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Organic Cultivation of Exotic & Traditional Vegetables under Inhana Rational Farming Technology – A Case Study from West Bengal, India

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A B S T R A C T

Food quality and food safety are the two important criteria that are gaining attention among the consumers. Conventionally grown foods have immensely adverse health effects due to the presence of pesticide residue, higher nitrate content, heavy metals, hormones and antibiotic residue. Hence, the popularity of organically grown foods is increasing day by day owing to their nutritional and health benefits. In the present study, Inhana Rational Farming (IRF), Technology a comprehensive package of practice, for sustainable organic farming was adopted to study its potential towards production of traditional as well as exotic vegetables in the new alluvial zone of West Bengal under hot moist sub humid agro-climatic condition. Fifteen different exotic and traditional vegetables viz. lettuce (variety : *Cos Rusty, Iceberg and Sangria*), Chinese pak choi, red cabbage, horse radish, radish, tomato, pumpkin, bitter gourd, okra, cauliflower, onion, brinjal, amaranthus, French bean, and coriander were taken under the study to evaluate their growth and productivity under organic farming. The results showed that it is possible to grow all the types of vegetables be it general or the exotic ones through the adoption of IRF Technology. This is because adoption of this technology helped in getting competitive crop productivity under organic management, that too in the very first year, when compared with conventional practice. The results might have been influenced by the intense plant health management approach under this technology driven by the potentized and energized Inhana 'Energy' Solutions as well as soil health management through the application of on-farm produced Novcom compost that embodies a very high population of self-generated microbes in the order of 10^{16} c.f.u. per gm moist compost. More importantly, 36 families were enrolled for blind taste test, and the results concluded better taste and longer shelf life in respect of the organic vegetables

Keywords: Organic Farming, Inhana Rational Farming Technology, Novcom Compost, Plant health management, Self-generated native microflora, Exotic vegetables, Productivity, Shelf life, Blind taste test, Shelf life

1. Introduction

Vegetables are important constituents of Indian agriculture and nutritional security due to their short duration, high yield, nutritional richness, economic viability and ability to generate on-farm and off-farm employment (Arora *et al*, 2015). India, with vegetable production of 146.55 million ton, is the second largest producer of vegetables contributing 14% of world's vegetable production (Ramchandra *et al*, 2015). Especially, exotic vegetable is more profitable business than cultivation of traditional ones (Rao and Sasanka, 2015). The international demand for exotic vegetables is increasing day by day at the rate of 15 to 20% per annum since India is importing more than 85% exotic vegetables (Rao and Sasanka, 2015).

However, with the increase in demand for vegetables vis-à-vis their cultivated area to meet both the domestic requirement as well as export, the use of pesticides on these crops has also increased to manage the menace of various insect-pests, thus adversely affecting man and his environment. Different studies have suggested that the excessive use of these agrochemicals may actually increase pest problems in the long run (Altieri and Nicholls 2003) and the results propose a hypothesis that higher synthetic fertilizer inputs may lead to higher levels of herbivore damage to crops (Letourneau *et al*, 1996). At the same time, accumulation of nitrate with applications of synthetic N-fertilizers was high to very high in case of most of the exotic vegetables like celery, lettuce, parsley, Chinese cabbage, etc. which might pose potential health risk (Santamaria, 2006).

Adoption of a comprehensive organic package of practice is the key for sustainable crop production and to eliminate the risk of health hazards. Moreover, sustainable agriculture is also the most apt solution to fight the climate change challenge. By increasing resilience within the agro-ecosystem, organic agriculture increases its ability to continue functioning when faced with unexpected events such as scanty rainfall, high temperatures, etc.. However, conventional organic farming which only replaces the chemical inputs with organic alternative fails to secure crop and thereby economic stability. In this background, IRF Technology, which has shown its potential towards economically viable organic farming in different crops under different agro-ecosystems (Barik et al, 2014a, 2014b, Bera et al, 2014, Seal et al, 2014) was adopted for organic cultivation of both exotic and traditional vegetables.

2. Materials and Methods

The study was initiated at Dattapukur village in the district of North 24 Parganas, West Bengal, India for organic cultivation of exotic and traditional vegetables with adaption of Inhana Rational Farming Technology Developed by Dr. P. Das Biswas, pioneer in sustainable organic tea cultivation in India.

2.1 Climatic Data of the study area

The area belongs to hot, moist subhumid ecological sub region (15.1) (Sehgal *et al*, 1992). The climate of the study area is characterized by oppressively hot summer, high humidity and high rainfall during the monsoon. Winter starts from the middle of November which continues up to the end of February. As per the last five years climatic data base , it received about 1579 mm annual rainfall. The maximum was received during April to October which was more than 90 % of total annual rainfall. The highest mean monthly temperature is observed in the month of May (40^0C) and the lowest (10^0C) in the month of January. Relative humidity varied in between 55% in March & 98% in July.

2.2 Physiography and soils of the study area

In terms of physiography, the study area belongs to riverine delta zone and is formed by the materials carried by the Ganga. The area was basically under Meander flood plain. According to Soil Survey Staff (1992) the soils of the study area was very deep, poorly drained fine loamy soils occurring on level to nearly level meander plain with loamy surface and moderate flooding associated with very deep, imperfectly drained fine loamy soils. According to soil classifications the soil belongs to Fine loamy Aeric Haplaquepts and fine loamy Fluventic Ustochrepts soils association . The land features of study area were medium physiography and it remains waterlogged for 2 to 3 months during monsoon season. The soil has a slightly heavy texture with moderate drainage and is slightly alkaline in reaction (pH varied from 7.75 to 8.10). The soil is non- saline in nature (EC < 0.10 dSm^{-1}) with low organic carbon (varied from 0.60 to 0.69 %), low available-N (280 -295 kg/ha), high available-P_2O_5 (65 – 82 kg/ha) and low available-K_2O (85 to 129 kg/ha).

2.3 Test Vegetables

The study was initiated at Dattapukur village in the district of North 24 parganas, West Bengal, India for organic cultivation of exotic vegetables viz., horse radish (*Armoracia rusticana* 'Pink Beauty'), lettuce (*Lactuca sativa 'Cos Rusty'; 'Iceberg'; 'Sangria'*), Chinese Pak Choi (*Brassica rapa subsp*. chinensis 'HK Baby'), red cabbage (*Brassica oleracea* var. *capitata f. rubra* 'Red Queen'), and traditional vegetables viz., tomato (*Lycopersicon esculentum* 'Naveen, local), pumpkin (*Cucurbita maxima* 'Chaitali'), bitter gourd (*Momordica charantia* 'Arka Harit'), okra (*Abelmoschus esculentus* variety : local), cauliflower (*Brassica oleracea* var. botrytis 'Sakama') radish (*Raphanus sativus ' VR860', 'F1 Hybrid No. 1039'*), onion (*Allium cepa* 'Faridpur bunch onion'), brinjal (*Solanum melongena* 'Debjhuri Hajari'), Amaranthus (*Amaranthus dubius* 'Red Garnet'), French bean (*Phaseolus vulgaris* local) and coriander (*Coriandrum sativum* 'KO1') using Inhana Rational Farming Technology (Barik *et al*, 2014a; Barik *et al*, 2014b).

