BULLETIN - II

Organic Farming

Effective Soil Management for Successful Organic Tea Cultivation

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A Joint Publication from

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

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FOREWORD

I am pleased to note that a bulletin on 'Effective organic soil management for successful organic tea cultivation' is being published jointly by Visva – Bharati University and Inhana Biosciences.

I note that this bulletin is the second in 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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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 "**Effective Organic Soil management for Successful organic Tea Culitvation**", 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)

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Date 21.12.2012

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

MESSAGE

*It gives me an immense pleasure that a Bulletin on "**Effective Organic Soil management for Successful organic Tea Culitvation**", 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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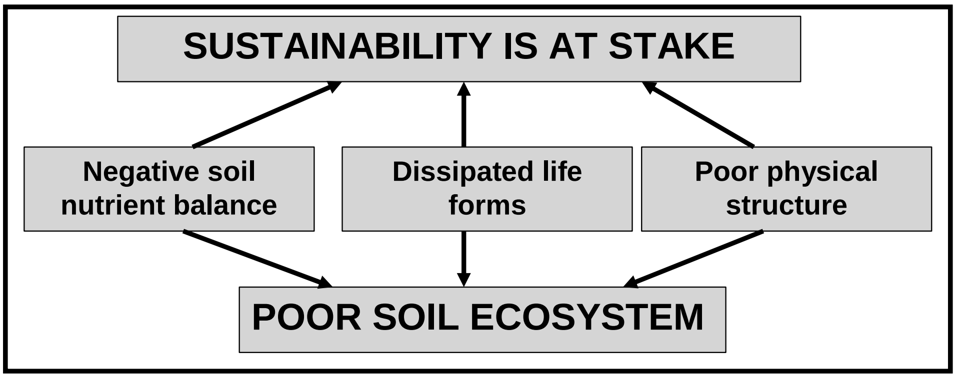
CONTENT

CONTENT

INTRODUCTION

Agriculture has for a long time been based on the notion of the soil as an inexhaustible resource for continually increasing production. On the contrary, because of its very slow formation rate (100-400 years/cm of topsoil), soil must be considered as a non-renewable resource and must be preserved (Montanarella, 2007).

The on-set of green revolution for achieving self- sufficiency in food production was primarily based on increased fertilizer abuse of soil. Soil was considered only as a medium for NPK application, for easy availability and in large amounts for plant use. The reductionist approach of chemical farming totally ignored the fundamental principle that soil is not an inert medium but enlivened by huge population and diversity of microorganisms, which are the primary drivers of all soil ecological processes.

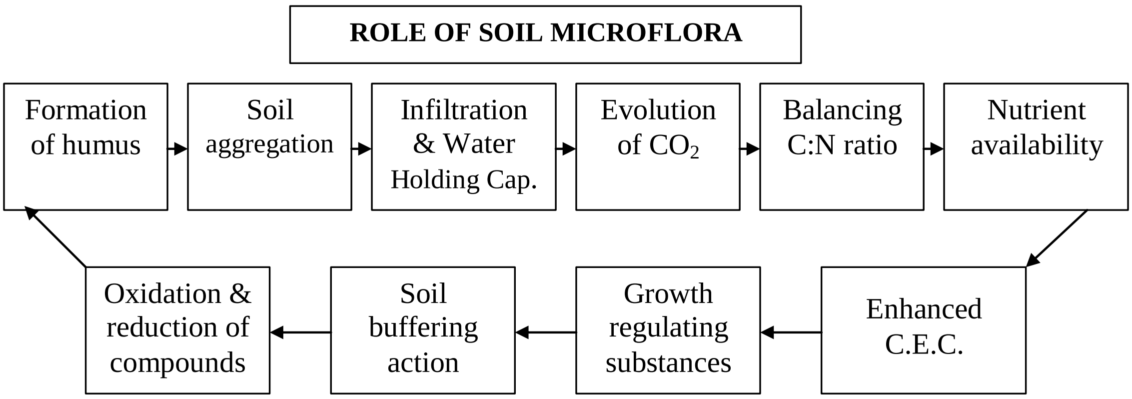


Henceforth, the elimination of micro flora population due to alteration in soil acidity following application of concentrated salts or synthetic fertilizers (especially nitrogenous ones) led to the disruption of such soil functions. The serious depletion of soil health as witnessed within few decades of chemical practice was a direct bearing of such unscientific approach. But more crucial was the indirect impact, in the form of severe curbing of the natural immunity of plants towards diseases due to severe depletion of the antibiotic producing microflora population, which primarily thrive around the plant root in a healthy soil.

APPLICATION OF ORGANIC AMENDMENTS HAS BEEN DEEMED NECESSARY FOR REGENERATION OF SOIL

However, the Remarkable Loss of Native Microflora over Years of Chemical Abuse is difficult to Fortify; especially under the presently available Slow Acting Organic Inputs having No Quality Assurance.

The primary role of organic amendments is to rejuvenate the soil by creating a favourable soil–plant–microbial environment, in addition to improving the physical properties of soil. In other words, to make the soil system live for healthy plant growth. Soil organisms act as the primary driving agents of nutrient cycling, soil carbon sequestration, modifying soil physical structure and water regimes etc. that cumulatively serve to enhance plant health. These services are not only critical to the functioning of natural ecosystems but constitute an important resource for sustainable agricultural systems (Scialabba, 2000).



However, in a deactivated environment any ordinary organic manure, compost or rotten organic material does not meet this objective. The addition of organic amendment to soil without first judging its qualitative components might increase the risk of possible health hazards to both humans and plants because of the presence of harmful pathogens. At the same time seed germination and plant growth might be hindered following exposure to phytotoxic compounds (Saviozzi *et al*., 1988).

ORGANIC SOIL MANAGEMENT IS ALSO IMPERATIVE FOR SUCCESSFUL ORGANIC CROP PRODUCTION

The soil resource base is the critical component of agro-ecosystems, and future strategies for increasing agricultural productivity must focus on more efficient use of soil resources (Killham, 2010). Healthy soil is the foundation of organic farming. Hence, organic agriculture should encourage and feed biologically-driven soil nutrient cycles to ensure that adequate levels of crop nutrition are maintained (Anonymous, 2013).

Organic soil management basically aims to restore, proliferate and rejuvenate the native soil microflora population towards re-instatement of the natural soil ecological processes. This in turn can bring about a positive change in the physicochemical properties and restore the natural soil-plant nutrient dynamics in order to enable soil to act as a good growing medium for plants. Plant growth receives positive stimulus from beneficial soil microbes not only through conversion of unavailable soil nutrient into plant available forms but also through production of metabolites or by their physical interactions with the host plants.

Restoration and rejuvenation of the native soil microbes has greater and direct implications, considering that plants rely on a complex community of soil microbes to defend themselves against pathogens. The complex phenomenon of disease suppression in soils cannot simply be attributed to a single bacterial group, but is most likely controlled by a community of organisms (Anonymous, 2011). Direct antagonism against pathogen by production of antibiotics, inactivation of the virulent traits of pathogen or bacterial stimulation of defense responses in the plant host have been found to be the different mechanisms of bio-control. Application of compost in soil has also indicated towards influencing several soil microbial enzyme levels, which have direct impact to reduced weed density.

Good soil health with naturally lower biotic potential has greater relevance towards ensuring successful organic crop production, with minimal support from external inputs.

SOIL MICROBIAL INOCULATION – PRO & CON

Introduction of green revolution undoubtedly showed some quick returns in terms of increase in total crop production through introduction of high yielding seed varieties, increased use of chemical fertilizer, improved irrigation facilities, mechanization in agri works, increased land use intensity etc. But in the long term it has cost more than what we have achieved from it. Due to heavy chemical fertilizer inputs land has become hard and carbon material has gone down. Weeds have increased, pest infestation has gone up and loss of biodiversity has been well accounted (Ninan and Chandrashekar, 1993; Times of India, 2004; Lunkad and Sharma, 2008).

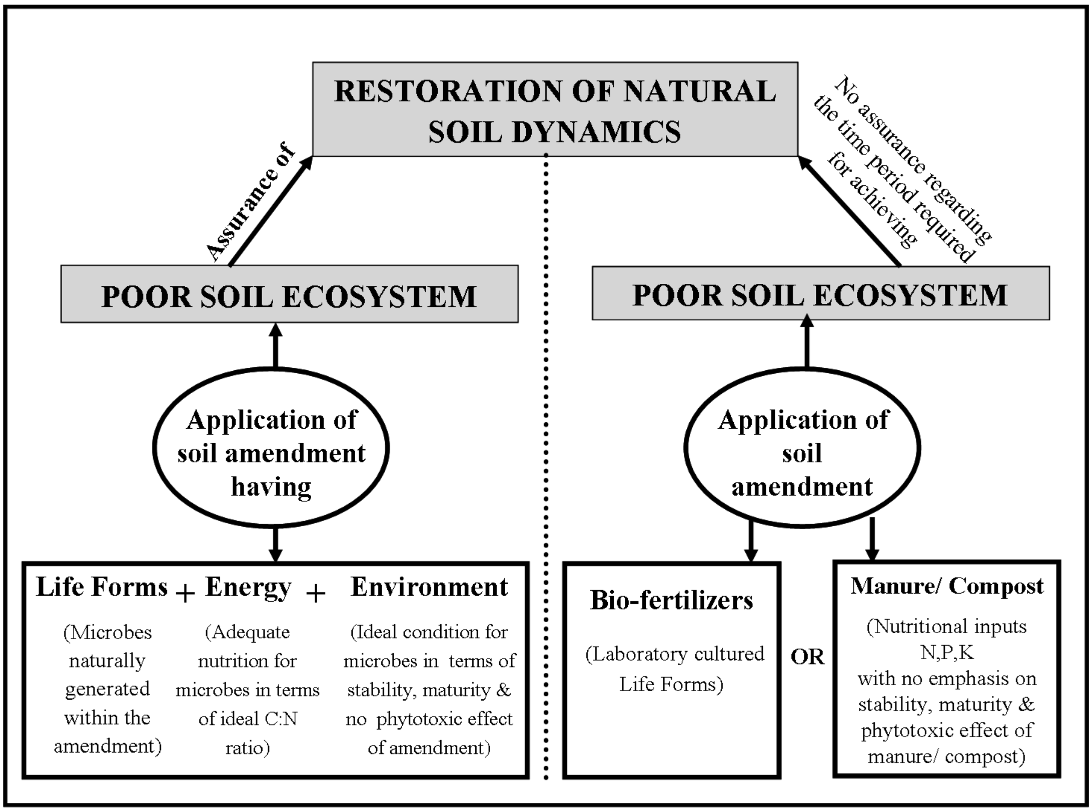
One of the main reasons behind loss of soil productivity is huge decline in soil microflora population and their activity due to injudicious application of chemical agents. Microflora is the driving factor behind all the soil ecological processes that enable soil to perform as a good growing medium for plants. Hence, to rejuvenate the soil for sustained crop productivity, microbial soil inoculation has become a popular concept. Microbial strains having beneficial role in agriculture *viz.* nitrogen fixers, phosphate solubilizers etc. are selected and their laboratory cultured population is inoculated in soil to get the desired benefits.

However, the approach has most often disappointed the objective because the microbes cultured under ideal laboratory conditions fail to perform in the heterogeneous and unpredictable (van Elsas and van Overbeek, 1993) soil environment. It is certain that a healthy soil have all types of microbial populations responsible for soil-plant functioning. Absence or non-performance of any type of microbes in soil means the soil-environment is not conducive for natural proliferation and activity of such strains due to multiple biotic and abiotic stress. Simple addition of soil inoculum without correcting the underlying cause for their natural disappearance from soil cannot provide the solution. Scientific researches have indicated progressive decline in bacterial population shortly after their introduction in soil (Bashan and Levanony, 1988; van Elsas et al. 1986). The inoculated bacteria sometimes cannot find an empty niche in the soil for survival except in sterilized soil, a condition which does not exist in large-scale agriculture. They must compete with the often better-adapted native microflora and withstand predation by protozoans. Limitation of this concept has been understood by the comments of Kenney (1997), who noted that "Biological products have had a less than spectacular penetration of the chemical pesticide market. Although great promises have been made, the fulfillment of those promises has not met expectations".

In India, several research workers have reported yield increase with application of soil inoculums. But the biggest hurdle faced by many workers was the unpredictability of effectivity post inoculation of microbial strains in soil. In order to harness the benefits of bio-fertilizers in agriculture, the consistency of their performance must be improved. **(Wani and Lee, 2002).** Legume inoculation by Rhizobium is the most long established practice but the results obtained from All India Coordinated Agronomic Research Project in case of mung bean, urad bean, soya bean, cow pea and groundnut under irrigated conditions indicated significant response only in a small proportion of locations tried. Residual effect on soil pool was not noted in most cases. The variance of responses is similar for Azotobacter and Azospirillium (Ghosh, 2011). The root cause of the failure was investigated as environmental factors *viz.* low soil organic carbon, high salinity, alkalinity, soil moisture deficit, high temperature, opposition from native soil microflora etc.

Commertial interest rather than scientific implication is more important for the supporters of this theory. According to Fages (1992) and Xavier *et al*. (2004) in spite of a central role of formulation in successful commercialization of inoculant products, research in this area has been largely ignored. In addition to limited availability of published scientific information with regard to inoculant formulation, the information available is fragmented. Besides this application or usage of bio-fertilizers require additional infrastructural cost, labour and technical knowledge. Semiarid conditions make survival difficult for introduced bacteria, harsh conditions including droughts, lack of sufficient irrigation, high salinity and soil erosion may quickly diminish the introduced bacteria population; even in developed nations (Brahmaprakash G.P. and Sahu P.K., 2012). According to Wani and Lee (1991) most important constraints for adoption of bio-fertilization in India have been attributed to poor quality of inoculants produced, lack of knowledge about inoculation technology for extension personnel and farmers; non-effective inoculant delivery/supply system and lack of committed policy to exploit bio-fertilizers successfully.

