). J. Ent. Res., 31, 37-41.

Borthakur, M., A. Rahman, M. Sarmah and G. Gurusubramanian (2005). Predators of phytophagous mites of tea (Camellia sinensis) in North East India. In: Proceedings of 2005 International symposium on innovation in tea science and sustainable development in tea industry, 11-15 November, 2005, Hangzhou, China. pp. 749-755 (2005a).

Chaboussou, F., (1985) (English 2004 trans.), Healthy Plants, A New Agricultural Revolution, Jon Carpenter, Charlbury, UK.

Conway, G.R., Pretty, J., (1991). Unwelcome Harvest: Agriculture and Pollution. Earthscan, London.

Das, A.K. (2009). SUSTAINABILITY IN TEA INDUSTRY: An Indian Perspective. Available in www.nits.ac.in/ department/Humanities%20new /new_hum/.../2.doc

De Costa, W.A.J.M., Mohotti, A.J. and Wijeratne, M.A. (2007). Ecophysiology of tea. Braz. J. Plant Physiol., 19(4) : 299-332.

Dobermann, Achim R., "Nitrogen Use Efficiency – State of the Art". 2005. Agronomy -- Faculty Publications. Paper 316. http:// digitalcommons. unl.edu /agronomyfacpub /316

Fred, F. (1991). Pesticides and the Environment. MISSOURI-COLUMBIA.

Fukushi, S., Minami, K. and Ishigaki, K. (1984). Potential denitrification rate in heavily fertilized kuroboku tea soil. Bull. Natl. Tea Res. Inst., 60, 37 – 41.

Gurusubramanian G., Rahman A., Sarmah M., Ray S. and Bora S. (2008). Pesticide usage pattern in tea ecosystem, their retrospects and alternative measures. J. Environ. Biol., 29(6), 813-826 (2008)

Gurusubramanian, G., M. Borthakur, M. Sarmah and A. Rahman (2005) Pesticide selection, precautions, regulatory measures and usage. In : Plant protection in tea (Eds.: A.K. Dutta, G. Gurusubramanian and B.K. Barthakur). Assam Printing Works Private Limited, Tocklai Experimental Station, TRA, Jorhat, Assam, India. pp. 81-91.

Gyaneshwar P, Kumar GN, Parekh LJ, Poole PS (2002) Role of soil microorganisms in improving P nutrition of plants. Plant Soil 245:83–93

Hayatsu, M (1993). Soil microflora and microbial activities in acid tea soils. Bull. Natl Res. Inst. Veg., Omam. Plants Tea, B, 6, 73.

Huber D. M. (2010).Ag chemical and crop nutrient interactions –current update. Available in http://www.fluidfertilizer.com/ Forum%20Presentations/ 2010/ 2010%20Forum%20Proceedings /Don%20Huber.pdf (Download 31st January, 2013)

Huber DM (1989) Introduction. In: Engelhard AW (ed) Soilborne plant pathogens : management of diseases with macro-and microelements. St Paul, Minn : APS Press, pp 1-8

Huber DM and Graham RD (1999) The role of nutrition in crop resistance and tolerance to diseases. In: Rengel Z (ed) Mineral nutrition of crops : fundamental mechanisms and implications. New York : Food Products Press, pp 169-206

Jerome, J.J. (2013). Organic Farming & Biodynamic Agriculture Training resource book. Available in http://www.sameti.org/ ORGANICFARMING/ 12%20Pest%20and %20Disease% 20Control %20in% 20Organic%20 and%20 Biodynamic%20 farming. pdf (Download 31st January, 2013).

Kanampiu, F.K., W.R. Raun, and G.V. Johnson. (1997). Effect of nitrogen rate on plant nitrogen loss in winter wheat varieties. J. Plant Nutr. 20:389-404.

Katsunori, S., . (2003). Sustainable and environmentally sound land use in rural areas with special attention to land degradation: APFED.

