THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Adoption of Rational Farming Technology for Development of a Model for Exploring Sustainable Farming Practice in Farmer's Field

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

Abstract:
The effectivity of Inhana Rational Farming (IRF) Technology was critically evaluated as a model of Sustainable Farming Practice in farmers' field using okra (variety : Shakti - F1 hybrid) as test crop. The stusy was conducted at Binuria village in Birbhum District of West Bengal during February to October (2013). The village is in close vicinity of Visva Bharati University, Santiniketan. The study area lies in 23.66^0 N and 87.63^{0}E at about 179 ft. above MSL, with level to nearly level landscape.
The experiment was laid down as per randomized block design (RBD) with 7 treatments replicated 3 times. The treatments included local farming practice with chemical inputs, organic farming practice (Inhana Rational Farming® (IRF) Technology' developed by Dr. P. Das Biswas, Founder, Inhana Biosciences, Kolkata) as well as integrated farming practice (combination of chemical and organic inputs for both soil and plant management).
The most significant finding was that 100% reduction of chemical pesticide can be economically viable in the very first year with adoption of IRF Organic Package of Practice, under which 13.6% yield increase was recorded as compared to conventional farmer's practice. Also when IRF was adopted for integrated cultivation model, higher yield as well as higher net income was obtained in comparison to conventional Farmer's practice. Upto 144.5% higher Nitrogen Utilization efficiency and 32.8 % higher partial factor productivity was recorded under treatments with IRF Package. This higher response might be due to increased uptake and utilization of indigenous nutrients under the influence of high quality Novcom compost containing huge population (in order of 10^{16} c.f.u per gm moist compost) of self- generated microbes, which led to better nutrient (both macro and micro) mineralization in soil for plant uptake. This was also complimented by IRF Plant Management Package, which perhaps enhanced plant physiological functioning in terms of better N uptake and its utilization within plants.

Key words : *Organic Farming, Integrated Cultivation Practice, Rational Farming Technology, Farmer's Practice, Okra, Soil Quality, N Use Efficiency*

1. Introduction

Food scarcity in the sixties had led to the need and initiation of green revolution. However, to augment crop production usage of chemical fertilizers in incremental dose has over the years led to the deterioration of soil character, made the plants fertilizer sensitive and disturbed the pest- predator relationships, which automatically generated the necessity for application of pesticides. Hence, today successful agriculture shall only depend upon how well and fast soil depletion is checked and the soil nutrient balance shifts towards a positive balance. But unfortunately no conclusive solution has been achieved till date (6).

The ultimate cost of the degradation of the natural bases on which agricultural system rests are borne the farmers themselves and the society at large, be they in lowered productivity, environmental clean up or further technology to serve technologically induced problem. An effective integrated farming system is a paramount importance as most farms are not in a position at present to completely do away with the use of synthetic agro-chemicals specially fertilizers. Hence systemic phasing out the use of agro-chemicals and synthetic fertilizers with integration of agro-chemicals may be a pragmatic approach towards sustainable crop production (16).
An integration of organic and inorganic inputs is required which is effective yet convenient to adopt and gradually brings back and restore the renew-ability of the agricultural resources. Sustainable Cultivation Model is a perfect blend between organic farming and chemical practice so that negative impact of chemicals can be reduced with the usage of available farm resources at the same time the threat of production loss can also be mitigated. Reduction of chemical load without compromising crop yield or depleting of soil quality may be the most lucrative option for small and marginal farmers, where full organic conversion might be difficult due to limited resource availability and uninsured marketability. At the same time sustainable cultivation model could be the stepping stone towards the adoption of organic farming. Comparative crop performance and soil development under present study will help to understand the potentials of organic package of practice in comparison with chemical farming as well as their integrated models towards crop sustainability.
Hence, development of organic and integrated farming model for vegetable as test crops were important not only to enable eco-friendly farming option but also to bring forth viable options for large scale reduction of chemical load. The ultimate objectivity is to maximize the benefits of the agricultural system and minimize the threats to the environment from the current practice of industrial agriculture.