2.4 Inhana Rational Farming (IRF) Technology :

The vegetables were cultivated through adoption of Inhana Rational Farming Technology which is inspired by the evolutionary concept of Vedic philosophy (Fig. 1) developed by Dr. P. Das Biswas, a pioneer in scientific organic tea cultivation in India (Chaterjee *et al*, 2014, Barik *et al*, 2014a). IRF technology was introduced as a complete organic package of practice in 2001 in tea. It aims at developing healthy plants through

I. Energization of soil system i.e., enabling the soil to function naturally as an effective growth medium for plants (Barik *et al*, 2014a) and

II. Energization of plant system i.e., enabling higher NUE alongside better bio-chemical functions that leads to activation of the plants' host defense mechanism (Barik *et al*, 2014a).

Energization of Soil System is aimed at enabling the soil to function naturally as an effective growth medium for plants. Soil Energization aimed at rejuvenation of soil micro-flora, is primarily attended by application of on-farm produced Novcom compost (that contains a rich population of self-generated micro flora in order of 10^{16} c.f.u); different types of on- farm produced Soil Energizers and adoption of Sustainable agricultural practices. However, the technology emphasizes plant health management as a precursor for resilient plant system that can ensure sustainability even under the changing climatic patterns.

Energization of Plant System is aimed at enabling higher nutrient use efficiency alongside better bio-chemical functions that leads to activation of the plants' host defense mechanism. Plant Energization under this technology is a systemic approach that utilizes a set of potentized and energized botanical solutions developed under Element Energy Activation (EEA) Principle. Details about the technology in terms of working principles and spraying protocols of the solutions had been done according to the workers who have followed this technology for organic crop production (Chatterjee *et al*., 2014 and Barik *et al*., 2014).

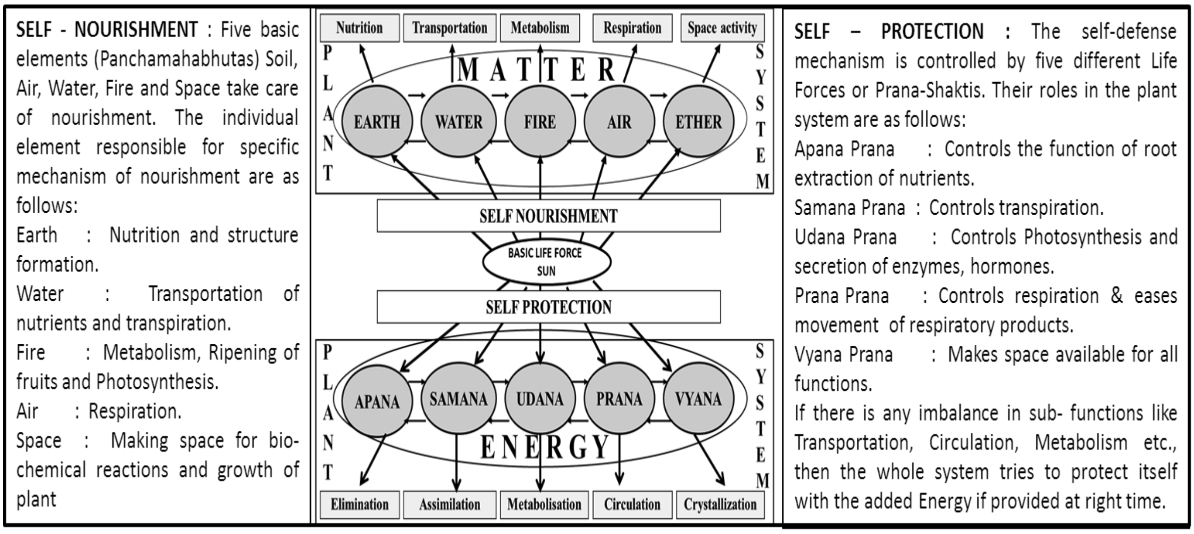

Fig. 1: Plant energization under IRF technology following EEA Principle

The Technology bears the essence of Trophobiosis theory (Fig. 2) and reaches to the root cause of pest interference and works towards amelioration of factors that favourably signals pest/disease advances (Seal *et al*, 2017).

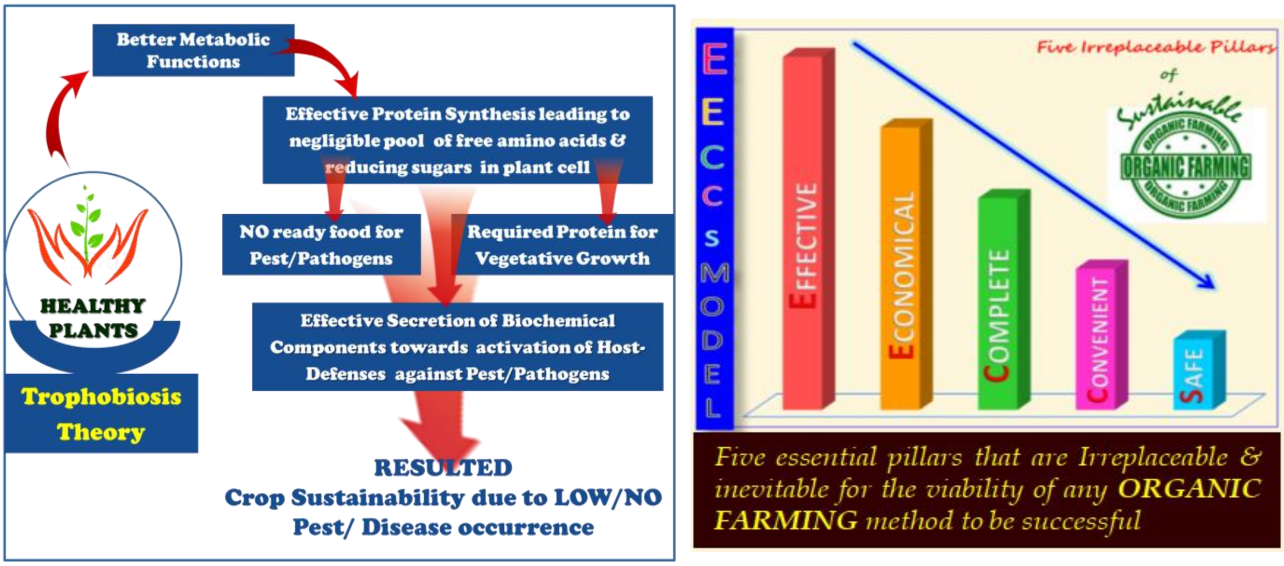

Fig 2 : Principles of Trophobiosis theory was practically demonstrated through organic package of practice under Inhana Rational Farming(IRF) Technology.

IRF Technology, a comprehensive organic farming method, which attempts to provide an ideal environment to both soil and plant thereby brings about qualitative changes in their performance. No quantitative application, no cidal approach and scientific explanation behind each step as well as its principle are the key parameters of Inhana Rational Farming (IRF) Technology.

