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Evaluation of Inhana Rational Farming (IRF) Technology as an Effective Organic Option for Large Scale Paddy Cultivation in Farmer's Field – A Case Study from Kowgachi-II Gram Panchayat, North 24 Parganas, West Bengal

Barik A. K.
Department of Agronomy, Visva Bharati University, Sriniketan, India
Chatterjee A. K.
Department of Soil Science, Visva Bharati University, Sriniketan, India
Datta A.
Inhana Organic Research Foundation (IORF), Kolkata, India
Saha S.
Inhana Organic Research Foundation (IORF), Kolkata, India
Bera R.
Inhana Organic Research Foundation (IORF), Kolkata, India
Seal A.
Inhana Organic Research Foundation (IORF), Kolkata, India

Abstract :
Comparative study of Chemical (Farmer's Practice) and Organic (under Inhana Rational Farming Technology developed by visionary scientist, Dr. P. Das Biswas, Founder, Inhana Biosciences, Kolkata) aman paddy (rainfed) cultivation was conducted at farmers' field under large scale production in Mathurapur village, Kowgachi-II Gram Panchayat, North 24 Parganas of West Bengal during crop year 2012 – 2013. Farmers from the village volunteered in the programme under encouragement from local gram panchyat towards hand on experience regarding effectivity of organic farming system in paddy. Compost was prepared locally using Novcom composting (Developed by Inhana Biosciences) method by the project farmers taking poultry litter as raw material. Well matured compost was prepared (as indicated by brownish colour and earthy smell) within 20 days. Analysis of compost quality as per standard guideline confirmed its high quality. Total nutrient content (NPK) was varied from 3.86 to 4.74 percent (on dry weight basis) with microbial population in the range of 10^{16} c.f.u per gram moist compost; which was significantly higher than reference value as obtained for poultry compost. CO_2 evolution rate (mean 2.74 $mgCO_2$ – C/g OM/day) and phytotoxicity bioassay test value (mean 0.82) tallied with ideal standard range, confirming the maturity and non- phytotoxicity of the compost.
Aman (rain fed) Paddy (Oriza sativa) variety Khitish and Minikit -3654 were used for the study. These two varieties were taken considering their common usage by the farmers of the Block. Seeds of Khitish variety were sourced from Gram Panchayat as provided by Government of West Bengal, while Minikit-3654 was sourced as foundation seed developed by Monduri Farm, BCKV, State Agricultural University, West Bengal, India. Agronomic components in terms of numbers of tillers/hill, productive panicles/m^2, filled grains/panicle and 1000 grains weight (g) of organically grown paddy was comparatively higher than conventionally grown paddy and its cumulative effect was considered in terms of total yield under two different management systems. In case of paddy variety Minikit- 3654 yield under organic practice (i.e., Inhana Rational Farming Technology) varied from 3375 kg/ha to 4125 kg/ha with average value of 3750 kg/ha while 3000 kg/ha to 3750 kg/ha with mean value of 3563 kg/ha under conventional chemical practice. In case of Khitish variety yield under organic (i.e. under Inhana Rational Farming) was almost at par to chemical farming practice and varied from 3750 kg/ha to 4500 kg/ha with a mean value of 4125 kg/ha.
Nutrient Use Efficiency (NUE) in terms of partial factor productivity (PFP) was higher in case of Khitish variety in comparison to Minikit-3654 irrespective of the practice undertaken. However, in both cases, nutrient use efficiency (NUE) was higher under organic practice which may be due to better N mineralization from Novcom compost as well as better N uptake efficiency of the plants under IRF Plant Management Package. This is perhaps significant because the nutrient availability is considered as a limiting factor under organic soil management particularly under waterlogged condition and in the soil which has been applied with synthetic fertilizers for many years. In terms of soil quality development, organic package of practice has shown positive indication towards enhancement of soil quality component like soil pH, available NPK and specially soil microflora enhancement where as under conventional practice no such variations were noted.

There is higher net income in case of Minikit variety but as the cost of cultivation under Inhana Rational Farming being is almost similar to chemical farming practice, there is potential for further higher net income if the produce is sold at even 10 percent premium price as organic item. The technology has most convincingly demonstrated its potential to ensure successful organic paddy cultivation in the most cost- effective manner and can definitely bring about economic prosperity among the farming community if adopted on a further larger scale. Significantly all these results were achieved in the very first year of application. The ecological and social cost of industrial agriculture, if considered; then this performance certainly promises clear potential towards sustainable organic cultivation for resource poor and marginal farmers.

***Key words :** Organic paddy cultivation, Rational Farming Technology, Novcom compost, Nutrient use efficiency, Soil quality development.*

1. Introduction

Rice (*Oryza* spp.) is the world's most important cereal considering the area under cultivation and the number of people dependant on it (13 and 1). In India, rice is cultivated in 42 million hectares (mha) under four major ecosystems, *viz.* irrigated (19 mha), rainfed lowland (14 mha), flood prone (3 mha) and rainfed upland (6 mha). Rice ecosystems in India represent 24% of irrigated areas, 34% of rainfed lowlands, 26% of flood-prone areas and 37% of rainfed uplands cultivated to rice in the entire world (25). West Bengal is predominantly paddy growing state where 7,19,800 ha of land is under paddy cultivation. The state of West Bengal has always contributed nearly 14-16 per cent of the all India rice production (15). Paddy is grown in three seasons *viz.* a*us*, a*man* and *boro.* The *aus* and *aman* is mainly rainfed whereas *boro* is irrigated which is mainly dependent on ground water.

However, the erratic climatic pattern, indiscriminate use of chemical fertilizer and pesticide, unplanned ground water upliftment etc. raise questions upon sustainability of paddy cultivation. Today it is no longer a debatable issue that since the "green revolution" of the 1960s, conventional agriculture and now biotechnology have been touted as solutions to the global hunger problem— but their high yields come at the cost of environmental degradation and lowered food security over the long term (2). In this backdrop, shifting focus towards organic paddy cultivation is the only option left for future crop sustainability along with ecological sustenance. Long-term studies conducted in a range of countries and over an array of crops have proven that organic agriculture yields as much food as conventional agriculture in drought years and organic methods almost always produce higher yields (2). However, organic agriculture faces some major bottle necks both principally and in practical applicability. First there is lack of proper guidelines; secondly application of organic inputs based on the same input substitution theory of chemical farming makes organic agriculture costly, as well as a risky proposition. Especially the anaerobic conditions under paddy cultivation render it difficult for the organic inputs to ensure successful crop production, as a result organic paddy cultivation in India remains mainly restricted to exportability options. Need of organic packages of practice was felt and effort was made under FAO-CFC-TBI Project entitled 'Development, Production and Trade of Organic Tea' to bring forth the most effective organic package, which could be the combination of different organic soil and plant application inputs but they must operate in an integrated manner, in order to be effectively functional.