It is very difficult to get success in soil microbial inoculation considering heterogeneous soil, environment and management system. Detailed research regarding specific strain, application methodology with infrastructural setup, awareness at users end, etc. might deliver some success in case to case basis but uncertainty remains in case of large scale application. In this scenario a more logical and practical approach remains to initiate the culture of on-farm compost production. This will not only enable recycling of the farm resources in best possible manner, moreover the microflora population generated naturally within the compost during biodegradation period shall well adapt and enrich the native microflora environment in the said system. Application of on-farm produced compost in soil means adding up a rich population of native microflora in their natural diversity along with ready food resources, in order to ensure speedy rejuvenation of soil microbial environment.



WHAT IS COMPOSTING ?

Composting involves the conversion of organic residues of plant and animal origin, into manure. It is largely a microbiological process based upon the activities of several bacteria, actinomycetes, and fungi (Bharadwaj, 1995). The end product is rich in humus and plant nutrients; the by-products are carbon dioxide, water, and heat (Abbasi and Ramasamy, 1999). As Per Zucconi and De Bertoldi (1987) composting is an aerobic process in which microorganisms convert a mixed organic substrate into carbon dioxide (CO_2), water, minerals and stabilized organic matter. Control of environmental conditions during the process distinguishes composting from natural rotting or decomposition. However, Composting can also be an anaerobic process, where breakdown occurs in the absence of oxygen. In this case, the main by products are methane, carbon dioxide, various organic acids and alcohols. However, aerobic composting is more efficient and presents fewer undesirable by products (Peter Moon, 1997)

BIODEGRADATION PROCESS OF COMPOST

In the composting process, aerobic microorganisms use organic matter as a substrate. The microorganisms decompose the substrate, breaking it down from complex to intermediate and then to simpler compounds (Epstein, 1997; lpek *et al.*, 2002). During composting, compounds containing carbon and nitrogen are transformed through successive activities of different microbes to more stable organic matter, which chemically and biologically resembles humic substances (Pare *et al.*, 1998). The rate and extent of these transformations depend on available substrates and the process variables used to control composting (Marche *et al.*, 2003).

$$\text{Fresh Organic Waste} + O_2 \xrightarrow[\text{Metabolism}]{\text{Microbial}} \text{Stabilized Organic Material (compost)} + CO_2 + H_20 + \text{Heat}$$

As per Chen and Inbar (1993) Controlled conditions, particularly of moisture and aeration are required to yield temperatures (120 to 140^{0}F) conducive to the microorganisms involved in the composting process. In this regard Levi-Minzi *et al*. (1990) said that the extent of organic matter decomposition at any particular time is related to the temperature at which composting takes place and the chemical composition of organic substrate undergoing composting. As per Palm and Sanchez (1991) due to the presence of readily degradable carbon (C), most organic materials initially decompose rapidly. However, higher the lignin and polyphenolic content of organic materials, the slower their decomposition. Rynk *et al*. (1992) in their work stated that proper conditions for active composting includes an adequate supply of oxygen for microbial respiration (approximately 5% of the pore space in the starting material should contain air), a moisture content between 40 and 65%, particle sizes of approximately 1/8 to 2 inches in diameter, and a C:N ratio between 20:1 and 40:1.

This first stage of composting lasts for one to two days, during which period mesophilic strains of microorganisms (species that are most active at temperatures of 90 to 110^0 F) initiate decomposition of readily degradable compounds (Chen and Inbar, 1993). Cooperband (2000) in his work showed that the first microorganisms to colonize a heap of biodegradable solid waste are mesophilic bacteria, actinomycetes, fungi, and protozoa. They grow between 10 and 45^{0}C and break down the easily degradable components such as sugars and amino acids (Hellmann *et al*., 1997). The degradation of fresh matter starts as soon as it is piled into heap and due to oxidative action of microorganisms, the temperature increases (Gajalakshmi and Abbasi, 2008). The pH typically decreases at the very beginning of composting as volatile fatty acids are produced (Chen and Inbar, 1993).

When the temperature of a waste heap reaches 45–50^{0}C, thermophilic microorganisms replace mesophilic ones (Hellman *et al.*, 1997). The second phase i.e. the active phase of composting is called the thermophilic phase and can last for several weeks. Most of the organic matter is degraded and consequently most oxygen is consumed in this phase. When active composting takes place, microbial activity in the pile causes an increase in temperature to about 120 to 140^{0}F in the center of the pile. Temperatures will remain in this range as long as decomposable materials are available and oxygen is adequate for microbial activity (Chen and Inbar, 1993). Many important processes take place during the thermophilic stage. Organic matter is degraded and particle size is reduced, pathogens are destroyed (above a critical temperature of 131^{0}F), fly larvae are killed and most weed seeds are destroyed at temperatures above 145^{0}F. The pH frequently rises above 7.0 as ammonia is liberated during protein degradation (Rynk *et al.*, 1992). According to Tuomela *et al.* (2000), lignin degradation also starts during this phase. The optimum temperature for thermophilic micro-fungi and actinomycetes, which mainly degrade lignin is 40–50◦C, above 60◦C, these microorganisms cannot grow and lignin degradation is slowed down (Hellman *et al.*, 1997).

After the pile has been turned several times, temperatures gradually fall to about 100^{0}F. Active composting is completed, and the volume of the original material is normally reduced by 25 to 50%. Decomposition continues beyond this point but at a much slower rate, and little heat is generated. When the compost pile temperature falls to that of ambient air, the compost is ready for curing (Rynk *et al.*, 1992). Curing period helps insure against any negative consequences of application of immature compost towards crop cultivation; e.g. inhibition of seed germination, root toxicity etc. Less heat is generated during this period and the final pH is normally slightly alkaline. Common microorganisms (pathogens and beneficial) as well as a microfauna re-colonize the compost. Intense microbial competition for food takes place through both direct antagonism and production of antibiotics (Chen and Inbar, 1993). It is in this competition that pathogens (e.g. *Pythium, Rhizoctonia, and Phytophthora* species) are often suppressed by beneficial microbial species (Hoitink and Fahy, 1986). As per Cooperband (2000) the last phase is important because humus-like substances are produced in this phase to form mature compost.

CHEMISTRY OF BIODEGRADATION PROCESS

During composting, mineralization and humification occur simultaneously and are the main processes causing the degradation of fresh organic matter. During mineralization, transformation of nitrogenous compounds occurs involving several biochemical reactions. Degradation of protein, urea or uric acid produces ammonium ion (NH_4^+) (Hansen *et al.*, 1990).

$$R{-}NH_3 + HOH \rightarrow R{-}OH + NH_3 + \text{Energy}$$

During this process, high pH, high temperature, and moisture determine the NH_3/NH_4^+ balance and NH_3 emission. The solubility of NH_3 is reduced by about 30% when temperature increases from 40 to 50^0C, and pH increases. Another step of degradation is nitrification, which transforms NH_4^+ into NO_3^+ (nitrate) by oxidation, under aerobic conditions. One of the by products of nitrification is N_2O.

$$NH_4^{\,+} + 1.5\,O_2 \rightarrow NO_2^- + H_2O + 2H^+ + \text{energy}$$

$$NO_2^- + 0.5O_2 \rightarrow NO_3^- + \text{energy}$$

Although composting is essentially an aerobic transformation of organic matter, anaerobic conditions can occur in pockets of the waste heap where free oxygen is exhausted. It may lead to formation of volatile fatty acids, which lower the pH of the anaerobic zone. Under these conditions NO_3 is reduced to N_2O and then to N_2.

$$NO_3^- \rightarrow NO_2^- \rightarrow N_2O(\text{nitrous oxide}) \rightarrow N_2(\text{gas})$$

In addition, N_2O, NO, and NO_2 may be produced in a compost heap that is not completely aerobic. Due to these reasons, steps must be taken to avoid anaerobic zones from developing in a compost heap. During composting, carbon is transformed into CO_2 and is integrated into humus-like substances as a result of humification.

$$\text{Proteins}+O_2 \rightarrow \text{complex amino compounds}+CO_2+\text{Energy}+\text{other products}$$

Methane can be released if anaerobic zones are formed within the compost heap (Lopez-Real and Baptista, 1996). According to Peigne and Girardin (2004), low redox potential and high temperature provide suitable conditions for the development of thermophilic methanogenic bacteria. Moreover, during the thermohilic phase, oxygen is liberally consumed by aerobic microorganisms; the subsequent reduction of oxygen concentration in the heap favors anaerobic conditions for methane production (Ott, 1990).

THREAT FROM IMMATURE COMPOST

There is a common belief that addition of compost can never harm the soil, plant or water ecosystem, but such an assumption is not correct. Immature compost when applied to the soil continues to decompose and produce odorous gases and products such as ammonia in its immediate surroundings that are often toxic to plants (Saviozzi *et al.*, 1988). Immature compost can induce high microbial activity and subsequent misappropriation of oxygen (Beefa *et al.*, 1996). In the presence of such inhibitory environment, plants typically reduce their metabolic rate and build up their resistance (Zucconi *et al.*, 1981b). Immature composts with a high carbon/ nitrogen ratio (C:N) cause nitrogen immobilization, starve roots of oxygen due to high microbial activity, support growth of pathogens as well as create high levels of organic acids (Inbar *et al.*, 1990). Simultaneously a low C/ N ratio in compost can create high ammonia concentrations in soil resulting in ammonium toxicity in plants. Numerous organic amendments have also exhibited direct or indirect inhibitory effect on seed germination (Pal and Bhattacharyya, 2003).

TEA GROWING SOILS - *Some Inherent Limitations*

- Acid soils have natural limitation of microflora and also nutrient availability.
- As a plantation crop tea causes mono cropping toxicity & hard pan formation.
- No scope for proper soil rejuvenation except at the time of new plantation.
- In the absence of an effective soil management guideline, there is further aggravation of the existing limitations.

APPLICATION OF CHEMICAL FERTILIZERS IN TEA SOILS - *Further Aggravates The Limitations*

- ✓ Chemical fertilizer application over decades that too N-fertilizers result in soil toxicity due to very high concentration of NO_3- with lesser uptake sites.
- ✓ Physical character of the soil is depleted in the form of lesser aeration, poor infiltration and poor water holding capacity.

- ✓ Inherently low soil microflora is further reduced due to chemical toxicity.
- ✓ Depletion of soil microflora causes disruption of the overall soil function leading to impaired soil-plant-nutrient dynamics.

EFFECTIVE ORGANIC SOIL MANAGEMENT FOR SUSTAINABLE/ HIGHER PRODUCTIVITY IS AN UPHILL TASK IN TEA PLANTATIONS

Organic soil amendment plays the key role both during conversion and for practicing organic agriculture.

- ➢ However, low quality of the presently available organic soil inputs in terms of nutrient (N, P and K) content, microbial status and stability, entails their huge quantity to suffice for crop nutrient requirement.
- ➢ The problem becomes magnified in case of plantation crops *viz.* tea/ coffee etc. where the huge quantity cannot be fully met by on- farm production.
- ➢ At the same time off- farm compost is most often of non-uniform quality as well as costlier alternative.
- ➢ Moreover, in organic cultivation cost of organic soil input, is an important criteria for consideration since, it comprises about 60 to 80 percent of the total expenditure made on inputs.

ORGANIC SOIL MANAGEMENT IS CENTRAL TO ORGANIC PRACTICES- *An FAO Outlook*

The Food & Agriculture Organization emphasizes that 'Soil building practices are central to organic practices and encourage soil fauna and flora, improving soil formation and structure and creating more stable systems'. In turn, nutrient and energy cycling is increased and the retentive abilities of the soil for nutrients and water are enhanced, compensating for the non-use of mineral fertilizers.

Efforts have been initiated by FAO to promote and accentuate organic crop production *vis-à-vis* improved soil management systems and in this respect the FAO-CFC-TBI Project 'Development, Production & Trade of Organic Tea was initiated (2009-11) in 3 tea growing zones of India i.e. Assam, Darjeeling and South India.

In the Assam chapter of the project, initiated at Maud Tea Estate (Dibrugarh) a serious effort in this direction was made by taking up on-farm composting programme using different available composting process to evaluate their biodegradation process, period, end product/ compost quality, cost of production and finally post soil application effectivity through impact study on crop yield and soil development.

OBJECTIVITY : To formulate Scientific Guidelines for Effective Organic Soil Management

DESIRED OUTCOME : Better Nutrient Utilization Efficiency to Enable Better Agronomic Efficiency of Plants Leading to Crop Sustainability & Speedy Soil Rejuvenation

Key findings from FAO-CFC-TBI Project entitled 'Development, Production & Trade of organic Tea' at Maud T.E., Assam (2009– 11)

- An Energized Soil System or Dynamic Soil complements both the effectivity of plant management package and plant productivity potential through sustainable crop performance.

- Organic soil management need Qualitative Approach not only for speedy rejuvenation of depressed soil system, but also to curtail the soil management cost, which comprise 60 to 80 percent of total expenditure made on inputs.

- High quality organic soil input (especially in terms of high status of microbial population generated naturally during the composting period) is the only requisite pathway for effective organic soil management at an affordable cost, for which on-farm compost production is obligatory.

- 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.

QUALITY EVALUATION OF DIFFERENT ORGANIC SOIL INPUTS & ASSESSMENT OF THEIR EFFECTIVITY TOWARDS CROP PERFORMANCE

On- Farm Compost production was done using available resources as per four different processes i.e. Vermicomposting, Indigenous, Biodynamic, & Novcom Composting Method.

All the Composting processes were evaluated in terms of their biodegradation process, period of composting, end product/ compost quality and cost of production.