Lampkin, N., (1990). Organic Farming. Farming Press Books, Ipswitch, UK.

LIU Yu, ZHANG, J.-b., & DU, J. (2009). Factors Affecting Reduction of Fertilizer Application by Farmers: Empirical Study with Data from Jianghan Plain in Hubei Province.Network for Substainable Agriculture. A Brief History of IPM.

McGuiness, H., (1993). Living Soils: Sustainable Alternatives to Chemical Fertilizers or Developing Countries. Consumers Policy Institute, New York.

Merrill, M.C., (1983). Eco-agriculture: a review of its history and philosophy. Biol. Agric. Hort. 1, 181–210.

Nioh, I., Isobe,T. and Osada, M. (1993). Microbial biomass and some biochemical characteristics of a strongly acid tea field soil. Soil Sci. Plant Nutr., 39, 617-625.

Oelhaf, R.C., (1978). Organic Agriculture. Halstead Press, New York.

Olsen, S.R. and Sommers L.E., 1982. Phosphorus. In page, R.H. Miller and D.R. Keeney. Methods of soil analysis. Part 2: Chemical and microbiological properties. Second Edition, Soil Sci. Soc. Am. Inc., pp: 581-893.

Othieno, C.O. (1975). Surface run-off and soil erosion on fields of young tea. Trop. Agric. 52 (4) : 299-308.

Phelan, P.L., Mason, J.F., Stinner, B.R., (1995). Soil fertility management and host preference by European corn borer, Ostrinia nubilalis, on Zea mays:

a comparison of organic and conventional chemical farming. Agric. Ecosyst. Environ. 56, 1–8.

Rabalais NN, Turner RE, Wiseman WJ Jr, Dortch Q (1998) Consequences of the 1993 Mississippi River flood in the Gulf of Mexico. Regul Rivers Res Mgmt 14:161–177

Rahman, A., M. Sarmah, A.K. Phukan, S. Roy, S. Sannigrahi, M. Borthakur and G. Gurusubramanian (2005b). Approaches for the management of tea mosquito bug, Helopeltis theivora Waterhouse (Miridae : Heteroptera). In: Proceedings of 34th Tocklai Conference – Strategies for Quality. (Eds.: A.K. Barooah, M. Borthakur and J.N. Kalita). Tocklai Experimental Station, TRA, Jorhat, Assam, India. pp. 146-161 (2005b).

Rodriguez H, Fraga R (1999) Phosphate solubilizing bacteria and their role in plant growth promotion. Biotchnol Adv 17:319–339

Senapati, B.K., Lavelle,P., Panigrahi,P.K., Giri, S. and Brown, G.G. (2002). Restoring soil fertility and enhancing productivity in Indian Tea plantations with earthworm and organic fertilizers. International Technical Workshop on Biological Management of Soil ecosystems for sustainable Agriculture, Brazilian Agril. Resrch Corp, Brazil, 182, 172-190.

Sharpley AN, Weld JL, Beegle DB, Kleiman PJA, Gburek WJ, Moore PA Jr, Mullins G (2003) Development of phosphorus indices for nutrient management planning strategies in the United States. J Soil Water Conser 58:137–152

Spann T. M. and Schumann A. W. (2012). Mineral Nutrition Contributes to Plant Disease and Pest Resistance. Publication HS1181. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida Available in https://edis.ifas.ufl.edu /pdffiles/HS/HS118100.pdf. (Download 20th September, 2012).

Steiner, R. (1924). In "Agriculture: A Course of Eight Lectures". Rudolph Steiner Press/Biodynamic Agriculture Association, London.

Tilman D (1998) The greening of the green revolution. Nature 396 : 211 –212

Vitousek PM, Aber JD, Howarth RW, Likens GE, Matson PA, Schindler DW, Schlesinger WH, Tilman DG (1997) Technical report: human alteration of the global nitrogen cycle: sources and consequences. Ecol Appl 7:737–750.

