Turkish Journal of Agriculture - Food Science and Technology, 5(5): 536-545, 2017

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X
www.agrifoodscience.com,
Turkish Science and Technology

Evaluation of an Organic Package of Practice Towards Green Gram Cultivation and Assessment of its Effectiveness in Terms of Crop Sustainability and Soil Quality Development

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ARTICLE INFO

Research Article

Received 11 November 2016
Accepted 28 December 2016

Keywords:
Trophobiosis theory
Inhana Rational Farming Technology
Healthy plants
Soil quality

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ABSTRACT

Restoration of soil has been identified as the option; to ensure crop sustainability. However, as per Trophobiosis Theory of French Scientist F. Chaboussou, focus on development of healthy plants is necessary to abate pest and disease invasion so as to ensure sustained crop performance, even under unfavorable environmental conditions. The present study, in randomized block design with green gram as test crop; was undertaken in Krishi Vigyan Kendra (Howrah, West Bengal) to evaluate the effectiveness of Inhana Rational Farming (IRF) Technology towards crop yield and soil quality development under different sustainable models *viz.* organic cultivation, integrated soil with organic crop management and non- chemical crop management; as compared to conventional farming practice. Highest yield was recorded under organic (933 kg ha^{-1}) followed by integrated (921 kg ha^{-1}) and non- chemical plant management (902 kg ha^{-1}). The results were well corroborated with the plant development index obtained under these treatments. Favorable trend of soil quality under sustainable models especially in terms of microbial properties indicated the role of quality compost towards speedy rejuvenation of soil dynamics. The study indicated that reduction of synthetic fertilizers and qualitative management of soil is essential to restrict yield decline. However, plant management shall be prerequisite for ensuring crop sustainability without any time lag and under the changing climatic patterns. In this respect the potential of IRF Technology has been well accounted.

DOI: https://doi.org/10.24925/turjaf.v5i5.536-545.1081

Introduction

In the 1960s, green revolution had helped to enhance food production but in exchange of irreversible loss of soil fertility, ecological degradation and food toxicity. Indiscriminate use of synthetic fertilizers and pesticides led to (Baishya, 2015; Hazell, 2003) destruction of soil micro-organisms and friendly insects (Xiang, 2012), making the crop more prone to diseases and depleting soil fertility; due to widening gap between nutrient removal and supplies (Mathur et al., 2010). Arresting the decline of soil organic matter has become necessary to restrict the unabated soil degradation and imperiled sustainability of agriculture (Mahdi et al., 2010). Rejuvenation of soil micro flora through application of compost/ organic manure (with proper quality control) can serve well towards the objective (Ramesh, 2008). But to re-establish the soil-plant-nutrient dynamics towards the sustainability objective, there has to be a wholesome compatibility between soil and plant system, unattainable by application of compost alone. An approach towards re-establishment of healthy soil should be abreast of comprehensive actions towards simultaneous development of healthy plant.

Inhana Rational Farming (IRF) Technology, a comprehensive Organic Package of Practice (POP), has shown promising results in various crops (Bera et al., 2014; Barik et al., 2014b); especially tea (Mazumdar et al., 2014; Bera et al., 2011; Seal et al., 2013); in the backdrop of changing climatic patterns. The technology, which provides an effective and adoptable Road Map for large scale organic agriculture; is an amalgamation of ancient wisdom and modern scientific knowledge bearing the core essence of Trophobiosis Theory of French Scientist, F. Chaboussou (Chaboussou, 1985). The present study was undertaken to evaluate the effectiveness of this organic POP towards yield sustainability and soil quality development, taking green gram as test crop.

Materials and Methods

Study Area

The study was conducted at Krishi Vigyan Kendra (Block: Jagatballavpur, District: Howrah, West Bengal, India) during 2014-15 (Pic. 1), taking green gram (cv. Samrat; PDM-84-139) as test crop. Experiment was laid out as per Randomized Block Design with 5 treatments (Table 1) and three replications. Situated in the hot, moist, sub-humid ecosystem (Agro-ecological zone 15.1) with alluvium derived soils and growing period of 210-240 days (Velayutham et al., 1999), the region receives annual rainfall of 1500 mm (75-80% received during June to September). With temperature fluctuation of 40.2° to 10.8°C, the soil of this area has been formed from deposits of alluvium brought down by river Ganga and its tributaries.