2. Material and Methods

Crop trial using okra and green gram as test crops were conducted at the farmers' field at Binuria village - Rupepur Gram Panchayat in Birbhum District of West Bengal. The village is in close vicinity of Visva Bharati University, Santiniketan. The study area lies in 23.66^0 N and 87.63^0E at about 179 ft. above MSL, with level to nearly level landscape (Pic. 2 & 3).The trial was conducted during February to October, 2013 to study the comparative effectivity of conventional farming practice (chemical farming), organic farming practice (Inhana Rational Farming® Technology' developed by visionary scientist, Dr. P. Das Biswas based in Kolkata, India) as well as integrated farming practice (combination of chemical and organic components of IRF for both soil and plant management). Okra (*Abelmoschus esculentus* Moench) representing vegetable segment was taken as test crop. Compost was made on-farm as a part of organic soil management under Novcom Composting Method of Inhana Biosciences (15). Final compost samples were drawn from composting heaps on 30^{th} day for analysis of different physicochemical and microbial properties, fertility status as well as maturity and phyto-toxicity parameters as per standard methodology (17). Soil samples were collected from individual experimental plots, air dried, sieved and analyzed for physico-chemical, fertility and microbial status as per standard procedure (7).

2.1. Brief details of Rational Farming Technology

Rational Farming Technology is based on Element - Energy Activation (E.E.A.) Principle developed by Visionary scientist Dr. P. Das Biswas. Rational Farming Technology works towards the development of an ideal environment for the soil and plant in order to bring about qualitative changes in their performance. It is perhaps the only method, which provides the assurance of 'No Reduction in Yield' and 'No Hike in Cultivation Cost' even from the first year of organic conversion.

2.1.1. Element- Energy Activation (E.E.A.)® Principle in Plant System

A brief details : All living bodies are like machines and the vital driving force or enemy behind them is "Chaitanya Shakti" or Basic Life Force. Solar energy is the manifestation of "Chaitanya Shakti". Except at birth and at death, two major processes (Nourishment & Self protection) are going on in every living body.

Self-Nourishment – Five basic elements (Panchamahabhutas) Soil, Air, Water, Fire and Space take care of nourishment till time we Humans do not interfere with these qualities, it performs without any problem. The individual element responsible or role of Panchamahabhutas for specific mechanism of nourishment are as follows.

- Earth : Nutrition and structure formation.
- Water : Transportation of nutrients for transpiration.
- Fire : Metabolism, Ripening of fruits, Photosynthesis.
- Air : Respiration
- Space : Making space available for any bio-chemical reaction .

The Self-Defense mechanism is said to be controlled by five different Life Forces or Prana-Shaktis. These are originated from the basic life-force ie, Solar energy. The life forces or Prana-Shaktis are actually vehicles of these basic elements and movement of nutrients is impossible without them. Their role in the plant system are as follow.

- Apana Prana : Controls the function of roots extraction of nutrients.
- Samana Prana : Controls transpiration.
- Udana Prana : Controls Photosynthesis and secretion of enzymes, hormones.
- Prana Prana : Controls respiration and eases movement of respiratory products.
- Vyana Prana : Makes space available for all functions.

Self Protection – If there is any imbalance in sub functions like structure, Formation, Circulation, Metabolism etc as well as nourishment then the whole system tries to protect itself. This self-defense mechanism is controlled by five different Life Forces or Prana Shaktis.

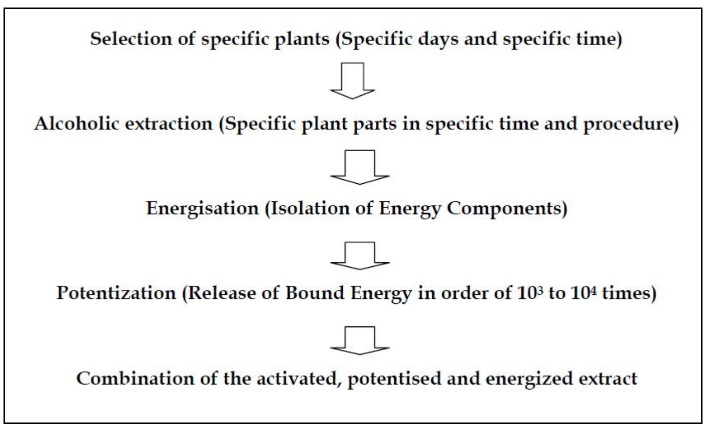
All these process, functions and sub-functions are interdependent and operate in an orchestral manner, in nature. Any imbalance leads to the disease or pest manifestation or lack of nourishment. According to EEA® Principle to overcome the disease or pest infestation, life forces are to be stimulated instead of encountering from outside leading to unfavourable repercussions.