ANNEXURES

Treatment Details of VMIP Package of Practice

SOIL MANAGEMENT

Application of Vermicompost at the rate 9.4 ton/ ha.

To supply 60 kg N that is required for 1500 kg crop target, considering 1.74 % N and 54.3 % moisture in compost- as per analytical data.

PLANT MANAGEMENT

Sl.No.	Microbial Inoculants		Criteria
1.	*Verticillium lecani*	:	For Aphids control
2.	*Paeciilomyces fumosoroseus*	:	For Red Spider Mite (RSM control)
3.	*Beauveria bassiana*	:	Control wide spectrum of insects.
4.	*Combination of Bacillus, Pseudomonas, Azotobacter and Azospirillum*	:	Growth promoter Application : March-April, April-May, July-August and August-September.
5.	*Trichoderma viride*	:	For Poria control
6.	*Metarhizium anisopliae*	:	Termite Control

Verticillium lecani, Paeciilomyces fumosoroseus & Beauveria bassiana was either given singly or in combination depending upon the Protocol suggested for single or mixed infection. Total 17 rounds were given, which included pest management and growth promotion.

The Protocol has been taken from the Group, which has developed the above Microbial Formulations.

****Note :** Growth Promoter is applied @ 250ml/ha & rest of the solutions were applied @ 500 ml/ha

Treatment Details of VCO Package of Practice

SOIL MANAGEMENT

Application of Vermicompost at the rate 9.4 ton/ ha.

To supply 60 kg N that is required for 1500 kg crop target, considering 1.74 % N and 54.3 % moisture in compost- as per analytical data.

PLANT MANAGEMENT

Sl. No.	Herbal concoctions	Pest/ Disease control & Rate of Application	No. of rounds given
1.	Polygunam hydropiper(PHC)	Red spider and other Mites (25 ltr./ha)	8
2.	Piro onio/ Bitter Fern (POC)	For Thrips, Green Fly, Helopeltis and other minor insects (25 ltr./ha)	Not available on-farm
3.	Ind-Safari (ISC) [fish waste & cow urine concoction]	All Insect Pests and Caterpillars (2.5 kg/ha)	1
4.	Garlic & Red Chilly (GCC)	All types of insects (5 kg/ha)	5
5.	Vitex negundo (nigandhi) [VNC]	Helopeltis and All Insects (25 ltr./ha)	2
6.	Copper Fungicide	Blister Blight (-)	-
7.	Equizitam (Horse Tail) Or Rice Husk (ERHC)	Blister Blight, Black Rot, any other fungal disease (5 ltr./ ha)	Not available on-farm
8.	Clerodendron infortunatum concoction (CIC).	Insecticidal and fungicidal properties. Ideal for Blister Blight and Insects (250 ltr./ ha)	8
9.	Artimisia vulgaris (titapatti) [AVC]	Mainly works as repellent and does not have much knock down effect (20 kg/ ha)	Applied with all others except, ISC
10.	Neem Seed Concoction (NSC).	All Insect Pests (12.5 ltr./ ha)	Not available on-farm

Total 24 rounds of spraying was done. All the sprays were for pest/ disease control Application was done as per Protocol of the Advisor of Conventional Organic Management

Treatment Details of IRF Package of Practice

SOIL MANAGEMENT

Application of Novcom Compost at the rate 8.0 ton/ ha.

To supply 60 kg N that is required for 1500 kg crop target and considering 2.19 % N and 56.7 % moisture - as per compost analytical data.

Novcom compost was applied after mixing with 40 kg Elemental- S and 80 kg Rock Phosphate per hectare.