The Mechanism of Self- Nourishment in Plant System

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 perform without any problem. The individual element responsible for specific mechanism of nourishment :

There are five different life forces or energies in all living bodies as well as in the plant system originated from the Basic Life Force i.e. Solar Energy. The Self-Protection mechanism is controlled by the Life Forces and they are also the vehicles of the basic elements and movement of nutrients is impossible without them. Plant system being 'PURE NATURE', energies directly activates on the matter or elements. Here Life Forces or Energies work as the power of expressing the former and moving the latter.

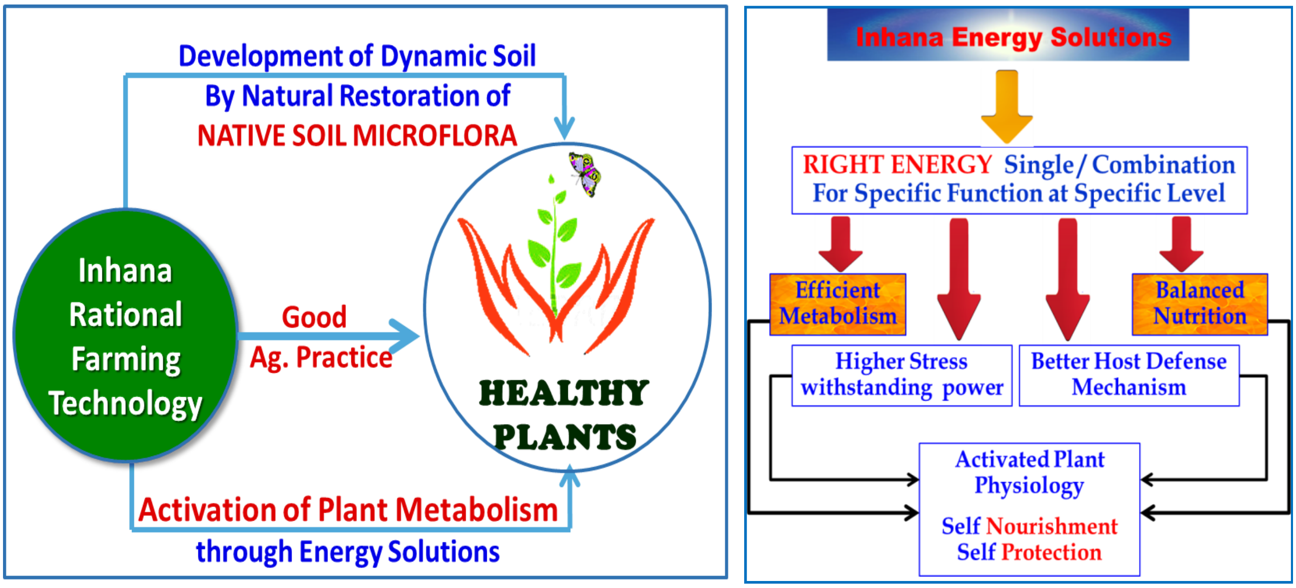

Fig 3 : Development of the healthy plants is the major objectives of Inhana Rational Farming Technology

2.5 Preparation of Novcom compost:

Compost was made through Novcom composting method using available green matter, water hyacinth and cow dung as described by Seal *et al*, 2012. Cow dung constituted approximately 30 to 35 percent of the total raw material used per heap. After a period of 21 days approximately 2.5 tons Novcom compost was obtained. Compost quality was analysed as per standard methodology (Black, 1965). Mature Novcom compost was applied @ 3 ton/acre in the field during land preparation 15 to 20 days prior to crop transplantation.

Fig 4: Preparation of Novcom compost heap at Dattapukur, West Bengal, India

Preparation of cow dung slurry (CDS) : Cow dung slurry is a concoction which have multipurpose role from enrichment of soil microbial activity to sanitation against pathogenic activity in the field as it is a rich source of beneficial microbial population. It acts as mild nutrient supplement to plant as well as acts as pest repellent when spray in plant. It also used as stress buster for crop especially in drought condition as well as help in growth enhancement.

For preparation of 100 litre CDS concoction 20 kg of fresh cow dung, 20 litre of fresh cow urine, 1 kg of jiggery, 100 gm yeast,200 ml of CDS solution (potentised and energized botanical extract of *Vernonia cineria* Less. & *Solanum verbascifolium*) and 100 litre water was required. For preparation of concoction, all the ingredients were taken and mixed in a wide mouthed cemented/ plastic tank. The mixture was stirred for 20 minutes, twice daily.

CDConcoction was ready within 3 days. Before spraying, CDS concoction was filtered with fine muslin cloth. It was sprayed @ 30 ltr/acre with required amount of water in soil just after compost application and in the plant at 15 days interval for steady growth and minimization of pest/disease infestation.

2.6 Preparation of Organic nursery under Inhana Rational Farming (IRF) Technology:

Preparation of organic nursery is one of the most important steps towards successful organic vegetable cultivation. Steps of the management practices taken are as follows:

1. An upland area was selected for raising the nursery. Each seed bed was 15-20 cm above the soil level with 3 meter length and 1 meter width. The sides of the bed were made slanting giving the bed an appearance of the tortoise back.

2. The soil pH of the nursery was tested and was found to be nearly the ideal neutral range (6.5 to 7.5).

3. The seed bed was thoroughly ploughed to remove any clod and make the soil finer for easier germination of the seeds. Ploughing also exposes many buried weed seed and insects for them to either destroyed or consumed by predators. Then well matured Novcom Compost 50-60 kg (for 3 m x 1 m size nursery bed) was mixed in the moist soil 10 days prior to seed sowing. After incorporation of Novcom compost, 10 ltr diluted CDS concoction (5 ltr CDS Concoction & 5 ltr water) was sprinkled over the top soil for increasing the soil microbial activity.

Fig 5: Preparation of organic seed bed and organic nursery as per IRF Package of practice.

4. Seeds were treated with Inhana seed treatment solution before sowing as per recommended procedure. Then they were sown 10 cm wide and 1 cm deep lines in the bed drawn parallel to its length maintaining a spacing of 3– 5 cm. Then they were covered with thin layer of soil and hay (mulch) followed by light sprinkling of water.

5. After 6-7 days of sowing, the mulch was removed to expose the germinating seeds to sunlight gradually with 1-2 hours of exposure in the morning and evening.

6. Inhana Nursery management solutions were sprayed as per the recommended schedule initiating 3 days after germination (Table 1).

7. Regular irrigation and weeding was done whenever required. The plants were transplanted at 4-5 leaf stage.

2.7 Seed treatment & spraying schedule for organic nursery management under Inhana Rational Farming (IRF) Technology:

Seed treatment is necessary before sowing to minimize the risk of seed borne diseases as well as better germination potential. Steps of organic seed treatment under IRF technology was as follows:

(1) 10 ml of Seed Treatment Solution (potentised and energized botanical extract of *Cynodon dactylon* and *Calatropis gigantea*) was mixed with 1ltr of water. Then the seeds were soaked in that solution for 30 minutes.

(2) Hard coated seeds viz., pumpkin, bitter gourd, okra which require longer germination period were soaked in normal water for 3 hours and then in Seed Treatment Solution for 30 minutes.

(3) In both the cases the seeds were dried in shade before sowing.