Similarly, deactivated plant system can't uptake, assimilate or utilize the stored and applied nutrients in an effective manner. Addition of nutrients can't change the phenomenon for which life forces are to be added.

2.1.2. Guiding Philosophy of EEA Principle behind Development of Various IRF Plant Management Solutions.

Inhana solutions are 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 in the plant system (matter). Now according to the requirement different extracted energy components are combined in desired proportion to make different solutions which regulate sequential physiological activities to attend the root cause. So a numerous number of solutions can be prepared as per requirement guided by this Element Energy Activation Principle.

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



3. Results and Discussion

The compost was produced within a short period of 21 days using Novcom composting method of Inhana Biosciences (15) utilizing the locally available weeds, water hyacinth and farm waste. The better quality and maturity of compost was confirmed through laboratory analysis where different parameters were tested as per (18) and (1). Crop performance under different treatments was evaluated in main field. Pre and post experimental soil quality was also analyzed to study the qualitative variation in soil properties especially microbial parameters under different treatments.

3.1. Evaluation of quality of Novcom compost

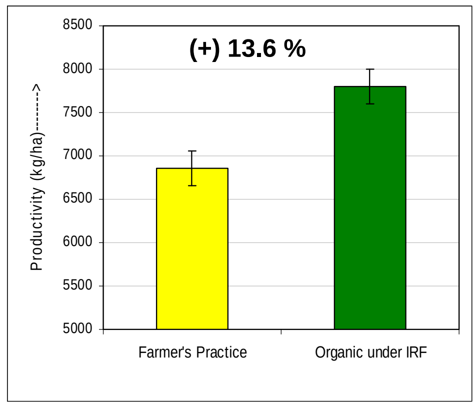
Compost samples were analyzed as per standard protocol to evaluate the quality and maturity of Novcom compost (Table 1). The results showed that the compost is of high quality as per National & International Compost Quality standards are concerned. The reasonably high nutrient value of the compost in terms of Total N, P and K content (1.9, 0.566 and 1.2 %, respectively, on dry weight basis) and the standard C/N ratio (11 :1) indicates faster mineralization potential. But the most important factor is the self-generated microbial population witnin compost, in the order of 10^{16} c.f.u. (10^4 to 10^6 times higher than any common well decomposed compost), which might be the driving force ensure better post soil application effectivity. Stability and phytotoxicity test of the compost samples confirmed it as mature and stable compost that is free from any phytotoxic effect. Similar results were obtained by other workers (2, 3, 4, 9 and 14) while working with different raw materials using Novcom composting method.

Pic. 1: Novcom Compost Heap on 1st day of composting.

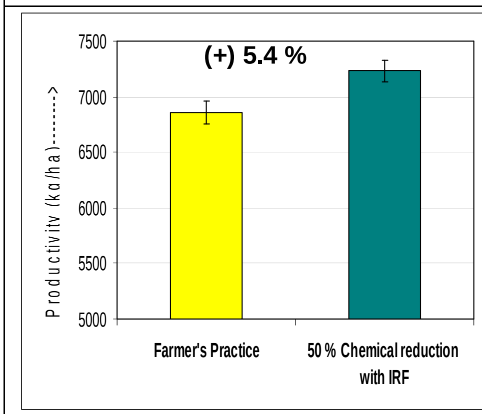
Pic. 2 : Final Novcom Compost Heap in farmer's field after 21 days

3.2. Yield Performance of Okra in Different Experimental Plots

Okra yield in organically treated plots of T_2 (7793 kg/ha) and Integrated treatment plots T_5 (7233 kg/ha) and T_7 (7011 kg/ha) were significantly higher than plot T_3 (6860 $kgha^{-1}$) which was under conventional chemical farming i.e., farmer's practice (Table 1). The higher yield was basically contributed from higher number of fruits per plant. Average number of fruits per plant was comparatively higher in case of organically treated plots of T_2 (644722 /ha), T_7 (595556 /ha) and T_5 (618056/ha) in comparison to chemically treated plots of T_3 (508056/ha), T_4 (575000/ha) and T_6 (569444/ha). The higher number of fruits per plant may be due to comparatively longer fruit bearing stage of organically treated plants. This might indicate positive influence of organic solutions used under IRF on plant functioning, which reflected in enhanced crop yield.



