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Evaluation of Inhana Rational Farming (IRF) Technology as a Cost Effective Organic Cultivation Method in Farmer's Field

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Abstract
Inhana rational farming (IRF) technology was studied as an organic package of practice in farmers' field using green gram (Samrat: PDM-84-139) as test crop. The study was conducted at Binuria village in Birbhum district of West Bengal during the crop season of 2013–14. The study area lies in 23.66°N and 87.63°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 seven treatments replicated three times. The treatments included local farming practice with chemical inputs, organic package of 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). Compost application was an integral part of soil management under the studied organic package of practice (POP) and the same was produced on farm using Novcom composting method (developed by Dr. P. Das Biswas, Founder, Inhana Biosciences, Kolkata). Evaluation of the biodegradation process along with quality analysis of its end product (Novcom compost) indicated that Novcom composting method could serve as an effective alternative for conversion of agro waste into good quality end product. Highest greengram production was obtained under chemical and organic soil input integration @ 75:25 along with organic plant management (Yield: 715 kg/ha) followed by 100% organic (Yield: 699 kg/ha) and chemical farming practice (Yield: 665 kg/ha). At the same time, gross income under organic POP was higher than that that obtained under conventional farming practice. Comparison of value cost ratio (VCR) under integrated management vis-à-vis chemical practice confirmed better scope for economic sustainability when chemical pesticides/growth parameters were replaced by organic plant management inputs; as compared to application of chemical alone. Post harvest soil analysis showed that the plots receiving Novcom compost showed an overall positive trend in soil quality specially in terms of soil biological parameters. The findings indicated that IRF technology as an organic POP can serve as an economically viable option for large scale adoption in farmers' field.

Keywords: *Novcom compost, organic package of practice (POP), green gram, agronomic efficiency, value cost ratio, soil quality*

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INTRODUCTION
Chemical farming has been practiced rigorously for increasing crop productivity towards achieving self-sufficiency in food production. However, this was achieved at a great cost to the nation, both economic and social; and now, after five decades of chemicalization, the present depletion of soil and surrounding ecology is reflective in the progressively declining crop productivity. Application of chemicals has weakened the plant system [1], which have slowly but steadily lost their capacity of effective nutrient absorption and assimilation, leading further to deactivation of their natural resistance against pests/diseases. At the same time, to augment crop production usage of chemical fertilizers in incremental dose has over the years led to deterioration of soil character, made the plants fertilizer sensitive and disturbed the pest-predator relationships, which automatically generated the necessity for application of pesticides [2]. Hence, today successful agriculture shall only depend upon how well

and fast soil depletion is checked and the soil nutrient balance starts showing a positive trend. However, it is now understood that sole application of organic inputs can neither ensure successful organic cultivation nor enable the much desired speedy restoration of soil health. The answer can be provided only through adoption of comprehensive and scientific organic POP, because in order to ensure the desired results under the existing complexities the steps of organic management should work in absolute harmony with each other. This was perhaps the background for development of Inhana rational farming (IRF) technology by an Indian scientist Dr. P. Das Biswas, who has pioneered scientific organic tea cultivation in India. The organic POP developed by Dr. P. Das Biswas through successful integration of ancient vedic philosophy and modern scientific findings has been successfully providing the road map for ecologically and economically sustainable tea cultivation and presently about 40 percent of total organic tea is produced under this technology. The present study was done with the objectivity of evaluation of Inhana rational farming (IRF) technology as an effective and economical way of organic crop cultivation taking green gram (*Vigna radiate*) as test crop in terms of crop productivity and soil quality developement vis-à-vis conventional farming practice.

MATERIALS AND METHODS

Experimental Design

Crop trial using green gram (*Vigna radiate*) as test crop was conducted at farmers' field at Binuria village, Rupepur gram panchayat in Birbhum district of West Bengal; during the crop year 2013–14. The village is in close vicinity of Visva Bharati University (Santiniketan). The study area lies in 23.66°N and 87.63°E being 179 ft above MSL, with level to nearly level landscape (Pictures 1 and 2). The trial was conducted to study the comparative effectivity of conventional farming practice (chemical farming), organic POP (Inhana Rational Farming® Technology) as well as integrated farming practice (combination of chemical and organic inputs for both soil and plant management).

Analysis of Soil and Compost Sample

Soil (0 to 50 cm) samples were collected from different treatments before initiation and post completion of experiment. The soil samples were divided into two parts. One part was kept in the refrigerator at 4°C for conducting microbial analysis. The other part was air dried, ground in a wooden mortar and passed through 2 mm sieve. The sieved samples were stored separately in clean plastic containers. Soil samples were analyzed for physicochemical, fertility and microbial status as per standard procedure [3]. Compost samples were also divided into two parts. One part was preserved for microbial analysis and the other part was air dried, cut into smaller pieces with the help of a grinder and then stored separately in clean plastic containers. 32 different compost quality parameters were analyzed as per international standards provided by USCC, 2002 [4–7].

Pic. 1: *Location of the University and Study Area.*

Pic. 2: *Satellite View of the Study Area.*

Pic. 3: *Prof A. K. Barik, PI of the Project along with Prof. A.K. Chatterjee and Developer of IRF Technology, Dr. P. Das Biswas Visited the Farmers' Field at Binuria Village, Birbhum, West Bengal before Project Initiation During Feb, 2013.*

Experimental Layout and Crop Trial

Green gram (*Vigna radiata*); variety: Samrat (PDM-84-139) seeds were directly sown in the field by dibbling on 1st week of April, 2013. Seed rate was 30 kg/ha. The seeds were sown on ridges 10 cm apart. The spacing between two ridges was maintained at 20 cm. Thinning out closely germinated plants was done at two leaf stage. The time for the first weeding was when the seedlings are 20 days old; subsequent weedings was done at intervals of 25 days. A total of two rounds of weeding was carried out from 20 days after sowing.