Raising of organic nursery and development of healthy seedlings is key components of organic vegetable cultivation. Spraying schedule of seedlings in the organic nursery under IRF Technology was as follows:

1. 3 days after germination, N.S. (Ag)-1 (potentised and energized botanical extract of *Ficus hispida*) was sprayed in a dose of 10 ml diluted in 1 ltr water.

2. At two leaf stage, N.S (Ag)-2 (potentised and energized botanical extract of *Erythrina variegata*) was sprayed with the same dilution (10 ml in 1 ltr of water).

3. After 7-10 days of 2nd spray N.S (Ag)-1 was again sprayed with the same dilution.

4. After 10 days from 3rd spray N.S (Ag)-3 (potentised and energized botanical extract *of Alstonia scholaris*) was sprayed with the same dilution.

Fig 6 : Dr. Antara Seal, scientist from IORF visited Novcom compost at the study area accompanied by Dr. P. Das Biswas, developer of IRF Technology (extreme right) at the study area.

2.8 Spraying schedule in main field under Inhana Rational Farming (IRF) Technology:

Organic package of practice under Inhana Rational Farming Technology is aimed at enhancement of plant physiological functioning towards sustainable growth and building resistance against pest/disease infestation as well as abiotic stress factors. Under this package of practice different energized and potentized botanical solutions prepared following Element Energy Activation (EEA) Principle were sprayed @ 300 ml/acre with required amount of water in a specific schedule towards attending the above mentioned objectivity.

Table 1 : Spraying schedule of Inhana Solutions for plant health management

Solutions to be sprayed	**Spraying Interval**	**Potentized and Energized extracts of**
IB- 1	After 2-3 days of germination/ Transplantation	*Hyoscyamus niger*, *Ficus benghalensis* and *Dendrocalamus strictus*
IB- 2	After 7 days of 1st spray	*Ocimum sanctum*, *Calotropis procera* and *Cynodon dactylon*
IB- 6	After 7 days of 2nd spray	*Cynodon dactylon* and *Calotropis gigantea*
IB- 5	After 10 days of 3rd spray	*Hyoscyamus niger* and *Solanum verbascifolium*
IB- 3	After 7 days of 4th spray	*Adhatoda vasica*, *Zingiber officinale* and *Embelia ribes*
IB- 2	After 10 days of 5th spray	*Ocimum sanctum*, *Calotropis procera* and *Cynodon dactylon*
IB- 1	After 7 days of 6th spray	*Hyoscyamus niger*, *Ficus benghalensis* and *Dendrocalamus strictus*
IB- 8	After 5 days of 7th spray	*Solanum verbascifolium*, *Prosopis spicigera* and *Ocimum basilicum*
IB- 4	After 7 days of 8th spray	*Calotropis procera* , *Dendrocalamus strictus* and *Bombax malabaricum*
IB- 5 + IB- 6	After 10 days of 9th spray	Mentioned above

2.9 Pest and disease management under Inhana Rational Farming (IRF) Technology:

Proper organic soil management, field sanitation activity, seed treatment, development of healthy seedlings and implementation of plant management schedule in time reduced pest/disease infestation. However some minor infestation occurred, which was tackled with on-farm prepared concoction along with Inhana solutions.

- For chewing and sucking pest : 2 ltr neem oil , 400 ml karanj oil, 400 ml cow urine, 400 ml IB-19 (potentised and energized botanical extract of *Bombax malabaricum, Calotropis procera and Ocimum basilicum*) and 1 ltr of Khari soap solution (100 gm khari soap soaked in 1ltr water overnight) were mixed together in 200 liter of water for spraying in 1 acre of area
- For mite infestation: 5 liter lime sulphur and 400 ml IB-19 were mixed with 200 liter of water and sprayed in 1 acre of area.
- For disease infestation: IB-2 (potentised and energized botanical extract of *Ocimum sanctum, Calotropis procera* and *Cynodon dactylon*) and IB-7 (potentised and energized botanical extract of *Ocimum sanctum*) were mixed with 200 liter of water and sprayed in 1 acre of area. The combination was repeated for 3 to 4 rounds as per severity of the disease infestation in the field at 5 to 7 days interval.

Fig 7 : Landscape view of the study area under organic vegetable cultivation

3. Results and discussions

Inhana Rational Farming Technology was adopted for organic cultivation of both exotic and traditional vegetables in the study area. Adoption of the organic package of practice ensured successful production of the selected vegetables despite the fact that the study was the first exposer of the field workers towards organic techniques as well as cultivation of the exotic vegetables.

3.1 Analysis of Novcom compost

Novcom compost prepared in the study area was ready for application within 21 to 30 days. Dark brownish black colour, earthy smell and presence of earth worms in the compost heap indicated its maturity, which was further confirmed by laboratory analysis. During the biodegradation period, temperature and volume reduction of the compost heaps were recorded on daily basis (Fig 8).

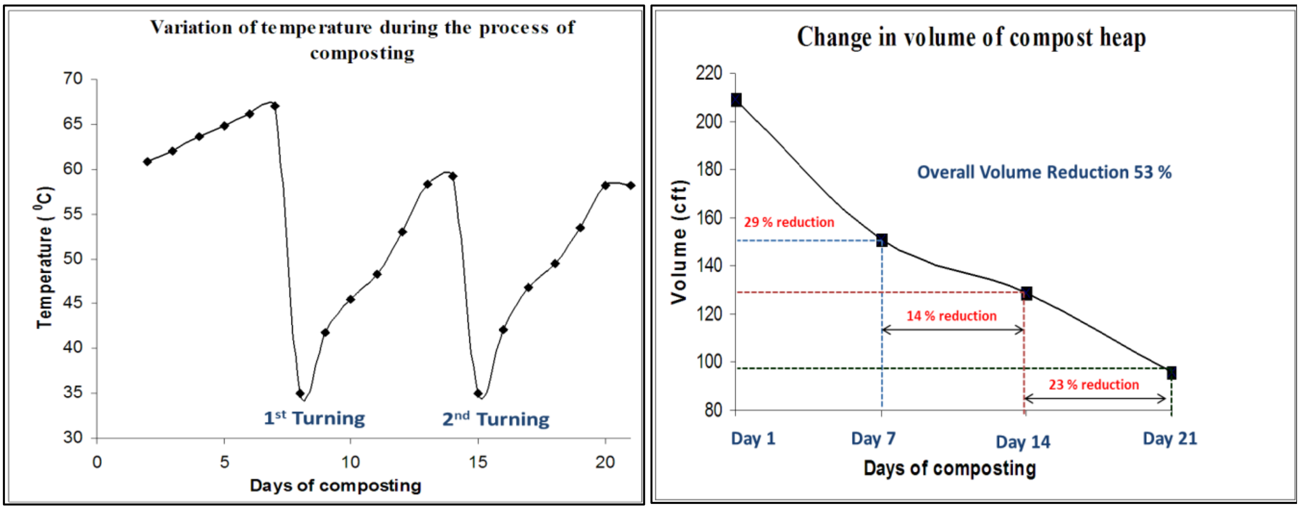

Fig 8: Variation of heap temperature and reduction of heap volume during biodegradation period under Novcom composting method in the study area.