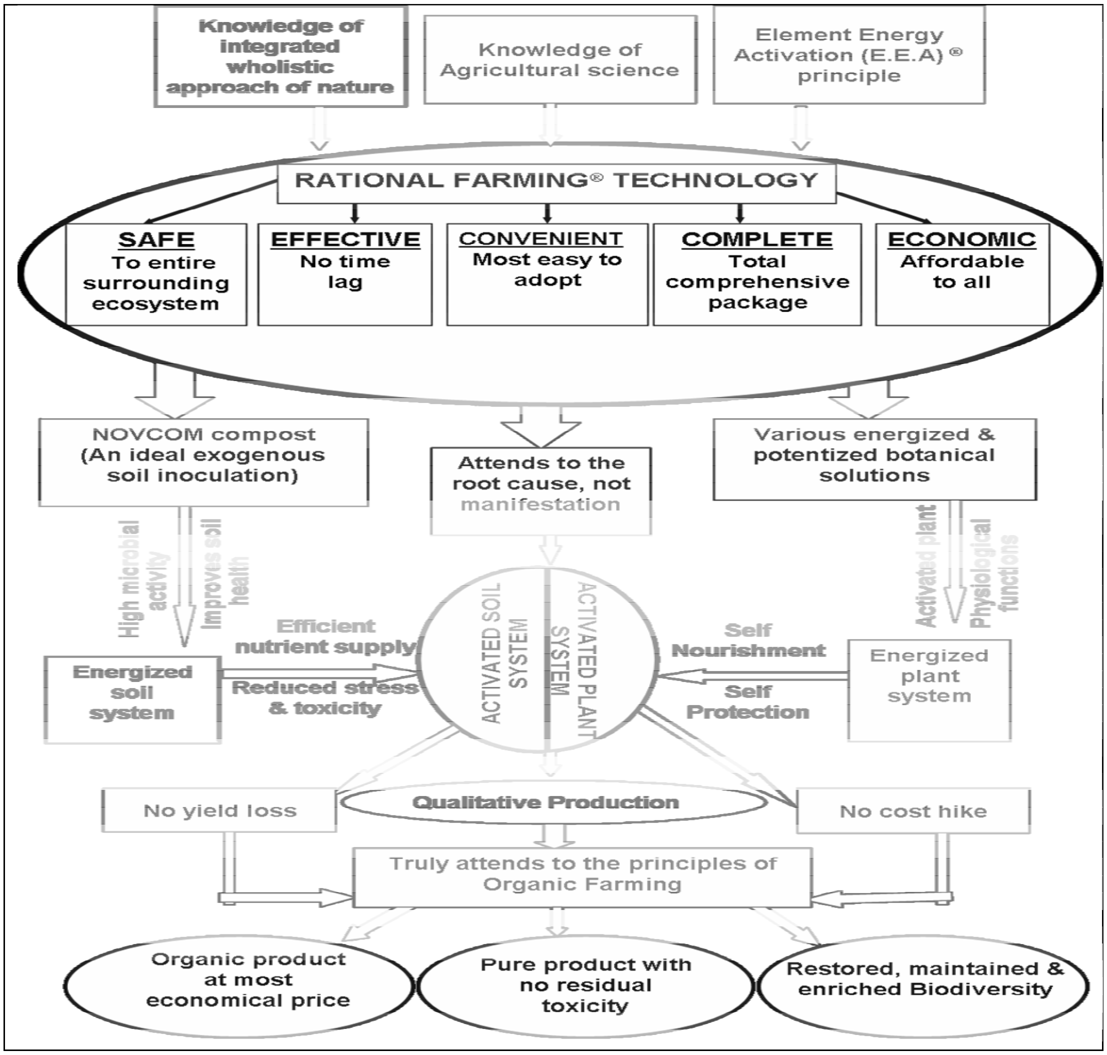
<table>
<tr><th colspan="2">Plant Management (For Plant Physiology Development)</th><td rowspan="11">Total 23 rounds of spraying was done. 13 rounds for activation of plant physiology and 10 rounds for pest/ disease control.

