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Impact of Bio-accelerated Farming against Conventional Farming System on Green Gram (*Vigna radiata* L.) under Rainfed Condition: Adaptive Management Enhances the Resilience to Climate Change

Dipen Dahal[1], J. Ghosh[2] and Binoy Chhetri[3*]

[1]Assistant Director of Agriculture, Madarihat Block, Alipurduar, West Bengal (736 122) India
[2]Dept. of Agricutural Entomology, Faculty of Agriculture, UBKV, Pundibari, Coochbehar (736 165), India
[3]Regional Research Station (HZ), Uttar Banga Krishi Viswavidyalaya, Kalimpong, West Bengal (734 301), India

Corresponding Author

Binoy Chhetri
e-mail: yonib2050@gmail.com

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Abstract

The field experiments was conducted at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal, India during 2011-2012. The objective was to assess the effect of chemical free bio-accelerated and conventional farming system on growth, yield attributes, yield, nutrients uptake, quality and microbial population of green gram. The farm is situated at 26° 19'86"N latitude and 89°23'53"E longitude at an elevation of 43.0 m above mean sea level. Results revealed that the growths, yield attributes, quality and microbial population of green gram were recorded higher in chemical free bio-accelerated compared to the conventional farming system. From the pooled data the highest yield was recorded under bio-accelerated farming (1500 kg ha^{-1}) compared to the conventional farming system (1375 kg ha^{-1}). The highest moisture percentage recorded under conventional farming (65.37%) than bio-accelerated farming system (63.35%). The nitrogen (50.40 and 73.88 kg ha^{-1}), phosphorus (10.53 and 11.32 kg ha^{-1}) and potassium (67.68 and 123.60 kg ha^{-1}) uptake by crop was recorded highest under the conventional farming compared to bio-accelerated farming system. The application jiwanmrita recorded significantly higher number of microbial population in the soil of bio-accelerated farming than the conventional farming system. From the pooled data analysis showed 62.50 microbes in bio-accelerated and 39.75 microbes in conventional farming before sowing which increased up to 97.25 microbes and decreased to 31.94 microbes in bio-accelerated and Conventional farming system. Among the chemical free bio-accelerated farming system pest incidence was found to be lower as compared to the conventional farming system.

Keywords: Bio-accelerated, conventional, greengram, growth, nutrient uptake

1. Introduction

Greengram or mungbean (*Vigna radiata* L.) is a third most important pulse crop of India after chickpea and pigeon pea (Tamang et al., 2015). However, major greengram producing states are Odissa, Madhya Pradesh, Rajasthan, Maharashtra, Gujarat and Bihar. It is cultivated over an area of 3.04 mha with a total production of 1.42 mt and productivity of 468 kg ha^{-1} (Anon, 2016). Green gram is an excellent source of protein (24.5%) with high quality of lysine (460 mg g^{-1} N) and tryptophan (60 mg g^{-1} N) and rich in protein and vitamin B. It contains also remarkable quantity of ascorbic acid and riboflavin (0.21 mg 100 g^{-1}) (Azadi et al. 2013). However, the yield of pulse crops is low due to lack of awareness in adoption of improved technology (Kumar, 2014b). The dose of fertilizer depends on the initial status soil fertility and soil moisture availability conditions (Saravanan et al., 2013). Moreover, greengram required more macro nutrients compared to the other pulse crops. In these cases farmers are applying large quantities of inorganic fertilizers without understanding its negative impact in the fertility status of the soil as well as the concerned environment (Baishya, 2015). Instead, restoring soil health by re-adopting chemical free agriculture would be a path towards sustainability (Tripura et al., 2016). In this regards, low yields of green gram are largely associated with uncertain rainfall, poor soil fertility, high weeds, pests, diseases infestation, low input availability, low input use and unavailability of appropriate variety and seeds (Singh and Sekhon, 2008). Hence, the climate variability is a major challenge to the crop production in this region. In this context adaption of chemical free bio-accelerated farming system does have the potential to produce enough food to feed the World. Developed of new technology like indigenous microbial culture prepared by mixing cowdung, cow-urine, mixed with pulse powder and molasses for their energy sources without any investment of costlier inputs from external sources. Use of organic mulch from crop residues continuously supply humus to improve soil quality and fertility through accelerating dynamics biological processes like enhancing activities of microorganisms, earth worms, parasites, predators and induced resistance against pest and disease which ultimately lead into sustained supply of plant nutrients and keep the pest and disease incidence always at lower level leading to betterment of the crop yield (Palekar, 2001). Moreover, adaptive management of natural resources enhances resilience to climate variability. Therefore, there is a direct need to systematically redirect agricultural knowledge, science and technology towards sustainable, biodiversity-based ecological agriculture and the underlying agro-ecological science. This is because it is postulated that the ecological model of agricultural production, which is based on principles that prioritize farmers and traditional knowledge, is climate resilient as well as productive. On the other hand, indigenously prepared microbial culture like *jiwamrita* and organic mulches are the major sources of nutrients in bio-accelerated farming. The practices recently are gaining much popularity to enhance and maintain soil organic status for obtaining a sustainable crop yield (Ravi et al., 2012).