Increase of heap temperature above 60 degree within 48 hours of compost heap erection indicated intense microbial activity within the compost heap which was further corroborated by sharp decrease of compost heap volume. During the initial phase of biodegradation, microbial activity caused the structural degradation of organic matter as a result of which there was a sharp decrease in volume (Seal *et al*, 2012). Maintenance of a stable temperature of > 62.8^{0}C within the compost heap for more than three consecutive days has been found to be effective for the destruction of most human pathogens, insect larvae and weed seeds within the compost heap (Rynk *et al*. 1992). Hence, the temperature curve for the compost heap suggested that the process ensured a safe end product for application in soil (Seal *et al*, 2012).

All the samples appeared dark brown in colour with an earthy smell indicating compost maturity (Epstein, 1997). Moisture of the compost samples varied within 52 to 60% which was within the ideal range (40 – 60 %). The pH value of the compost samples ranged between 7.2 and 8.3, with a mean of 7.89, which was well within the stipulated range for good quality compost (Jime´nez and Garcia 1989). Electrical conductivity of the compost samples ranged between 1.62 and 2.47 with a mean of 1.88 dSm^{-1}, indicating safely below (>4.0) the stipulated range for saline toxicity (Evanylo 2006). The organic matter content of compost is a necessity for determining the compost application rate to obtain sustainable agricultural production (Mukhopadhyay *et al*, 2015). Organic carbon content in the compost samples ranged between 16.5 and 21.2 percent, with a mean value of 20.6 percent.

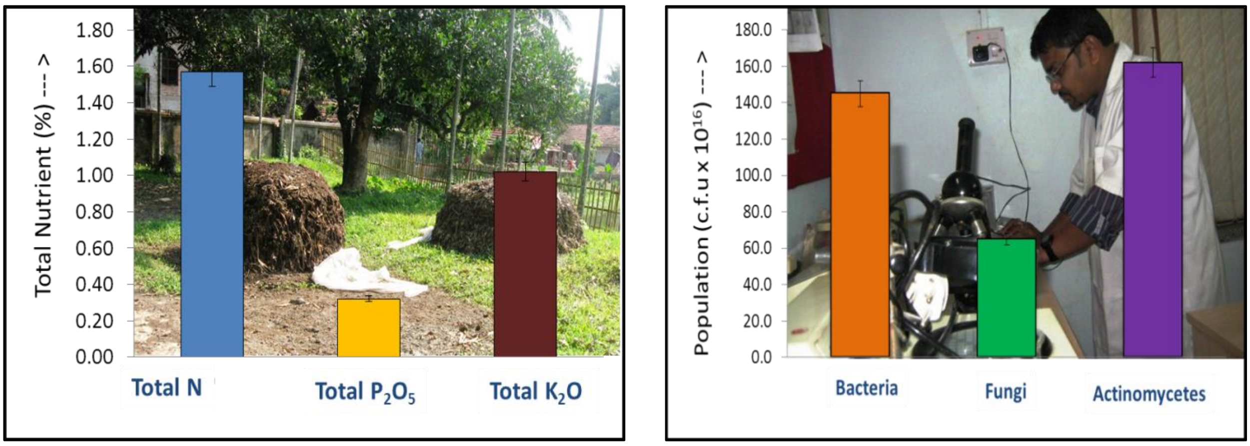

Fig 9 : Nutrient status and microbial population of Novcom compost

Although 36 different nutrients are required for plant growth, but the contribution of macronutrients (N, P, K) is usually of major interest (Tisdale S.L., 1985). The total nitrogen content in the compost samples ranged between 1.51 and 1.82 percent (Fig 4), which was within the reference range (1.0 to 2.0 percent) (Alexander, 1994 and Watson, 2003). Total phosphate (0.26 to 0.42 percent) content was found to be higher than the minimum suggested standard of 0.22% (Fertilizer Association of India 2007),). Total potash content (0.91 to 1.21 percent) was also higher than the minimum suggested standard (Watson, 2003). However, the most important criteria of compost quality are the microbial population within the compost. Microorganisms participate in disintegration and decomposition processes leading to the release of nutrients trapped in plant and animal debris, rock and minerals. They as well as synthesize and release hormones that are essential for plant growth [Gogoi *et al*, 2003]. Total count of bacteria, fungi and actinomycetes in per gram moist compost sample was assessed to be 142 x 10^{16}, 63 x 10^{16} and 160 x 10^{16} c.f.u. respectively (Fig 9). Such high generation of microbial population might have been possible due to the generation of an ideal micro atmosphere within the composting heap as influenced by the application of Novcom solution (Mukhopadhyay *et al*, 2015).

3.2 Production of organic vegetables

15 different types of vegetables were produced in the study area with adoption of Inhana Rational Farming Technology. The vegetables grown healthy and minor problem of pest was noticed during the entire cultivation period which was controlled through alternate pest management options.

3.2.1 Organic lettuce (Lactuca sativa) production:

Lettuce is one of the most consumed foliage vegetable in the world. Agricultural practices followed for cultivation are important pre- harvest factors affecting the quality of the fresh-cut product (Luna *et al*, 2012). Furthermore, manure and organic nutrient usage has been observed to have improved both productivity and quality of this crop (Villas Bôas *et a*l., 2004; Lopes *et al*., 2005). In the project area 3 different varieties of lettuce viz 'Cos Rusty', 'Iceberg' and 'Sangria' was cultivated. Among 3 varieties, Iceberg verity produce significantly higher (457 g/plant) than other two varieties.

Table 2: Comparative study of yield components of different variety of lettuce under IRF Organic package of practice

Agronomic Parameters	**Lettuce (*Lactuca sativa*) varieties**		
	'Cos Rusty'	**'Iceberg'**	**'Sangria'**
Average plant length (cm)	23 ± 0.09	18.0 ± 0.09	23 ± 0.09
Average Leaves (No.)	23 ± 0.09	21.0 ± 0.09	23 ± 0.09
Average Leaf length (cm)	20.0 ± 0.09	17.5 ± 0.09	19.5 ± 0.09
Average Leaf breadth (cm)	12 ± 0.09	15.0 ± 0.09	13.3 ± 0.09
Average weight (g)	210 ± 0.09	457 ± 0.09	147.5 ± 0.09

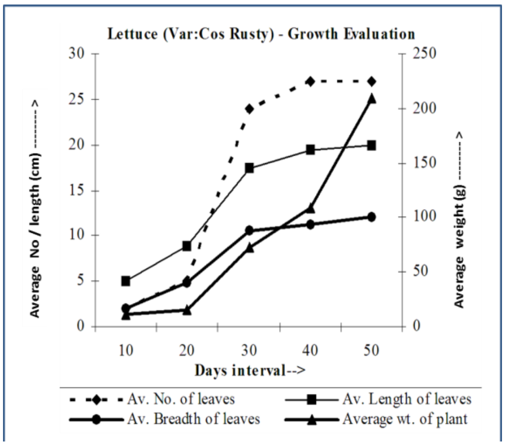

Fig 10: Growth of organic lettuce (Variety: Cos Rusty) under IRF Organic package of practice.