At the same time another interesting fact is that average flower to fruit conversion ratio was significantly higher under organic treatment with respect to their chemical counter parts in the study area. The results provide an indication towards efficient soil-plant nutrient dynamics in organically treated plots as well as activation of plant physiology through application of different plant management solutions under IRF, which perhaps led to higher flower to fruit conversion ratio.



When the productivity of okra was compared among farmer's practice and integrated management practice, it was found that highest yield increase (13.6 %) was obtained in case of organic management under Inhana Rational Farming (IRF) Technology. This was followed by treatments with 50% reduction of chemical soil input along with IRF plant management package, where about 5.4 % higher yield increase was noted against farmer's practice.

As per relative agronomic efficiency (RAE), value obtained under chemical treatments were significantly lower than 100 % organic treatments under IRF, which might indicate influence of IRF package of practice towards enhancement of plant physiological functioning leading to higher crop efficiency.

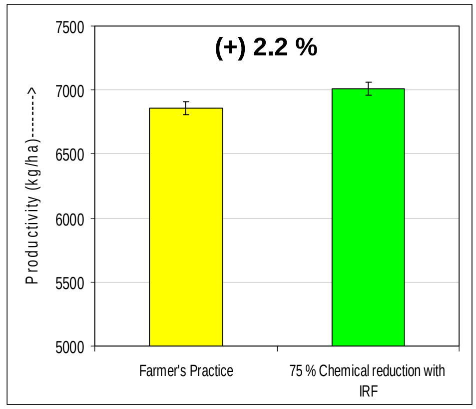


Figure 1 : Comparative Yield performance under farmer's practice as well as different integrated treatments.

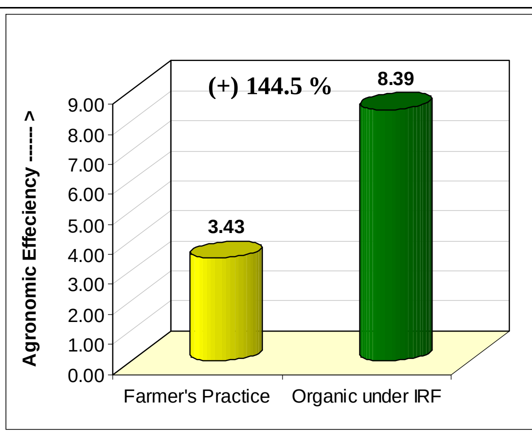
Treatment	Yield (kg/ha)				% over control	RAE[1]
	R1	R2	R3	Mean		
T_1 : Control	5493	6254	6267	6005^e	0.00	-
T_2 : 100 % Organic [Inhana Rational Farming Technology (IRF)]	6949	9110	7321	7793^a	29.78	100.00
T_3 : 100 % Chemical [Chemical Farming (farmer's practice)]	6892	6883	6804	6860^d	14.24	47.82
T_4 : Chemical & Organic Input (50 : 50) & Chemical Plant Management	6873	6429	7085	6796^e	13.17	44.24
T_5: Chemical & Organic Input (50 : 50) & Organic Plant Management	7739	8192	5767	7233^b	20.45	68.68
T_6: Chemical & Organic Input (25 : 75) & Chemical Plant Management	7746	7346	5817	6969^{cd}	16.05	53.91
T_7: Chemical % Organic Input (25 : 75) & Organic Plant Management	7508	7308	6217	7011^c	16.75	56.26

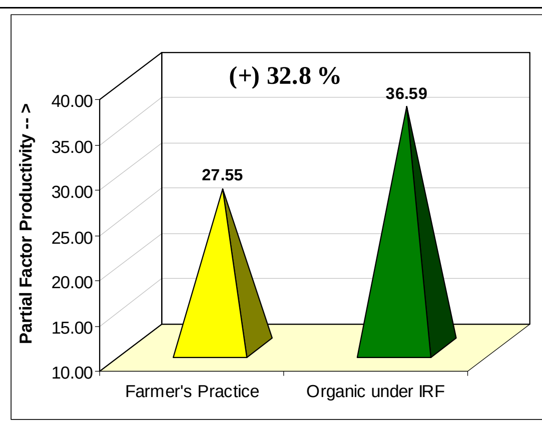
Table 1 : Yield Performance of okra under different treatments

- Note : RAE[1] : Relative agronomic efficiency. It was calculated as per the methodology of Law-Ogbomo et al. (2011); Letters shown in superscript beside mean values are results of Duncan's Test ($p < 0.05$)

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

Nitrogen Use Efficiency (NUE) and Partial Factor Productivity of applied N (PFP) is used to evaluate the efficiency of N utilization under different cultivation practice (12). Fig.2 indicated that N utilization is comparatively better not only under organic practice but also in case of integration treatments, where IRF was used as a component of practice. This indicated the probable influence of IRF Package of practice not only towards mineralization of indigenous soil- N but also towards high N uptake and utilization by plants, which reflected in higher crop production.