However, in the General Garden Area (130 ha approx.) of Maud T.E. where IRF was adopted in 2009 and continued till 2011, Total 17 Rounds of spraying was done. 6 rounds for pest/ disease control and rest for plant development.</td></tr>
<tr><td>IB 1 (Samridhi)</td><td>IB 7 (Solution PP 5)</td></tr>
<tr><td>IB 2 (Immunosil)</td><td>IB 8 (Atermit)</td></tr>
<tr><td>IB 3 (OrganiK)</td><td>IB 9 (ZXN)</td></tr>
<tr><td>IB 4 (OrganiN)</td><td>IB 10 (Special Solution I)</td></tr>
<tr><td>IB 5 (Solution I)</td><td>IB 11 (Special Solution II)</td></tr>
<tr><td>IB 6 (Solution II)</td><td>IB 12 (Special Solution III)</td></tr>
<tr><th colspan="2">Plant Management (For Pest/ Disease Management)</th></tr>
<tr><td>IB 13 (Sp. Immunosil)</td><td rowspan="3">Neem & Karanj oil concoctions in combination with Jay Vijay were primarily used for Pest Management</td></tr>
<tr><td>IB 15 (CDS - F)</td></tr>
<tr><td>IB 19 (Jay Vijay)</td></tr>
</table>

All the IB Solutions (except IB 15) were applied at the rate of 500 ml/ ha. IB 15 was used for preparation of charged cow dung concoction. Neem & Karanj oil was applied at the rate of 4 & 2 ltr./ ha repectively.

Application of solutions were done as per the Protocol of Inhana Biosciences

Working Mechanism of Inhana Rational Farming® Technology (IRF)



PROCESS FLOWCHART OF INHANA SOLUTIONS UNDER E.E.A PRINCIPLE

Selection of specific plants (Specific days and time)

Radiant energy from the Basic Life force (Solar Energy) is stored in plants. As the specific energies are stored in specific parts of the different plants, selection of the plants or more precisely selection of specific plant parts are most important. Not only that, specific days and time are also important as the energy storage potential of the plants varies with lunar cycle and the occurrence of various stars & planets. So the astronomical parameters are important to extract maximum stored energy.

Alcoholic Extraction (Specific plant parts in specific time and procedure)

Specific plant parts viz. roots, stem, leaf, root hair, leaf vein etc. are taken for extraction as early as possible from the collection time, before the living parts become inert and stored radiant energy is dissipated. Since the energy components are extremely subtle and abstract in nature and simultaneously they need a medium (matter). Hence after / during extraction they should be transferred to a medium which is less gross and the same time has higher surface tension. Ethyl alcohol is used for the extraction process because it has the potential to isolate the bound energy in gross form and store within it.

Energization (Isolation of Energy Components)

Energization is the process through which energy components are isolated from its gross form and stabilized in alcoholic medium. Both extraction and energization process operates simultaneously as the extracted gross components should be immediately transferred to a medium from which these can be liberated easily. The total energization procedure continues for several days up to 21 days to extract maximum stored energy to this medium. Still only a part of the stored energy can be isolated from its plant source.

Potentization (Release of Bind Energy in order of 10^3 to 10^4 times)

Potentization is the process through which the extracted bind energy is activated to erform in desired order when applied in plants. In this process specific energy is transformed to its nearly original form or more specifically as it was transformed to differential energy from Basic Life Force. This form is Lifetron, which are much subtler than electron, proton or atom. The bind energy manifests when it is separated from the binding agents. In this process the medium used is pure filtered water free from heavy particles. The potentization is done in the order of 10^3 to 10^4 times according to the individual energy components and the specific objectives. Potentized energy components are actually in the binding form but are separated from other differential energy and posses a huge liberating potential than its previous stage.

Combination of the Energized and Potentized extracts

Combination of these potentized and energized extract are done according to the specific objectivity of the solutions. As all solutions have regulatory role and no inhibitory action, these are applied to regulate specific plant functions in desired and successive order. These solutions try to solve any problem attending to the root cause and not the manifestation.