Fig 11 : : Manual weeding in the study area

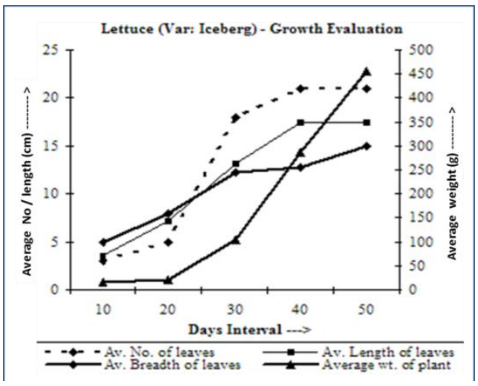

Fig 12: Growth of organic lettuce (Variety: Iceberg) under IRF Organic package of practice.

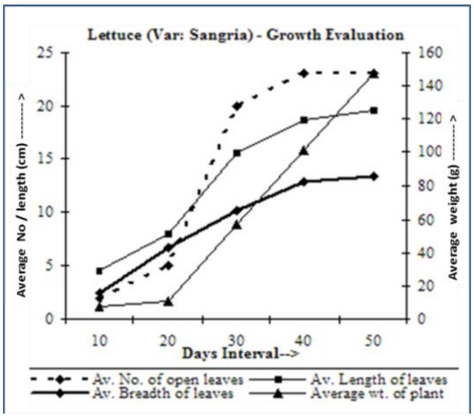

Fig 13 : Growth of organic lettuce (Variety: Sangria) under IRF Organic package of practice.

3.2.2 Organic Red Cabbage (Brassica oleracea var. capitata f. rubra) production:

Red cabbage (*Brassica oleracea* L. var. *capitata f.rubra*) is one of the most important cool season vegetables belongs to the family Cruciferae. It is an herbaceous plant distinguished by a short stem upon which is crown with a mass of red colored leaves (head). It is used as salad, boiled vegetable, cooked in curries, used in pickling as well as dehydrated vegetable (Mnasa *et al*, 2017). This crop has been recognized as modern multitaskers dream food for its numerous benefits that it provide us (Das *et al.*, 2014). The crop can be harvested after 3 months of harvesting. It is cultivated in America, Europe, Asia (China, India etc.).

Table 3: Yield components of red cabbage

CROP	**:**	**Red Cabbage**
Variety	**:**	**Red Queen**
Crop Area (acre)	**:**	0.08
Initiation of Ball formation	**:**	90 – 95 days after sowing.
Average weight of full grown fruit (g)	**:**	487

In the study area, red cabbage was grown successfully with adoption of Inhana Rational Farming Technology. Average weight of full grown red cabbage was 487 gm.

3.2.3 Organic Raddish (Raphanus raphanistrum) and Horseraddish (R. raphanistrum subsp. sativus) production :

Radish belongs to the family Brasicacceae. It is a popular root vegetable in both tropical and temperate regions. It can be cultivated under cover for early production but large scale production in field is more common in India (Verma *et al*, 2017). Radish is grown for its young tender tuberous root, which is consumed either cooked or row. It is a good source of vitamin-C and minerals like calcium, potassium and phosphorus. In the year 2015-16, area and production of radish in India was 199 thousand hectare and 2844 thousand metric tonnes, respectively.

Table 4: Comparative study of yield components of different variety of radish under IRF Organic package of practice

Agronomic Parameters	***Radish (*****Raphanus raphanistrum*****) variety***		
	(Red Long, var : VR 860)	(White Long, var : F1 Hybrid 1039)	**(**Horseradish, varity : Pink Beauty)
Average plant length (cm)	92 ± 0.09	71.5 ± 0.09	27.0 ± 0.09
Average Fruit length (cm)	37 ± 0.09	41.5 ± 0.09	8.6* ± 0.09
Average plant weight (g)	1450 ± 0.09	1570 ± 0.09	128 ± 0.09
Average root weight (g)	900 ± 0.09	932 ± 0.09	75 ± 0.09
Percent root weight per plant weight	62.1 ± 0.09	59.4 ± 0.09	58.6 ± 0.09

* *Average Fruit diameter (cm)*

3 different type of redish variety was studied under Inhana Rational Farming Technology. Highest production was recorded in case of red long variety raddish followed by White long and Horseredish variety.

Fig 14 : Different variety of radish organically grown in the study area.

3.2.4 Organic Beet Root (Raphanus raphanistrum) production :

Sugar beet (*Beta vulgaris* L.), a member of Chenopodiaceae family, is a plant whose root contains a high concentration of sucrose. Sugar beet plant consists of three parts, namely crown, neck and root. The crown produces leaves and the root stores the sugar. It is a significant crop of arable rotations throughout the major growing regions. It has a conical, white, fleshy root (a taproot) with a flat crown. The plant consists of the root and a rosette of leaves. Sugar is formed by photosynthesis in the leaves, and is then stored in the root. In the study area, the growth of sugar beet plants under IRF organic packages of practice was satisfactory and average sugar beet weight was 268 g/plant, which was higher than conventionally grown sugar beet in that locality.

Table 5 : Yield component of beet root under IRF Organic package of practice

Agronomic Parameters	***Beet Root(*****Raphanus raphanistrum)** Varity : Ruby Queen
Average Foliage length (cm)	32.5 ± 0.09
Average Fruit Diameter (cm)	8.0 ± 0.09
Average plant weight (g)	400 ± 0.09
Average Fruit weight (g)	268 ± 0.09
Percent fruit weight per plant weight	67 ± 0.09

3.2.5 Organic Chinese Pak Choy (Brassica rapa subsp. chinensis) production :

Pak choi (*Brassica rapa*, Chinensis group) is a cool-season crop similar to many other Brassica vegetables, such as kale and broccoli, and was domesticated in China. It is an exotic vegetable which is getting more popular in India lately. Pak Choy prefers a cool weather and this vegetable has optimal growth and development at temperatures between 15 and 20ºC (Maroto, 1995). In summer, the plant bolts or goes into seed very quickly and this can change the taste of the leaves, making them bitter. Pak Choy thrives in well-drained fertile soil, rich in organic matter. In the study area, average weight of pak choi was 485 gm/plant which was satisfactory considering as documented by other research workers (Echer *et al*, 2015).

Table 6 : Yield component of Chinese Pak Choy under IRF Organic package of practice

Agronomic Parameters	Chinese Pak Choy ***(****Brassica rapa* subsp. *chinensis****)***
Average Full Grown Leaves (No.)	12 ± 0.09
Initiation leaves (No.)	2 ± 0.09
Average Leaf length (cm)	44.3 ± 0.09
Average Leaf Breadth (cm)	17.5 ± 0.09
Average weight (g)	485 ± 0.09

3.2.6 Organic Tomato (Lycopersicon esculentum) production :

Tomato (*Lycopersicon esculentum*) belongs to the genus Lycopersicon under Solanaceae family. Plants showed a very healthy growth and the crops started attaining maturity (harvestable) even within 70 to 80 days of sowing in case of hybrid variety while it took 90 – 95 days in case of local verities. Leaf curl disease was identified after 30 days of planting, but after timely application of Inhana solution the disease was arrested. After further 17 – 18 days, early blight and 70 – 75 days later bacterial canker was reported but the diseases were successfully managed with Inhana disease management solutions. Average number of fruits in case of hybrid tomato (52.8 / plants) was significantly higher w.r.to its local counterpart. Also average weight of the mature fruit was higher in case of hybrid verities (59.4 g/ fruit). Average yield of hybrid tomato variety under IRF organic practice was 42.54 ton/ha where as that of local variety was 30.42 ton/ha.