Inhana Rational Farming (IRF) Technology

Inhana Rational Farming Technology (IRF) developed by Indian Scientist Dr. P. Das Biswas, is a comprehensive organic POP aiming at restoration of soil and plant health that simultaneously deflates pest pressure due to alleviation factors responsible for pest – parasite interactions (Bera et al., 2014). The package works towards (i) energization of soil system i.e., enabling the soil to function naturally as an effective growth medium for plants and (ii) energization of plant system i.e., enabling higher nutrient use efficiency alongside better bio-chemical functions that leads to activation of the plants' host defense mechanism (Barik et al., 2014a). Soil energization aimed at rejuvenation of soil microflora, is primarily attended by application of on-farm produced Novcom compost (that contains rich population of self-generated micro flora) (Seal et al., 2012); different types of herbal concoctions and adoption of cultural practices. However, the technology emphasizes plant management as a precursor for resilient plant system that can ensure sustainability even under changing climatic patterns. Plant management under this technology is a systemic approach that utilizes a set of potentized and energized botanical solutions developed on Element Energy Activation (EEA) Principle. According to EEA Principle, radiant solar energy is stored in plants and the bound or stored energy components from energy rich plants are extracted on specific day, time, by specific extraction procedure and subsequently potentized so that energy components can be effectively received by plant system for activation of various metabolic functions. Each solution has one or more defined functions, but work in an integrated manner when applied in a schedule, for bringing about harmonized plant growth with ensured aggregation of biological compounds responsible for flavor, nutrition and medicinal properties.

Production of Novcom Compost

Novcom compost was produced at Krishi Vigyan Kendra using banana stump and fresh cow dung (80:20 ratio) utilizing Novcom composting method[14]. The compost attained maturity within 21 days as indicated by earthy smell and brownish coloration, further confirmed by maturity and phytotoxicity analysis in the laboratory.

The Hypothesis

Inhana Rational Farming Technology that aims at developing healthy plants; bears the essence of Trophobiosis theory (Chaboussou, 1985). The technology reaches to the root cause of pest problem and works towards amelioration of factors that favourably signal pest/disease interference (Fig 1). Alleviation of biotic and abiotic factors, that depress plant metabolism require a prolonged stepwise programme and might not be still completely manageable. On the other hand focusing on plant management towards activation of plants' metabolic functions alongside other curative steps; can sustain yield and provide a way out from the vicious cycle of pesticides in a time bound manner.

For all experimental plots, land was prepared by deep ploughing followed by laddering. Seeds were sown @ 30kg/ha. Seeds for T_2, T_3 and T_4 were organically treated with seed solution-2 prior to sowing. Seeds for T_5 were treated with 1% concentration of potassium chloride. In T_2 plots (OCM), Novcom compost was mixed with soil @ 7.5 ton/ha during land preparation and cow dung slurry concoction (CDS) was sprayed thereafter on soil @ 100 ltr/ha. In T_4 (NCPM) and T_5 plots (CCM), NPK was applied @ 20:40:40 kg/ha in the form of urea, single super phosphate and muriate of potash. In T_3 (ICM) plot half dose of Novcom compost and synthetic fertilizer was applied in a combined manner at 50:50 ratio. One third of synthetic nitrogen fertilizer and full dose of phosphorus and potash were applied during land preparation while rest was given at 25 days after sowing (DAS). For organic plant management, seven rounds of different Inhana solutions (single or in combination) were sprayed as per recommended schedule (Table 2) towards activation of plant metabolic functions in T_2, T_3 and T_4 experimental plots (Table 3). In T_5, nitrobenzene was sprayed as growth regulator before flower bud initiation stage and one round of pesticide (combination of Propanophos and acephate) was applied @ 1.5 ml/ltr. water to counter mild infestation of stem borer and sucking pest at 45 DAS. Two rounds of weeding were carried out at 20 DAS and again at 45 DAS. Other intercultural operations like thinning and irrigation were done equally under all treatments as and when required; to ensure best performance by plants.

Generation of Agronomic Data Base

Ten sample plants were randomly selected from each plot for taking necessary data. Agronomic parameters *viz.* root length, shoot length, number of leaves and fresh weight of both root and shoot were recorded from matured sample plants following standard technique. Number of branches, pod cluster as well as root nodules for each plant were also noted. Number of pods/cluster, pod length, number of pods per plant, number of seeds/ pod and 1000 seed weight are the parameters which directly attribute to yield. These were recorded from the ten sample plants at harvesting followed by calculation of mean value (Manoj et al., 2014). Crop was harvested at 85 DAS and plot wise crop yield was documented for all the five treatments. Relative agronomic efficiency was calculated according to Law-Ogbomo et al. (2011).