Sl.No.	Treatment		
(i)	T-1	:	**Control**
(ii)	T-2	:	Under Inhana rational farming® technology with Novcom compost application (@ 2 t/bigha) for soil management and IRF (Plant) management package.
(iii)	T-3	:	Under convention chemical package.
(iv)	T-4	:	50% chemical fertilizer and 50% organic soil inputs through Novcom for soil management and conventional (chemical) plant management package.
(v)	T-5	:	50% chemical fertilizer and 50% organic soil inputs through Novcom for soil management and IRF (Plant) management package.
(vi)	T-6	:	25% chemical fertilizer and 75% organic soil inputs through Novcom for soil management and conventional (chemical) plant management package.
(vii)	T-7	:	25% chemical fertilizer and 75% organic soil inputs through Novcom for soil management and IRF (Plant) management package.

Under Inhana rational farming (IRF) technology, Novcom compost was mixed with soil (@ 2 t/ha) during land preparation [7]. After that cow dung slurry concoction (CDS) was sprayed in the soil @ 100 l/ha. Green gram seeds were organically treated with seed solution-I before sowing. After three leaf stage seven rounds of different Inhana solutions (single or in combination) were sprayed as per recommended schedule (Table 1) for activation of plant physiology.

Table 1: *Spraying schedule of IRF Package of Practice for Green Gram Cultivation.*

Sl. No.	Solution Name	Role of Solutions Towards Activation of Plant Physiology
1.	Seed Solution	Initiation of metabolic resources during germination and faster independence of seedling from the seed reserve.
2.	IB-(AG)-1	Organic growth promoter, activator and regulator: energizes and stimulates the plants system for best use of inputs both applied and stored in the soil and regulates every stage of the grand growth period.
3.	IB-(AG)-2	Silica induced immunity against fungal pathogens: activates plant’s host defense mechanism through silica management. It also stimulates plants immune system by activating the biosynthesis of phenolic compounds and works as stress regulator.
4.	IB-(AG)-4	Ensures biological absorption and utilization of atmospheric-N by plant. It also balances the quantity of nitrogen in the plant system at the right time. Thereby prevents deleterious effect on the quality of the produce. Ensures gradual reduction in chemical nitrogen application.
5.	IB-(AG)-5+ IB-(AG)-7	Energizes the various biochemical process of plant resulting in harmonious grand growth period. Regulates and stimulates the cellular oxidation process and 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. IB (Ag)-7 stimulates root function, activates root growth and penetration and energizes soil in the root zone thus improves soil-plant relationship. It also helps to develop CEC of the soil, energizes the production of microflora and bioflora around the root zone, improves the degree of base saturation to the desired level, enhances the root cation exchange capacity and stimulates root growth and penetration by activating contact exchange capacity of the root.
6.	IB-(AG)-3+ IB-(AG)-7	Organic solution for potash absorption and utilization: It converts the fixed soil potash into available form and energises the root capacity for its absorption. It also ensures optimum utilization of applied potash. Hence no loss or ill effect to the soil and gradual reduction in the application is ensured + Role of IB (Ag)-7 given above.
7.	IB-(AG)-2	Same as above.
8.	IB-(AG)-1	Same as above.

Under conventional chemical practice, recommended dose of N:P:K was applied during land preparation. Nitro benzene was sprayed as growth regulator before flower bed initiation stage. One round of pesticide (combination of propanophos and acephate) was applied (@ 1.5 ml/l) to counter mild infestation of stem borer and sucking pest at 45 DAS. Crop yield was harvested at 85 DAS and plot wise crop yield was recorded. Profitability in terms of net return and benefit cost ratio was calculated using prevailing market price for various commodities as per standard method.

RESULT AND DISCUSSION

Analysis of Compost Quality

The experiment was initiated with the erection of Novcom compost heap in the project farmer's (Mr. Syam Mete) field on February, 2013. The compost was produced with water hyacinth and cow dung using Novcom composting method of Inhana biosciences as documended by Seal *et al.*, which enabled production of mature compost within a short period of 21 days [7]. Better quality and maturity of compost was confirmed through laboratory analysis as per 32 different parameters following international standards (Tables 2 and 3).

Physical and Physicochemical Parameters

All the compost samples appeared dark brown in colour with an earthy smell, deemed necessary for mature compost [8]. Average moisture varied from 59.06 to 65.42 percent, which may be placed in the high value range (40 to 50) as suggested by Evanylo [5]. Water holding capacity of 202 to 234 percent, was also found in the high value range (standard range of 100 to 200 with preferred value of >100) as suggested by Evanylo [5]. High water holding capacity may be attributed to the abundance of humus particles in the compost [6], and the addition of such compost in soil helped in retaining soil moisture during the dry months [9].

pH value of the compost samples ranged between 8.14 and 8.58 with mean of 8.29, which was well within the stipulated range for quality compost and indicated compost maturity as well [10]. Electrical conductivity value ranged between 2.04 and 2.15 with mean 2.09, indicating its high nutrient status. The organic matter content of compost is a necessary parameter for determining compost application rate to obtain sustainable agricultural production. Organic carbon in compost samples ranged between 19.93 to 21.88 percent with mean value of 20.52, qualifying even the standard suggested value of >19.4 percent for nursery application with few exceptions [11]. CEC is one of the most important properties of compost and is usually closely related to fertility. The cation exchange capacity of the compost samples ranged between 212.4 to 228.0 cmol (p+)kg^{-1}, which is comparable to the values obtained for any quality compost as per Estrada *et al.* [12].