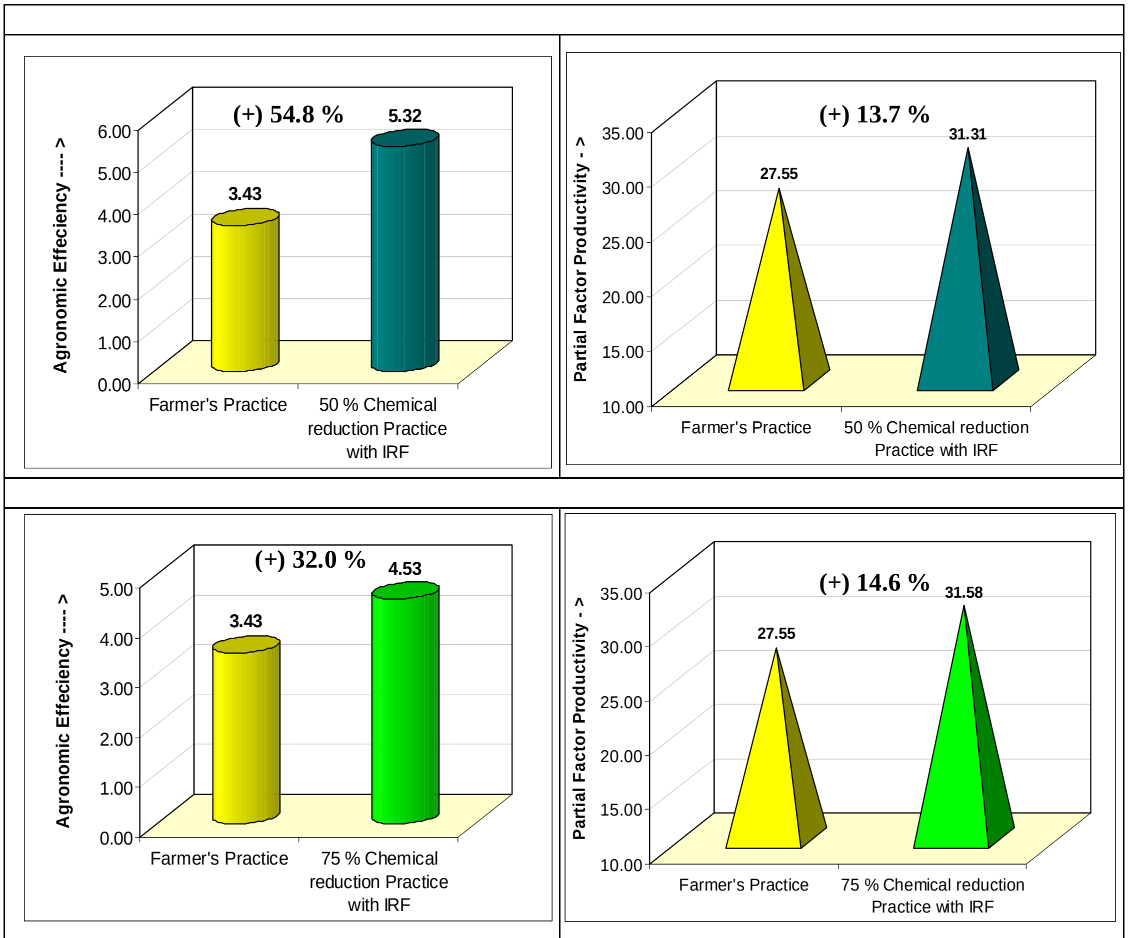


Figure 2 : Comparative evaluation of Agronomic Efficiency (AE) and Partial Factor Productivity (PFP) under farmer's practice as well as different integrated treatments.