Table 1 Treatment details

1.	T_1 :	Control [No fertilizer or pesticide applied]. (C)
2.	T_2 :	Organic Green gram Cultivation [utilizing Inhana Rational Farming (IRF)] (OCM)
3.	T_3 :	Integrated Green gram cultivation [synthetic fertilizer and compost at 50:50 alongside organic plant and pest management] (ICM)
4.	T_4 :	Non- chemical Plant Management [use of plant management package under Inhana Rational Farming (IRF)] alongside synthetic fertilizer for soil management (NCPM)
5.	T_5 :	Conventional Green gram Cultivation. (CCM)

Table 2 Spraying schedule of the Inhana Solutions

Sl. No	Solution Name	Dose & Dilution	Time of application
1.	IB (Ag)- 1	750 $mlha^{-1}$	3 leaf stage
2.	IB (Ag) -2	750 $mlha^{-1}$	7 days after 1^{st}spray
3.	IB (Ag) - 4	750 $mlha^{-1}$	7 days after 2^{nd} spray
4.	IB(Ag)-5+ IB(Ag) - 7	750 $mlha^{-1}$ (each)	7 days after 3^{rd} spray
5.	IB (Ag)- 3 + IB(Ag)- 7	750 $mlha^{-1}$(each)	7 days after 4^{th} spray
6.	IB (Ag) -2	750 $mlha^{-1}$	7 days after 5^{th} spray
7.	IB (Ag)- 1	750 $mlha^{-1}$	7 days after 6^{th} spray

Note: IB (Ag) - 7 is added with other Inhana solutions to enhance the potency of primary solution.

Table 3 Details of the solutions for organic plant management and their respective role in plant physiological development.

1.	Seed solution- 2: The solution is biologically activated and potentized extract of *Calotropis procera* R. and *Tinospora crispa* Miers. It plays role in mineralization of metabolic resources during germination, faster independence of seedling from the seed reserve, photosynthesis enhancement and increased uptake of organic and inorganic solutes through roots.
2.	IB (Ag)- 1 : The solution is biologically activated and potentized extract of *Hyoscyamus niger* L., *Ficus benghalensis* L. and *Dendrocalamus strictus* Nees. It acts as an organic growth promoter, activator and regulator. It energizes and stimulates the plant system for efficient use of soil nutrients (both applied and stored). It also regulates every stage of Grand Growth Period; influencing growth correlation.
3.	IB (Ag)- 2 : The solution is biologically activated and potentized extract of *Ocimum sanctum* L. , *Calotropis procera* R. and *Cynodon dactylon* (L.) Pers. It acts as silica induced immunity against fungal attack. It activates plants' host defense mechanism through silica management providing structural defense against fungal pathogens. It also stimulates plants' immune system by activating the biosynthesis of different phenolic compounds having fungi-toxic property.
4.	IB (Ag)- 3:The solution is biologically activated and potentized extract of *Adhatoda vasica* Nees., *Zingiber officinale* Roscoe and *Embelia ribes* Burm. f. It acts as an organic solution for potash absorption and utilization. It increases the efficiency of potash uptake through energized root capacity so that gradual reduction in application is ensured. At the same time it activates suction pressure by influencing diffusion pressure deficit.
5.	IB (Ag) – 4: The solution is biologically activated and potentized extract of *Calotropis procera* R., *Dendrocalamus strictus* Nees. and *Bombax malabaricum* D.C. It ensures biological absorption of atmospheric-N directly by plant. It helps the plant to utilize atmospheric nitrogen and balances the quantity of nitrogen within plant system at the specific time so as to prevent its deleterious effect on end product quality.
6.	IB(Ag)- 5 : The solution is biologically activated and potentized extract of *Cynodon dactylon* (L.) Pers. and *Calotropis gigantea* L. It energizes the various biochemical process of the plant resulting in harmonious grand growth period. It regulates and stimulates the cellular oxidation process. It energizes the phloemic function resulting in encouraged translocation of organic solutes. Stimulates the hydrolysis of starch to D-Glucose units by enhancing enzymatic activity.
7.	IB(Ag)- 7 : The solution is biologically activated and potentized extract of *Ocimum sanctum* L. It stimulates the root function, activates root growth/ penetration and energizes soil in the root zone thus improving soil-plant relationship. It helps to improve soil CEC, energizes the production of micro-flora and bio-flora around the root zone, improves the degree of base saturation to the desired level and enhances the root cation exchange capacity. It stimulates the root growth and penetration by activating the contact exchange capacity of the root.