So, in this context the approach for chemical free bio-accelerated farming provides a better solution for conjunctive use of natural resources (organic) of plant nutrients for crop productivity as well as sustaining soil health and environment. Considering the above mentioned reason a study on growth, yield and quality of greengram as influence by chemical free bio-accelerated farming system.

2. Materials and Methods

The field experiment was carried out at Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal, India during 2013 and 2014. The farm is situated at 26° 19'86"N latitude and 89°23'53"E longitude at an elevation of 43.0 m above mean sea level. The soil of the experimental field was sandy loam in texture with pH 5.7. The experimental area was divided by two types (treatments) of farming system *viz.* bio-accelerated and conventional farming. For bio-accelerated farming system indigenous microbial culture *(Jiwamrita)* was prepared with fresh cow dung, cow urine, lime and a handful of soil from the bund (uncultivated soil). After sowing, the indigenous microbial culture (*Jiwamrita*) prepared by fresh cow dung (10 kg) + cow urine (10 litre)+molasses (2 kg)+pulse dust (2 kg)+handful of bund soil mixed in water (200 liter for one acre) stirred thrice daily for three days was applied at 15 days interval till grain filling stage. Application was done by spreading diluted microbial culture according to its requirement entirely in the plots at late afternoon hours simply with plastic mug available. The results were analyzed taking consideration of pre harvest parameters like plant height (cm), root length (cm), leaf width (cm), number of nodule plant^{-1}, nodule weight plant^{-1}, trichem plant^{-1} and number of branches plant^{-1} at 30, 60, 90 days after sowing (DAS) and at harvest where as post harvest parameters were number of pod plant^{-1}, pod length (cm), pod weight (g), number of seeds pod^{-1}, 100-seed weight (g), grain length (cm) and grain yield (kg ha^{-1}). Estimation of micro-organism population was done by the methods of Waksman and Fred (1922) after the samples were homogenized in mortar with a pestle and sieve through 2-mm sieve. One gram each of organic based and inorganic based soil sample were mixed with 9 ml of sterile distilled water in two different test tube to prepare 10^{-1} dilution. These suspensions were used for serial dilution up to 10^{-7}. One ml of each suspension from 10^{-5} to 10^{-7} were plated separately in potato dextrose agar medium and incubated at 28±1 °C for 3-5 days. The moisture percentage was determined by following the procedure of Paul et al. (1992).

Moisture %=(Weight of fresh leaves-Weight of dry leaves)/ Weight of fresh leaves×100

Economic analyses were gross return, net return and benefit cost ratio. The replicated data generated were analyzed statistically using statistical package of SAS and determined the probability for significant variation among the treatments.

3. Results and Discussion

3.1. Relative performance of vegetative parameters of green gram

Plant height of green gram highest was recorded under bio-accelerated farming compared to the conventional farming system at all stages of crop growth. The height of plant increased with the advancement of the crop age due to its growth and reached its maximum at harvest irrespective of the treatments tried. However, it was revealed that from the pooled data the height of the plant was increased gradually from 22.54 cm and 23.91 cm at 30 DAS; 51.96 cm and 51.41 cm at 60 DAS and 58.62 cm and 57.11 cm at maturity in conventional farming and bio-accelerated farming system (Table 1). The maximum plant height in bio-accelerated farming system might be due to stimulated biological activities which enhanced the plant growth by improving soil nutrient status, secreting plant growth regulators and suppressing insect pest populations throughout growth period. The application of organic source of nutrients such as farm yard manure and vermicompost significantly enhance the plant height of green gram (Singh and Singh, 2014). From the 't'-test value it was revealed that plant height was non-significant in all observations of 30 DAS, 60 DAS and at maturity (Table 2). The highest number of branches plant^{-1} was recorded at 30 days after sowing in bio-accelerated (4.02) and conventional farming (4.27) branches plant^{-1}. The highest number of branch plant^{-1} at maturity was recorded under bio-accelerated (8.12 branches plant^{-1}) compared to the conventional farming system (7.48 branches plant^{-1}) (Table