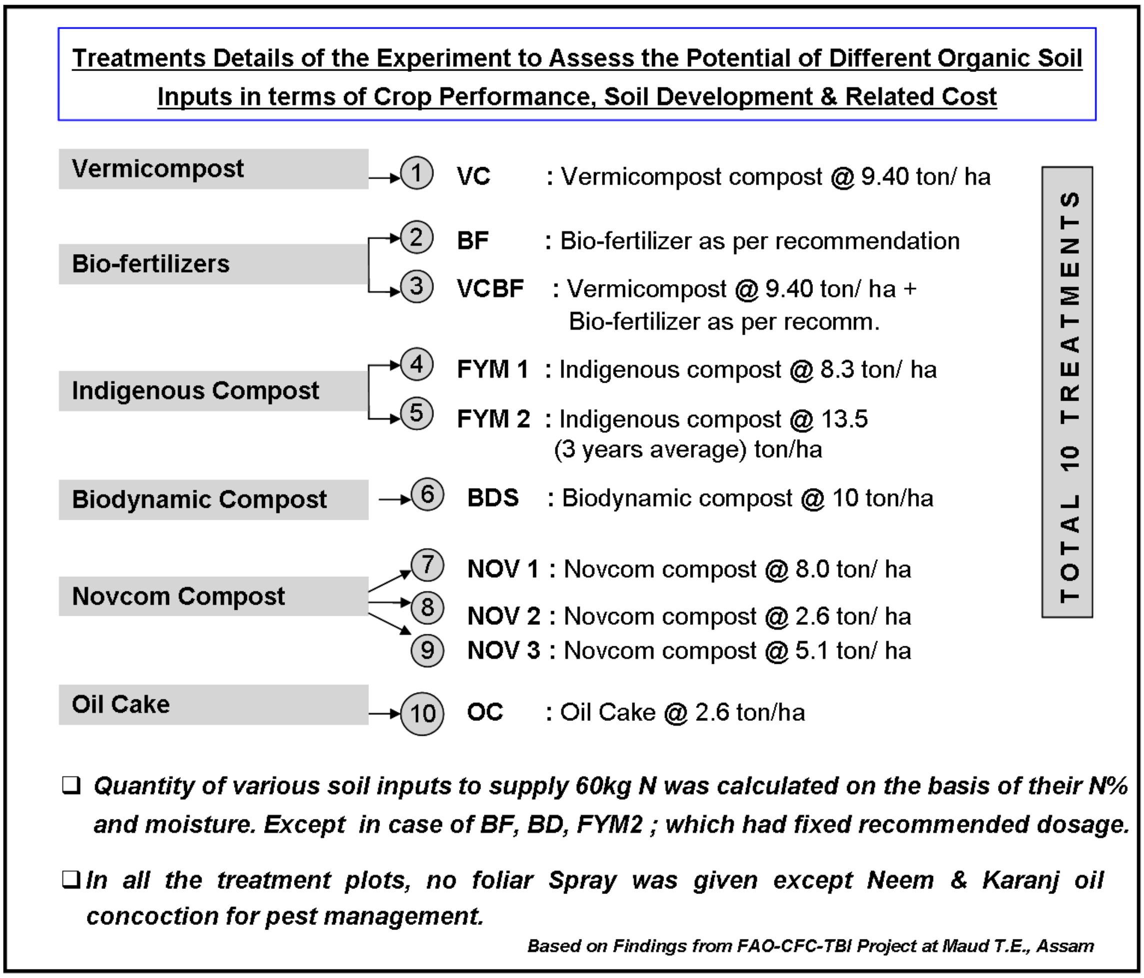


Table 1 : Qualitative Evaluation of Different On-Farm Produced Organic Soil Inputs.

PARAMETERS	Ideal range	VC[1]	BD[2]	IND[3]	NOV[4]
Moisture (%)	35.0 - 55.0	54.3	48.5	46.5	56.7
pH_{water} (1 : 5)	7.2 - 8.5	6.56	7.23	7.03	7.61
Org. C (%)	16.0 - 38.0	25.5	26.3	23.7	27.9
Total (N+P+K) Nutrient (%)	> 3.0	3.26	3.73	2.69	**4.05**
C/N ratio	10.0-20.0	14.6	14.8	14.1	**12.8**
Compost Min. Index (CMI)[5]	0.79-4.38	2.12	2.00	2.42	1.78
Total microbial population(log_{10} value)	> 13.00	13.78	14.07	13.91	**18.00**
CO_2 evolution rate ($mgCO_2$-C/g OM/ day)	< 5.0 - stable	1.43	1.89	1.81	2.16
Nitrification Index	>0.03 to <7.14	0.40	0.36	0.39	0.22
Phytotoxicity Bioassay	>0.8	0.92	1.01	0.85	**1.28**

[1]VC : Vermi Compost; [2]BD : Biodynamic Compost; [3]IND : Indigenous Compost (FYM); [4]NOV : Novcom compost; [5]CMI : Compost Mineralization Index.

- The different types of compost were found to have more or less similar moisture content, pH values and organic carbon status.
- In terms of total nutrient while vermicompost and Biodynamic compost showed similar values, the status was comparatively higher in case of Novcom compost.

- Most notable point was the microbial status in Novcom compost (in the order of 10^{16} c.f.u.), which was at least 10^3 to 10^4 times higher as compared to the population recorded in case of the other types of compost.

Table 2 : Comparative evaluation of different Organic Soil Inputs *vis-à-vis* Novcom Compost on the basis of data generated from FAO-CFC-TBI Project

Parameter	VC[1]	BD[2]	IND[3]	NOV[4]
Raw material Specificity	Yes	No	No	No
Biodegradation Period	60 - 75	80 - 90	80 - 90	**21 - 30**
Recovery Percent	67.0	61.0	57.0	**69.4**
Total nutrient (N+P+K) content (%)	3.26	3.73	2.69	4.05
N enrichment (% increase over initial value in raw material)	52.63	56.14	47.37	**92.11**
Cost of Production (Rs./ ton final compost)	4000/-	920/-	**770/-**	860/-
Total Soil Mgt. Cost (Rs.) **on the basis of 60 kg N applied/ ha**	37,600/-	10,838/-	10,395/-	7,894/-
Crop efficiency (%) (w.r.t. target yield of 1500 kg made tea/ ha)	89	85	88	**100**
Cost/ kg made Tea- CMT (Rs.)	26.9	7.19	7.81	**5.16**

[1]VC : Vermi Compost; [2]BD : Biodynamic Compost; [3]IND : Indigenous Compost (FYM); [4]NOV : Novcom compost; [5]CMI : Compost Mineralization Index.

On-farm compost production using available resources is the best choice because off-farm soil inputs are not only high priced; they are often poor in quality. But, on-farm compost production is still not taken up on large scale due to several associated limitations *viz.* time period required for biodegradation, raw material specificity etc. Hence, adoption potential of the different composting methods was evaluated in terms of different factors *viz.* raw material specificity, biodegradation period, compost recovery percent etc.

Interpretation of Compost Evaluation Report :

- Except vermi compost, all others have no raw material specificity.

- Novcom compost was produced within the shortest time period of 21-30 days where as Biodynamic and FYM compost required 80 to 90 days.

- Shorter biodegradation period has been indicated to curtail chances of nutrient losses leading to appreciated total nutrient value of the end product/ compost.

- Hence, though the different types of compost were prepared from similar raw materials i.e. garden weeds and cow dung, however; highest nutrient content in terms of total NPK was found in case of Novcom compost (4.05 %),

- Most significant finding was the appreciation of Nitrogen in the end product, which was once again highest (92.10 %) for Novcom compost.

- N-enrichment in final compost not only indicated an intensive biodegradation process but also the presence of huge self-generated microbial population.

➢ This was once again substantiated by the very high population of self- generated microflora (in the order of 10^{16} c.f.u.) in Novcom compost.

Table 3: Evaluation of Different On-Farm Composting Processes in terms of Efficiency & Effective Cost.

Parameter	VC[1]	BD[2]	IND[3]	NOV[4]
Made Tea(kg/ ha)	1338 kg/ha	1279 kg/ha	1479 kg/ha	1500 kg/ha
Crop Efficiency (w.r.t. Target yield of 1500 kg/ha)	89 %	85 %	99 %	100 %
Unit Cost of compost (Rs./ ton)	Rs. 4000/-	Rs. 920/-	Rs. 770/-	Rs. 860/-
Total Soil Mgt. Cost/ ha	Rs. 37,600/-	Rs. 10,838/-	Rs. 10,395/-	Rs. 7,894/-
Cost Increase (w.r.t. lowest cost)	376% Higher	37% Higher	32% Higher	Lowest

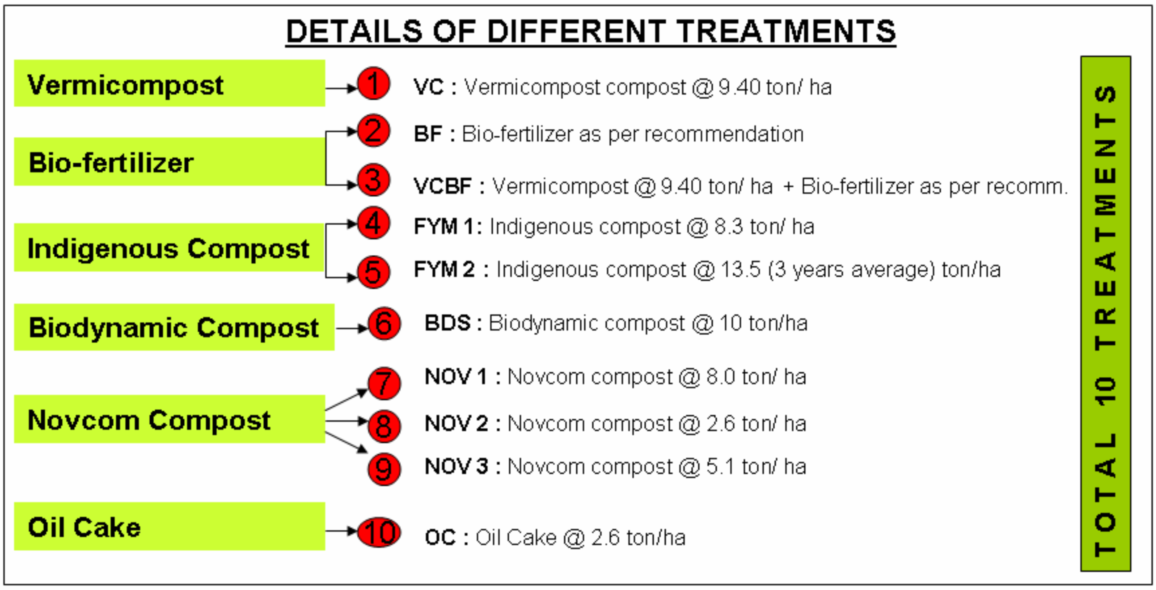
[1]VC : Vermi Compost; [2]BD : Biodynamic Compost; [3]IND : Indigenous Compost (FYM); [4]NOV : Novcom compost; [5]CMI : Compost Mineralization Index.

❑ Though Crop Efficiency forms the first criteria for selection of any specific compost, but if the related cost becomes exorbitant then it ultimately fails to provide the desired sustainability.

❑ This is clearly demonstrated for Indigenous compost where its high potential in terms of crop efficiency (99%) is marred by the 32% hike in cost w.r.t. lowest one.

LAB TO LAND EVALUATION OF THE QUALITY OF DIFFERENT TYPES OF COMPOST IN TERMS CROP RESPONSE & SOIL REJUVENATION.

In order to corroborate the quality of different types of compost as obtained through laboratory analysis, with their respective post soil application effectivity, a study was taken up at Maud tea estate (Assam, India) under FAO-CFC-TBI Project (2008-2011). In the study, post soil application effectivity of the different types of compost was judged in terms of crop response as well as degree of soil rejuvenation.



Note :

1. Dose of VC (also in VCBF), FYM-1, NOV-1 and Oil Cake were calculated to meet the crop –N requirement of 60kg (for 1500 kg made tea target at 4% N). Moisture and N content were considered during dose calculation of respective organic soil input.
2. Dose of BF, FYM-2, BDS, NOV-2 & NOV-3 were as per Expert recommendation.

INTERPRETATION OF RESULTS :

- Crop response in terms of made tea production was found to be highest in Novcom compost applied plots (30.8 percent higher than control) followed by plots receiving Indigenous compost

(27.9 percent higher than control) and Vermi compost in combination with bio-fertilizers (22.9 percent higher than control).

Table 4: Ranking of Different Organic Soil Inputs in terms of Crop & Cost per hectare in Mature Tea.

Rank	Organic Soil Input (Dose of Organic Soil Inputs)	Yield (kg/ha)	Percent over control	RAE[1]	Cost/ ha (Rs.)	VCR[2]
1.	**Novcom compost-1 (Nov-1)** (@ 8 ton/ha)	1500	30.75	100	7,894	8.49
2.	**Indigenous compost-2 (FYM-2)** (@13.5ton/ha)	1479	27.89	93.73	10,395	6.04
3.	**Vermi Compost+ Bio-fertilizer (VCBF)**	1427	22.85	78.21	57,025	0.92
4.	**Novcom compost-3 (Nov-3)** (@ 5.1 ton/ha)	1372	18.57	61.79	5,400	7.67
5.	**Oilcake (OC)** (@ 2.6 ton/ha)	1347	17.29	54.33	13,150	2.77
6.	**Vermi compost (VC)** (@ 9.4 ton/ha)	1338	16.23	51.64	37,600	0.92
7.	**Indigenous compost-1 (FYM-1)** (@ 8.3 ton/ha)	1321	14.40	46.57	6,422	4.86
8.	**Novcom compost-2 (Nov-2)** (@ 2.6 ton/ha)	1320	13.76	46.27	3,250	9.54
9.	**Biodynamic compost (BDS)** (@ 10 ton/ha)	1279	11.33	34.03	10,838	2.10
10.	**Bio-fertilizer (BF)** (1.125 ton City compost + 37.5 kg Bio-NPK)	1268	9.44	30.75	19,425	1.06

- Another phenomenon worth mentioning is that except Novcom compost, better crop response in case of other treatments was obtained only under high quantitative application i.e. either single compost applied in high dose (Indigenous compost @ 13.5 ton/ ha) or combined application as in case of VCBF where vermi compost was applied at the rate of 9.4 ton ha in combination with city compost organic fertilizer induced with N fixing bacteria and PSB @ 1.12 ton and 37.5 kg of Bio-NPK (combination of *Bacillus, Pseudomonas, Azotobacter and Azospirillum*) as per recommendation.