Rational Farming Technology developed by Dr. P. Das Biswas, Founder Director of Inhana Biosciences and a noted scientist who was pioneering in introduction of Scientific Organic Farming in India from the last decade; is an unique Organic Package of Practice which blends ancient wisdom with scientific knowledge, ensuring an effective road map for successful and large scale organic agriculture. Rational Farming Technology is not based on the quantitative application of inputs for nutritional management of plants or cidal approach for pest/disease control but strives towards qualitative development of the soil and plant functions leading to sustainable organic crop production that too in the most economical manner. Effectivity of Rational Farming Technology is well established by the crop sustainability in India's two largest organic certified tea estates for the last 10 years as well as under the recently concluded FAO-CFC-TBI Project entitled "Development Production and Trade of Organic Tea' at Maud T.E. (2009 to 2012). Hence the present study was under taken to show the potential of Rational Farming Technology towards large scale organic paddy cultivation in farmers' field in the most cost effective manner as compared to the conventional farmers' practice.

2. Materials and Methods

The present study was undertaken in the crop season of 2012-2013 at Mathurapur village, in Kowgachi-II Gram Panchayat, Barrackpore–I Development Block, North 24 parganas, West Bengal. At the initiation farmers meetings were conducted in the study area. Post discussion regarding the limitations of the present cultivation practice and importance of organic farming towards sustained crop productivity and soil quality improvement, some progressive farmers (table 1) came forward to participate in the project for actual on- field comparison of crop productivity under organic farming (Rational Farming Technology) *vis-a-vis* Conventional farming i.e. as per their usual practice. Local Panchayat members also extended help in selecting progressive farmers and facilitating the project.

Sl No	Farmers Name	Area (bigha)		Sl No	Farmers Name	Area (bigha)
Area under Organic (Inhana Rational Farming Technology) paddy cultivation				Area under Organic (Inhana Rational Farming Technology) paddy cultivation		
1.	Susanta Chari	6 bigha		9.	Bistu Audok	3 bigha
2.	Nitai Jana	3 bigha		10.	Ganesh Khelo	5 bigha
3.	Prabir Majhi	2 bigha		11.	Narayan Shit	2 bigha
4.	Sahadeb Maity	3 bigha		12.	Ravan Bera	3 bigha
5.	Ashoke Beto	2 bigha		13.	Nepal Khelo	3 bigha
6.	Bapi Shanki	2 bigha		14.	Ashoke Mondal	5 bigha
7.	Bhabothosh Beto	2 bigha		15.	Umapado Meto	5 bigha
8.	Ojhe Maity	2 bigha				
Area under Conventional (Chemical) paddy cultivation (Farmer's Practice)				Area under Conventional (Chemical) paddy cultivation (Farmer's Practice)		
1.	Rabindranath Maji	6 bigha		4.	Nitai Jana	3 bigha
2.	Paritosh Khelo	3 bigha		5.	Jamir Ali	7 bigha
3.	Pulak Beto	7 bigha		6.	Bhabotosh Das	2 bigha

Table 1 : Details of Progressive Farmers associated with the project.

Aman (Rain fed) Paddy *(Oriza sativa*) variety Khitish and Minikit -3654 were used for the study. These two varieties were taken considering their common usage by the farmers of the Block. Seeds of Khitish variety were sourced from Gram Panchayat as provided by Government of West Bengal, while Minikit-3654 was sourced as foundation seed developed by Monduri Farm, BCKV, Kalyani. Total 10 kg/bigha and 8 kg/ bigha seeds of Khitish and Minikit -3654 were used for seed bed.
Soil and Compost samples were collected as per standard methodology (8). Compost samples were analysised for 11 quality parameters as per the guideline of U.S. Composting Counsil, 2002 (12) and Australinan Standard,1999 (3). Soil samples were collected pre project initiation and post harvesting from 10 different points in the project area and analyzed as per standard methodology (8).

2. 1. Inhana Rational Farming (IRF) Technology

Inhana Rational Farming (IRF) Technology developed by Dr. P. Das Biswas, associated with organic research for the last 15 years; has a WHOLISTIC approach so that all components of the ecosystem are taken in an integrated manner i.e. soil system, plant system and their interrelated and integrated relationships with the environment as a whole. It provides the right environment for all the components, be it plant or soil, which ultimately leads to ecological improvement thereby ensuring economic sustainability. Inhana Rational Farming Technology is till now probably the only package of practice which provides complete solutions for organic farming from seed showing to harvesting in an effective and Economic way.

2. 1. 1. Objectivities of Rational Farming Technology

- Energization of the Soil System i.e., enabling the soil to function naturally and in the most effective way as an effective growth medium for plants.
- Energization of the Plant System i.e., the plants become efficient in optimum extraction, utilization and assimilation of nutrients as well as enhancement of the biochemical and structural defense of the plant system through the activation of the plants host defense mechanism.

2.1.2. Inhana Solutions

Rational Farming Technology utilizes various In-House solutions for soil and plant energization. Technology specific plants, which store the energy of these five basic elements as well as five basic life forces, are selected in accordance with parameters related to sunset, seasons and various factors. Botanical extracts of these plants are then potentized and energized following Element Energy Activation Principle (E.E.A.). Each and every solution individually has one or more function but when applied as a complete package the solutions work in an integrated manner giving a comprehensive result. However, since the situations vary as per crop species and agro-climatic situation hence Rational Farming Technology also ensures need-based solutions for all problems.