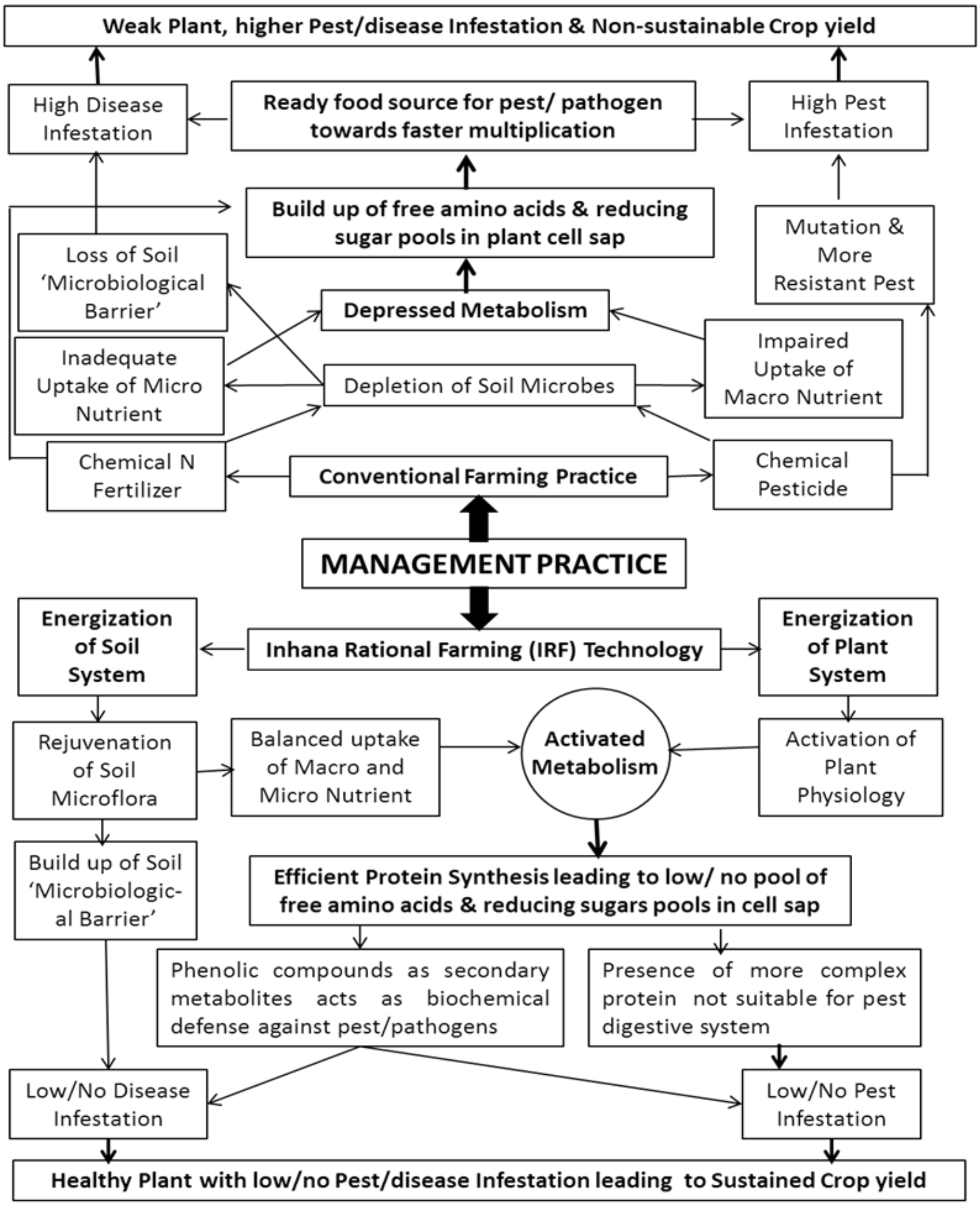

Fig. 1 Principle of IRF Technology in comparison to conventional farming practice for crop sustainability in light of Trophobiosis Theory of F. Chaboussou

Plant Development Index (PDI)

Performance of green gram under different treatments was adjudged through various agronomic parameters *viz.* plant dry weight, number of branches/ plant, number of pods/ plant, pod length, number of seeds/ pod and 1000 seed weight. However, to understand treatment effect towards overall plant development, Plant Development Index (PDI) was calculated using the method described by Bera et al. (2014).

$$PDI = 1/n\left\{\sum \frac{100(X_1 - C_1)}{C_1} + \frac{100(X_2 - C_2)}{C_2} + \frac{100(X_n - C_n)}{C_n}\right\}$$

PDI: Plant Development Index
X : **A**gronomic parameters of treatments
C : **R**espective agronomic parameter of control
n : **N**o. of agronomic parameters taken for observation

Compost Analysis

12 samples were collected from the compost heap prepared on- farm in the study area; for analysis of compost quality as per standard methodologies (Black 1965; Jackson 1973; Trautmann and Krasny, 1997). This was followed by estimation of Compost Quality Index as per the equation formulated by Bera et al. (2013).

$$CQI = \frac{NV_{NPK} \times MP \times GI}{C/N\ Ratio}$$

Where;
CQI :Compost Quality Index
NV_{NPK} :Total nutrient value in terms of total ($N+P_2O_5+K_2O$) percent.
MP :$\log_{10}$ value of total microbial population in terms of total bacteria, total fungi and total actinomycetes.
GI :Germination Index.