Table 1: Influence of cultivation practices on plant parameters of green gram at different stages

Plant parameters	Stage of observation	1st year		2nd year		Pooled	
		BF	CF	BF	CF	BF	CF
Plant height (cm)	30DAS	24.12	25.08	20.96	22.74	22.54	23.91
	60DAS	50.00	49.34	53.91	53.49	51.96	51.41
	At maturity	56.45	55.31	60.80	58.92	58.62	57.11
Root length (cm)	30DAS	13.19	14.22	11.54	11.41	12.36	12.81
	60DAS	15.44	15.41	14.46	16.02	14.95	15.72
	At maturity	21.04	20.27	24.37	26.20	22.70	23.23
Nodules plant^{-1}	30DAS	28.33	21.00	26.67	23.12	27.50	22.06
	60DAS	34.33	22.67	30.67	24.42	32.50	23.54
	At maturity	31.42	20.88	22.67	20.63	27.04	20.75
Nodules wt. plant^{-1}	30DAS	1.71	0.97	2.21	2.00	1.96	1.49
	60DAS	2.14	1.29	2.44	2.06	2.29	1.68
	At maturity	2.41	1.44	2.27	2.05	2.34	1.74
Leaf width (cm)	30DAS	6.35	6.41	6.24	5.75	6.30	6.08
	60DAS	8.25	8.24	7.31	7.32	7.78	7.78
	At maturity	8.29	8.23	7.60	7.86	7.94	8.05
Trichme leaf^{-1}	30DAS	9.13	5.67	5.80	4.63	7.46	5.15
	60DAS	14.96	10.13	9.33	5.33	12.15	7.73
	At maturity	13.83	9.92	11.79	7.75	12.81	8.83
Branches plant^{-1}	30DAS	4.00	3.79	4.04	4.75	4.02	4.27
	60DAS	5.00	4.88	6.00	7.13	5.50	6.00
	At maturity	8.00	7.54	8.25	7.42	8.12	7.48
Moisture percentage (%)	At maturity	61.48	64.19	65.22	66.55	63.35	65.37
Pods plant^{-1}	At maturity	27.58	26.17	31.67	29.46	29.63	27.81
Pod length (cm)	At maturity	11.01	10.75	9.67	9.45	10.34	10.10
Pod wt. (g)	At maturity	0.61	0.59	0.51	0.50	0.56	0.55
Grains pod^{-1}	At maturity	13.33	12.92	12.42	11.75	12.88	12.33
100 grain wt. (g)	At maturity	4.87	4.72	4.68	4.48	4.77	4.60
Grain length (cm)	At maturity	0.46	0.42	0.40	0.36	0.43	0.39
Yield (kg ha^{-1})	At maturity	1521.30	1367.40	1479.80	1382.60	1500.50	1375.00

BF: Bio-accelerated; CF: Conventional farming

1). This might be due to the application of organic sources nutrients like *jiwamitra* are the store house of plant nutrients which might have improved the physico-chemical as well as biological properties of the soil to enhance the number of branches plant^{-1} (Table 1). These results also conformity with the findings of Giri and Joshi (2010) and Sinha et al. (2010). The't'-test revealed that number of branches plant^{-1} was non-significant between two practices (Table 2). However, the root length of the plant was observed from 30 days after sowing upto maturity stage. The length of root at 30 DAS is (12.36 and 12.81 cm), at 60 DAS (14.95 and 15.72 cm) and at maturity (22.70 and 23.23 cm) in bio-accelerated and conventional farming system (Table 1). The increased of root length on chemical free bio accelerated farming system might be due to application nutrients like jiwamitra under this fertility levels favoured the root proliferation by stimulating cellular activities and translocation of certain growth stimulating compounds to roots. However, Sutaria et al. (2010) reported that the extensive root growth and development system with balanced fertilization and organic manure assisted the efficient absorption and utilization of other nutrients. The values of't'-test showed that the root length showed non-significant

Table 2: 't'-test analysis on influence of cultivation practices on pl. parameters of green gram at different stages