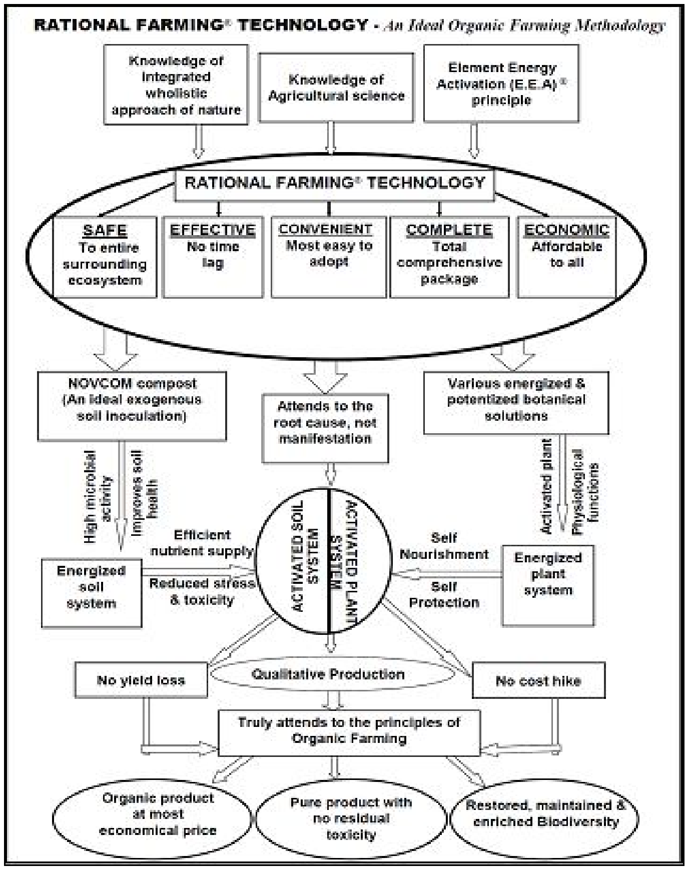


Figure 1 : Flow diagram depicting working mechanism of Inhana Rational Farming (IRF) Technology
Source: Website of Inhana Biosciences- www.inhana.com

2.1.3. 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. Hence when they are applied on the plant system they enters primarily through the stomatal opening and they are being accepted by the plant system because of this primary (Subtler) form. Thereafter they can reach to the desired sight more quickly as no transformation of that energy form is required.

- **Combination of the Potentised and Energized Eextracts**
  Combination of this potentised and energized extract are done according to the specific objectivity of the solutions. As all solutions have regulatory role and no inhibitory action, these are applied to regulate specific plant functions in desired and successive order. These solutions try to solve any problem leading to the root cause of the problem. For example Immunosil has been developed for disease management of crop. For effective disease management, both structural and biochemical defense of plant is a must. Simultaneously, any cidal approach to fungal pathogens is not only ineffective, this is unscientific and unethical. Modern research reveals that silica can provide structural defense against fungal pathogens. But most of the plants can not uptake the silica from the soil to the desired level that is required to elevate their structural defense. Two physiological processes are involved in the silica absorption – anaerobic glycolysis and aerobic respiration. Immunosil gives specific energy components which hastens the intensity and quality of these processes. Root systems need to be energized hence 'Apana Prana' is provided; then silica should be translocated where water element is involved, so 'Udana Prana" is provided and so on. So according to the sequential regulatory plant functions and their required intensity specific energy components are combined in different proportions to develop individual solution.

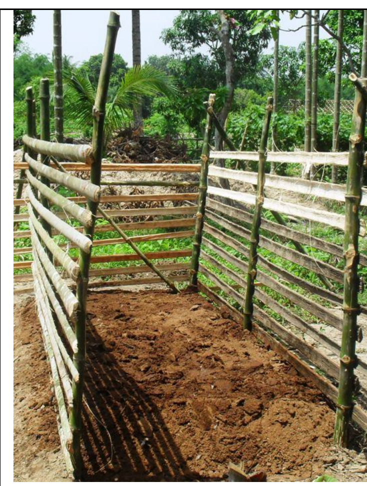
2.2. Method of Novcom Poultry Litter Composting

The Project was initiated with preparation of Novcom Compost under Novcom composting method (Seal et al, 2012). Project farmers erected total 20 Novcom composting heaps of average size of 8 ft. length x 6ft. width x 6 ft. height during March - April, using poultry litter as raw material.

2.2.1. Novcom Solution

Novcom solution is developed by Dr. P. Das Biswas, Founder Director of Inhana Biosciences, (a R&D organization based in Kolkata, India) under the Element Energy Activation (E.E.A principle. Radiant solar energy is stored in plants and the bound stored energy components are extracted from energy-rich plant parts using a specific extraction procedure and subsequently potentized in the order of 10^3 to 10^4. The process flowchart of Novcom Solution under the Element Energy Activation (EEA) Principle is provided by Seal *et al.*,2012 (27). The solution contains biologically activated and potentized extracts of Cynodon dactylon, Sida cordifolia L. and Ocimum bascilicum. The solution is used on the initiation day i.e. during erection of Novcom composting heap and further on 10^{th} day of composting, i.e. during heap restructuring.

2.2.2. Preparation of Novcom compost

Day 1 : At a selected upland and flat area, poultry litter was spread to make a base layer 8 ft. long, 6 ft. wide and 1 ft. thick. Water was sprinkled to moist the raw material followed by diluted Novcom solution (5 ml/litre of water). This was followed by a second layer of poultry litter, again 1 ft. thick. Four sides of the layer were pressed hard for straight alignment of the heap. The poultry litter layer was again sprinkled with water followed by diluted Novcom solution (5 ml/litre of water). The process was continued until the final height of compost heap reached to about 6 ft. After construction of each layer of poultry litter, it was compressed from the top and inward from the sides for compactness. All total 150 ml Novcom solution/ ton of raw material was used on initiation day. Day 10 : On day 10 the compost heap was demolished and churned properly. The material was next laid down layer-wise and each layer was sprinkled thoroughly with diluted Novcom solution (5 ml/litre of water), as on day 1. After 10 days, the volume of the composting material decreased due to decomposition. Hence, to maintain the height of the compost heap at about 6 ft. (as per the guidelines of Novcom composting method), the length of the heap was reduced to 7 ft. during heap reconstruction. The heap was once again made compact, as described earlier.	 Pic. 1 : Bamboo structure to support the Novcom poultry compost Heap

Pic. 2 : Layerwise application of Novcom solution during Composting of poultry litter.

Pic. 3 : Novcom compost heap using poultry litter on 1st Day.

Pic. 4 : Temperature generated (> 60^0C) within Novcom compost heap ensure complete destruction of pathogens.

Day 20 : The composting process was complete (as per the Novcom composting method guideline) and compost was ready for use

2.3. Method of Paddy Seed Bed Preparation

The seed bed area was ploughed twice under wet conditions and then puddled by giving three more ploughings. After 10 days, the field was again ploughed twice and leveled. When the field was brought to fine soft puddled condition, raised beds (4 - 5 cm high) 1.2 m wide and of convenient length, with 45 cm channel all around was constructed. Excess water was drained off to maintain a water level just sufficient to cover the soil. The surface of seed bed was so leveled that there was gradual inclination toward both sides to facilitate drainage of water during the first few days. For 1 bigha of paddy cultivation 1.5 cottah seed bed was prepared. In conventional seed bed under farmers' practice 10 kg mustard cake and 5kg complex fertilizer (N,P,K) 10:26:26 was mixed with soil before sowing. In organic seed bed, 50 kg Novcom poultry litter compost was applied during final seed bed preparation.