Higher NUE as found under organic IRF practice might be due to increased uptake and utilization of indigenous nutrients under the influence of Novcom compost. The compost contains huge population of self- generated microbes, which might have not only led to better N mineralization from compost but also complimented IRF plant management package towards better N uptake efficiency of the plants. Similar conclusion was also obtained by (3) while working with tomato as a test crop.

3.4. Effectivity of Organic Plant Management over Chemical Practice

Assessment of agronomic efficiency of okra under organic treatment i.e. IRF plant management package *vis-a-vis* chemical treatment, showed that even though soil management was same under both treatments, considerable improvement in crop productivity was noted under application of Organic Solutions on plant as compared to chemical spraying. On an average of 6.84 increase (varied from 0.63 to 13.60 percent) in crop productivity was recorded under organic plant management which might indicate activation of plant physiological functioning under the same.

In general nutrient use efficiency in terms of AE_{CN} was found to increase with addition of organic plant management along with organic soil management i.e. under comprehensive organic package of practice. The study showed that organic plant management has relevance towards achieving higher crop potential.

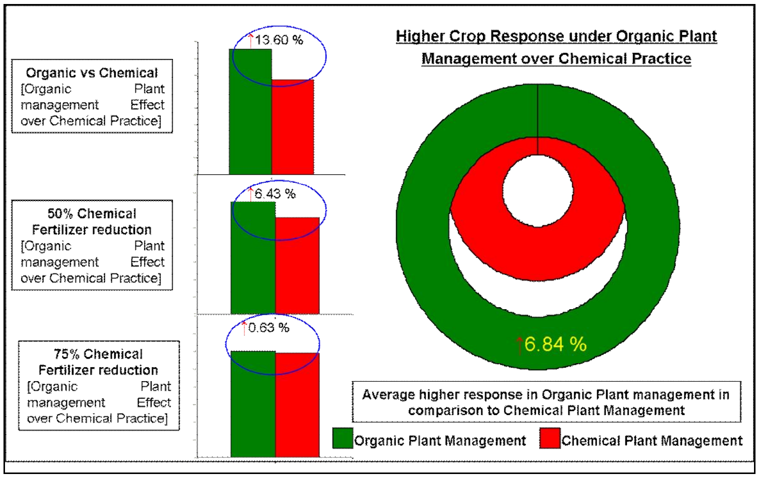


Figure 3: Comparative crop response under Organic Plant Management over Chemical Practice

3.5. Variation in Soil Quality Parameters

In order to evaluate qualitative variation in soil status under application of different treatment, soil samples from individual plots were tested twice [*i.e.,* before initiation of experiment and after harvesting of okra]. The soils were found to be strongly acidic to very strongly acidic in reaction but with application of compost, pH value was found to show an increasing trend. Increase in soil pH after application of compost is important, as very low pH is often harmful for the crops (11). Similarly the low organic carbon status (0.41 %) also reflected a positive trend with compost application (Table 2). Available macronutrient (NPKS) status was found to be low to moderately low. Soil analysis after crop harvesting showed an overall increasing trend of fertility in the plots receiving Novcom compost, as compared to their chemical counter parts. This might indicate potential for the improvement of soil quality under with application of good quality compost. Similar observation was also made (3) in case of tomato cultivation with application of Novcom compost. Similar post compost application effects were also obtained by 10 and 19.

Treatment Plots	< ---------------- Physico-chemical Properties ------------------ >						
	pH (H_2O)	EC (dSm^{-1})	Organic Carbon (%)	Av. N	Av. P_2O_5	Av.K_2O	Av. SO_4^{2-}
				< ------------($kgha^{-1}$)---------------- >			
Before initiation of experiment							
$T_{Overall}$	4.90	0.029	0.41	254.4	22.2	138.1	34.6
After completion of crop harvest							
T1	5.05	0.031	0.40	247.1	20.2	127.4	30.2
T2	5.34	0.044	0.67	272.1	28.7	156.3	38.4
T3	4.85	0.053	0.44	289.4	32.6	161.2	41.2
T4	5.05	0.050	0.53	278.2	30.4	147.4	42.4
T5	5.25	0.051	0.51	280.2	28.6	158.6	44.4
T6	5.06	0.048	0.57	275.4	25.4	142.2	37.5
T7	5.09	0.042	0.60	280.6	26.8	149.4	39.6

Table 2 : Soil Chemical properties in Okra experimental Plots

Population of bacteria, fungi, actinomycetes and Phosphate Solubilizing Bacteria (PSB), was found in the order of 45 x 10^5, 36 x 10^3, 36 x 10^3 and 12 x 10^3 c.f.u. in Novcom compost applied plots (Table 3). Improvement in soil microbial population in these plots indicated the positive influence of good quality compost towards speedy rejuvenation of soil microflora leading to soil quality improvement.