Table 7: Comparative study of yield components of different variety of radish under IRF Organic package of practice

Agronomic Parameters	***Tomato (Lactuca sativa)*** Local variety	Hybrid variety (Nabin)
Average plant length (cm)	47.8 ± 0.09	76.2 ± 0.09
No. of branches/plant (cm)	10.2 ± 0.09	15.3 ± 0.09
Fruiting initiation (Days after showing)	85 - 90	75 - 80
Average No. of full grown fruits per plant	36.6 ± 0.09	52.8 ± 0.09
Average Fruit weight (g)	52.1 ± 0.09	59.4 ± 0.09

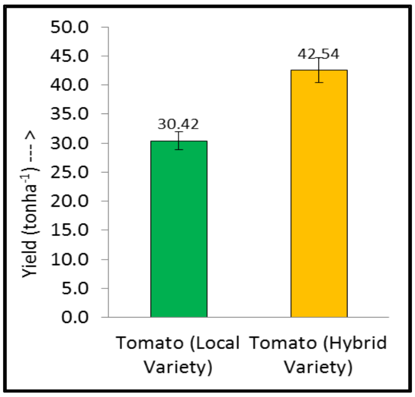

Fig 15 : Comparative productivity of local & hybrid variety tomato

3.2.7 Organic pumpkin (Cucurbita maxima) production :

Pumpkins (*Cucurbita maxima* Duch.) are cultivated throughout the world for culinary and medicinal uses. They are referred to as high-yielding vegetables, which are easy to grow and thereby cost-effective. Pumpkins have received considerable attention in recent years owing to their nutritional and healthprotective values (Rozylo *et al*., 2014) Pumpkins are a good choice for the grower who is considering organic vegetable production, as they may be included early in rotations or in a conversion plan.

Table 8 : Yield component of pumkin under IRF Organic package of practice

CROP	:	Pumkin
Variety	:	Chaitali
Crop Area (acre)	:	0.04
Flower initiation	:	40 -42 days after shoot initiation
Harvesting maturity	:	80 – 85 days
Fruit radius	:	22 cm
Average weight of full grown fruit (g)	:	4.5 kg
Average yield		10.8 ton/acre

Different Inhana solutions for plant health management was applied as per recommended schedule and flower initiation started 40 to 45 days after shoot initiation. Green fruits were ready for harvesting just 80 – 85 day after shoot initiation. During harvesting, average weight of green pumpkin was 4.5 kg. As most of the pumpkins were harvested well before maturity, actual productivity could not be recorded. But average productivity of 10.8 per acre within 90 to 100 days indicated its growth performance.

3.2.8 Organic bitter gourd (Momordica charantia), production :

Bitter gourd belongs to Family Cucurbitaceae (Cucumber family) has importance as vegetable and medicinal plant as well. Green fruits were ready for harvesting just 60 - 65 day after shoot initiation and average productivity of bitter gourd was 4.2 ton per acre.

Table 8 : Yield component of bitter gourd under IRF Organic package of practice

CROP	:	Bitter gourd
Variety	:	*Ark Harit*
Crop Area (acre)	:	0.02 Acre
Flower initiation	:	40-42 days after seedling initiation
Average yield (per acre)	:	4.2 ton
Average yield under chemical farming (per acre)	:	3 - 4.2 ton

Fig 16 : Organic leafy vegetables grown under IRF Technology at the study area

3.2.9 Organic lady's finger (Abelmoschus esculentus,) production :

Okra is one of the major vegetable crops of India. Specific IRF package of practice was implemented for the growth of the okra. Average productivity of Lady's finger was 10.5 ton per ha in the study area under organic package of practice which was comparable to the conventional productivity of okra in that region.

Table 9 : Yield component of lady's finger under IRF Organic package of practice

CROP	:	**Lady's finger**
Variety	:	Local
Crop Area (acre)	:	0.08 Acre
Flower initiation	:	40-42 days after seedling initiation
Avg yield (per acre)	:	4.6 ton
Average yield under chemical farming (per acre)	:	4.2 - 4.8 ton

3.2.10 Organic cauliflower (Brassica oleracea) production :

Cauliflower is one of the most important winter vegetables grow in India. It is a European origin, probably develop from broccoli. In India, cauliflower cultivation is done in almost all the states. Average yield of cauliflower was 22 ton per acre under IRF organic practice.

Table 10 : Yield component of cauliflower under IRF Organic package of practice

CROP	:	**Cauliflower**
Variety	:	*Sakama*
Crop Area (acre)	:	0.02 Acre
Flower initiation	:	40-42 days after seedling initiation
Avg yield (per acre)	:	22 ton
Avg yield under chemical farming (per acre)	:	18 to 24 ton

3.2.11 Organic onion (Allium cepa) production :

Onion (*Allium cepa*) is one of the second most important commercial crops of the India which is next to Potato Average productivity of onion was 7.6 ton per acre in the study area under organic package of practice which was comparable to the conventional productivity of okra in that region.

Table 11 : Yield component of onion under IRF Organic package of practice

CROP	:	**Onion**
Variety	:	*Faridpur Bunch Onion*
Crop Area (acre)	:	0.02 Acre
Average yield (per acre)	:	7.6 ton
Average yield under chemical farming (per acre)	:	6 to 8 ton

3.2.12 Organic brinjal (Solanum melongena) production :

Brinjal is a versatile crop adapted to different agro-climatic regions. It can be grown throughout the year. In India, brinjal covers over 8.14% of total vegetable area and produces 9% of the total vegetable production. Under IRF organic package of practice productivity of brinjal was recorded 10.84 ton / acre.

Table 12 : Yield component of brinjal under IRF Organic package of practice

CROP	:	Brinjal plant
Variety	:	*Debjhuri Hajari*
Crop Area (acre)	:	0.42 Acre
Flower initiation	:	40-42 days after seedling initiation
Avg yield (per acre)	:	10.84 ton
Avg yield under chemical farming (per acre)	:	10.0 to 13.0 ton

3.2.13 Organic French bean (Phaseolus vulgaris) production :

French bean is one of the most significant leguminous vegetables in India It is grown widely because of its short duration and nutritive values. It is a good source of calcium, protein, iron, phosphorus, carotene, thiamine, riboflavin, and vitamin C. Under IRF organic package of practice productivity of french bean was recorded 4.60 ton / acre.

Table 13 : Yield component of French bean under IRF Organic package of practice

CROP	:	**French bean**
Variety	:	Local
Crop Area (acre)	:	0.06 Acre
Average yield (per acre)	:	4.8460 ton
Avg yield under chemical farming (per acre)	:	3.6 - 4.8 ton

3.2.14 Organic Amaranthus (Amaranthus dubius) production :

Amaranthus is one of the oldest warm climate leafy vegetable crops grown since centuries. Leaves and succulent stem are good sources of iron, calcium, vitamin A and vitamin C. Under IRF organic package of practice productivity of amaranthus was recorded 2.96 ton / acre.