Table 2: *Physical, Physicochemical and Nutritional Properties of Novcom Compost Samples.*

Sl. No.	Parameter	Analytical Values of Novcom Compost		
		Range Value	**Mean Value**	**±S. E.**
	Physical Parameters			
1.	Moisture percent (%)	59.06–65.42	60.87	±1.362
2.	Bulk density (g/cc)	0.37–0.48	0.44	±0.020
3.	Porosity (%)	59.06–71.46	67.39	±2.149
4.	WHC[1] (%)	202–234	217.40	±5.528
	Physicochemical Parameters			
5.	pH_{water} (1:5)	8.14–8.58	8.29	±0.095
6.	EC (1:5) dS/m	2.04−2.15	2.09	±0.176
7.	Total ash content (%)	60.62–64.12	63.07	±0.702
8.	Total volatile solids (%)	35.88–39.38	36.93	±0.702
9.	Organic carbon (%)	19.93–21.88	20.52	±0.390
10.	CEC (cmol(p+)kg^{-1})	212.4–228.0	215.2	±3.633
11.	CMI[2]	2.77–3.22	3.07	±0.091
12.	Sorption capacity index	9.71–11.14	10.48	±0.236
	Nutrient Content			
13.	Total nitrogen (%)	1.76–2.08	1.91	±0.060
14.	Total phosphorus (%)	0.53–0.59	0.56	±0.012
15.	Total potassium (%)	1.09–1.21	1.16	±0.034
16.	C/N ratio	9.58–11.89	10.73	±0.490

[1]WHC: Water Holding Capacity; [2]CMI: Compost Mineralization Index.

Nutrient Content and Microbial Status

The total nitrogen content in the compost samples ranged between 1.76 and 2.08 percent, which was well above the reference range suggested by Alexander and Watson [13, 14]. Mean value of total phosphate and total potash (0.56 and 1.16 percent respectively) were also higher than the minimum suggested standard. The ideal C/N ratio of any mature compost should be about 10, as in humus; but it can hardly be achieved in composting [15]. However, of greater importance is its critical value (C/N ratio 20), below which further decomposition of compost in soil did not require soil nitrogen, but released mineral nitrogen into the soil [16]. C/N ratio of Novcom compost resembled the values obtained for any good quality compost.

In case of open-air composting processes, further colonization in compost material occurs naturally during heap construction as well as turning of heap. At the same time very high microbial population (in order of 10^{16} in case of total bacteria, fungi and actinomycetes count) in compost samples, corroborated the uniqueness of its production method in terms of fast conversion, high and balanced nutrient dynamics and desirable electrical conductivity etc. i.e., benefits which can be contributed only by high and diversified microbial population generated within compost heap during the bio-degradation process. Measurement of microbial biomass is considered as an indicator of compost bio-maturity [16]. The values obtained for compost samples (1.03 to 1.62) was well within the critical limit of <1.7 percent for compost maturity/stability, as proposed by Mondini *et al*. [17].

Table 3: *Nutrient Supplying Potential, Microbial Content, Stability, Maturity and Phytotoxicity Status of Compost Samples.*

Sl. No.	Parameter	Analytical Values of Novcom Compost		
		Range Value	Mean Value	±Std. Error
Ready Nutrient Supplying Potential				
17.	Water soluble carbon (%)	0.360–0.440	0.382	±0.017
18.	Water soluble inorganic N (%)	0.080–0.109	0.091	±0.005
19.	Water soluble organic N (%)	0.060–0.080	0.066	±0.004
20.	Organic C/N ratio	5.43–6.50	5.79	±0.197
21.	Humification ratio	0.017–0.022	0.019	±0.001
Microbial Parameters (per gm Moist Soil)				
22.	Total bacterial count[3] (Log_{10} value)	16.03–16.98	16.47	±0.151
23.	Total fungal count[3] (Log_{10} value)	15.06–15.87	15.45	±0.161
24.	Total actinomycetes[3] count (Log_{10} value)	15.10–15.96	15.65	±0.164
25.	MBC[4] (%)	1.44–1.74	1.58	±0.056
Stability Parameters				
26.	CO_2 evolution rate ($mgCO_2$–C/g OM/day)	2.12–3.48	2.88	±0.222
Maturity and Phytotoxicity Parameters				
27.	NH_4^+-Nitrogen (%)	0.016–0.020	0.017	±0.001
28.	NO_3^--Nitrogen (%)	0.064–0.089	0.074	±0.004
29.	Nitrification Index	0.22–0.25	0.24	±0.007
30.	Seedling emergence (% of control)	104.2–126.2	111.61	±3.973
31.	Root elongation (% of control)	98.6–116.4	105.73	±3.318
32.	Germination index (phytotoxicity bioassay)	1.03–1.47	1.18	±0.075

[3]Count in MPN Method, [4]MBC: Microbial Biomass Carbon.

Steps of Novcom Composting on Initiation Day, at Farmer's Field (Vill. Binpur, District Birbhum)

Pic. 4: *Initiation of Novcom Composting Heap.*

Pic. 5: *Application of Novcom Solution Over Green Matter Layer.*

Pic. 6: *Cow Dung Layer Over Green Matter Layer.*

Pic. 7: *Progression of Novcom Compost Heap.*

Pic. 8: *Final Novcom Compost Heap after 1st Day Activity.*

Pic. 9: *Final Novcom Compost Heap after 21 Days.*

Ready Nutrient Supplying Potential

Water soluble forms of carbon and nitrogen representing the plant available forms, increased during compost maturation phase [18] and for the compost samples water soluble carbon, inorganic nitrogen and organic nitrogen values varied from 0.360–0.440, 0.080–0.109 and 0.060–0.080 percent respectively. Organic C/N ratio in compost water extract is considered to be one of the important index for compost maturity [10, 19]. In the compost, the mean organic C:N ratio value of 5.79 remained in the stipulated range of 5.0–6.0 as proposed by Chanyasak *et al.* [19].