When the various Inhana Solutions are applied on the plant system they enter primarily through the stomatal opening and are naturally accepted by the plant system because of their primary (Subtler) form. Thereafter, they can reach to the desired sight more quickly as no transformation of that energy form is required.

COMPOSITION OF SOLUTIONS USED UNDER INHANA RATIONAL FARMING (IRF) PACKAGES OF PRACTICE.

Sl. No.	Solution code	Name of the solution	Biologically activated & potentised extract of
1.	**IB 1**	**SAMRIDHI**	Hyoscyamus niger, Ficus benghalensis and Dendrocalamus strictus Nees.
2.	**IB 2**	**IMMUNOSIL**	Ocimum sanctum, Calotropis procera R. and Cynodon dactylon
3.	**IB 3**	**ORGANIK**	Adhatoda vasica Nees, Zingiber officinale Roscoe and Embellia ribs.
4.	**IB 4**	**ORGANIN**	Calotropis procera R., Dendrocalamus strictus Nees and Bombax malabaricum D. C.
5.	**IB 5**	**SOLUTION I**	Cynodon dactylon and Calotropis gigantea
6.	**IB 6**	**SOLUTION II**	Hyoscyamus niger and Solanum verbascifolium
7.	**IB 7**	**PP5**	Ocimum sanctum
8.	**IB 8**	**ATERMIT**	Solanum verbascifolium, Prosopis spicigera and Ocimum bascilicum.
9.	**IB 9**	**ZXN**	Albizia maranguises, Tinospora crispa and Erythrina variegate Linn.
10.	**IB 10**	**SPECIAL SOLUTION I**	Costus speciosus sm. and Tylophora indica mer.
11.	**IB 11**	**SPECIAL SOLUTION II**	Solanum xanthocarpum schrad and Aristolochia indica Linn.
12.	**IB 12**	**SPECIAL SOLUTION III**	Sida cordifolia Linn. and Berberis asiatica Roxb. Ex. De.
13.	**IB 13**	**SPECIAL IMMUNOSIL 1**	Ficus racemosa Linn. and Calotropis procera R.
14.	**IB 15**	**CDS - F**	Veronica cinerea Less. and Solanum verbascifolium (Root and stem)
15	**IB 19**	**JAYVIJAY**	Bombax malabaricum D.C., Calotropis procera R. and Ocimum bascilicum.
16	**IB 31**	**NOVCOM**	Cynodon dactylon, Ocimum bascilicum and Sida cordifolia Linn.

COST COMPONENTS OF DIFFERENT ORGANIC PACKAGES OF PRACTICE STUDIED AT MAUD T. E., ASSAM UNDER FAO – CFC – TBI PROJECT.

Table 1 : Cost components and Total Cost of **Inhana Rational Farming 2 (IRF 2)** Packages of Practice.

Target Yield : 1500 kg/ha (UP)	Crop Efficiency : 113.34 % (Avg.)
Period of Study : 3 years (2009-2011)	(Over Target yield)
Pruning : UP- Corrected LP- UP	Rank : 1st (Out of 10)

Sl No.	Inhana Rational Farming Package (IRF 2) Inputs	Application	Total Cost/ha
Soil Management			
1.	Novcom Compost	Average 8.0 ton/ha @ Rs. 860 /ton (Based on actual N value on dry weight.)**	Rs. 6880/-
2.	Rock Phosphate (RP)	80 kg RP/ha mixed with Novcom compost	Rs. 360/-
3.	Elemental Sulphur (E-S)	40 kg /ha E-S mixed with Novcom compost	Rs 556/-
4.	Cowdung slurry (CDS)	200 ltr CDS /ha for ground application	Rs 98/-
Plant Management			
5.	Various Inhana Solutions for activation of plant physiology.	About 12 rounds average/year @ 500 to 1000 ml solution (each) /ha /round	Rs 2,500/-
7.	Micronized sulphur (MS) and Jay Vijay (JV) concoction	On an average 600 ml MS and 500 ml of JV was used for pest mgt, average 2 round in a year	Rs. 202/-
6	Neem oil (NO), Karanj Oil (KO) and Jay Vijay (JV) concoction	On an average 4 ltr of NO, 2 ltr. of KO and 500 ml of JV was used for pest mgt, average 8 round in a year	Rs 3200/-
Total Inhana Rational Farming (IRF 2) Package cost per ha			**Rs 13,796/-**