2.4. Organic Seed Treatment

Paddy seeds were immersed in 6 to 8 ltr. of water in which 200 ml Inhana Seed Solution-I was added. The seeds were soaked for 30 minutes and then air dried under shade before use. Seeds were shown during 30th to 31st July, 2012 and were ready for transplanting during 22nd to 24th August, 2012.

2.5. Land Preparation and Transplanting of Seedlings

Land was prepared conventionally during 25th July to 20th August, 2012. Final land preparation was done by ploughing and cross ploughing by two wheel power tiller with two laddering two days before transplanting. Transplanting of seedlings was done during 22nd to 24th both in case of Minikit -3654 and Khitish. In both the cases 23 to 25 days old seedlings were uprooted from the seedbed carefully and transplanted on the same day. Four to five seedlings hill^{-1} were transplanted maintaining row spacing at 15 cm and plant to plant spacing of 15 cm. Before transplanting between the furrows of bed, irrigation water was applied one day in advance to make the soil soft.

2.6. Weed Management

In case of organic paddy cultivation manual weeding was done twice during the growth period of transplanted aman rice i.e. Minikit -3654 and Khitish variety. The plots were weeded 21 and 42 days after transplanting. Under conventional paddy cultivation 1 to 2 rounds of Glyphosate 75% was applied for weed management.

2.7. Fertilizer Application

- *Under Conventional Farmers' Practice* : In case of Minikit-3654 variety, chemical fertilizers in terms of complex NPK (10 : 26 : 26) 20 kg, Urea 15 kg and Murate of Potash 20 kg were applied per bigha in the conventional plots. The fertilizer was applied in two split doses, first during land preparation and second 21 days after transplanting. In first split dose 20 kg complex NPK (10 : 26 : 26) were applied and in the 2nd split dose 15 kg Urea and 20 kg Murate of Potash were applied per bigha. Similarly in case of Khitish variety, chemical fertilizer application was same as applied for Minikit-3654 variety.
- *Under Organic (Inhana Rational Farming Technology) Practice* : Novcom poultry litter compost was applied during final land preparation. Total 25 bags (each containing 50 kg compost) of Novcom compost, i.e. 1250 kg compost/bigha was applied for both Minikit-3654 and Khitish variety. The actual dose applied was about 60 percent of the recommended dosage of 2.00 ton/ bigha. Considering slow release of nutrient from organic source, especially under anaerobic condition in paddy field, lower application of compost may be a big hindering block for proper crop response.

Paddy Cultivation	Total Nutrient Used/bigha		
	Nitrogen	Phosphorus	Potassium
Conventional Cultivation Practice	8.9 kg	5.2 kg	5.2 kg
Organic (IRF) Cultivation Practice	8.6 kg	2.8 kg	3.0 kg

Table 2 : Total NPK applied in Conventional and Organic Paddy Cultivation.

2.8. Organic Plant Management Under Inhana Rational Farming Technology

Organic plant management package under Inhana Rational Farming Technology was applied as per the schedule provided by Inhana Biosciences. The protocol was initiated from organic seed bed by giving two sprays of Inhana solutions namely IB (Ag)– I and IB (Ag)– II at an interval of 10 days. Before transplanting into the main field, the seedlings were immersed in root deep water mixed with Inhana Seed Solution II, for nearly 1 hour. This was done to limit or erase out the possibility of any seed borne diseases and to initiate better growth process from the beginning.

Sl. No	Solution Name	Dose & Dilution	Growth stage (time of application)
Organic Seed Bed Management			
1.	IB (Ag) - I	200 ml/litre of water	3 days after germination
2.	IB (Ag) -II	200 ml/litre of water	10 days after 1st spray
3.	Seed solution II	200 ml/5 litre of water	Uprooted seedlings ready for transplantation
Organic Paddy Management (Post Transplantation)			
1.	IB (Ag)- 1	200 ml/bigha	7 days after transplanting.
2.	IB (Ag)- 2 + IB(Ag)- 7	(200 ml + 200 ml)/ bigha	10 days after 1st spray in main field.
3.	IB (Ag) - 5	200 ml/bigha	10 days after 2nd spray in main field.
4.	IB (Ag) - 2	200 ml/bigha	20 days after 3rd spray in main field.
5.	IB (Ag)- 3	200 ml/bigha	10 days after 4th spray in main field.

Table 3 : Different Solutions under Inhana Plant Management Package for organic paddy cultivation.

Sl. No	Solution Name	Biologically activated & potentised extract of	Role in Plant Physiological Development
1.	IB (Ag) - I	Ficus hispida Linn.	**I**nitiation of metabolic resources during germination.
2.	IB (Ag) -II	Erythrina Variegate Linn.	**F**aster independence of seedling from the seed reserve.
3.	Seed solution III	Calotropic procera R. & Tinospora crispa	**P**hotosynthesis enhancement and increased uptake of organic and inorganic solutes through roots.
4.	IB (Ag)- 1	Hyoscyamus niger, Ficus benghalensis & Dendrocalamus strictus Nees.	• **O**rganic growth promoter, activator and regulator • Energizes and stimulates the plants system for the best use of inputs both applied and stored in the soil. • Regulates every stage of the Grand Growth Period influencing growth correlation.
5.	IB (Ag)- 2	Ocimum sanctum, Calotropic procera R. & Cynodon dactylon	• **S**ilica induced immunity against fungal attack • Activates plant's host defense mechanism through silica mgt. against fungal pathogens providing structural defense. • It also stimulates plants Immune System by activating the biosynthesis of different phenolic compounds having fungi-toxic property.
6.	IB (Ag) - 3	Adhatoda vasica Nees, Zingiber officinale Roscoe & Embellia ribs.	• **O**rganic solution for potash absorption and utilization • Increases the efficiency of potash uptake through energized root capacity & gradual reduction in the application is ensured. • It activates suction pressure by influencing diffusion pressure deficit.
7.	IB (Ag) - 5	Cynodon dactylon & Calotropic gigantean.	• **E**nergizes the various biochemical process of the plant resulting in harmonious grand growth period. • Regulates and stimulates the cellular oxidation process. • Energizes the phloemic function resulting in encouraged translocation of organic solutes.