Maturity and Phytotoxicity Parameters

Compost maturity and phytotoxicity rating are the most important criteria for ensuring soil safety post compost application. Free ammonia released from decaying organic matter inhibited seed germination [20], delayed shoot growth [21], and root elongation processes. Analytical interpretation revealed that it satisfied the critical limit (<0.04%) for NH_4^+-N [22] and (>300 mgkg^{-1}) for NO_3^--N [23]. The ratio of NH_4^+-N to NO_3^--N ranged between 0.22 and 0.25, which was in optimum conformity with the standard reference range (0.03 to 18.9) for compost maturity [24]. Assessment of phytotoxicity revealed that percent seed germination and root elongation over control ranged from 104.2 to 126.2 and 98.6 to 116.4 respectively, which was well above the one proposed by US Composting Council (>90) for very mature compost with no phytotoxic effect [4]. Germination index (phytotoxicity bioassay) value ranged between 1.03 and 1.47 (mean 1.18), and was well above the highest order of rating (1.0), which indicated not only the absence of phytotoxicity [25] in compost samples but moreover confirmed that compost enhanced rather than impaired germination and radical growth [6].

Comparative Growth Performance of Green Gram

Growth performance of green gram under different treatments was evaluated at harvesting stage in terms of different agronomic parameters viz. number of pods/plant, number of seeds/pod and 1000 seed weight (gm); following standard method [26]. Number of pods/plant varied from 9.9 to 13.5 under different treatments, highest value being recorded for plots reciving chemical and organic soil input at 25:75 along with organic plant management package. However, number of seeds/pod and 1000 seed weight was found to be highest in case of treatment plots which received organic POP (IRF Technology). The result might indicate towards better plant physiological efficiency of plants under organic treatment (Table 4).

Table 4: *Agronomic Data of Green Gram Under Different Treatments.*

Treatments	Number of Pods/Plant	No. of Seeds/Pod	1000 Seed Weight (gm)
	Range Value (Mean Value) (±S. E.)	Range Value (Mean Value) (±S. E.)	Range Value (Mean Value) (±S. E.)
T_1	7–14 (9.9) [±0.321]	5–10 (8.2) [±0.211]	26.31–28.44 (27.11) [±0.669]
T_2	9–18 (13.1) [±0.426]	6–12 (9.5) [±0.278]	29.01–33.93 (30.98) [±1.502]
T_3	9–18 (13.1) [±0.496]	4–12 (9.2) [±0.358]	27.28–32.39 (29.69) [±1.483]
T_4	7–25 (10.3) [±0.667]	2–12 (8.6) [±0.388]	26.0–31.77 (29.85) [±1.728]
T_5	7–20 (11.5) [±0.628]	3–12 (9.5) [±0.386]	30.22–32.42 (30.98) [±0.721]
T_6	9–18 (13.3) [±0.500]	4–11 (8.5) [±0.386]	2.59–35.30 (29.26) [±3.167]
T_7	8–22 (13.5) [±0.591]	5–12 (9.4) [±0.337]	27.02–33.88 (30.76) [±2.003]

Yield Performance and Economics of Green Gram in Different Experimental Plots

Total number of pods per plant, mass of 1000 pods, test weight of 1000 seeds and crop yield were calculated for all the experimental plots. Data revealed highest yield under T_7 (715 kg ha^{-1}) followed by T_2 (699 kg ha^{-1}), T_3 (665 kg ha^{-1}), T_6 (656 kg ha^{-1}), T_5 (626 kg ha^{-1}), T_4 (568 kg ha^{-1}) and T_1 (454 kg ha^{-1}) plots respectively (Table 5). Crop yield in case of T_7, T_2 and T_3 was significantly higher as compared to control (T_1). Information on relative agronomic effectiveness (RAE) of green gram under various treatments could assist in selection of proper input thereby leading to economic crop production [27].

Table 5: *Yield Performance of Green Gram Under Different Treatments.*

Treatment	Yield (kg/ha)				% over control	RAE[1]
	R1	R2	R3	Mean		
T_1	432	489	441	454^{e}	0.00	-
T_2	736	675	687	699^{ab}	54.04	94.00
T_3	642	689	665	665^{b}	46.55	80.97
T_4	483	535	687	568^{d}	25.18	43.81
T_5	778	523	576	626^{c}	37.81	65.77
T_6	657	712	598	656^{b}	44.42	77.27
T_7	687	723	734	715^{a}	57.42	100.00

Note: *RAE[1]: Relative Agronomic Efficiency. It was calculated as per the methodology of Law-Ogbomo et al. [27]; Letters shown in superscript beside mean values are results of Duncan's Test ($p<0.05$).*

Agronomic Efficiency (AE) of Applied Nutrients (NPK) and Partial Factor Productivity (PFP) under Chemical and Organic (IRF) Management of Green Gram