** Based on 9.4 ton/ha (*considering standard value of 2 % N & 60 % moisture*) the package cost would be Rs.15,000/- i.e. 17.50 % efficiency in the cost.

Table 2 : Cost components and Total Cost of **VMIP** Packages of Practice**.**

Target Yield	: 1500 kg/ha (UP)	Crop Efficiency	: 98.88 % (Avg.)
Period of Study	: 3 years (2009-2011)	(Over Target yield)	
Pruning	: UP- Corrected LP- UP	Rank	: 6th (Out of 10)

Sl No.	VMIP Inputs	Application	Total Cost/ha
Soil Management			
1.	Vermi Compost	Average 9.4 ton compost/ha @ Rs. 4000/ton	Rs 37, 600/-
Plant Management			
2.	Bio-NPK (combination of *Bacillus*, Pseudomonas, Azotobacter and Azospirillum	250 ml per ha and 4 times in a year	Rs 475/-
3.	Combination of *Verticiliium chlamydosporium*, *Beauveria bassiana* and *Paeciilomyces fumosoroseus*	500 ml per ha (each) and 5 times in a year	Rs 5437.5/-
4.	Combination of *Verticiliium chlamydosporium* and *Beauveria bassiana*	500 ml per ha (each) and 2 times in a year	Rs 1450/-
5.	Combination of *Verticiliium chlamydosporium*, and *Paeciilomyces fumosoroseus*	500 ml per ha (each) and 2 times in a year	Rs 1450/-
6.	*Trichoderma viride*	250 ml per ha once in pruned & skipped year	Rs 56/-*
7.	*Paeciilomyces fumosoroseus, Verticiliium chlamydosporium and Metarhizium anisoliae per ha.*	500 ml per ha once in pruned & skipped year	Rs. 363/-*
Total VMIP input cost per ha			**Rs. 46,832/-**

Note : *Paeciilomyces fumosoroseus, Verticiliium chlamydosporium, Metarhizium anisoliae and Trichoderma viride spray (1 round each) was only recommended in pruned & skipped year.*

* Total cost incurred in one year is divided in 3 years to derive average cost.

Table 3 : Cost components and Total Cost of **VCO** Packages of Practice.

Target Yield : 1500 kg/ha (UP)	Crop Efficiency : 92.83 % (Avg.)
Period of Study : 3 years (2009-2011)	(Over Target yield)
Pruning : UP- Corrected LP- UP	Rank : 7th (Out of 10)

Sl No.	VCO Inputs	Application	Total Cost/ha
Soil Management			
1.	Vermi Compost	Average 9.4 ton compost/ha @ Rs. 4000/ton	Rs 37,600/-
Plant Management			
2.	Polygunam hydropiper (PHC) and Artimisia vulgaris (AVC) concoction	@ 25 ltr. concoction of PHC and 20 ltr. concoction of AVC in 500 ltr. water/ ha 8 times in a year	Rs 176/-
3.	Clerodendron infortunatum (CIC) and Artimisia vulgaris (AVC) concoction	@ 250 ltr. concoction of CIC and 20 ltr. concoction of AVC in 500 ltr. water/ ha, 10 times in a year	Rs 1350/-
4.	Garlic and red chilli(GCC) and Artimisia vulgaris (AVC) concoction.	@ 5 ltr. Concoction of GCC and 20 ltr. concoction of AVC in 500 ltr. water/ ha, 5 times in a year	Rs 1078/-
5.	Vitex negundo (VNC) and Artimisia vulgaris (AVC) concoction.	@ 25 ltr. concoction of VNC and 20 ltr. concoction of AVC in 500 ltr. water/ ha 2 times in a year	Rs 77/-
6.	Ind-Safari (ISC) and Artimisia vulgaris (AVC) concoction	@ 2.5 ltr. Concoction of GCC and 20 ltr. concoction of AVC in 500 ltr. water/ ha, once in a year	Rs 30/-
Total VCO input cost per ha as per recommendation			**Rs 40, 311/-**