- Relative Agronomic Effectiveness (RAE) i.e. comparative crop response under different treatments with respect to the best performer (Novcom compost in this case), indicated that only FYM-2 and VCBF scored highly (RAE: 93.73% and 78.21% resp.) while rest all others obtained values lower than 55 percent.

- Finally the cost of inputs is a major regulating factor towards adoption of any soil input.

  Expense under different types of soil input was assessed through Value Cost Ratio (VCR), which indicated extra crop grain per rupee invested for input. VCR was highest in case of Novcom compost followed by FYM- 2, however; its VCR was 41 percent lower than that obtained under Novcom compost.

  Agricultural economists have also pointed out that VCR < 2.00 (as obtained in case of VC, BF, VCBF) **can not provide the necessary risk coverage against investment towards input cost**.

APPRAISAL OF CROP PERFORMANCE UNDER SINGLE INPUT APPLICATION

Potential of the different organic soil inputs were evaluated in terms of crop response. The dose of each soil input was calculated to meet the crop-N requirement (Except Biodynamic compost which was applied as per expert recommendation). N requirement was calculated as 60 kg per hectare on the basis of 1500 kg made tea as target yield with four percent N required for one kg of made tea. Total- N and moisture percent along with utilization efficiency (80 percent) of the organic soil inputs were considered during their respective dose calculation.

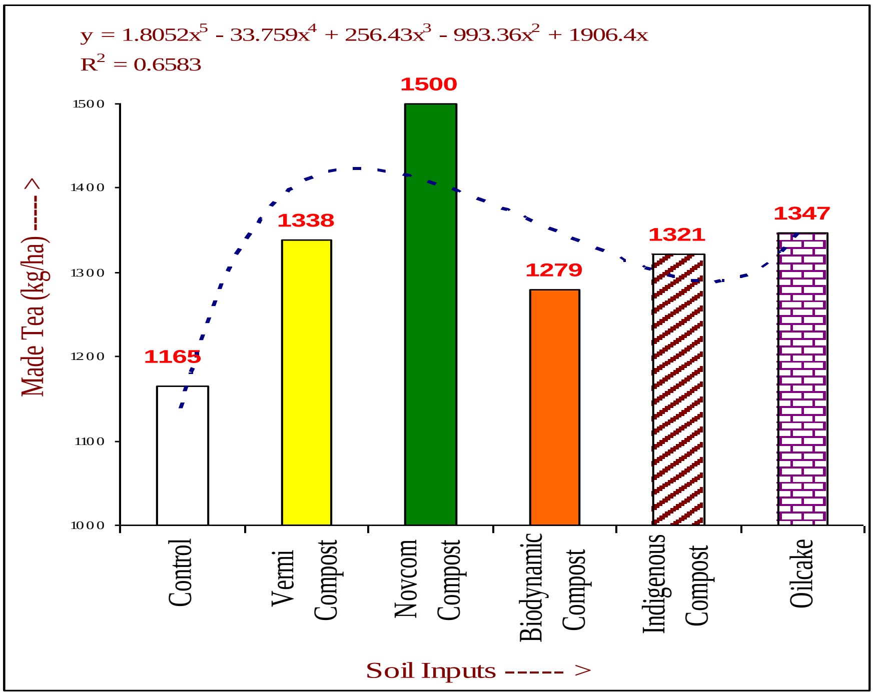


Fig. 1: Made Tea yield (kg/ha) under application of different organic soil inputs.

- Highest yield (28.8 % increase over control) was obtained under Novcom compost.
- Oil cake, Vermicompost ranked 2nd and 3rd respectively, recording almost similar crop hike (17 & 16 % respectively) over control.

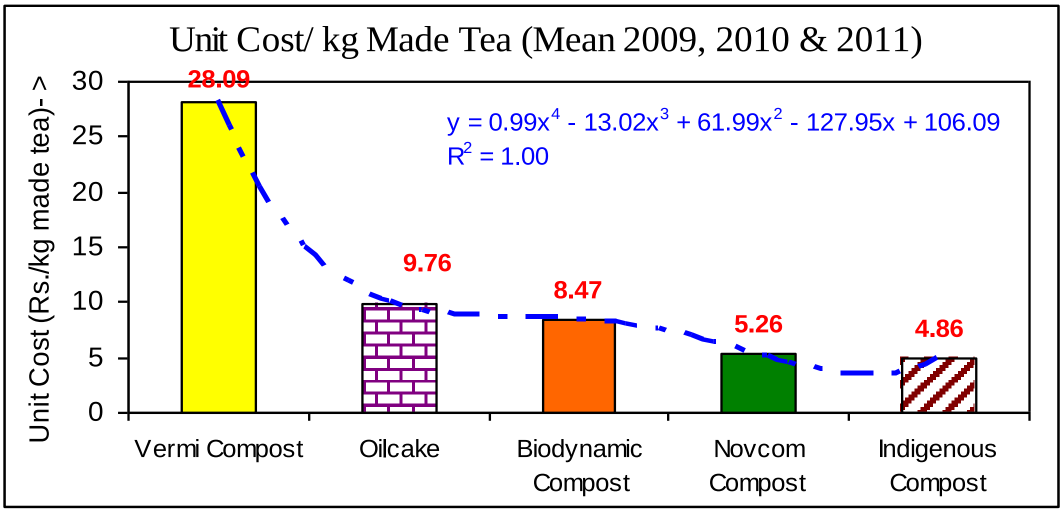


Fig. 2: Cost per kg Made tea (Rs./kg) under application of different organic soil inputs.

- Although lowest cost of production (COP) was obtained for Indigenous compost but in terms of crop performance it ranked 4th, next lower COP was obtained for Novcom compost with highest production.
- Vermicompost showed highest COP (i.e. Rs. 28.09/- for 1 kg made tea), which was corroborated by equally low Production Efficiency i.e. only 3.6 kg made tea could be obtained for each Rs. 100/- spent.

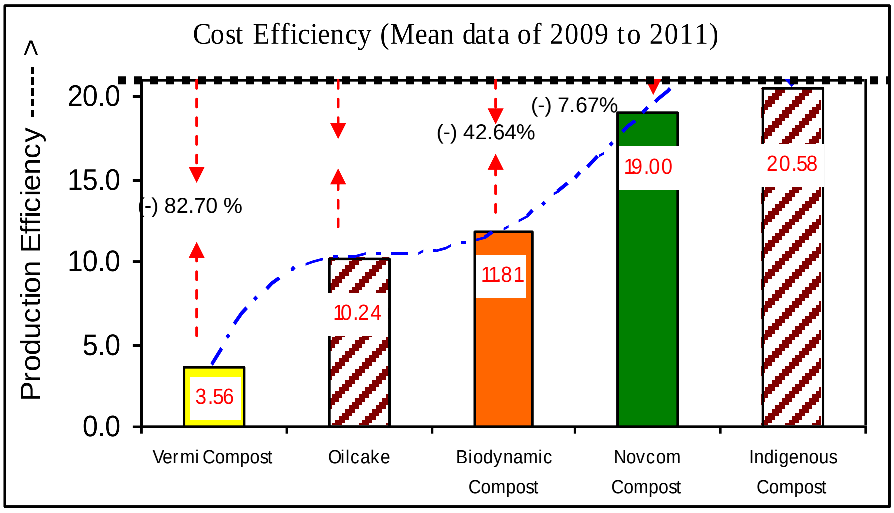


Fig. 3: Cost efficiency (Rs./kg) under application of different organic soil inputs.

CROP PERFORMANCE UNDER SINGLE SOIL INPUT & APPRAISAL OF ADDITIVE EFFECT (IF ANY)

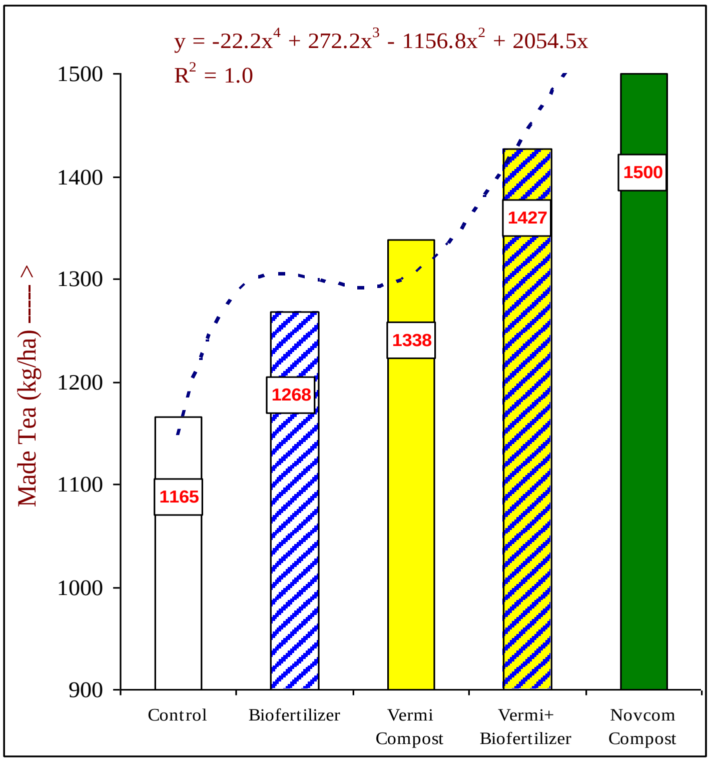


Fig. 4: Comparative crop performance (kg/ha) under single and combined input application.

The figure represents crop response under application of vermi-compost, bio-fertilizer, Novcom compost and vermicompost in combination with bio-fertilizer.

Vermicompost has low microflora potential while bio-fertilizers are often known to perform better in the presence of energy or food resources. The study was done to combined application *vis-a-vis* Novcom compost.

- Bio-fertilizer or Vermicompost applied alone registered crop hike of 8.8% and 14.8% respectively over control.
- Where as Novcom compost showed highest performance i.e. 28.8% higher yield over control.
- Though slightly higher (22.5 % over control) crop increase was observed under combined application of Vermicompost + Bio-fertilizer (as compared to yield obtained under individual application), it could not meet the potential of Novcom compost

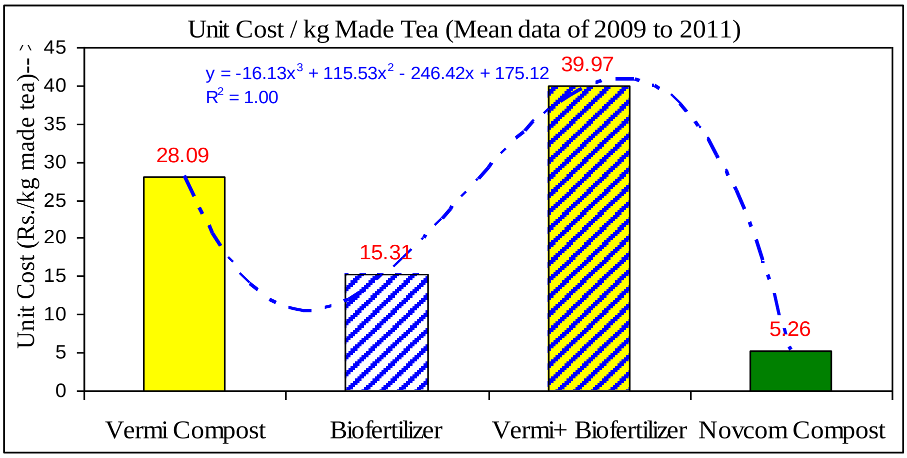


Fig. 5: Cost efficiency (Rs./kg) under single and combined input application.

❖ Application of vermicompost in combination with bio-fertilizer resulted in highest cost of production (COP) of approx. Rs. 40/- per kg made tea.

❖ Comparison of COP under vermicompost (Rs.28.09/kg made tea) and Novcom compost (Rs. 5.26/kg Made Tea) revealed that Novcom compost was about 1/5th cost of vermicompost.

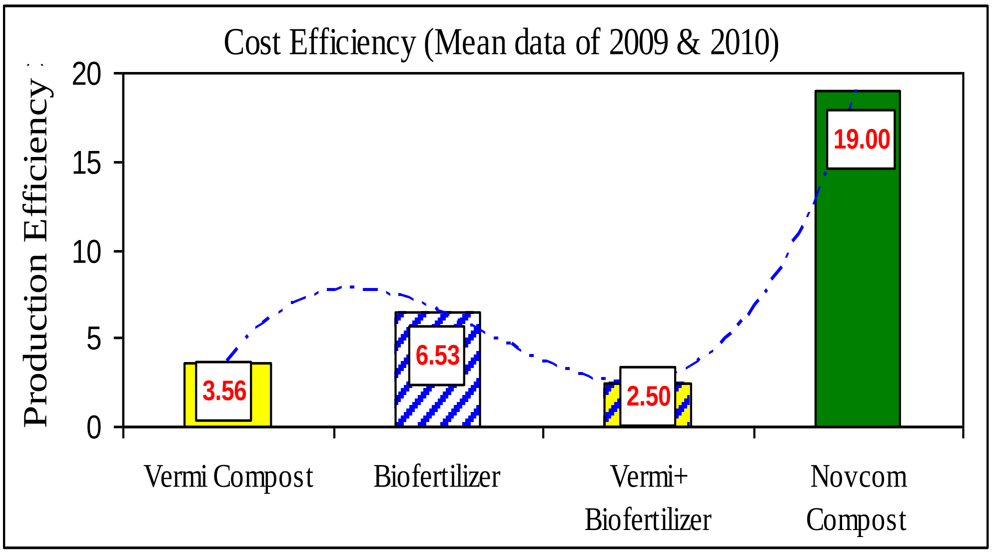


Fig. 6: Cost vs. production efficiency (Rs./kg) under single and combined input application.

SOIL INPUT QUALITY IS THE DETERMINANT FACTOR FOR COST EFFICIENCY

Fact Finding From Practice Done in General Garden Area of Model Farm Maud T.E.

Soil Input Applied : 3 ton castor cake

Crop Productivity[1] : 2000 kg made tea/ ha

Cost of Inputs : Rs. 18,000/-

If the same crop productivity has to be achieved only using On-Farm produced Novcom compost……….