Classification of compost as per Compost Quality Index

Compost Quality Index (CQI)	Compost Quality Classification
< 2.00	Poor
2.00 – 4.00	Moderate
4.00 – 6.00	Good
6.00 – 8.00	Very Good
8.00 – 10.00	Extremely Good

Pic. 1 Location map of the study area

Soil Analysis

15 soil samples were collected from the different treatment plots before initiation of experiment and post crop harvest; for analysis of physicochemical, fertility and biological properties of soil following the methodology suggested by Weaver et al. (1998).

Statistical analysis *viz.* standard error and Duncan's New Multiple Range Test (MRT) were done using the statistical package SPSS 11.5.

Results and Discussion

Evaluation of Novcom Compost Quality

Transformation of composting material to dark brown colour with an earthy smell was recorded around 21 days composting period (Pic. 2). Such changes are expected to be adequate for promoting plant growth (Radovich and Arancon, 2011) and are indicative of compost maturity (Epstein, 1997). Moisture percent in compost was found to be 58.65 percent; suggesting it ideal for microbial sustenance (Table 4). Average value of compost pH (7.11) was well within the stipulated range for good quality and mature compost (Jime´nez and Garcia 1989) indicating lower chances of NH_3 volatilization and favourable for balanced micro flora generation (Nain et al., 2009). The organic carbon content (32.29 percent) fulfilled the criteria for good composting and rendered the compost suitable even for nursery application; as per the standards of Australian composting council (Australian Standard, 1999). Nutrient content in terms of total NPK was considerably higher than minimum suggested range by Alexander (1994), authenticating its rich nutrient status. C/N ratio was within the reference range of ≤ 20 as suggested for maturity and suitability of the compost for soil application (FAI, 2007). Microbial status of compost is one of the most important parameter for judging compost quality because microbes are the driving force behind soil rejuvenation and play a crucial role towards crop sustenance by maintaining soil–plant–nutrient dynamics (Seal et al., 2015). Microbial population in the compost samples were in the order of 10^{14} to 10^{16} c.f.u. per gm moist compost. Generation of such huge microbial population in the final compost may have been facilitated by the presence of an ideal micro-atmosphere within composting heap (Seal et al., 2012). Mean microbial respiration as expressed by CO_2 evolution rate (2.21 mg CO_2–C/g OM/day) was within the stipulated range of 2.0 - 5.0 as proposed by Trautmann and Krasny (1997) for stable compost. The phytotoxicity bioassay test, as represented by germination index ranged between 0.87 and 1.32 signifying the absence of phytotoxic effect in final compost; as suggested by Trautmann and Krasny (1997). Compost quality index (Bera et al., 2013) was estimated to adjudge the overall quality of compost and index value of 3.48 to 5.96 indicated Novcom compost to be of moderate to good quality.

Growth Response of Green Gram under Different Treatments

The agronomic parameters considered for evaluation of plant growth response was found to vary significantly under different treatments (Table 5). Root length, root fresh weight and number of nodules per plant; which play important role towards higher crop response were found to be significantly higher under organic management (OCM) as compared to that recorded in case of conventional treatment (CCM). Higher growth under OCM may be due to compost application in soil, which perhaps fashioned a hospitable micro- environment for bacteria to thrive well and have good symbiotic association resulting in better crop response. In terms of above ground characters too as expressed by shoot length, fresh weight of shoot, number of leaves, branches and cluster per plant; higher values were noted wherever above ground synthetic inputs were completely shunned and the plants received organic management (i.e., irrespective of OCM, ICM and NCPM treatment). This may be due to stimulatory effects of organic plant management on cell division, enlargement as well as protein and nucleic acid synthesis (El-Banna et al., 2006).

Yield Components under Different Treatments

Yield components *viz.* number of pod per plant, pod length, number of seed per pod and 1000 seed weight showed significant variation among the different treatments (Table 6). Higher value of these characters ensure better crop yield, which in turn are governed by various plant metabolic functions *viz.* phloem transport that determine how efficiently photosynthates are made available to the harvestable plant parts (Thavaprakash et al., 2006). The study revealed that focus on plant management towards activation of plants' metabolic functions may have influenced higher pod and seed characters under OCM followed by ICM and NCPM; as compared to CCM. The results were corroborated by the findings of several other researchers (Sengupta et al., 2011; Barik et al., 2014b; Bera et al., 2014).

Plant Development Index

Plant Development Index (PDI) was used to understand the impact of different treatments towards overall crop performance. Index value was found to be significantly higher in case of organically treated plots (OCM) and a general higher trend was noted in case of all other treatments (i.e., ICM and NCPM) where organic management was applied above ground, in place of conventional synthetic inputs (Fig 2).