			Stimulates the hydrolysis of starch to D-Glucose units by enhancing the enzymatic activity.
8.	IB (Ag)- 7	Ocimum sanctum	• **S**timulates the root function, activates the root growth and penetration and energizes the soil in the root zone thus improves the soil-plant relationship. • Developes the CEC of the soil. • Energizes the production of micro-flora and bio-flora around the root zone. • Improves the degree of base saturation to the desired level. Enhances the Root Cation Exchange Capacity. • Stimulates the root growth and penetration by activating the Contact Exchange Capacity of the Root.

Table 4 : Details of the solutions for organic plant management and their respective role in plant physiological development.

2.9. Pest And Disease Management

No pest/disease infestation was reported both in Conventional as well as organic treated fields during the cultivation period. However in chemical paddy plots cyphermethrin was sprayed @ 2 kg/bigha as preventive spray for fungal disease infestation.

2.10. Crop Harvesting

Paddy variety Minikit-3654 was harvested and thrashed by using pedal thresher during 18th October to 20th October, 2012; aged 85 to 90 days.

Paddy variety Khitish was harvested during 13th November to 18th November, 2012; aged about 100 to 105 days.

Pic. 5 : Landscape view of Paddy Field under Inhana Rational Farming (IRF) Technology in Kowgachi – 2 Gram Panchayat, North 24 Parganas, West Bengal, India.

3. Results and Discussion

Novcom compost samples were analyzed as per standard methodology. Comparative crop performance in farmer's field was evaluated as per different agronomic parameters as well as crop yield and economics. Pre and post experimental soil quality was also analyzed to study the qualitative variation in soil properties especially microbial parameters in the compost applied plots.

3.1. Evaluation of Novcom Compost Quality

Pungent and fowl odour from raw poultry litter stock and the nuisance of fly completely phased out 4 to 5 days after erection of composting heap. All the final compost samples appeared dark brown in colour with an earthy smell, deemed necessary for mature compost (11). Average moisture in compost samples varied from 58.81 to 68.56 percent (table 5) which was higher than the standard reference range (40 to 50 percent) (12). pH values of the Novcom poultry litter compost samples varied from 6.64 – 8.23, which indicated that they were within neutral range as suggested for good quality and mature compost (16).

Sl. No.	Parameter	Novcom Poultry Litter Compost		
		Range Value	Mean	± Std. Error
1.	Moisture percent (%)	58.81 – 68.56	62.90	± 2.02
2.	pH_{water} (1 : 5)	6.64 – 8.23	7.75	± 0.41
3.	Organic carbon (%)	22.90 – 31.20	26.30	± 1.60
4.	CMI[1]	1.41 – 2.57	2.00	± 0.31
5.	Total NPK (%)	3.86 – 4.74	4.03	± 0.22
6.	C/N ratio	13:1 – 16:1	14:1	± 0.62
7.	Total bacterial count[2] (Log_{10} value)	15.000 -15.531	15.279	± 1.08
8.	Total fungal count[2] (Log_{10} value)	14.954 – 15.114	15.041	± 0.82
9.	Total actinomycetes count[2] (Log_{10} value)	14.602 – 14.954	14.845	± 0.76
10.	CO_2 evolution rate (*$mgCO_2$ – C/g OM/day*)	2.34 - 3.91	2.74	± 0.16

11.	Germination index *(phytotoxicity bioassay)*	0.78 – 0.92	0.82	± 0.04

Table 5 : Quality parameters of Novcom compost produced at Farmers' Field at Mathurapur village, North 24 Parganas, W.B.
[1]CMI : Compost Mineralization Index; [2]Microbial count : c.f.u. per gm moist compost.

Organic carbon content in the compost samples varied from 22.90 – 31.20 percent, qualifying not only the criteria for field application (16 to 38 percent) as per the standard range (12) but also the standard suggested value of >19.4 percent (3); for nursery application. Compost mineralization index (CMI) expressed as ash content/ oxidizable carbon indicated the ready nutrient supplying potential of compost for plant uptake. The mean CMI values of the compost samples (2.00) were well within the standard range (0.79 to 4.38) as suggested (26).

The chemical composition of poultry manure generally varies because of several factors such as source of manure, feed of animals, age and condition of animals, storage and handling of manure and litter used (22). In this project, total nutrient content in poultry litter compost (3.86 to 4.74 percent) was found to be high as compared to any green matter compost. However; the values were comparatively lower than that obtained in case of standard Novcom poultry litter compost, which might be due to lack of farmers experience (being the first time) towards large scale composting along with probable lapses in quality monitoring. C/N ratio varied from 13:1 to 16:1, which was within the reference range of $\leq$ 20 (14) as suggested for well-matured compost; indicating that all the samples were mature and suitable for soil application. Similar observation was made by other workers (17) while working with aerobically decomposed poultry manure.

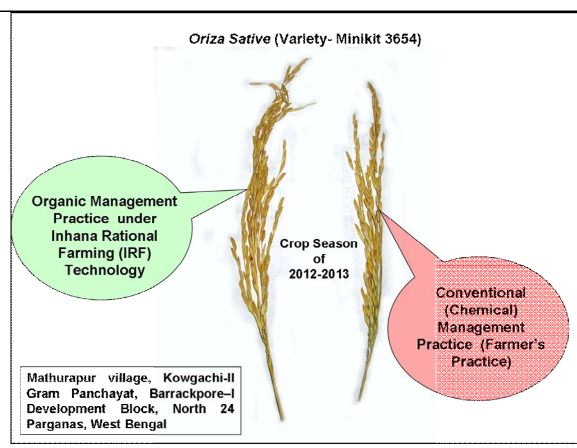
The total count for bacteria, fungi and actinomycetes (expressed in $\log_{10}$ value) in final compost was 14.854 to 15.279. Such high generation of microbes could be possible only due to presence of an ideal micro-atmosphere within the composting heap as influenced by application of Novcom solution (27). At the same time intense microbial activity sustained the vigorous heating that is necessary for destruction of pathogens, fly larvae, and weed seeds. The diversity of microbial population also enabled decomposition of a wide range of material i.e. simple, easily degradable material to more complex, decay resistant ones such as cellulose. Not only that NH_3 generated during biodegradation process was tapped by chemolithotrophic ammonia-oxidizing bacteria (18) to produce more stable organic- N compounds.