Novcom compost required : 12 ton/ha*

Cost of Production : Rs. 10,320/-

Difference in Cost of Production :

Rs.18,000 - Rs. 10,320 = Rs. 7680 per ha

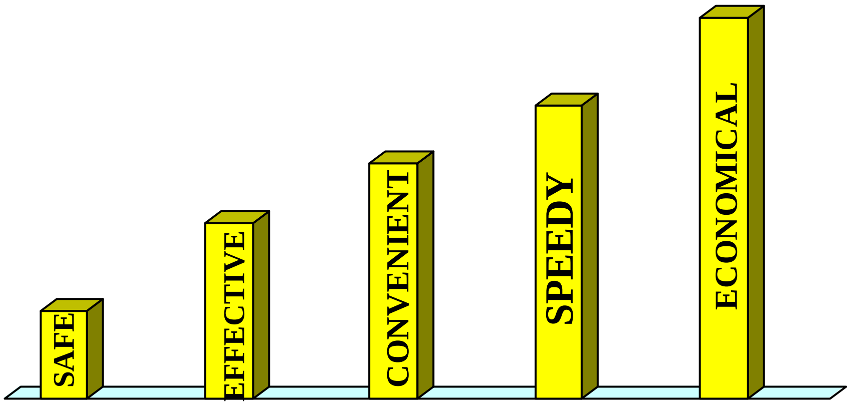
THAT MEANS

On-Farm Produced Compost is 43 % More Cost Efficient than Oilcake.

[1] *Performance is not sole contribution of Oil cake as Novcom compost was also applied @ 1ton/ha along with RFT Plant Management Package.*

WHAT IS THE PATHWAY FOR PRODUCTION OF AN IDEAL ORGANIC AMENDMENT?

<u>Only a process based on the five irreversible pillars can enable the production of such high quality compost/ organic amendment.</u>



To Rejuvenate the Deactivated Soil Dynamics, High Quality Compost is the Prime Requisition but to Ensure Widespread Application the Compost Must Satisfy FIVE IMPORTANT CRITERIA

1. SAFETY : There is a belief that compost cannot harm soil, plant or water ecosystem.

<u>Modern Research Confirms</u>- 'Immature Compost' can cause N-immobilization, starve roots of oxygen, create high levels of organic acids and support growth of pathogens *viz.* Salmonella and Pythium in soils **(Inbar *et al.*, 1990).**

Today most of the available compost/ or even bio- fertilizers, do not ensure this criteria except Novcom.

Rapid and intense generation of high temperature (up to 75^{0}C) during 'Novcom Composting' ensures total destruction of weed seeds and any harmful pathogens thereby ensuring absolute safety of Novcom compost.

This has been scientifically proved by the 'Stability/ Maturity & Phytotoxicity evaluation of Novcom compost as per 'National & International Protocol'

2. EFFECTIVITY : Today when the ever increasing food demand necessitates not only soil health regeneration but insists a progressive soil potential for stepping up agricultural production; success of compost without any time lag is a compulsion.

Most of presently available composts cannot assure the exact time period required for soil health restoration and bio- fertilizers too have their own limitations.

But Novcom compost successfully answers the challenge through regeneration of the native soil microflora – 'Major Drivers' for rewind of soil dynamism/ natural soil- nutrient dynamics.

Novcom compost contains huge population (of order 10^{16}) of naturally generated microbes along with sufficient energy resources for their natural proliferation.

On soil application, prolific activities of these microbes create favourable environment for restoration and enhancement of native soil microflora – 'Major Drivers' for a dynamic soil.

Sustained production of about 2 million kg (1/3rd of total Indian organic tea production) from Jalinga & Belseri T.E's with total stoppage of fertilizers and application of NOVCOM compost @ only 1-2 ton/ ha, is a **BIGGEST PROOF** of this.

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

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

4. SPEEDY : Most of the presently available composting methods require huge time period (minimum 80-90 days) for production, hence it becomes difficult to maintain a constant supply for satisfying crop requirements during the growth period.

However, a speedy process of composting can not only satisfy the demand but also optimize the production capacity of composting units.

NOVCOM COMPOSTING METHOD SATISFIES BOTH THESE

NOVCOM compost fulfils criteria of convenience & speed in one shot.

CONVENIENCE

- Novcom compost can be prepared on- farm using 'Novcom Composting Method', by even a small farmer utilizing the available resources
- Novcom method does not require digging or construction of any pits or require any other infrastructure.
- All types of bio- degradable organic materials can be composted using this method, which uses Novcom solution designed specifically according to the raw material type.

SPEED

- Novcom method is the quickest pathway for generation of high quality compost where composting completes within a period of just 21 days.
- In case of raw material like poultry litter/ cow dung etc. the composting period is further lowered to 15-18 days.

5. ECONOMICAL : Most important factor remains the economics because even a high quality but costly compost becomes economically unviable. This is one of the main drawbacks behind widespread application of vermicompost in recommended dosage.

'Novcom Composting Method' again scores in this front . . .

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

'Novcom Composting Method' of Inhana Biosciences is based on these 5 Determinant Pillars

MICROBIAL POPULATION OF ORDER 10^{16} c.f.u PER GRAM COMPOST - MYTH OR FACT ?

- Data available regarding microbial potential of compost suggest population in the order 10^{8} – 10^{12}, but never confirms that it is the highest potential possible.
- Experiments conducted on soil micro flora confirm microbial population of order 10^{12} – 10^{13} during the pre-chemical era (Ashworth, 1969).
- Organic carbon bound in organic matter (content 1-5% in soil) is the prime source of energy for micro flora.
- Highest value of organic carbon in soil could be about 2.8 – 3% whereas in any standard compost it is not less than 30% (USDA Composting Council, 2000).

- But most importantly in compost the entire carbon content is in utilizable form, which triggers profuse microbial population and activity.

If 3% energy/ food source can nourish and maintain microbial population of 10^{13}/ g moist soil, 10^{16} or more population in compost with 30% energy source is very natural.

WHY MICROBIAL POPULATION IN THE ORDER OF 10^{16}/g IS POSSIBLE ONLY IN NOVCOM COMPOST ?

- The difference lies in the underlying principle of Novcom Composting Method.
- Most of the compost is produced by windrow, digester or inoculum method, but in Novcom composting method, Novcom solution, which is potentised and energized botanical extract, is added.
- The Novcom solution transforms solar energy and induces the radiant energy on organic matter to activate it, producing energy source for prolific microbial generation and growth.
- The microbes simultaneously break down organic matter in the speediest and intensified manner. Through this process more energy is infused into the compost pit, which triggers the growth potential of the microbes substantially.
- Most importantly, being self- generated these microbes have the inherent potential of better space utilization within the compost, remaining in attenuated forms and simultaneously changing to their normal structure as per requirement.

If such a process is augmented by any composting method, microbial population of order 10^{16} c.f.u. or even more than that shall not be an unbelievable number.

WHETHER ADDITION OF MICROBIAL INOCULUMS /BIO-ACTIVATOR IS NEEDED FOR COMPOSTING ?

There is a debate in scientific community regarding the usefulness of microbial inoculums/bio-activator for producing quality compost. Scientists associated with commercial houses indicate studies regarding enhancement of composting processes with addition of microbial inoculums/bio-activator. However, independent composting studies confirm that addition of microbial inoculum, enzymes, hormones, preserved living organisms, activated factors, biocatalyst, etc. are unnecessary towards achieving the objectivity of composting (Washington State University, 2013).

Composting is the natural process of 'rotting' or decomposition of organic matter by microorganisms under controlled conditions (FAO, 2003). Composting involves conversion of organic residues of plant and animal origin, into manure. It is largely a microbiological process based upon the activities of several bacteria, actinomycetes and fungi (Bharadwaj, 1995). The end product is rich in humus and plant nutrients; the by-products are carbon dioxide, water, and heat (Abbasi and Ramasamy, 1999). As per Zucconi and De Bertoldi (1987) composting is an aerobic process in which microorganisms convert a mixed organic substrate into carbon dioxide (CO_2), water, minerals and stabilized organic matter. Control of environmental conditions during the process distinguishes composting from natural rotting or decomposition.

In the composting process, aerobic microorganisms use organic matter as a substrate. The microorganisms decompose the substrate, breaking it down from complex to intermediate and then to simpler compounds (Epstein, 1997; lpek *et al.*, 2002). During composting, compounds containing carbon and nitrogen are transformed through successive activities of different microbes to more stable organic matter, which chemically and biologically resemble humic substances (Pare *et al*., 1998). The rate and extent of these transformations depend on available substrates and the process variables used to control composting (Marche *et al*., 2003).

Microorganisms are always present in every bit of organic matter, whether manure, vegetable waste or leaves, and can be eliminated only by drastic sterilization methods. In this regard, Lynch and Wood (1985) in their study observed that the microbial flora built up rapidly with composting initiation. Xi *et al*. (2003) while working with various types of inoculation for MSW composting documented that high concentration of existing indigenous microorganisms could inhibit the prevalence of inoculated microorganisms due to competing of indigenous microorganisms,. When indigenous microorganisms concentration in the raw material was $4x10^8$ CFU/g, the inoculated microorganisms did not grow up. With the process, population inoculated microbes declined rapidly and the non-inoculated ones rose up quickly and reached a peak of 10^{10} CFU/g. Moreover inoculated microbes do not compete well under practical conditions (Bartha, 1986 and Golueke, 1990).

The number of microbes is rarely a limiting factor in composting because, if the environmental factors are appropriate, indigenous bacteria multiply rapidly, being much better adapted when forms attenuated under laboratory like conditions. Thus the rate of composting is governed simply by the environmental conditions (Washington State University, 2013). Research on composting at the University of California in the 1970s concentrated on the effectiveness of manure, “rich” soils, composting material, and two commercial preparations as inocula. These studies concluded that the composting process was neither accelerated nor the final product improved by the inoculums, even though the inoculums were rich in bacteria. Similar observation was also made by Dr. Vern Grubinger of University of Vermont Extension (USA) and according to him "all of the microbes required for a healthy compost process are already present in most wastes that can be composted, and therefore the utility of adding compost inoculant is limited".

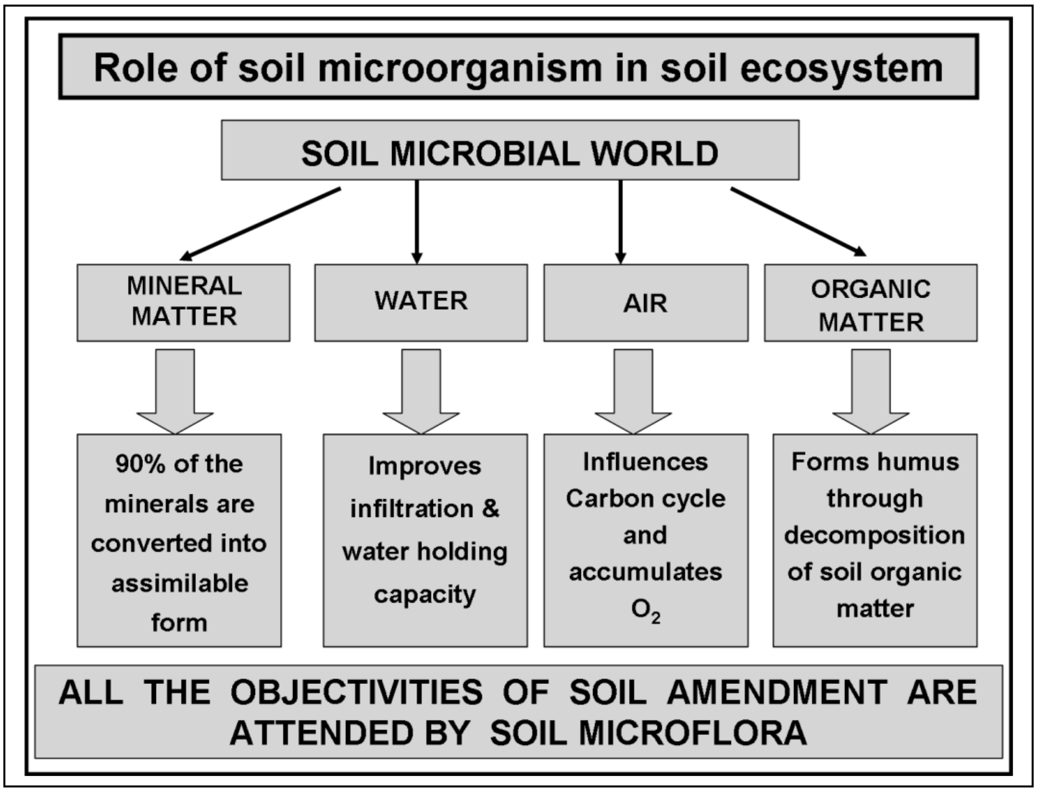
Research conducted under United Nations Environment Programme (2005), indicated that characteristically most of the wastes encountered in compost practice have an indigenous population so that inoculation would be unnecessary. On the other hand, inoculation would be useful with wastes that are deficient in/lack an indigenous population *viz.* pharmaceutical manufacturing wastes, wastes that have been sterilized or pasteurized etc. Moreover, it should be noted that, generally, inoculated microbes do not compete well under practical conditions (Bartha, 1986 and Golueke, 1990). Acevedo *et al.* (2005) also studied the effectivity of microbial inoculum in composting process and concluded that i) there were no significant differences among a range of microbial inocula and an un-inoculated control when these were evaluated in terms of capacity to reduce residence time or to improve desirable characteristics of the organic substrates used in the present study; ii) addition of inocula to the organic substrates traditionally used in composting processes (municipal solid waste and farm residues) has not been translated into statistically significant differences that justify their application.

Successful composting operations that don't use special inocula in the Netherlands, New Zealand, South Africa, India, China, USA and a great many other places, provide convincing evidence that inocula and other additions are not essential in composting. On the whole, though, when the environment is appropriate, varied indigenous (originating in a particular region) biological population will multiply rapidly and composting happen (Washington State University, 2013).