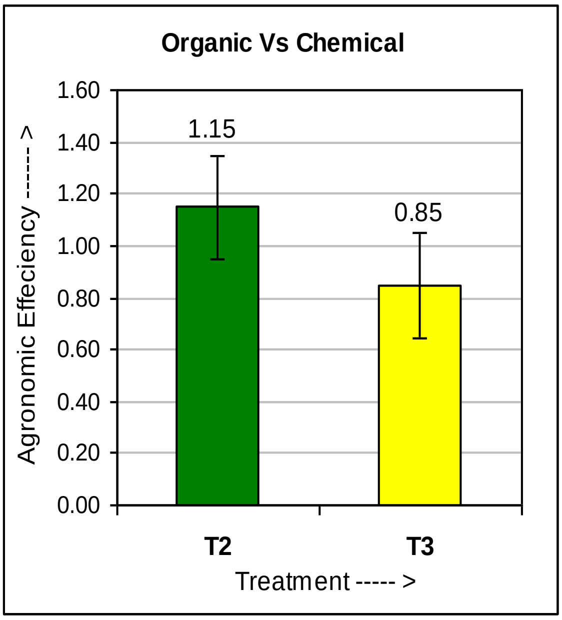

Fig. 1: *Comparative AE of T_2 and T_3.*

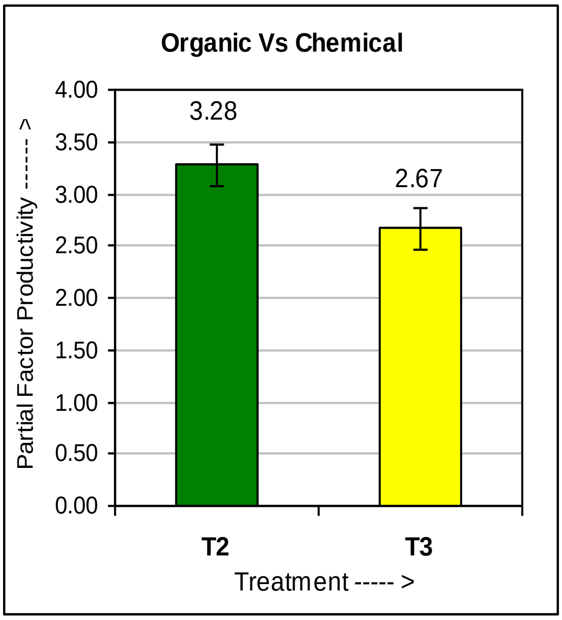

Fig. 2: *Comparative PFF of T_2 and T_3.*

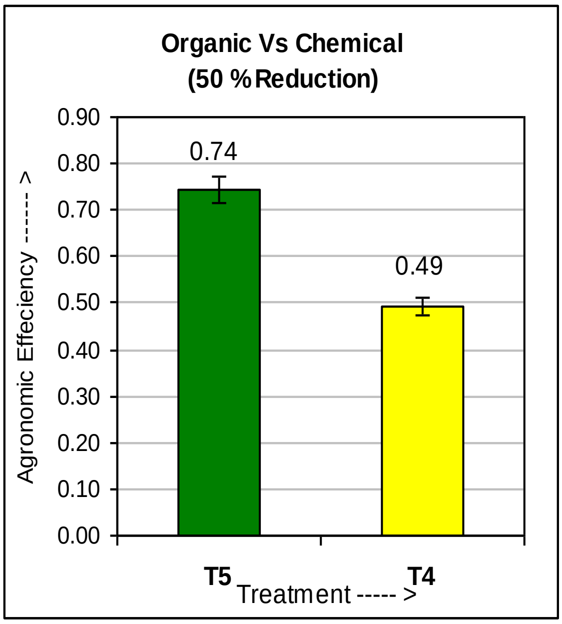

Fig. 3: *Comparative AE of T_5 and T_4.*

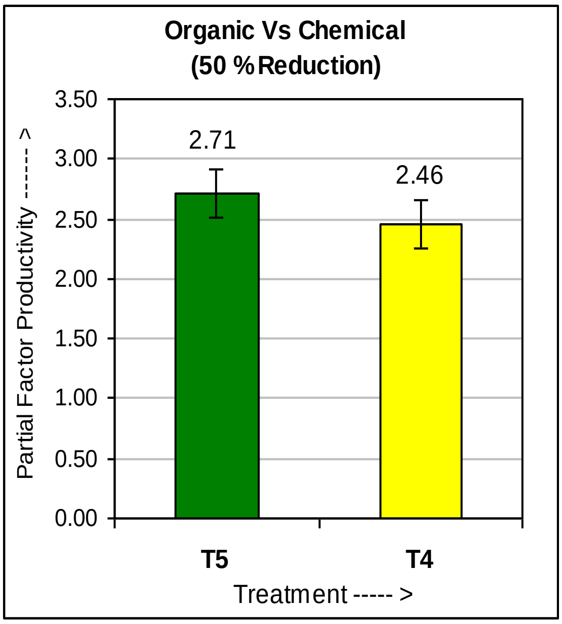

Fig. 4: *Comparative PFF of T_5 and T_4.*

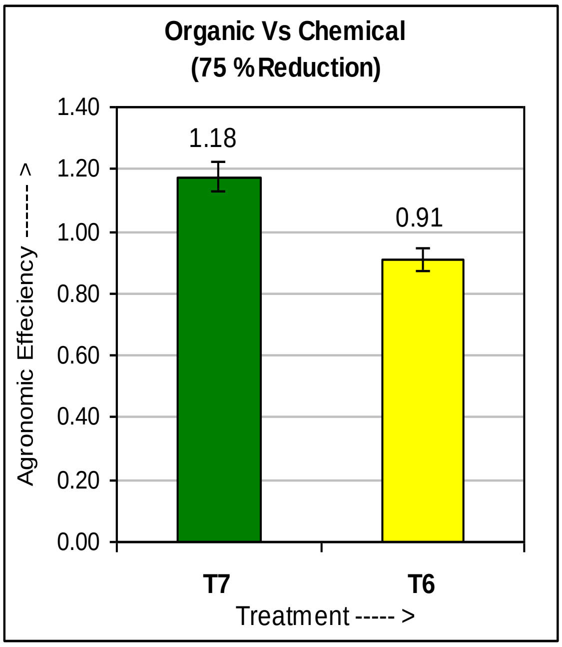

Fig. 5: *Comparative AE of T_7 and T_6.*

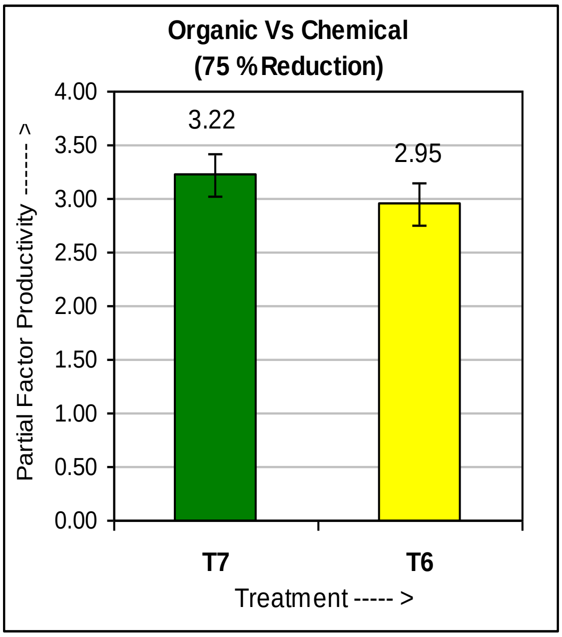

Fig. 6: *Comparative PFF of T_7 and T_6.*

As highest crop production was obtained under chemical and organic soil input integration @ 25:75 along with organic plant management hence; taking its yield as reference (RAE: 100) the next best treatment i.e., organic POP (IRF Technology) plots had the relative agronomic effectiveness of 94.00 percent followed by plots under chemical farming practice (80.97%) i.e., farmers' practice. The results clearly indicated better effectiveness of organic crop management as compared to conventional farming practice.

Effectivity of Organic Plant Management over Chemical Practice

Assessment of agronomic efficiency of green gram under organic (IRF) plant management package showed that there was considerable improvement in crop productivity with respect to its chemical counter part, even while soil management remained same; as also found by other workers. Average 9.54 percent increase in crop productivity was recorded under organic plant management, which might indicate towards its positive impact on plant physiological functions. In general nutrient use efficiency in terms of AE_{CN} and partial factor productivity (PFP) [28] was found to increase under full organic POP i.e., when organic (IRF) plant management package was complimented by organic soil management practice (especially Novcom compost application). The study showed the relevance of organic plant management towards achieving higher crop potential (Figures 1–6).