Plant parameters	Stage of observation	t-value	Pr>t
Plant height (cm)	30 DAS	-1.95	0.0611
	60 DAS	0.52	0.6076
	At Maturity	1.31	0.1999
Root length (cm)	30 DAS	-0.86	0.3979
	60 DAS	-3.09	0.0043
	At Maturity	0.45	0.6590
Nodules plant^{-1}	30 DAS	5.54	<.0001
	60 DAS	8.99	<.0001
	At Maturity	4.00	0.0004
Nodules wt. plant^{-1}	30 DAS	2.21	0.0345
	60 DAS	4.19	0.0002
	At Maturity	5.52	<.0001
Leaf width (cm)	30 DAS	1.96	0.0596
	60 DAS	0.00	1.0000
	At Maturity	-0.91	0.3712
Trichme leaf^{-1}	30 DAS	4.12	0.0003
	60 DAS	3.35	0.0022
	At Maturity	4.92	<.0001
Branches plant^{-1}	30 DAS	-0.73	0.4711
	60 DAS	-1.28	0.2101
	At maturity	1.73	0.0944
Moisture percentage (%)	At maturity	-2.65	0.0128
Pods plant^{-1}	At maturity	1.27	0.2145
Pod length (cm)	At maturity	0.89	0.3831
Pod wt. (g)	At maturity	0.58	0.5635
Grains pod^{-1}	At maturity	1.55	0.1321
100 grain wt. (g)	At maturity	2.22	0.0343
Grain length (cm)	At maturity	2.41	0.221
Yield (kg ha^{-1})	At maturity	7.76	<.0001

DAS: Days after sowing

relation between the treatments (except 60 DAS where root length was significantly higher in conventional farming) at all stages of growth (Table 2).

From the data it was revealed that the bio-accelerated farming system produced maximum number of nodules plant^{-1} compared to the conventional farming practices. The average number of nodules plant^{-1} at 30 DAS was 27.50 nodules plant^{-1} and 22.06 nodules plant^{-1}, 32.50 nodules plant^{-1} and on 23.54 nodules plant^{-1} at 60 DAS and at maturity it was 27.04 nodules plant^{-1} and 20.75 nodules plant^{-1} in bio-accelerated and conventional farming system (Table 1). Weight of the nodules plant^{-1} was significantly higher in bio-accelerated farming compared to the Conventional farming system. From the pooled data the average weight of the nodules plant^{-1} was 1.96 g plant^{-1} at 30 DAS in bio-accelerated farming 1.49 g plant^{-1} in conventional farming, during 60 DAS it was 2.29 g plant^{-1} in bio-accelerated farming and 1.68 g plant^{-1} in conventional farming while at maturity, it was 2.34 g plant^{-1} in bio-accelerated and 1.74 g plant^{-1} in Conventional farming system (Table 1). Maximum number of nodule plant^{-1} and nodules weight in bio-accelerated might be due to availability of macro and micronutrients from applied organic nutrients which improving the micro environment of root growth and number of nodules plant^{-1} Singh et al. (2011). Hence't'-test revealed that, the number of nodules plant^{-1} and weight of nodules plant^{-1} was significantly higher in bio-accelerated farming compared to the conventional farming system (Table 2).

The highest leaf width was recorded 6.30 cm in bio-accelerated farming and 6.08 cm in conventional farming at 30 DAS. However, from the pooled data it was revealed that at 60 DAS the leaf width was found to be at par in the both farming system. At maturity the size of the leaf was maximum (8.05 and 7.94 cm) under the conventional farming than bio-accelerated (Table 1). This might be due to the absorption and translocation of applied synthetic nutrients is easily available during active vegetative growth of plant in conventional farming system. From the 't'-test it was revealed that the leaf width on bio-accelerated farming and conventional farming was non-significant. The trichome leaf^{-1} was 7.46 and 5.15 trichome leaf^{-1} at 30 DAS, 12.15 and 7.73 trichome leaf^{-1} at 60 DAS and at maturity it was 12.81 trichome leaf^{-1} and 8.83 trichome leaf^{-1} in bio-accelerated and chemical farming (Table 1). 't'-test showed that trichome leaf^{-1} had significant relation between the treatments at all stages of growth *i.e.* bio-accelerated farming recorded more trichome leaf^{-1} than conventional farming (Table 2). Moisture percentage was always found to be higher in bio-accelerated farming (65.37%) compared to the conventional farming (63.35%) (Table 1). 't'-test showed, significant higher percentage of moisture in conventional than bio-accelerated farming (Table 2).