WHAT SHOULD BE THE OBJECTIVITY OF ORGANIC SOIL MANAGEMENT ?

A 'Dynamic Soil System' with adequate fertility status and effective nutrient utilization efficiency, which can be achieved primarily by increasing the Soil Microbial Status to 10^7 c.f.u. or higher.

The soil microbial population particularly bacteria, fungi and actinomycetes, through their prolific activities bring about restoration, maintenance and enhancement of soil - ecological processes that re- ensure soil dynamism.

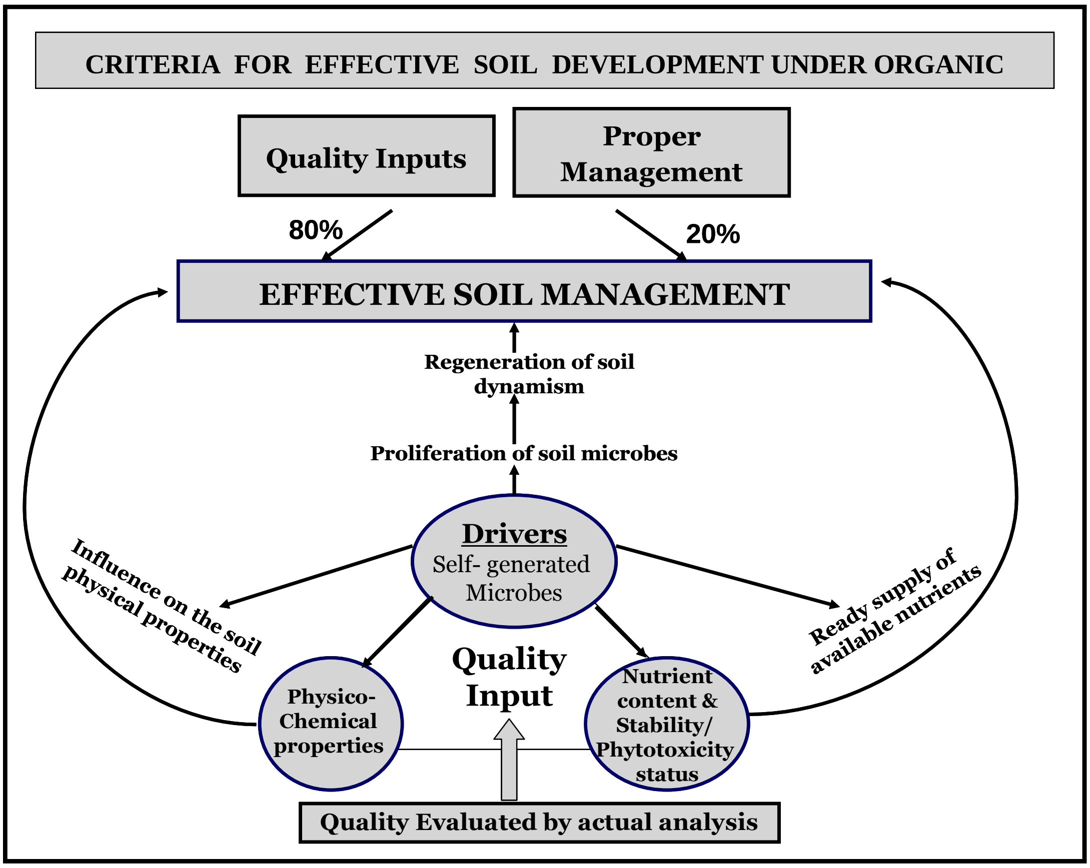


CRITERIA FOR EFFECTIVE ORGANIC SOIL MANAGEMENT

The objectivity of organic soil management is to rejuvenate the depleted soil quality leading to sustenance of crop productivity, through restoration of the 'Soil-Microbes-Nutrient-Plant' Dynamics.

This can achieved through a dual component approach i.e. i) application of good quality compost, ii) adoption of proper application procedures to ensure minimal loss of compost nutrients through volatilization or leaching, along with cultivation practices to build up the soil carbon reserve.

The quality of compost can be ensured through adoption of an ideal composting method along with through laboratory analysis of final compost in terms of physiochemical properties, nutrient content, microbial potential and stability/maturity/ phytotoxicity status.

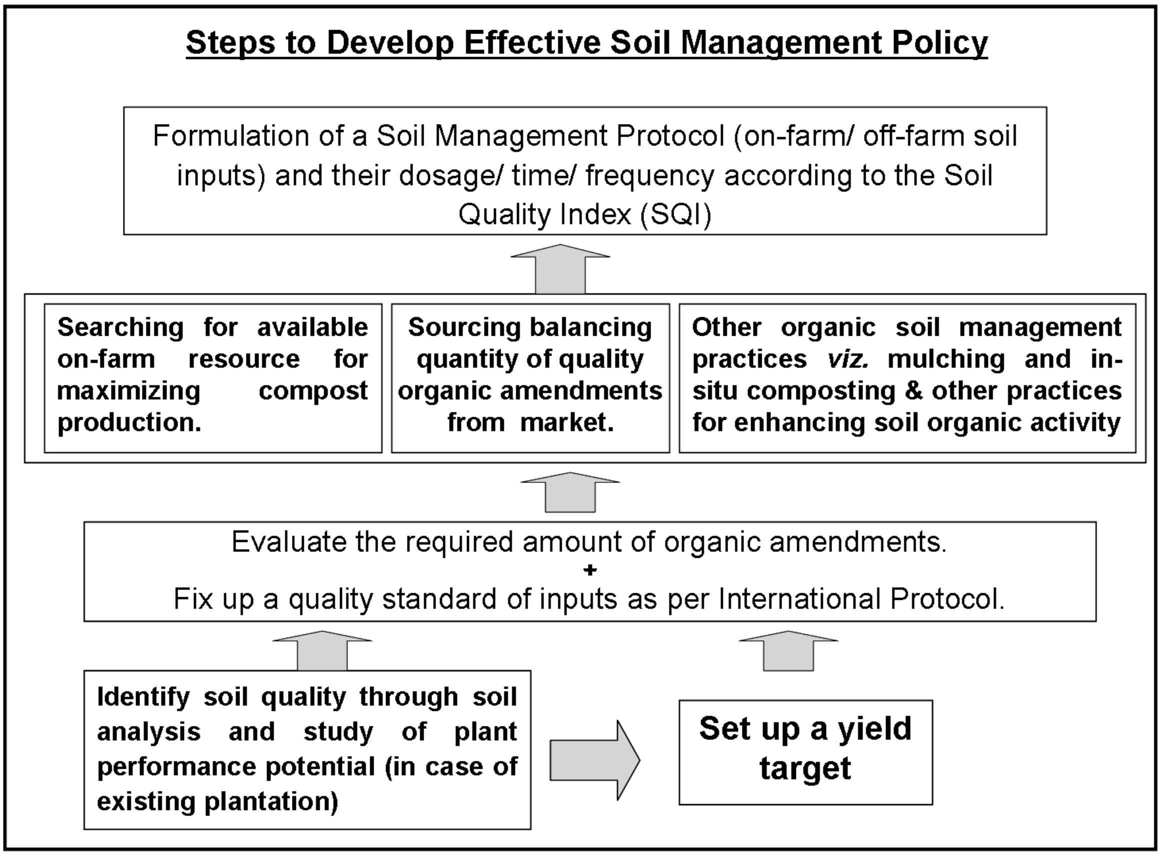


Good quality compost with huge self-generated microbial population shall not only enable ready supply of plant nutrients, but also work towards restoration of natural soil-plant-nutrient dynamics through rejuvenation of the native soil microflora.

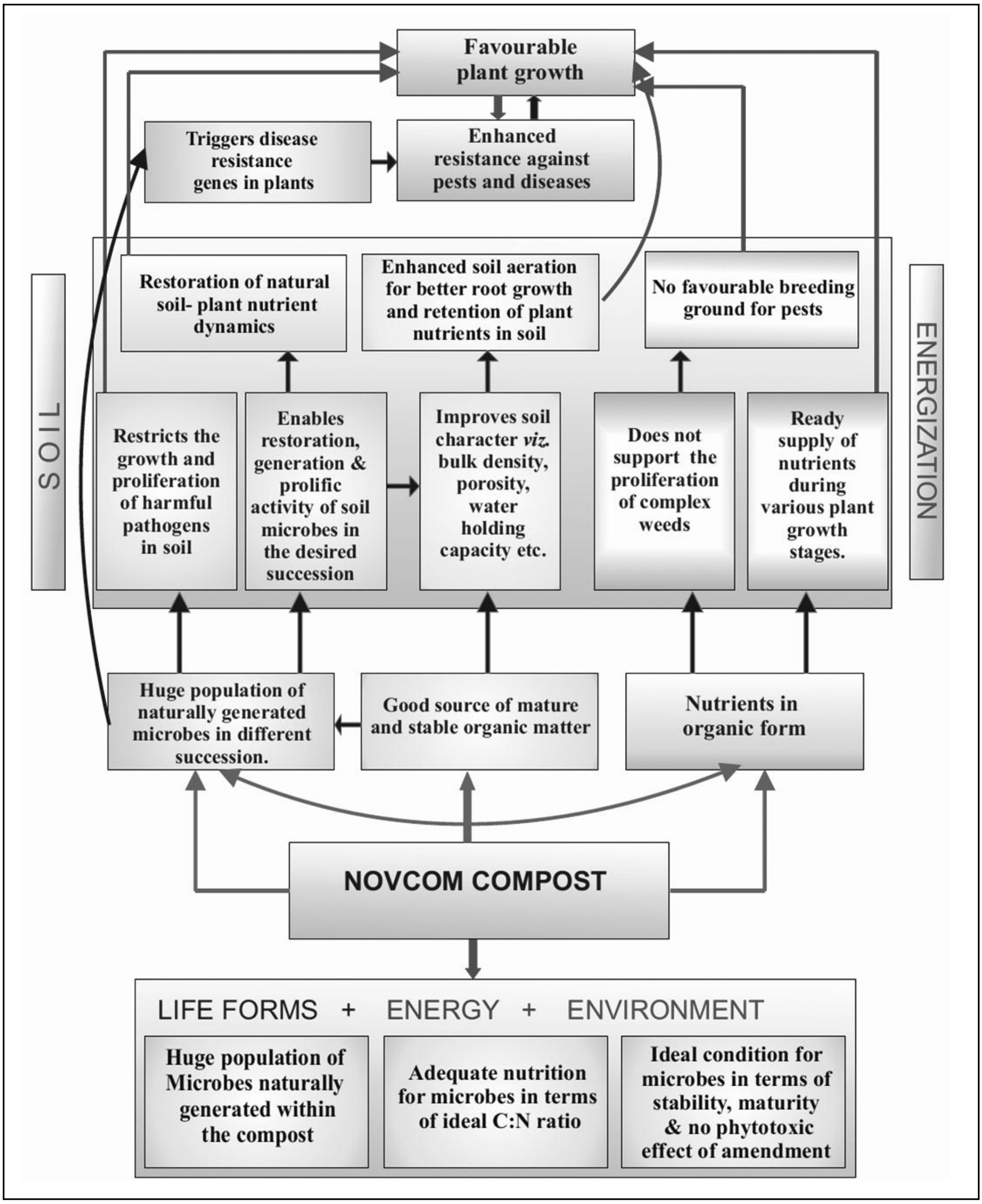
The post soil application effectivity of compost is greatly influenced by the application method. Scientific research has indicated that approximately 95% loss of available N from compost within 7 days post broadcast application. Rapid loss of moisture loss under broadcast application also adversely affects the microbial potential of compost. All these negativities can be minimized through soil incorporation of the compost, application of mulches etc. Adoption of cultivation practice *viz.* green manuring, in-situ composting etc. can also enable to build up the soil carbon reserve, which forms the store-house of all the 36 different macro and micro nutrients that are required for healthy plant growth.

DEVELOPMENT OF EFFECTIVE ORGANIC SOIL MANAGEMENT POLICY

The following diagram elucidates the steps towards formulation of site specific 'Soil Management Policy' to enable effective organic soil management leading to speedy soil rejuvenation and simultaneously sustained crop productivity.

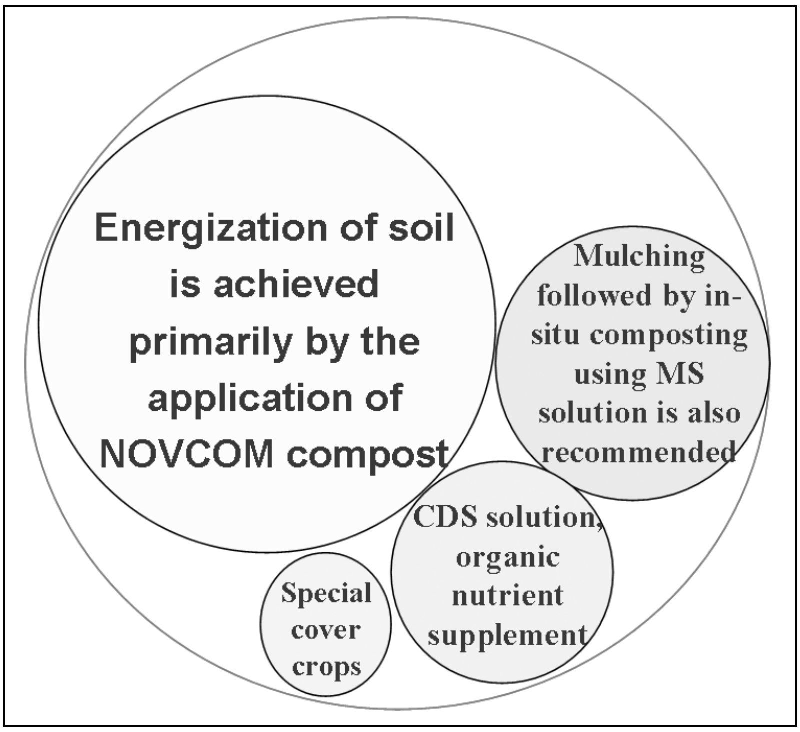


EFFECT OF NOVCOM COMPOST ON SOIL & PLANT SYSTEM



INHANA BIOSCIENCES RECOMMENDS ENERGIZATION OF SOIL SYSTEM FOR SPPEDY RESTORATION OF SOIL HEALTH

Soil energization is primarily brought about through application of Novcom compost. The objective is to ensure steady supply of nutrients to plants, at the desired time and in required quantity. But the major role remains to restore, rejuvenate and energize the native soil microflora population in order to bring about the restoration of natural soil-plant-nutrient dynamics in the speediest manner.