Compost maturity refers to the degree of decomposition of phytotoxic organic substances produced during the active composting stage (34). Mean respiration or CO_2 evolution rate of all compost samples (2.34 to 3.91 mgCO_2–C/g OM/day) was more or less within the stipulated range (2.0 - 5.0 mgCO_2–C/g OM/day) for stable compost (32 and 5). The phytotoxicity bioassay test, as represented by germination index provides a means of measuring the combined toxicity of whatever contaminants may be present (38). The mean test value (0.82) indicated absence of phytotoxic effect in the final compost as per the standard value of 0.8 to 1.0 suggested by (32). However, the value was not in accordance with standard Novcom compost, where Germination Index is usually found to be more than 1.0.

3.2. Yield Components of Paddy under Conventional and Organic Farming System

Maximum plant height in case of both the paddy varieties was observed under organic farming system (mean value 108.20 cm and 110.70 cm in case of Minikit-3654 and Khitish varieties respectively). Similar observations were made by other workers (29) in their study regarding paddy cultivation using organic soil input and chemical fertilizer respectively. These differences might be attributed to the more vigorous root growth and nutrient availability for plants during the stem elongation stage (20**).** Number of tillers per hill was assessed from 20 days after transplanting until flowering. Tillers/hill was comparatively higher in case of Khitish variety irrespective of treatment (mean 8.11 and 8.06) as compared to minikit-3654 (mean 8.06 and 8.02) variety. However, in term of management tillers/hill was slightly higher under organic as compared to conventional chemical.

Pic. 6 : Project Coordinator, Inhana Biosciences inspecting the setting of paddy grains in organically cultivated paddy in Kowgachi – 2 Gram Panchayat.



Pic. 7 : Panicles developed under Organic (IRF) and Conventional (Farmer's Practice) in Kowgachi – 2 Gram Panchayat, North 24 pargans, West Bengal.

In case of Minikit– 3654 maximum number of panicles per square metre area was noted in plants under organic management (mean 372.36) in comparison to plots under chemical management (mean 367.72.). Increase in the number of tillers and panicles in residue-treated plots could be attributed to the increased and sustained availability of nutrients to synchronize better with crop needs (31). However in case of Khitish variety, number of panicles per square meter area was almost same under both treatments. Similar trend was observed in case of number of productive panicles, in case of both the varieties. Maximum panicle length was noted in case of organically treated plants (mean 27.16 cm). The plants receiving chemical treatment exhibited panicle length of 27.12 cm. The increased number of spikelet could be attributed to the increased and sustained nutrient availability and uptake under those treatments as also reported by others (37) regarding N uptake.

Agronomic Parameters of Paddy Variety Minikit-3654	Paddy under Organic Farming			Paddy under Conventional Farming		
	Range Value	**Mean Value**	**Std. Error**	**Range Value**	**Mean Value**	**Std. Error**
Plant height (cm)	104.56 - 110.66	108.20	± 2.89	101.56 - 108.43	104.78	± 3.02
Hills/m^2	56 - 60	58.00	± 2.04	56 - 60	58.00	± 2.01
No. of tillers/hills	7.50 - 9.19	8.06	± 0.76	7.40 - 9.10	8.02	± 0.74
No. of panicle/hills	5.92 - 7.26	6.42	± 0.57	5.84 - 7.16	6.34	± 0.55
Panicles/m^2	355.20 -406.56	372.36	± 7.52	351.24 -402.51	367.72	± 7.45
Productive panicle/m^2	316.28 - 360.63	335.12	± 6.32	311.34 - 353.45	327.27	± 6.12
Panicle length (cm)	25.41 - 29.68	27.12	± 1.44	25.39 - 29.54	27.12	± 1.53
No. of grains/panicle	89 - 104	94.00	± 3.05	86 - 102	92.00	± 3.01
Filled grains/panicle	67 - 78	71.00	± 2.16	66 - 75	68.00	± 2.54
Unfilled grains/panicle	22 - 26	23.00	± 2.12	20 - 27	24.00	± 2.45
1000 grains wt.(g)	17.21 - 18.04	17.62	± 0.99	17.34 - 17. 68	17.56	± 1.02

Table 6A : Agronomic component of Paddy (Variety: Minikit- 3654) at Farmers' Field in Mathurapur village, North 24 Parganas, W.B.

Agronomic Parameters of Paddy Variety Khitish	Paddy under Organic Farming			Paddy under conventional Farming		
	Range Value	**Mean Value**	**Std. Error**	**Range Value**	**Mean Value**	**Std. Error**
Plant height (cm)	108.23 - 114.12	110.70	± 3.23	106.51 - 112.23	106.22	± 3.29
Hills/m^2	56 - 60	58.00	± 2.06	56 - 60	58.00	± 1.98
No. of tillers/hills	7.46 - 9.34	8.11	± 0.78	7.41 - 9.21	8.06	± 0.86
No. of panicle/hills	5.82 - 7.31	6.43	± 0.67	5.89 - 7.14	6.42	± 0.74
Panicles/m^2	349.20 - 409.36	372.94	± 7.82	353.40 - 399.84	372.36	± 8.06
Productive panicle/m^2	317.44 - 364.01	331.92	± 6.02	314.52 - 355.85	335.12	± 7.14
Panicle length (cm)	25.87 - 30.13	28.12	± 1.84	25.89 - 30.54	28.21	± 1.98
No. of grains/panicle	91 - 108	97.00	± 3.07	89 - 112	98.00	± 3.02
Filled grains/panicle	72 - 79	73.00	± 2.76	68 - 77	72.00	± 2.53
Unfilled grains/panicle	18 - 29	24.00	± 2.66	20 - 35	26.00	± 2.59
1000 grains wt.(g)	19.42 - 19.98	19.71	± 1.09	19.40 - 19.97	19.69	± 1.16

Table 6B : Agronomic component of Paddy (Variety: Khitish) at Farmers' Field at Mathurapur village, North 24 Parganas, W.B.

However, in case of Khitish variety, panicle length was slightly higher in the plots receiving chemical treatment. Spikelet fertility i.e. the percentage of spikelets that turn into grain is dependent upon pollen grain meiosis, anthesis, pollination, fertilization and carbohydrate translocation as influenced by environmental conditions, especially 10 days before and after flowering (21) together with management undertaken. Number of filled grain was comparatively higher in the plots receiving organic management (mean 71 and 73 in case of Minikit-3654 and Khitish variety respectively) as compared to their chemical counterparts (mean 68 and 72 in case of Minikit-3654 and Khitish variety respectively). There was a marginal increase in 1000 grains weight under organic management as compared to chemical treatment. 1000 grains weight of variety Minikit-3654 was 17.62 gm and 17.56 gm under organic and chemical cultivation practice respectively. Similar trend was observed in case of Khitish also, where 1000 grain weight under organic management was 19.71 gm as compared to 19.69 gm under chemical cultivation practice (Table 6A & 6B).