Economics of Green Gram Cultivation

Gross income under different treatments was also recorded and is shown in Figure 7. Highest gross income (Rs. 57,173/ha) was obtained from plots receiving chemical and organic soil inputs (@ 25:75) alongwith organic (IRF) plant management package followed by plots under organic POP (Rs. 55,947/ha). Similar trend was observed in case of net returns/ha where highest value (Rs. 21,743/ha) was received from the same plots where gross income was also highest (Figures 8 and 9). 2nd highest net return (Rs. 20,187/ha) was obtained under conventional farming practice closely followed by organic plots which gave Rs. 18,517/ha i.e., with no additional premium for organic product. However, even if slightly higher (10%) premium is charged it entails approximately 19% hike in net returns per hectare as compared to that obtained under chemical farming practice.

The findings indicated the economic viability of organic package of practice (IRF Technology) for organic pulses. In this relation it was again proved that IRF has the desired potential as a scientific yet comprehensive organic farming method for vegetable and pulse production; in the most economical manner [29, 2]. Value cost ratio (VCR), which indicated excess revenue generated per unit rupee invested; is generally used to assess economic sustainability under different management practices [30, 31]. The scope of sustainability increased with increase in ratio value. Comparison of VCR (Figures 10 and 11) under integrated management vis-à-vis chemical practice confirmed better scope for economic sustainability when chemical pesticides/growth parameters were replaced by organic (IRF) plant management package as compared to application of chemical alone.