Although mulching is commonly done to preserve soil moisture, minimize volatization loss of soil-N and restrict weed growth; it can cause depletion in soil pH if practiced for a long period. Hence, Inhana Biosciences recommends in- situ composting of mulches through Inhana MS Solution to enable quicker bio-degradation and faster availability of plant nutrients through development of the soil microflora.

Energized cow dung slurry solution (CDS), concoctions for organic nutrient supplement, etc. are also used to enable site specific nutrient availability in soil through intense proliferation and vigorous activity of the native microflora. This is complimented by growing of special cover crops which not only help in conserving soil moisture and enable atmospheric- N fixation in soil but also positively influence the native microflora in the active area.

HOW NOVCOM COMPOSTING METHOD WORKS

The Method Advocates 6 Steps of Bio-degradation.

- High Temperature of 65-70^0 C to pasteurize and kill pathogens.
- Production of Thermophilic Bacteria & Actinomycetes.
- Preventing the proliferation of mineralizing bacteria and loss of valuable substances and preparation of the field for fungi.
- Temperature falls. Manure worms & crustaceans chew up org. matter.
- Break up of organic matter and multiplication of fungi.
- Break up of cellulose and lignin fibre into simpler form.

In the Novcom composting process high temperature of 65-70^{0}C pasteurizes and kills pathogens. At the same time thermophilic bacteria and actinomycetes are produced while proliferation of mineralizing bacteria is prevented and thereby loss of valuable substances is restricted. The first stage of decomposition henceforth prepares the field for fungi. After a period of 12-14 days from initiation, the temperature falls. At this stage manure worms chew organic matter and enable its breakdown; and multiplication of fungi takes place.

This is followed by the last and the final segment where cellulose and lignin components are acted upon by the fungal population. Lignin, a complex polymer of phenyl-propane units can only be broken-down by the necessary enzymes produced by certain fungi and the most scientific process is to attain such degradation only at the last stage of the decomposition process. This stage if tried to pre-pone unnecessarily by adding any microbial culture or any agent hinders the bio- availability of other constituents by reducing the surface area available for enzymatic penetration and activity. The degradation process continues further for a period of 7-8 days after which the final matured compost is ready for use within 21 days of initiation.

ANALYTICAL PARAMETERS FOR INTERPRETATION OF COMPOST QUALITY

The pH value of compost is considered an indicator of the process of decomposition and stabilization. Ideally, the pH value of compost should be neutral to slightly acid (6.0~7.5) and efforts should be made to control it if it exceeds a value of 8.5 (Benito, 2003). Moisture content higher than 65 percent leads to anaerobic condition, which not only causes liberation of foul odour but also kills favourable aerobic bacteria, whereas value less than 40 percent reduces bacterial activity for decomposition (Rahman, 2004). Electrical conductivity values increased with progress in biodegradation, which might be due to increase in salt concentration following degradation of organic matter (Campbell *et. al*, 1997). The composting process involves slow transformation of volatile matter to a less digestible, more stable form (humic substances). Volatile solids represent the main source of energy for the composting process, the mass of volatile solids decreased during the composting process. According to Namkoong *et al.* (1999), the progress of the composting process can be measured in terms of the reduction in volatile solids over time because not all biodegradable (organic) matter is immediately available for consumption by the composting microbes; therefore, measuring the change in the biodegradable portion of the waste provides an indication of compost stability.

C/N ratio is a traditional parameter, which has been used to evaluate the compost maturity and stability. The composting process results in fall of C/N ratio where the ideal C/N ratio of well-matured compost is about 10, but it is usually difficult to achieve by composting (Mathur, 1991). Harada *et al.* (1981) found that an initial C/N ratio of 22 usually drops to 12 after 5 weeks of composting. It has been stated that when C/N ratio is less than 20, the compost is mature and can be used without any restrictions (Saviozzi *et al*., 1987; Jiminez and Garcia, 1989). The CEC in an organic material increases as a function of humification due to the formation of carboxyl and phenolic functional groups (Roig *et al*., 1988). The higher the CEC the greater the ability of a particle to retain cations (Harada and Inoko, 1980). According to Mathur *et al.* (1993), Microbial biomass, which decreased as the composting process progressed towards completion; may be considered as an indicator of compost bio-maturity/ stability.

NH_4^+ - N / NO_3^- - N ratio is a clear indicator of nitrification and is considered as a maturity and stability index for composting (Haug, 1993). According to Haug (1993), high ammonia concentration is usually found in the early stages of composting and eventually reduced due to volatilization or oxidation to nitrate form. The concentration of NO_3^- and NO_2^- should be higher than NH_4^+ at the end of composting. NH_4^+ - N/ NO_3^- - N ratio is a relatively reliable and important parameter in determining maturity and stability of compost and Bernal *et al.* (1998) established a value 0.16 between NH_4^+ - N / NO_3^- - N for well-matured, stable compost. Zucconi and De Bertoldi (1987) through their composting experiments concluded that the ratio should not exceed 0.04% in mature compost. Degree of humification is often suggested as a measure of compost maturity and stability. Humic substances are products of secondary synthesis from simple organic compounds formed by the microbiological breakdown of organic matter (Hur et al., 2009).

Respiration rate is close related to the level of microorganism metabolism and thus represents the state of microbial activities. Respiration methods are now considered as the most suitable method of determining the stability of organic materials (Zucconi, 1981a; Iannotti et al., 1994). Germination Index (GI) is the best way to test the phytotoxicity of compost to plant growth because the results of it are quite straightforward and reliable. Germination bioassays are widely used to test for salinity, soil pathogens, toxic substances (such as phenolic compounds and heavy metals), and some other physical and chemical properties of compost (Zucconi et al. 1985; Handreck and Black1991; Gajdos 1997), which could be the major potential reasons of phytotoxicity.

MODEL COMPOST ANALYSIS REPORT WITH INTERPRETATION

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ANALYSIS REPORT

Sample Code : XXXXX		**Ref. No**	: XXXX
Sample Details : Novcom Compost from Green matter and Cow dung		**Dated**	: XXXXXX
		Received on	: XXXX
Sample sent by : XXX Company, India		**Analyzed between**	: XXXX –XXXX

Test Parameters	Novcom Compost Sample	Method
PHYSICOCHEMICAL PARAMETERS		
Moisture (%)	**60.94**	*Wolf & Wolf, 2003*
pH (H_2O)	**7.89**	*Black, 1965*
EC (dSm^{-1})	**2.69**	”
Ash Content (%)	**46.98**	”
Volatile Solids (%)	**53.02**	”
Organic carbon (%)	**29.46**	”
NUTRIENT PARAMETERS		
Total N (%)	**2.35**	”
Total P_2O_5 (%)	**0.76**	”
Total K_2O (%)	**1.32**	”
C:N	**12.5 : 1**	”
CMI	**1.59**	*Rekha et al, 2005*

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INHANA IN HARMONY WITH NATURE INHANA BIOSCIENCES

ANALYSIS REPORT

Continuation from previous page

Test Parameters	Vermi Compost Sample	Method
TOTAL MICROBIAL COUNT (c.f.u. per gm moist compost)		
Bacterial	**$43X10^{16}$**	*Black, 1965*
Fungy	**$12X10^{16}$**	”
Actinomycetes	**$7X10^{16}$**	”
Microbial Biomass C (%)	**1.23**	*Vance et al, 1987*
STABILITY		
CO_2 evaluation rate ($mgCO_2$–C/g OM/day)	**2.57**	*Trautmann & Krasny, 1997*
READY NUTRIENT SUPPLYING POTENTIAL		
Water Soluble Carbon (%)	**0.49**	*Chanyasak & Kubota, 1981*
Water Soluble Inorganic N (%)	**0.13**	”
Water Soluble Org N (%)	**0.08**	”
Organic C/N Ratio	**6.4 : 1**	”
Humification Ratio	0.02	*Rekha et al, 2005*
MATURITY & PHYTOTOXICITY PARAMETERS		
NH_4^+ - N (%)	**0.02**	*Chanyasak & Kubota, 1981*
NO_3^- - N (%)	**0.09**	”
Nitrification Index	**0.20**	*Rekha et al, 2005*
Seedling Emergence (% over control)	**110**	*Trautmann & Krasny, 1997*
Root Elongation (% over control)	**104**	”
Germination Index (phytotoxicity bioassay)	**1.14**	”

INHANA BIOSCIENCES LABORATORY

Technical Manager

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INHANA BIOSCIENCES
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INTERPRETATION

Moisture : Analytical value : **60.94** Desirable range : 35.0 – 55.0

Moisture Percent is the measure of water present in the compost and expressed as a percentage of total weight. Moisture content of <35 percent is a deterrent factor towards survival of the inherent microbial population but around 50% supports towards best microbial potential. While moisture higher than the desirable range provides difficulty in handling and transport as well as proportionately low dry matter/ nutrient content.

pH : Analytical value : **7.89** Desirable range : 7.2 – 8.5

pH measures the acidity or alkalinity of the compost where an alkaline pH indicates compost maturity, since the acidic by-products decrease with the progress in biodegradation. In general compost with neutral to slightly alkaline pH serve as a good growing media for plants especially nursery plants/seedlings, which can be severely affected by the presence of acidic by-products in compost with low pH.

Organic carbon : Analytical value : **29.46** Desirable range : 16.0 – 38.0

Organic carbon improves soil and plant efficiency by improving soil physical properties, providing energy source for beneficial organisms and enhancing the reservoir of soil nutrients. Low organic carbon status on the other hand will not support crop food requirement especially in case of perennial crop and require higher application dose.

Nutrients ($N+P_20_5+K_20$): Analytical value: **4.43** Desirable range: 2.0 – 5.0

The nutrient status is important to assess the capacity of compost towards maintaining a steady supply of nutrition to plants albeit in a controlled manner. In general average nutrient level ($N+P_2O_5+K_2O$) in most compost is found below 4%.

C/N ratio : Analytical value : **12.5 : 1** Desirable range : 10.0 – 20.0

The most commonly used index of compost maturity, is the C:N ratio. When C:N ratios is close or above the upper limit, mineral-N and any subsequently mineralized organic-N in compost can become immobilized in microbial biomass and made unavailable for plant uptake. While close or less than the lower limit induce faster availability, hence needs cautious handling. But the individual value of C and N need to introspected for proper interpretation of this parameter.

CMI : Analytical value : **1.59** Desirable range : 0.79 – 4.38

Compost mineralization index [CMI] indicates the degree of mineralization occurring during composting and primarily indicates the potentials of compost in terms of ready nutrient availability for plants. Compost with low CMI value is not desirable for short term crop cultivation.

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INHANA BIOSCIENCES

In harmony with nature

INTERPRETATION

Microbes (Bacteria+Fungi+Actinomycetes): Analytical value: **62×10^{16}**

Desirable range: > 10×10^{12}

The microbial population within ready compost is probably the most indicative parameter for its effectivity post soil application. In open-air composting processes, colonization of microbes in compost material occurs naturally during heap construction as well as turning of heap. The mineralization and immobilization of soil-N and the turnover of organic materials in soil and compost is affected by the heterotrophic soil organisms, including bacteria and fungi. High and comparative population of all the three categories of microbes in compost not only indicates ideal composting process but also ensures its better post soil application effectivity.

Stability : Analytical value : **2.57** Desirable range : < 2 Very stable

2 – 5 Stable

5 – 10 Moderately stable

Stability in terms of CO_2 evolution rate of compost samples determines whether the biodegradation process is completed or not and the material is ready for soil application. Generally CO_2 evaluation rate is high during compost biodegradation and once the process is completed, the value comes down as the microbial activity also ceases.

Organic C:N Ratio : Analytical value : **6.4 : 1** Desirable range : 5.0 – 6.0

Organic C/N ratio in compost water extract is an important index for compost maturity. Organic C:N ratio also indicates ready availability of nutrients to plant.

Nitrification Index: Analytical value: **0.20** Desirable range: < 7.14 Mature

Nitrification index is an important indicator to determine the maturity of the compost as well as presence of ammonia in toxic amount. The very appearance of significant amounts of nitrates in compost could be a sign of maturity as it produced in expense of ammonia.

Phytotoxicity Bioassay: Analytical value: **1.14**

Desirable range: > 1.0 Enhanced plant growth

0.80 – 1.00 No inhibition of Plant growth

0.60 – 8.00 Mild Inhibition

Phytotoxicity within compost can hinder seed germination, plant growth and root proliferation. A mature, good quality compost should not possess any type of phytotoxicity. Cucumbers (*Cucumis sativus*) were used for this test because they are not salt tolerant and very sensitive to ammonia and organic acid toxicity. Values above 80% for both percent emergence & vigor are indicative of well-cured compost.

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ANNEXURE

ON-FARM COMPOSTING METHODS

On-farm available green matter comprising common garden weeds *viz. Mikania micrantha, Ageratum houstonianum, Axonopus compressus, Digitaria setigera Roth, Clerodendrum viscosum Vent., Scoparia dulcis Linn., Paspalum longifolium Roxb* etc. were used for making four different types of compost *viz.* vermi compost, Indigenous compost or Farm Yard Manure (FYM), Biodynamic compost and Novcom compost; as per their standard processes (described below) at Maud tea estate in Dibrugarh, Assam (India). Vermicompost was produced within a period of 75 days, the biodegradation period for Indigenous and Biodynamic compost was 90 days while that for Novcom compost was 21 days.

VERMI COMPOST PRODUCTION AT MAUD T.E.