Comparative study of PDI under different treatments brought forth the relevance of organic soil and plant management and the importance of activated plant physiology towards development of healthy plants. Conventional management practice on the other hand failed to support healthy plants due to the ill effects of agrochemicals and pesticides on plant metabolic functions (Altieri and Nicholls, 2003).

Yield Performance of Green Gram under Different Treatments

Highest yield of green gram was recorded under organic management practice (933 $kgha^{-1}$) followed by ICM (921 $kgha^{-1}$) and NCPM (902 $kgha^{-1}$) (Fig 3). At the same time significantly higher yield as compared to CCM (819 $kgha^{-1}$) was noted under all other treatments where IRF plant management schedule was adopted in place of synthetic inputs; irrespective of the type of soil management undertaken. Higher crop yield under organic plant management indicated the favourable impact of activated plant metabolic functions considering the positive correlation between enhanced photosynthesis, biomass, and yield. When other genetic factors are not altered, increasing photosynthesis leads to yield increase (Long et al., 2006; Sevik and Cetin, 2015; Yigit et al., 2016; Guney et al., 2016) as higher rates of photosynthesis may be caused by greater N allocation to Rubisco (Makino et al., 1992) and higher mesophyll conductance (von Caemmerer and Evans, 1991). Rubisco is the primary CO_2 fixation enzyme, and the amount and kinetic properties of this enzyme strongly affect the photosynthetic rate. Relative agronomic efficiency (RAE) or the comparative measure of gain in yield (Devasenapathy et al., 2008) under different treatments, also pointed towards the need for developing healthy plants; efficient nutrient absorption, photosynthesis and assimilation being the sole key for enhancing crop productivity.

Table 4 Evaluation of on-farm produced Novcom compost quality.

Sl No	Parameters	Novcom compost	
		Range Value	Mean
1.	Moisture (%)	62.24- 66.04	64.65 ± 2.79
2.	pH_{water} (1 : 5)	6.69 – 7.65	7.11 ± 0.32
3.	Organic carbon (%)	31.55 – 33.04	32.29 ± 1.09
4.	Total NPK (%)	3.05 – 3.74	3.31 ± 0.12
5.	C/N ratio	16.9:1 – 17.5:1	17.5:1 ± 0.10
6.	Total bacterial count (per gm moist compost)	(23–49) x 10^{16}	$33x10^{16} ± 5.3x10^{16}$
7.	Total fungal count (per gm moist compost)	(24 – 48) x 10^{14}	$31x10^{14} ± 2.2 x10^{14}$
8.	Total actinomycetes count (per gm moist compost)	(21–39) x 10^{14}	$31x10^{14} ± 2.1 x10^{14}$
9.	CO_2 evolution rate (mgCO_2 – C/g organic matter/day)	1.53 – 2.79	2.21 ± 0.18
10.	Germination index (phytotoxicity bioassay)	0.87 – 1.32	1.09 ± 0.03
13.	Compost Quality Index	3.48 – 5.96	4.72 ±0.08

Table 5 Agronomic parameters indicating crop response under different treatments.

Parameters	T_1 : C	T_2 : OCM	T_3 : ICM	T_4 : NCPM	T_5: CCM
Shoot Length	68.23^{c}±2.03*	76.45^{ab}±2.01	74.41^{b}±1.79	78.11^{a}±3.21	77.15^{ab}± 2.19
Root length	25.46^{d}±0.84	29.76^{a}±0.95	28.79^{ab}±1.02	28.07^{ab}±0.97	27.01^{c}±1.32
No. of leaves	8.8^{d}±0.22	10.60^{a}±0.24	10.40^{ab}±0.21	9.5^{c}±0.13	10.60^{a}±0.22
Fresh wt. of shoot	92.4^{e}±4.03	109.4^{cd}±3.29	111.5^{c}±3.27	124.5^{a}±3.33	119.6^{b} ±2.13
Fresh wt. of root	8.79^{d}±0.04	10.47^{a}±0.06	10.01^{ab}±0.05	9.96^{b} ±0.05	9.67^{bc} ±0.07
Shoot : Root ratio	10.51^{d}±0.23	10.45^{d}±0.31	11.14^{c}±0.47	12.5^{a}±0.39	12.37^{ab} ±0.17
No. of branches/ plant	2.20^{cd} ±0.01	3.40^{ab}±0.01	3.60^{a} ±0.01	2.40^{c} ±0.01	2.40^{c} ± 0.01
No. of cluster/ plants	5.10^{cd}±0.01	7.20^{a}±0.02	6.40^{b}±0.02	5.20^{c}±0.01	4.40^{e} ± 0.03
No. of root nodule/ plant	7.20^{d}±0.04	12.4^{a}±0.06	11.6^{b}±0.06	10.4^{bc} ±0.09	7.0^{d} ±0.08

*Standard Error [±]. The means marked with different letters in the same row were significantly different at $P<0.05$ of Duncan's New Multiple Range Test.