Table 14 : Yield component of Amaranthus under IRF Organic package of practice

CROP	:	**Amaranths**
Variety	:	Local
Crop Area (acre)	:	0.02 Acre
Avg yield (per acre)	:	2.96 ton
Avg yield under chemical farming (per acre)	:	2.5 – 3.0 ton

3.2.15 Organic coriander (Coriandrum sativum) production :

Coriander (*Coriandrum sativum* L.) is an important seed spice crop mainly grown in rabi season and belongs to family Apiaceae. India is the largest producer of coriander. Under IRF organic package of practice productivity of coriander was recorded 1.72 ton / acre.

Table 15 : Yield component of coriander under IRF Organic package of practice

CROP	**:**	**Coriander**
Variety	:	Ko-1
Crop Area (acre)	:	0.02 Acre
Harvesting	:	45 - 50 days after seedling initiation
Avg yield (per acre)	:	1.72 ton
Avg yield under chemical farming (per acre)	:	1.60 – 2.0 ton

3.3 Evaluation of the taste quality of the vegetables cultivated organically.

As the demand for organic foods has grown globally, disputes have arisen on whether organic foods are more nutritious, safer, and better for the environment (Fillion & Stacey 2002). There are many ambiguities and controversies regarding taste of organically grown food w.r.to their conventional counterpart. Most studies report no consistent or significant differences in taste and organoleptic quality. It is extremely rare that the taste of organically grown fruits and vegetables is found to be poorer than that of fruits and vegetables grown conventionally or with integrated techniques. Several studies have reported that organic produce stores better and has longer shelf life than conventional produce due to the lower nitrate levels in organic produce (Theuer, 2006). In the present study, we organized a blind taste test with 36 selected families who were taken these vegetables regularly vegetables and hence had a pretty good idea about its taste. They were given samples of the produce viz., sample A and sample B; without revealing which was organic and which was conventional and asked to judge which tasted better and which has better shelf life.

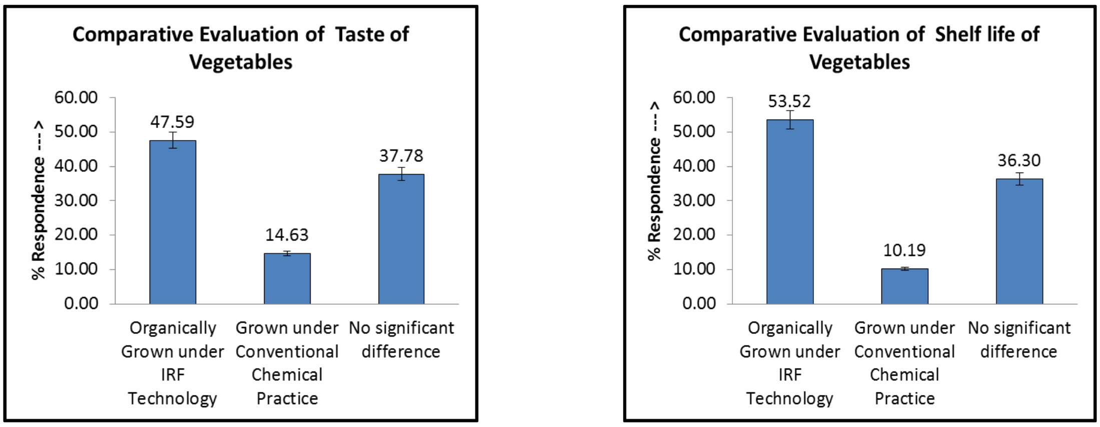

Fig 17 : Blind taste test and shelf live test of Organically grown vegetables under IRF Technology at the study area

Table 16 : Blind Taste Test of the Vegetables grown under IRF Technology

Vegetables	Taste			Shelf life		
	[1]OV	[2]CV	[3]ND	[1]OV	[2]CV	[3]ND
< -------- No of Respondence --------- >						
Lettuce	26 (72.22)	6 (16.67)	4 (11.11)	28 (77.78)	2 (5.56)	6 (16.67)
Red Cabbage	18 (50.00)	6 (16.67)	12 (33.33)	21 (58.33)	0 (0.00)	15 (41.67)
Radish	34 (94.44)	0 (0.00)	2 (5.56)	22 (61.11)	2 (5.56)	12 (33.33)
Beet Root	31 (86.11)	0 (0.00)	5 (13.89)	21 (58.33)	6 (16.67)	9 (25.00)
Chinese Pak Choy	22 (61.11)	5 (13.89)	9 (25.00)	24 (66.67)	6 (16.67)	6 (16.67)
Tomato	18 (50.00)	8 (22.22)	10 (27.78)	20 (55.56)	4 (11.11)	12 (33.33)
Pumkin	12 (33.33)	8 (22.22)	16 (44.44)	10 (27.78)	4 (11.11)	22 (61.11)
Bittergourd	8 (22.22)	10 (27.78)	18 (50.00)	12 (33.33)	4 (11.11)	20 (55.56)
Okra	19 (52.78)	3 (8.33)	14 (38.89)	17 (47.22)	7 (19.44)	12 (33.33)
Cauliflower	8 (22.22)	4 (11.11)	24 (66.67)	24 (66.67)	2 (5.56)	10 (27.78)

Onion	2 (5.56)	2 (5.56)	32 (88.89)	6 (16.67)	4 (11.11)	26 (72.22)
Brinjal	14 (38.89)	8 (22.22)	14 (38.89)	15 (41.67)	5 (13.89)	16 (44.44)
French bean	15 (41.67)	9 (25.00)	12 (33.33)	21 (58.33)	3 (8.33)	12 (33.33)
Amaranths	16 (44.44)	4 (11.11)	16 (44.44)	22 (61.11)	4 (11.11)	10 (27.78)
Coriander	14 (38.89)	6 (16.67)	16 (44.44)	26 (72.22)	2 (5.56)	8 (22.22)

Note : [1]OV : Organically Grown under IRF Technology, [2]CV : Grown under Conventional Chemical Practice, [3]ND : No significant difference; Figure in parenthesis represents % of total despondence.

Many food experts and chefs actually do believe that organic foods tend to taste better. The food experts give credit to the soil care practiced by organic farmers. Strong nourishment of the soil leads to well-nourished plants, which in turns yields food with a high nutritional content and optimal flavor (Albert's Organics, 2013). Our interpretation of the findings went somewhat in the same line that development of the 'Health Plant's is the key. Application of the microbially rich Novcom compost definitely played a significant role towards soil-plant – nutrient equilibrium, but adoption of a plant health management practice under IRF technology is the major influencing factor towards development of the healthy plants. Energized and potentised botanical solutions under Inhana Plant Health Management Practice helps to activate plant physiological functioning which helps to fulfill plants nourishment in proper order to provide quality end product apart from sustainable production as also collaborate by the results of fellow workers studying crop response with IRF technology ([Barik *et al*, 2014a, 2014b, Bera *et al*, 2014, Seal *et al*, 2014].

4. Conclusion

Successful organic cultivation of exotic and traditional vegetables under Inhana Rational Farming Technology indicated the potential of this technology towards safe and sustainable crop production. The study also pointed out the importance of developing healthy plants to attend the dual objectives of crop sustenance and quality enhancement at a time. Hence, yield sustenance and quality enhancement under IRF Technology indicates the scope for large scale viable organic vegetable cultivation.

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