Raw materials used: Common garden weeds *viz. Mikania micrantha, Ageratum houstonianum, Axonopus compressus, Digitaria setigera Roth* etc. and cow dung at 60 : 40 ratio was used for making compost.

Earth worm: 4000 – 4500 earth worms (*Esenia foetida*) were required for each layer comprising about 600 to 650 kg of raw materials.

Vermi shed and Vermi compost pit : A plastic shed with bamboo structure was made for protecting the vermi pit from direct sunlight as well as rainfall. A vermi compost pit was prepared measuring 15 ft. in length, 4 ft. in breadth and 4 ft. in height. Base of the pit was soled with bricks followed by a sand layer. At the top of sand bed, thick cow dung slurry was sprayed.

Production of Vermi Compost:

At a selected upland chopped green matter and cow dung was stacked in a heap measuring 10 ft. in length, 6 ft. in breadth and 4 ft. in height. Proper watering was done, so that decomposition was initiated. This was kept for about 20 to 25 days and frequent watering was done till the materials were semi decomposed and temperature of the heap came down. Then the materials were ready for using in the vermi pit. The semi decomposed raw materials were transferred into the vermi pit and vermi was added layer wise in the specific quantity. Watering on regular basis was done to keep the vermi pit moist. The vermi compost was ready in 40 to 50 days time.

BIODYNAMIC COMPOST PRODUCTION AT MAUD T.E.

Raw materials used: Common garden weeds *viz. Mikania micrantha, Ageratum houstonianum, Axonopus compressus, Digitaria setigera Roth* etc. and cow dung at 70 : 30 ratio was used for making compost.

Production of Biodynamic Compost:

At first 2 kg Cow Pat Pit (CPP) was mixed with some water and kept for 4-6 hours. After that at least 30 ltr. of water was added to it and stirred well. A plain land facing east- west direction was chosen for better effectivity. After cleaning the land, the soil was moistened by spraying water on the surface. A 15 ft. long bamboo strip was placed in the middle of the land with the help of two bricks. Two 2 ft. long bamboo strips (lying across) were placed at every 2ft. interval on the main strip. Dry grasses were spread over the bamboo structure (up to 6 inches height) and watered to make it wet. A layer of cow dung (about 3 inches thick) was made next and water was sprayed on it. 2 ltr. CPP mixture was sprayed on the layer. The processes of layering with grasses and cow dung were repeated until the height was raised up to 2 ft. Then a layer of fresh green matter was made over it (about 4 inches height) and 15 kg CaO was broadcasted on top of the layer. The process of layering with grass and cowdung was again repeated until the height of the heap reached to about 4 ft. The top layer of the heap was made of cow dung. 3 holes were made on the heap and some CPP mixture was poured in those holes. After that CPP mixture was used to moisten the heap. Concentrated cow dung slurry was prepared by mixing a certain amount of soil with cow dung and the entire heap was plastered by it.

Method for Production of CPP :

A structure 1.5 ft. in length x 1.5 ft. in breadth x 1 ft. in height was made using bricks and the inner wall was pasted with fresh cow dung. The bottom of the structure was not lined with bricks. The pit was filled with fresh firm cow dung, eggshells and basalt dust was inserted into the dung (for 20kg of manure 65gms crushed eggshells and 166gm basalt dust was used) and spaded for an hour, next jaggery solution (100gm jaggery and one liter water) was sprinkled over it. After gently patting the cow dung six holes, 2 inches deep were made in it, followed by incorporation of Biodynamic preparations (1gm each of 503-506 and 1ml of 507). Fresh jute sack was placed over the pit to maintain moisture and to avoid excessive drying. The mixture was aerated once during a month with a garden fork. CPP gets ready in 60 days.

INDIGENOUS COMPOST (FYM) PRODUCTION AT MAUD T.E.

Raw materials used: Common garden weeds *viz. Mikania micrantha*, *Ageratum houstonianum*, *Axonopus compressus, Digitaria setigera Roth* etc. and cow dung at 70 : 30 ratio was used for making compost.

Production of Indigenous compost:

At a selected upland and flat area chopped green matter was spread to make a base layer measuring 15 ft. in length and 4 ft. wide. Green matter was chopped down to 1/2'' Size and placed evenly till 1 ft. followed by a layer of cow dung. The process was repeated till the heap reached a height of about 5 ft. The heap was covered with clay mud. The heap was demolished and upturned once the height reduced below 4 ft. and reconstructed to a height of about 5 ft. Compost was ready in 3 months time.

NOVCOM COMPOST PRODUCTION AT MAUD T.E.

Raw materials used: Common garden weeds *viz. Mikania micrantha*, *Ageratum houstonianum*, *Axonopus compressus, Digitaria setigera Roth* etc. and cow dung at 80 : 20 ratio was used for making compost.

Novcom solution: Biologically activated and potentized extract of Doob grass (*Cynodon dactylon*), Bel (*Sida cordifolia L*) and common Basil (*Ocimum bascilicum*).

Total requirement of Novcom solution: Total 250 ml Novcom solution is required for 1 ton of raw materials (100 ml on day 1 followed by 75 ml each, on day 7 and day 14).

Production of Novcom compost:

Day 1 : At a selected upland and flat area chopped green matter was spread to make a base layer measuring 10 ft. in length, 5 ft. in breadth and 1 ft. in thickness. This layer was sprinkled thoroughly with diluted Novcom solution (5 ml/ ltr. of water) and over this layer, a layer of cow dung (3 inches in thickness) was made followed by a second layer of chopped green material, once again

1 ft. in thickness. The green matter layer was once again sprinkled with diluted Novcom solution (5 ml/ ltr. of water) and the process was continued till the total height reached to about 6 ft. After construction of each layer of green matter it was compressed downward from the top and inward from the sides for compactness.

Day 7 : On the 7th day compost heap was demolished and churned properly. The material was next laid layer wise and after making each layer diluted Novcom solution (5 ml/ ltr.) was sprinkled thoroughly as done on 1st day. After seven days the volume of the composting material decreased due to progress in decomposition process. Hence, to once again maintain the heap height to about 6 ft.; the length and breadth of the heap was maintained at 6 ft. x 6 ft. respectively. The heap was once again made compact as described earlier.

Day 14 : The same process was repeated as on day 7 and to maintain heap height to about 6 ft., the length and breadth of the heap was further reduced to 6 ft. x 4 ft. respectively.

Day 21 : The composting process was complete and compost was ready for use.

Pic. 23: Large scale Novcom composting at Maud T.E.

(1) Chopping of green matter (garden weeds) for large scale Novcom composting Programme; (2) Formation of base layer using green matter (garden weeds) under Novcom composting Method; (3) Watering on green matter layer during erection of Novcom compost heap for ensuring adequate moisture during composting; (4) Formation of cowdung layer over green matter layer during Novcom composting programme; (5) Final Novcom compost Heap on the first day of composting; (6) Novcom compost heap after 7 days of composting; (7) Heat generation during demolition of Novcom compost heap on 7th day of composting (8) Reconstruction of Novcom compost heap on 7th day (9) Full view of Novcom compost heap after re-construction on 7th day (10) Re-construction of Novcom compost heap after demolition and proper churning on 14th day (same as day 7); (11) Large scale Novcom composting programme at Maud T.E.; (12) Inhana Technical personnel with Ms. Joelle Kato, Programme Manager, IFOAM, Germany, inspecting Novcom Coompost Heap at Maud T.E.

COST COMPONENTS OF DIFFERENT TYPES OF COMPOST STUDIED AT MAUD TEA ESTATE UNDER FAO-CFC-TBI PROJECT.

Table 1 : Cost components of NOVCOM Compost.

Parameters	**Value**
Basic Information	
Size of Heap	360 cft. (10 ft. x 6 ft. x 6ft.)
Total Raw Material used/heap	4500 kg
Duration of biodegradation (composting)	21 - 30 days
Weight of Final Compost	2925 – 3375 kg (Mean 3128 kg)
Recovery (percent)	65 - 75 % (mean 69.5 %)
Total Mandays required/heap	13.2
Various Cost Components of Novcom Compost	
Cost of 3500 kg Green matter (@ Rs. 0.23/kg)	Rs. 805/-
Cost of 1000 kg cowdung (@ Rs. 0.40 /kg)	Rs. 400/-
Cost of total 13.2 Mandays (@ Rs. 89/-) (5 mandays for chopping of green matter, 4 man days for 1st day heap construction, 2 mandays each for 1st and 2nd turning, 0.2 mandays for watering and monitoring)	Rs. 1175/-
Cost of Novcom solution (@ Rs. 600/ltr.)	Rs. 525/-
Total Cost	Rs. 2905/-
Cost of 1 kg Final Compost (*with chopping*)	Rs. (0.86 - 0.99)/- **(Mean Rs. 0.93/-)**
Cost of 1 kg Final Compost (*without chopping*)	Rs. (0.73 – 0.84)/- **(Mean Rs. 0.79/-)**

Based on market rate as on 1st April, 2013

Table 2 : Cost components of Biodynamic Compost.

Parameters	Value
Basic Information	
Size of Heap	240 cft. (15 ft. x 4 ft. x 4 ft.)
Total Raw Material used/heap	2200 kg
Duration of biodegradation (composting)	80 - 90 days
Weight of Final Compost	1188 - 1408 kg (Mean 1342 kg)
Recovery (percent)	54 – 64 % (Mean 61 %)
Total Mandays required/heap	4.2
Various Cost Components of Biodynamic Compost	
Cost of 1500 kg Green matter (@ Rs. 0.23/kg)	Rs. 345/-
Cost of 700 kg cowdung (@ Rs. 0.40 /kg)	Rs. 280/-
Cost of total 4.2 Mandays (@ Rs. 89/-) (3 man days for 1st day heap construction, 1 mandays for covering the heap with mud and 0.2 mandays for watering and monitoring)	Rs. 374/-
Cost of Biodynamic solutions (BD 502 to 507) (@ Rs. 150/set)	Rs. 150/-
Cost of Lime (@ Rs 16/kg)	Rs. 80/-
Cost of Bamboo (@ Rs 29/-)	Rs. 87/-
Total Cost	**Rs. 1316/-**
Cost of 1 kg Final Compost	Rs. (0.94 – 1.11)/- **Mean 0.98/-**

**Based on market rate as on 1st April, 2013*

Table 3 : Cost components of Indigenous (FYM) Compost.

Parameters	Value
Basic Information	
Size of Heap	300 cft. (15 ft. x 4 ft. x 5ft.)
Total Raw Material used/heap	2700 kg
Duration of biodegradation (composting)	80 - 90 days
Weight of Final Compost	1430 – 1594 kg **(Mean 1536 kg)**
Recovery (percent)	53 - 59 % **(Mean 57 %)**
Total Mandays required/heap	6.2
Cost Component of Indigenous (FYM) Compost	
Cost of 2000 kg Green matter (@ Rs. 0.23/kg)	Rs. 460/-
Cost of 700 kg cowdung (@ Rs. 0.40 /kg)	Rs. 280/-
Cost of total 6.2 Mandays (@ Rs. 89/-) (3 man days for 1st day heap construction, 1 mandays for covering the heap with mud, 2 mandays for 1 turning and 0.2 mandays for watering and monitoring)	Rs. 552/-
Total Cost	**Rs. 1292/-**
Cost of 1 kg Final Compost	Rs. (0.81 – 0.90)/- **(Mean Rs. 0.84/-)**

Based on market rate as on 1st April, 2013

Guiding Philosophy of EEA Principle behind Development of Novcom Solution.

Novcom solution is developed under the Element Energy Activation Principle. Radiant solar energy is stored in plants and the binded stored energy components are extracted from energy rich plant part by a specific extraction procedure and subsequently potentised in the order of 10^3 to 10^4, so that the activated energy forms release the energy components when sprayed on the medium (matter).

Process Flowchart of Inhana Solutions under E.E.A Principle

Selection of specific plants (Specific days and specific time)

⇩

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

⇩

Energisation (Isolation of Energy Components)

⇩

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

⇩

Combination of the activated, potentised and energized extract

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 potentials of the plants varies with various star occurrence.

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) and after / during extraction they should be transferred to a medium which is less gross and the same time has higher surface tension. Alcohol is used for the extraction process because it has the potential to isolate the bound energy in gross form and stored within it.

Energization (Isolation of Energy Components)

Energization is the process through which energy components are isolated from its gross form and stabilize 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 Bound Energy in order of 10^3 to 10^4 times)

Potentization is the process through which the extracted bind energy is activated to perform in desired order when applied in plants. In this process specific energy is transformed to its nearly original source or more specifically as it was transformed to differential energy from Basic Life Force. This form is Lifetrons, 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 specific energy components and the objectives of the specific role. 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 Potentised and Energized extracts

Combination of this potentised and energized extract is done according to the specific objectivity of the solution.

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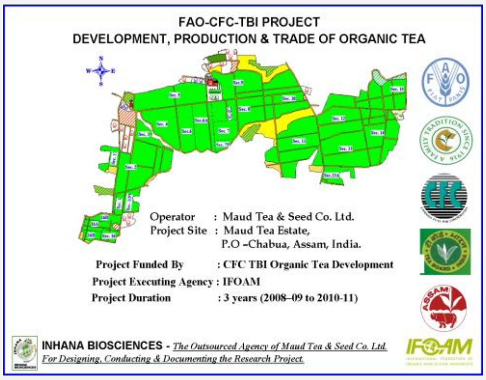
Organic soil management has become the pressing need today for reversing the cycle of soil degradation and thereby putting a step forward towards soil and crop sustainability. However, the objective has been far fetched even after application of organic soil inputs/ compost over a period of years. Quality of input has been the primary criteria for ensuring successful organic sol management but at the same time cost of input decides its potential for large scale adoptability.

This bulletin is the second 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 soil management especially with respect to tea plantation. The write-up explains the relevance of organic soil input quality and on-farm compost production towards effective soil management and sustained organic tea production.



Comparative evaluation of different types of organic soil inputs on the basis of their quality, crop efficiency as well as economics have also been provided on the basis of findings from FAO-CFC-TBI project entitled 'Development, Production and Trade of organic Tea' (2009-2011) at Maud T.E.

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