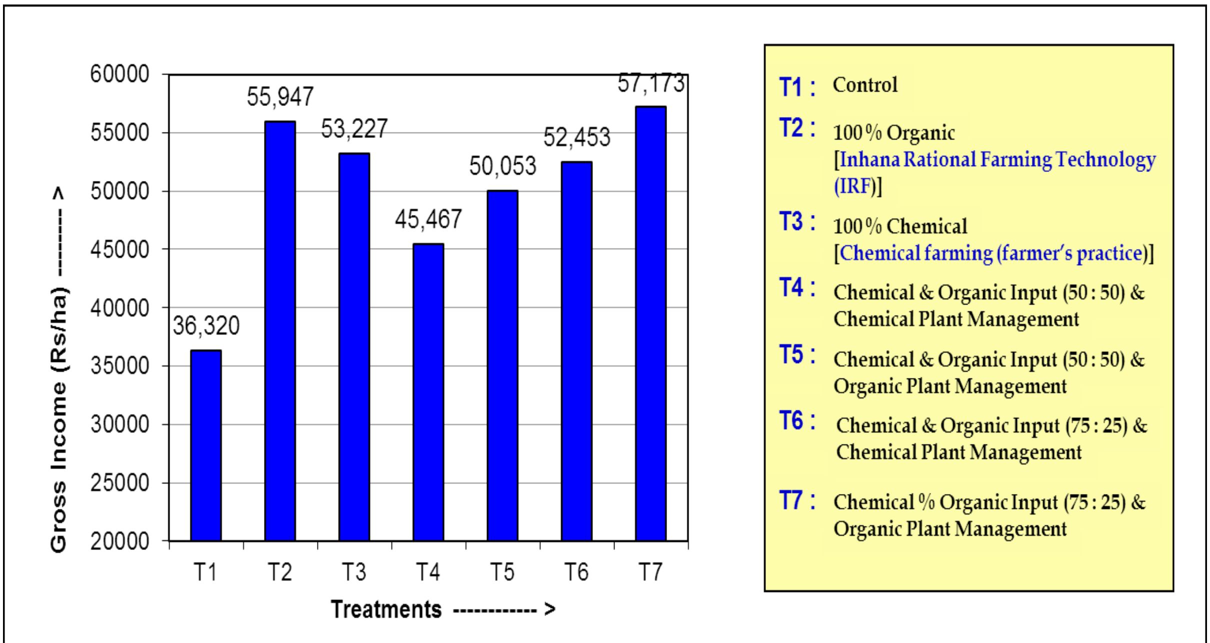

Fig. 7: *Gross Income of Green Gram Under Different Treatments.*

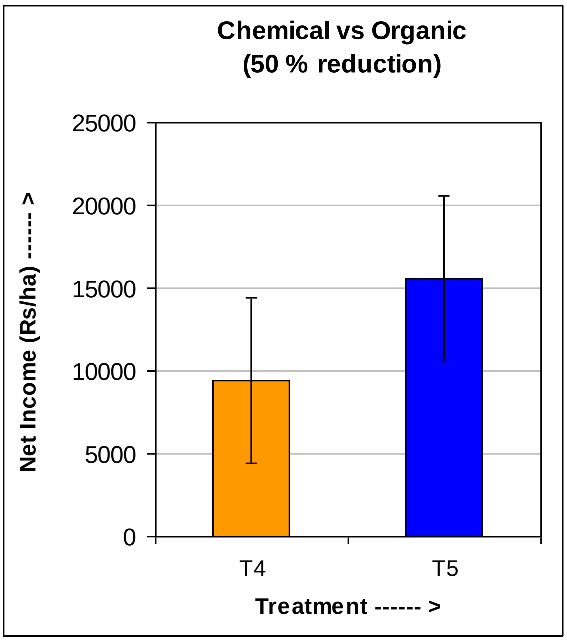

Fig. 8: *Comparative NR of T_4 and T_5.*

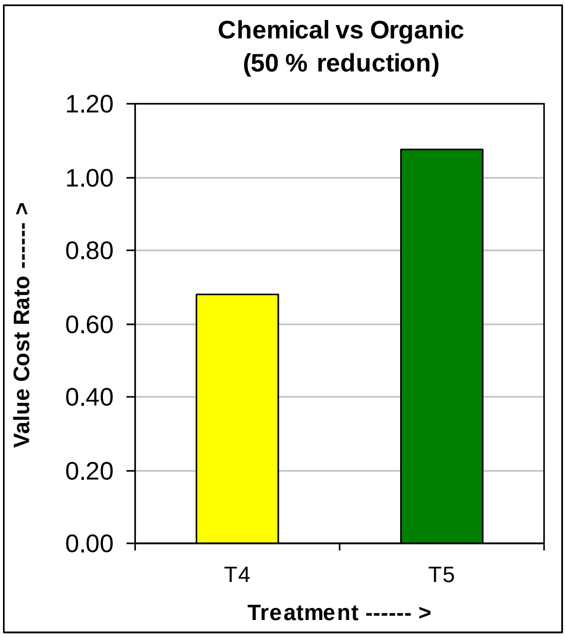

Fig. 9: *Comparative VCR of T_4 and T_5.*

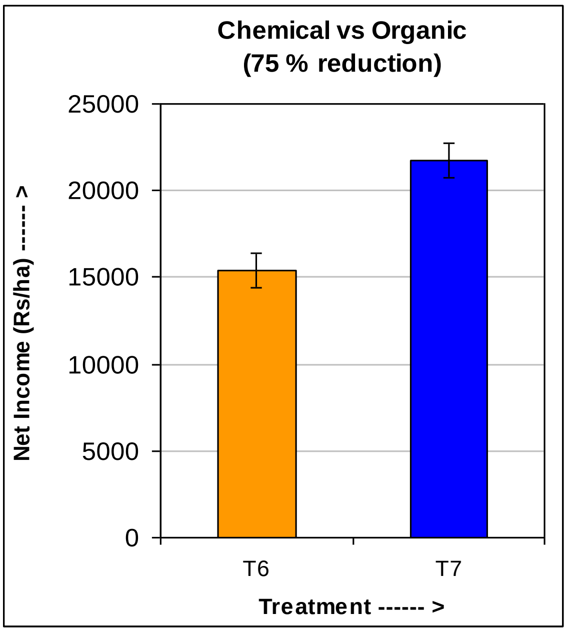

Fig. 10: *Comparative NR of T_6 and T_7.*

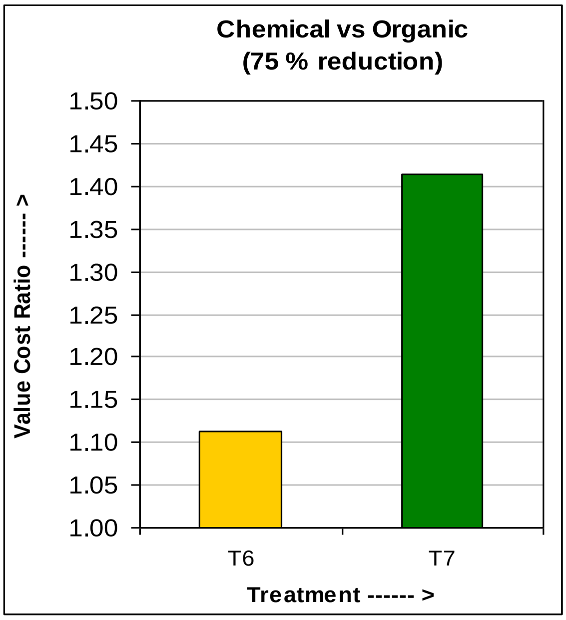

Fig. 11: *Comparative VCR of T_6 and T_7.*

Assessment of Soil Quality

Soil samples from the different treatment plots were collected before initiation of experiment and after crop harvest. Soil samples were analyzed for physicochemical, fertility and microbial properties.