Treatment Plots	< --------------- Soil Microbial Properties ---------------------- >			
	Total Bacterial Count	Total Fungal Count	Total Actinomycetes	Total PSB count
Before initiation of experiment				
$T_{Overall}$	45×10^5	36×10^3	17×10^3	12×10^3
After completion of crop harvest				
T1	48×10^5	31×10^3	21×10^3	14×10^3
T2	86×10^6	24×10^4	19×10^4	27×10^3
T3	54×10^5	27×10^3	12×10^3	10×10^3
T4	69×10^6	19×10^4	8×10^4	16×10^3
T5	62×10^6	23×10^4	22×10^4	18×10^3
T6	74×10^6	31×10^4	16×10^4	20×10^3
T7	79×10^6	30×10^4	18×10^4	21×10^3

Table 3 : Soil microbial properties in Okra experimental plots

The microbial population was found to increase after compost application (8) while working on post application effectivity of compost on soil. In this respect even slight increase in the population of phosphate solubilizing bacteria is an important phenomenon, which might cause a positive influence towards phosphate availability in acidic soils.

3.6. Economics of Okra Cultivation

Cost of okra cultivation under conventional farmer's practice as well as under Inhana Rational farming technology were documented during the study. Highest gross income was obtained under 100% organic practice (Rs. 1,94,825/ha) followed by chemical and organic inputs (50 : 50 & Organic Plant Management). Net Income (Fig. 4) from okra cultivation under different treatments showed that organic cultivation was compatible to chemical practice and even higher in some cases. This indicated the economic viability of Inhana Rational Farming Technology for organic vegetable cultivation.

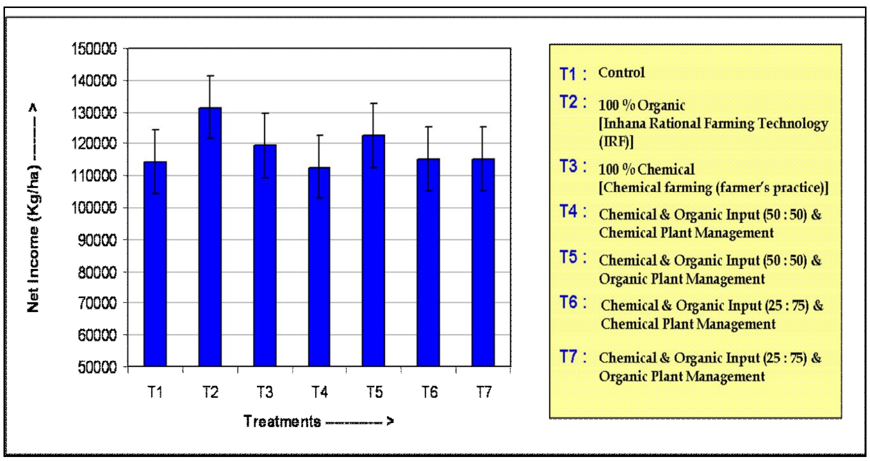


Figure 4 : Net income from Okra cultivation under different treatments

4. Conclusion

Evaluation of Inhana Rational Farming® (IRF) Technology towards development of sustainable cultivation pathway indicated potential of the method towards crop sustainability, higher income generation as well as farmer's adoptability. Adoption of this technology can lead to restoration of depleted soil productivity and health within a defined time frame. The findings also indicated that the technology has potential towards successful organic management of different agricultural crops as well as integrated cultivation progrmme, where reduction of chemical load can be initiated without any compromise in crop yield or income potential.

5. References

1. Australian Standards. (1999). 4454: 1999. Composts, soil conditioners and mulches. Standards Association of Australia, Homebush, NSW.
2. Bera R. Khan M. and Mazumdar D. (2013a). Soil Development Index (SDI) to Evaluate Effectivity of Different Organic Inputs towards Soil Quality Development under FAO-CFC-TBI Project at Maud Tea Estate, Assam in 100th Indian Science Congress (2012-13),Page 272.
3. Bera R.,. Dutta A and Sengupta K. (2013d). Evaluation of Inhana Rational Farming (IRF) Technology as an Effective, Comprehensive & Economical Method for Organic Vegetable Cultivation taking Tomato as a Test Crop in 100th Indian Science Congress (2012-13), Page 226.