On an average 24 rounds of spraying/year (26 round per year was recommended) was done in 3 years, so the **actual input cost of Indigenous Package (CO) was 40,184/-**

Table 4 : Cost components and Total Cost of **Biodynamic (BD)** Packages of Practice.

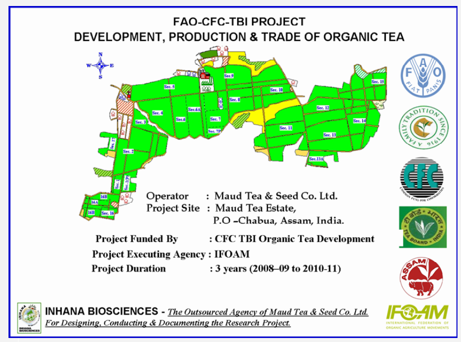
Target Yield : 1500 kg/ha (UP)	Crop Efficiency : 87.36 % (Avg.)
Period of Study : 3 years (2009-2011)	(Over Target yield)
Pruning cycle : UP-Corrected LP- UP	Rank : 9th (Out of 10)

Sl No.	**Biodynamic Inputs**	**Application**	**Total Cost/ha**
Soil Management			
1.	Biodynamic Compost (BD 502 – 507)	10 ton /ha@ Rs. 920 /ton	Rs 9,200/-
2.	Cow Pat Pit (CPP) (BD 502 – 507)	2.5 kg CPP per ha, every 3 months as per BD calendar Date	Rs. 138/-
3.	Cow Horn Manure (BD 500)	75 gm BD 500/ ha, every 4 times in a year i.e. late afternoon/ evening – descending moon	Rs. 1500/-
Plant Management			
4.	Cow Horn Silica (BD 501)	2.5 gm BD 501/ ha, every 4 times in a year i.e. early morning 6-8 a.m. at sunrise.	Rs. 1500/-
5.	Urja	Urja @ 500 g /ha + 10 kg leaves (each) of Neem, Datura and Papaya. Recommended as pest repellent to be given after the pest occurrence. (*Average- 8 rounds/year based on 3 years actual application*)**	Rs. 2576/-
Total Biodynamic Package (BD) cost per ha			**Rs 14, 914/-**

** This cost may vary according to the pest intensity/occurrence of individual garden.

Scientific **O**rganic **F**arming is the only option for ecologically and economically sustainable food production. Though there is no doubt regarding the necessity of organic practice to sustain and enhance both soil and crop productivity, there are lot of related ambiguities and misconceptions. Lack of any scientific guideline towards successful organic farming often fails to achieve the desired objectivity and ultimately leads to crop loss.

This bulletin is the first part of a series on 'Organic Farming' jointly published by Department of ASEPAN, Visva – Bharati University, Santiniketan & Inhana Biosciences, Kolkata. In this publication the authors have tried to explain the scientific concept behind organic farming especially in relevance to tea plantation. The write-up explains the relevance of organic and also provides scientific guidelines towards effective soil and plant management leading to sustainable organic tea production.



The recommendation for organic tea plantations i.e. both for Assam and Darjeeling gardens are based on the findings from FAO-CFC-TBI project (2009-2011) at Maud T.E.

Though the bulletin primarily focuses on organic tea plantation, it will be immensely helpful for all organic crop growers to erase out the ambiguities regarding practical adoption of Organic Farming as a Road Map for Achieving Crop Sustainability.

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