Soil Physical Properties

Evaluation of soil physical properties (Table 6) revealed that the soils were mainly dominated by sand fractions with sandy clay loam textural class. At the same time high saturated conductivity rendered both benefits and problems in these soils considering that it helped in quick water percolation after a sudden downpour, but at the same time risked the leaching of soil available nutrients especially in the absence of adequate organic matter in sub soils. Soil acidity was slightly higher as compared to the ideal value required for green gram, which might probably be due to leaching of base ions as well as acidic nature of parent material.

Table 6: *Soil Physical Properties in Green Gram Experimental Plots.*

Parameter		**Experimental Plots**
Particle size distribution (%)	Sand	43.80
	Silt	27.70
	Clay	28.50
	Texture	Sandy clay loam
Bulk density (g/cm³)		1.36
Wilting point (cm³ water/cm³ soil)		0.16
Field capacity (cm³ water/cm³ soil)		0.28
Porosity (cm³ voids/cm³ soil)		0.49
Sat. hydraulic conduct.(cm/h)		0.36
Available Water (cm³ water/cm³ soil)		0.12

Pic. 10: *Experimental Plot Under Green Gram.*

Variation in Soil Physicochemical Properties and Fertility Status

To evaluate the changes in soil quality especially with respect to organic soil management, soil samples from individual plots were tested twice (i.e., before initiation of experiment and after harvest of green gram). Analysis revealed slight to moderately acidic soil reaction, which showed an increasing trend with post compost application (Table 7). Similarly organic carbon status which was found to be very low (0.41%) at initiation, showed slight status improvement post experimentation i.e. with compost application. A positive trend was also observed in case of the initial low to moderately low available macronutrient (NPKS) status. Post harvest soil analysis revealed an overall improving trend in terms of the different soil quality parameters for plots receiving Novcom compost as compared to the ones receiving fertilizer alone, which corroborates that speedy soil quality rejuvenation of can be brought through application of good quality compost. Similar observation was documented by other workers in reference to post soil application effectivity of Novcom compost [32–34].

Table 7: *Soil Chemical Properties in Green Gram Experimental Plots.*

Treatment Plots	< ------------- **Physicochemical 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 the experiment							
$T_{Overall}$	5.05	0.034	0.38	278.3	31.2	157.3	46.7
After completion of crop harvest							
T1	5.01	0.032	0.41	237.1	23.2	123.5	30.2
T2	5.30	0.041	0.65	269.1	29.9	155.7	39.6
T3	4.89	0.052	0.46	279.5	36.8	161.8	36.1
T4	5.02	0.056	0.51	278.4	32.4	147.2	40.0
T5	5.21	0.050	0.57	282.2	29.1	158.1	41.9
T6	5.02	0.045	0.53	265.4	22.3	142.9	35.7
T7	5.12	0.041	0.62	270.8	25.5	149.2	39.5

Variation in Soil Microbial Parameters

Population of bacteria, fungi, actinomycates and phosphate solubilizing bacteria was found in the order of $68x10^5$, $31x10^3$, $22x10^3$ and $19x10^3$ in the different experiment plots (Table 8) However, post harvest microbial status was found to increase in case of Novcom compost applied plots. Improvement in soil microbial population in case of plots receiving Novcom might indicate its positive influence towards regeneration of native soil microflora population leading to improvement in soil quality.

Table 8: *Soil Microbial Properties in Green Gram Experimental Plots.*

Treatment Plots	**< --------------- Soil Microbial Properties ---------------------- >**			
	Total Bacterial Count	**Total Fungal Count**	**Total Actinomycetes**	**Total PSB Count**
Before Initiation of the Experiment				
$T_{Overall}$	$68x10^5$	$31x10^3$	$22x10^3$	$19x10^3$
After Completion of Crop Harvest				
T1	$43x10^5$	$30x10^3$	$22x10^3$	$13x10^3$
T2	$80x10^6$	$27x10^4$	$29x10^4$	$17x10^3$
T3	$53x10^5$	$29x10^3$	$32x10^3$	$12x10^3$
T4	$61x10^6$	$29x10^4$	$18x10^4$	$15x10^3$
T5	$72x10^6$	$13x10^4$	$20x10^4$	$19x10^3$
T6	$64x10^6$	$21x10^4$	$17x10^4$	$22x10^3$
T7	$69x10^6$	$31x10^4$	$19x10^4$	$26x10^3$

Pic. 11: *Green Gram in Experimental Plots 30 Days after Sowing.*

CONCLUSIONS

Evaluation of Inhana rational farming (IRF) technology indicated its potential as an organic POP towards ensurance of crop performance as well as soil quality development without any time lag. Study also revealed that IRF technology could be effectively employed for integrated crop management, where sustained production vis-a-vis financial returns can be ensured even under fertilizer reduction as high as 75 percent, and 100 percent reduction of pesticides. The finding is of great importance in present day agriculture where 100 percent organic crop management sometimes becomes unrealistic due to limited resource availability. In such a scenario even significant reduction in chemical load in end product could be made possible though use of this technology.

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