3.3. Yield performance of paddy under conventional and organic farming system

In case of Minikit-3654 variety maximum grain yield was observed under organic cultivation practice (varied from 3375 kg/ha to 4125 kg/ha with mean value of 3750 kg/ha.) as compared to plots receiving chemical treatment (varied from 3000 kg/ha to 3750 kg/ha with a mean value of 3563 kg/ha.). However, in case of Khitish variety, grain yield under organic (mean 4125 kg/ha) remained almost at par to the yield obtained under chemical cultivation practice (mean 4105 kg/ha) (table 7).

Sl. No.	**Name of Farmers**	**Crop Performance in Farmers' Field**	
		Average Yield in Organic (IRF) Plots	**Average Yield in Conventional (Chemical) Plots***
Variety : Minikit-3654			
1.	Nitai Jana	Varied from 3375 kg/ha to 4125 kg/ha Mean 3750 kg/ha	Varied from 3000 kg/ha to 3750 kg/ha Mean 3563 kg/ha
2.	Sahadeb Maity		
3.	Bapi Shanki		
4.	Bhabothosh Beto		
5.	Bistu Audok		
6.	Ravan Bera		
7.	Nepal Khelo		
8.	Ashoke Mondal		
Variety : Khitish			
1.	Susanta Chari	Varied from 3750 kg/ha to 4500 kg/ha Mean 4125 kg/ha	Varied from 3750 kg/ha to 4500 kg/ha Mean 4105 kg/ha
2.	Prabir Majhi		
3.	Ashoke Beto		
4.	Ojhe Maity		
5.	Ganesh Khelo		
6.	Narayan Shit		
7.	Umapado Meto		

Table 7 : Comparative crop performance in farmers' field under the Organic management (Inhana Rational Farming) and Conventional (Chemical) cultivation practice
**Data of conventional paddy yield as taken from farmers' field is listed in table 1*

The most significant findings from crop performance assessment in the farmers' field is the at par or slightly higher crop yield under organic cultivation practice (IRF) as compared to conventional chemical practice. There has been a general belief as well as scientific documentation that yield under organic practice can reach at par status to conventional chemical farming only after a wide time lag; especially due to slow and gradual release of nutrients from organic inputs, which fails to support increased yields (30). However, in this study, better crop performance under organic cultivation practice even in the very first year and under compromised compost application, might be primarily due to high quality of Novcom compost as well as effectivity of IRF plant management package towards activation of plant physiology. The findings indicated that a comprehensive organic package of practice can effectively ensure crop sustainability without any time lag through harmonization of the soil-plant-nutrient relationship brought about by effective soil and plant management practice

Pic. 8: Paddy at harvestable stage at Mathurapur village in Kowgachi – 2 Gram Panchayat, North 24 Parganas, West Bengal, India.

3.4. Nitrogen Utilization Efficiency (NUE) or Partial Factor Productivity of Applied N (PFP_N) under Paddy Cultivation

Partial Factor Productivity of applied N (PFP) often simply called Nitrogen Utilization Efficiency or NUE (19), quantifies the total economic output per unit of applied N, relative to its utilization from all resources in the system, including indigenous soil – N as well as N from applied inputs (9). Yield data recorded in case of both the paddy varieties indicated comparatively higher NUE under organic (IRF) practice than conventional chemical farming practice. Lower N efficiency under chemical farming has often been reported under cereal based systems leading to higher investment in N to maintain higher yields, however; with mitigated results.

On the other hand improvement in NUE, which will require increased mineralization of indigenous soil- N as well as higher efficiency of applied N; can definitely lead towards higher yields. This can be brought about through adoption of an efficient N management programme (35). Higher NUE under organic IRF practice might be due to increased uptake and utilization of indigenous nutrient under the influence of Novcom compost containing huge population of self- generated microbes, which also led to better N mineralization from compost as well as better N uptake efficiency of the plants under IRF plant management package.

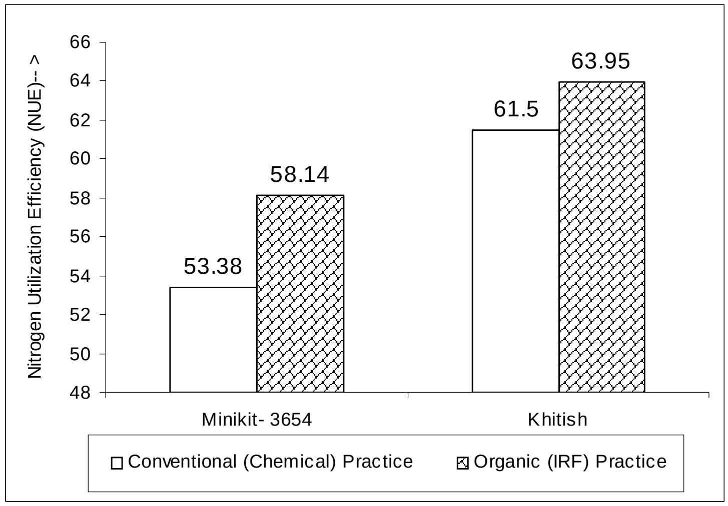


Fig. 2 : Nitrogen Utilization efficiency in Paddy Cultivation under Organic (IRF) Practice and Conventional (Chemical) Practice.

3.5. Soil Quality Development under Conventional and Organic Farming System

Variation in Soil Physicochemical and Fertility Parameters : In order to evaluate any qualitative improvement in soil status in relation to organic soil management, soil samples from project plots were tested twice [*i.e.,* before initiation of the experiment and after harvesting of tomato]. The soils in the experimental plots were slightly acidic in reaction with moderate organic carbon (mean value 0.81 and 0.82 in case of organic and conventional farming plots), medium soil available nitrogen (mean value 352 kg ha^{-1} and 364 kg ha^{-1} in case of organic and conventional farming plots), moderate available phosphate and available potash (Table 8).