4. Bera, R., Datta, A., Bose, S., Dolui, A.K., Chatterjee, A.K., Dey, G.C., Barik, A.K., Sarkar, R.K., Majumdar, D., Seal, A. (2013b). Comparative Evaluation of Compost Quality, Process Convenience and Cost under Different Composting Method to asses their Large Scale Adoptability Potential as also Complemented by Compost Quality Index, International Journal of Scientific and Research Publications, 3(6) :406-417.
5. Bera, R., Datta, A., Saha, S., Dolui, A.K., Chatterjee A.K., Sarkar, R.K., De, G.C., Barik, A.K., Majumdar, D., Sahu, S.S. and Bhattacharyya, P. (2011). Quality of soil inputs as a determinant factor for its quantitative requirement and soil dynamics resultant into effective organic tea production– A case study under CFC–TBI Project at Maud Tea Estate, Assam, India. Tea-Organic-Low Carbon International Symposium', China (2011). held on June 6-9, 66 – 88.
6. Bhattacharyya, P. and Chakkraborty, G. (2005). Current status of organic farming in India and other countries. Indian Journal of Fertilizers. 1(9) : 111-123.
7. Black, C.A. (1965). Methods of soil analysis, Part 1 and 2. American Society of Agronomy Inc.: Madison, Wisconsin, USA.
8. Chitravadivu C, Balakrishnan V, Manikandan J, Elavazhagan T, Jayakumar S (2009). Application of Food Waste Compost on Soil Microbial Population in Groundnut Cultivated Soil, India. Middle-East J. Sci. Res., 4(2): 90-93.
9. Dolui, A.K., Khan, M.M., Bera, R. and Seal, A. 2013. Qualitative Approach in Organic Soil Management – the Key Factor behind Development of Acid Tea Soils, International Journal of Scientific Research, 2(8) : 7-9.
10. Gill MPS (1995). National Seminer on developments in soil science Abstr. J. Indian Soc. Soil Sci., pp. 146-147.
11. Hutchinson TC, Collins FW (1978). Effect of H^+ Ion Activity and Ca2+ on the Toxicity of Metals in the Environment. Environ. Health Perspect., 25: 47-52.
12. Krishnakumar, S., Muthukrishnan, R., Rajendran, V. and Kaleeswari, R.K. (2013). Evaluation of various sources of organic manures on nitrogen use efficiency in rice-rice cropping system. Scientific Research and Essays, 8(42) : 2087-2099.
13. Law-Ogbomo, K. E., Remison, S. U. and Jombo, E. O. (2011). Effects of organic and inorganic fertilizer on the productivity of Amaranthus cruentus in an ultisol environment**.** International Journal of Plant Physiology and Biochemistry Vol. 3(14), pp. 247-252.
14. Sarkar, R.K., Bera, S.K. and Das, A.K.. (2011). Comparative Evaluation of Different Composting Method in terms of End Product Quality, Process Convenience and Cost of Product for Large Scale Adoption – A Case Study from FAO-CFC-TBI Project at Maud T.E., Assam, India in 99th Indian Science Congress (2011-12), Page 130.
15. Seal, A., Bera, R., Chatterjee, A.K. and Dolui, A.K. (2012). Evaluation of a new composting method in terms of its biodegradation pathway and assessment of compost quality, maturity and stability. Archives of Agronomy and Soil Science, 58 (9): 995-1012.
16. Sharma, H.R. (1996). Mountain Agricultural Development Process and Sustainability - Microlevel Evidence from Himanchal Pradesh, Discussion Paper, Series No. MFS 96/2, ICIMOD, Kathandu, Nepal.
17. Trautmann, N.M. and Krasny, M.E. (1997). Composting in the classroom. http://www.cfe.cornell.edu/compost/schools.html.
18. US Composting Council. (2002). Available in http://www.compostingcouncil.org.
19. Vasnthi D, Kumaraswamy K (2000). Effects of manure-fertilizer schedules on the yield and uptake of nutrients by cereal fodder crops and on soil fertility. J. Indian Soc. Soil Sci., 48(3): 510-515.