Table 6 Comparison of the yield attributing characteristics under different treatments.

Treatments	Number of Pods/ plant	Pod length (cm)	No. of Seeds /Pod	1000 Seed Weight (gm)
T_1: C	$10.2^d \pm 0.314$*	$7.44^c \pm 0.21$	$8.1^c \pm 0.203$	$28.12^c \pm 0.432$
T_2: OCM	$14.1^a \pm 0.405$	$8.04^a \pm 0.31$	$9.8^a \pm 0.212$	$31.98^a \pm 1.102$
T_3: ICM	$13.6a^b \pm 0.406$	$8.01^{ab} \pm 0.41$	$9.6^{ab} \pm 0.310$	$30.69^{ab} \pm 1.021$
T_4: NCPM	$13.3^b \pm 0.531$	$8.09^a \pm 0.22$	$9.5^{ab} \pm 0.312$	$30.65^{ab} \pm 1.321$
T_5: CCM	$12.5^c \pm 0.421$	$7.94^b \pm 0.19$	$9.4^{ab} \pm 0.322$	$30.58^{ab} \pm 0.234$

*Standard Error [±]. The means marked with different letters at the same column were significantly different at P<0.05 of Duncan's New Multiple Range Test.

Table 7 Physicochemical properties and soil fertility under different treatments pre and post experimentation.

Treatments	Soil Physicochemical Properties			Soil Fertility			
	pH (1 : 2.5)	EC (dSm$^{-1)}$	Org C (%)	Av N kgha^{-1} ←	Av. P_2O_5	Av. K_2O	Av. SO_4 →
T_1: C	7.17 (7.15)*	0.077 (0.077)	1.27 (1.27)	360.29 (334.61)	56.16 (55.94)	392.03 (388.97)	85.76 (84.59)
T_2: OCM	7.25 (7.27)	0.078 (0.078)	1.27 (1.30)	353.40 (365.95)	57.81 (59.50)	382.81 (384.38)	84.33 (85.67)
T_3: ICM	7.26 (7.27)	0.073 (0.073)	1.27 (1.26)	346.39 (354.12)	56.21 (58.03)	381.09 (382.83)	74.80 (77.62)
T_4: NCPM	7.30 (7.28)	0.076 (0.076)	1.26 (1.26)	349.00 (354.28)	57.93 (59.32)	374.87 (379.25)	78.05 (79.41)
T_5: CCM	7.38 (7.36)	0.078 (0.078)	1.23 (1.22)	356.36 (359.76)	56.15 (57.15)	377.92 (380.27)	74.40 (73.92)

*Figures in parenthesis indicate values obtained post-harvest.

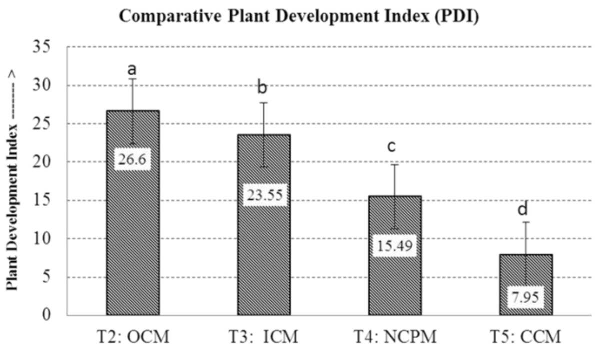

Fig 2 PDI under different management practices.

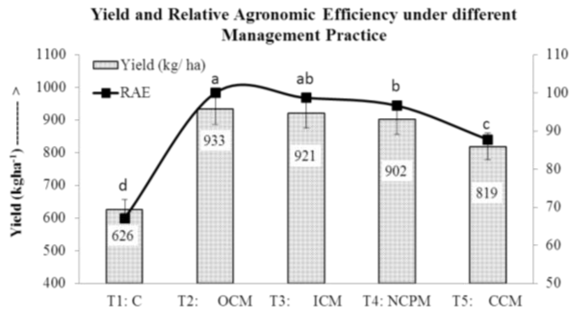

Fig 3 Crop productivity and RAE (Relative Agronomic Efficiency) under different treatments.

Evaluation of Soil Quality

Evaluation of soil quality under different treatments pre and post experimentation revealed no considerable changes in soil pH and EC. However, slight increase in organic carbon was noted in case of OCM plots. Available N, P, K and S showed increasing trend under all treatments, other than control (Table 7). In OCM plots, comparative higher value of available- N may be due to efficient fixation of atmospheric N through symbiotic legume – *Rhizobium* association (Bohlool et al., 1992).