Treatments	Before initiation of Field Experiment (After Harvesting Tomato)									
	Soil Physico-chemical Properties						Soil Microbial Properties			
	pH (H_2O)	EC (dSm^{-1})	Org. C (%)	N	P_2O_5	K_2O	Bacteria	Fungi	Actino*	PSB
				< ---- (kg ha^{-1}) ---- >			< - Total microbial count (per g moist soil)- >			
T_1 (Organic)	6.04 (6.19)	0.07 (0.07)	0.81 (0.87)	352 (369)	43 (49)	316 (310)	24 x 10^5 (87 x 10^5)	21 x 10^4 (37 x 10^5)	19 x 10^4 (39 x 10^5)	13 x 10^4 (28 x 10^4)
T_2 (Chemical Practice)	6.05 (5.86)	0.07 (0.08)	0.82 (0.81)	364 (380)	41 (35)	292 (303)	20 x 10^5 (62 x 10^5)	23 x 10^4 (18 x 10^4)	21 x 10^4 (17 x 10^4)	14 x 10^4 (13 x 10^4)

Table 8 : Temporal variation of soil physicochemical and microbial parameters in Conventional and Organic Farming plots at Mathurapur village, North 24 Parganas, W.B.
**Actino : Actinomycetes, Figure in the perenthesis represent post harvest soil analytical value.*

Soil analysis after crop harvesting showed that the plots receiving Novcom compost showed increasing trend of soil fertility as compared to their chemical counter parts. The soil pH also increased in the compost treated plots, indicating its positive effect on acid soils, which might influence better soil-plant nutrient dynamics. Comparable increase in organic carbon, available N, P and K through addition of organic materials was reported by several workers (24 and 36). Superior soil fertility status on organic farms compared to soils fertilized with chemical fertilizers was reported by other workers (28).

- *Variation in Soil Microbial Parameters* : In soils of the study area bacteria, fungi and actinomycetes population was found to be in the order of 10^5 to 10^4 (primary values ranging between 19 to 24), which was found to increase in Novcom compost applied plot post crop harvest. Phosphate solubilizing bacterial (PSB) count also showed similar trend with application of Novcom compost. Similar observation was also reported in paddy soil by different workers (23). Post-harvest soil analysis showed significant improvement in soil microbial population in Novcom compost treated plots. Development of soil microbial population with application of Novcom compost was also observed by several workers (10, 6, 7 and 4).

3.6 Economics of Paddy Cultivation under Conventional and Organic Farming System

Cost of aman (rainfed) paddy cultivation under conventional (chemical) and organic (Inhana Rational Farming Technology) farming practice was worked out with the data pool collected from project farmers as well as from other progressive farmers of the same locality. Total cost of cultivation per hectare was Rs. 50,588/- and Rs. 49,485/- for organic and chemical cultivation practice respectively. Total cost of cultivation was almost same for paddy variety Minikit- 3654 and Khitish and so the minor difference was overlooked during cost calculation (table 9).

In case of Minikit-3654, gross income per hectare was Rs. 83,100/- under IRF package of practice and Rs. 78, 386/- per ha under conventional cultivation practice. Hence, the net income was higher by Rs. 3611/- per ha in case of IRF package. However, the most significant fact is that, if the produce could be marketed as organic item with even 10 % premium price, the net income can rise up by Rs. 11,861/- and Rs. 5,817/- per ha i.e., about 40 to 35 percent higher profit than conventional paddy cultivation for Minikit- 3654 and Khitish variety respectively.

Sl. No	Parameters	Cost under Organic (IRF) Paddy Cultivation	Cost under Conventional Paddy Cultivation
		Cost/ha	Cost/ha
1.	Seedbed Preparation	Rs. 5,400/-	Rs. 7,613/-
2.	Land Preparation & Transplanting	Rs. 12,188/-	Rs. 11,625/-
3.	Fertilizer, Pesticide & weedicide	-	Rs. 12,060/-
4	Compost & IRF Plant Mgt Package	Rs. 12,000/-	-
5.	Intercultural Operation	Rs. 4,500/-	Rs. 1,688/-
6.	Harvesting	Rs. 15,750/-	Rs. 15,750/-
7.	Miscellaneous cost	Rs. 750/-	Rs. 750/-
Total Cost*		Rs. 50,588/-	Rs. 49,485/-
Variety : Minikit 3654			
Gross Income		Rs. 83,100/-	Rs. 78,386/-
Net Income		Rs. 32,512/-	Rs. 28,901/-
Considering even 10% premium price in case of Organic Production, Net Income will be Rs. 40,762/-			
Variety : Khitish			
Gross Income		Rs. 66,600/-	Rs. 66,280/-
Net Income		Rs. 16,012/-	Rs. 16,795/-
Considering even 10% premium price in case of Organic Production, Net Income will be Rs. 22,612/-			

Table 9: Cost components of Aman (Rainfed) Paddy cultivation under conventional and IRF package of practice.
**Total cost of cultivation was almost same for Paddy variety Minikit- 3654 and Khitish*

Ecological cost paid for commercial agriculture has never been accounted under conventional farming system, but it is the most important factor for future crop sustainability. As per the organic principle, restoration and enhancement of ecology remains the primary objectivity of organic agriculture. If the maintenance/ development of soil and surrounding ecology along with residue free food products for human health could be accounted in terms of economics, conventional chemical farming shall utterly fail to even compete with organic agriculture.

4. Conclusion

Shifting focus towards organic management is necessary considering the negativities associated with chemical farming practice. However, organic paddy cultivation without loss in crop yield is a challenging task. Large scale organic paddy cultivation in farmers' field under Inhana Rational Farming Technology (IRF) showed that adoption of the technology can enhance crop yield in comparison to conventional farmers' practice. Hike in crop productivity under organic management that too in the very first year comes as an outstanding achievement considering that all the organic plots were scattered and surrounded by chemical plots, also compost application was less than 60 percent of recommended dosage along with lower number of spraying than the recommended Inhana Plant Management package.

Another significant finding was that crop yield under organic practice was achieved under comparatively lower dose of NPK (especially with about 50 percent lower P and K) than conventional chemical practice. Such crop response under organic practice (i.e. IRF) is really magnificent considering the imperative requirement of nutrients during initial growth stage of paddy *vis-à-vis* inherent limitation of slow nutrient release under anaerobic conditions associated with the crop; which further curtails the already low nutrient mineralization potential of the applied compost. The finding gives an insight that such achievement under IRF could be only due to enhancement of agronomic efficiency of plants as achieved under comprehensive soil and plant management programme leading to activation of the plant physiology.

	Pic. 9 : Project Farmers participating in Organic Paddy Cultivation under Inhana Rational Farming (IRF) Technology in Kowgachi – 2 Gram Panchayat North 24 Parganas, West Bengal, India.

At the same time optimum potential of IRF is yet to be explored through maximum adherence to its recommendation and close monitoring of on- field implementation process.

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