Soil micro-organisms play a significant role in regulating the dynamics of organic matter decomposition and availability of plant nutrients (Chen, 2006). An important feature of green gram crop is its ability to establish a symbiotic partnership with specific bacteria, setting up biological N_2-fixation in its root nodules that supply the plant's needs for N_2 (Mahmood and Athar, 2008). High values of soil MBC, FDAH activity, etc. in case of OCM followed by ICM treatment plots indicated the favorable role of compost towards soil micro flora rejuvenation, which was applied for full or partial soil management under these treatments (Fig 4). On the other hand, comparatively higher soil basal respiration, qCO2 and Qr values (as noted for CCM treatment plots) indicated environmental stress and higher expense of energy by soil microbial community for sustenance; rather than for growth aspects (Anderson and Domsch, 1985).

Conclusion

Healthy Plants i.e., the essence of Trophobiosis Theory can be practically demonstrated only by such cultivation practice which imparts focus towards activation of plant metabolism alongside soil quality rejuvenation. The study indicated the scope for attaining higher crop productivity even without tweaking crop genetics, through adoption of a cultivation practice that fosters positive correlations between enhanced photosynthesis, assimilation and phloem transport i.e., the attributes of Healthy Plants; apart from facilitating the dynamics of organic matter decomposition and plant nutrient availability. Highest plant growth, yield response as well as qualitative development of soil especially micro floral attributes under Inhana Rational Farming (IRF) indicated the relevance of comprehensive organic approach towards reversal of the imperilled sustainability in agriculture. At the same time higher yield aspects under organic plant management (as imparted by IRF plant management) alongside partial/ no substitution of synthetic fertilizers with compost, indicated the scope for yield sustenance even under complete stoppage of synthetic pesticides and reduction of synthetic fertilizers, which are primary causal factors behind ecological destruction and food toxicity.

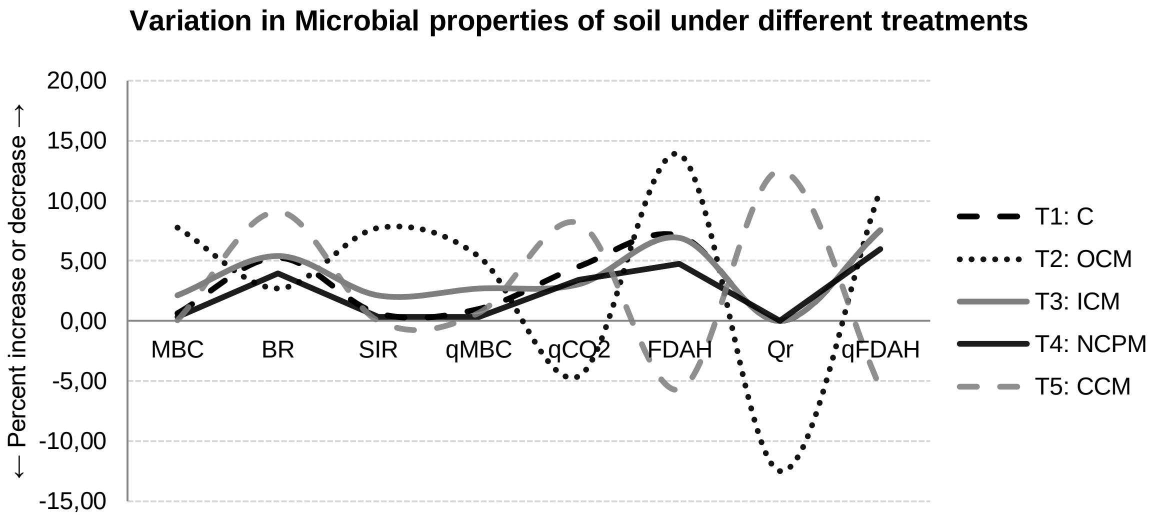

Fig 4 Percent variation in soil microbial properties under different treatments pre and post experimentation

MBC: Microbial Biomass Carbon; BR: Basal Respiration; SIR: Substrate Induced Respiration; qMBC: Microbial quotient; qCO_2: microbial metabolic quotient; FDAH: Fluorescent Di-Acetate Hydrolysis; Qr: microbial respiration quotient; qFDAH: FDAH per unit organic carbon.

Pic. 2 Novcom compost and green gram at Howrah KVK (ICAR), India

Acknowledgement

Authors would like to express gratitude to Dr. P. Das Biswas for providing guidance regarding organic management under IRF Technology and Inhana Biosciences for providing part finance for conducting the project. Authors are thankful to Department of Agricultural Chemistry and Soil Science (Calcutta University) and Krishi Vigyan Kendra (ICAR, Howrah; West Bengal) for lending infrastructural facilities for conducting the project.

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