3.2. Relative performance of yield attributing and yield

Irrespective of bio-accelerated and conventional farming system yield attributes such as number of pods plant^{-1}, pod length, grain length, seeds pod^{-1}, pod weight, test weight and yield as more in bio-accelerated farming system due to more vigorous growth of the crop which was reflected on yield attributes of greengram. However, from the pooled data it was pertinent that the highest number of pods plant^{-1} was recorded in bio-accelerated (29.63) and conventional farming (27.81) (Table 1). The length of pod was 10.34 cm in bio-accelerated and 10.10 cm in conventional farming. The highest grain length of 0.43 cm was recorded in bio-accelerated compared to the 0.39 cm in conventional farming.

Bio-accelerated farming (12.88) was recorded highest number of seeds pod^{-1} than conventional farming system (12.33). From the pooled data it was revealed that the pod weight maximum recorded under (0.56 and 0.55 g pod^{-1}) in bio-accelerated farming and conventional farming (Table 1). This might be due to the increased population of microbes which helps mobilization of the nutrients from unavailable form to available form. The similar result also made by Rajkhowa et al. (2002) in greengram the application of organic source of nutrients significantly increases the number of seed pod^{-1}. From the't'-test analysis showed the number of pods plant^{-1}, length of pod, numbers of seeds pod^{-1}, grain length and pods weight were significantly higher in bio-accelerated farming than the conventional farming though the values were non-significant between the treatments (Table 2). From the pooled data highest test weight was recorded under bio-accelerated farming (4.77 g) compared to the conventional farming system (4.60 g) (Table 1). The application of organic sources nutrient like Jiwamitra and other organic source of nutrients are the store house of plant nutrients which might have improved the physico-chemical as well as biological properties of the soil to enhance yield attributes. However, application of only chemical fertilizers for the soils which deprived all the these advantages necessary for more production of functioning leaves, greater accumulation of carbohydrates, protein and their translocation to the reproductive organs, which in turn increased the number of pods plant^{-1}, number of seeds pods^{-1} and other associated yield attributing parameters (Table 1). These results are in conformity with the findings of Kumar et al. (2010), Dekhane et al. (2011) and Sharma and Verma (2011). From't'-test revealed that seed index/100 seed weight was found to be significant between the two treatments *i.e*. bio-accelerated farming and conventional farming (Table 2). The highest yield was recorded under bio-accelerated farming (1500.5 kg ha^{-1}) compared to the in conventional farming systems (1375.0 kg ha^{-1}) (Table 1). This might be due to the fact that soils of bio-accelerated farming system contained enough indigenous microbial population to allow maximum growth and yield. These results are in conformity with the finding of Kumar and Kumar (2006). The't'-test comparison showed that the yield showed significant difference between bio-accelerated farming and conventional farming (Table 2).

1.3. Effect of treatments on availability and uptake of nutrients

1.3.1. Nutrients status

Nutrient status of the soil was analyzed and found that the availability of nitrogen was lower in bio-accelerated farming system as compare to the conventional farming system. The highest availability of nitrogen was recorded under conventional farming system (123.97 kg ha^{-1}) compare to the bio-accelerated farming system (121.24 kg ha^{-1}) (Table 3). This might be owing to the continuous application of inorganic fertilizers on conventional farming system enhanced the nitrogen availability in soil. However, Ginting et al., (2003) reported that the continuous application of organic manures increases the level of N, P and K, in the soil. The application of FYM, vermicompost and green leaf manures in releasing N and improving N availability in soil (Singh et al., 2008). Hence,'t'- test of statistical analysis revealed that nitrogen availability showed similar trend between the bio-accelerated and conventional farming system and was found to be non-significant (Table 4). From the pooled data suggested that conventional farming recorded higher available phosphorous (18.79 kg ha^{-1}) than bio-accelerated farming (17.73 kg ha^{-1}). The status of the soil after harvest was also improved and enhances the fertility of soil this might be due to residual effect of organic nutrients. Similar findings also reported by Tanwar et al. (2010) and Patel (2012). This might be due to the

Table 3: Nutrient status in the soil and nutrient uptake by green gram

Nutrients	1st year		2nd year		Pooled	
	BF	CF	BF	CF	BF	CF
Available Nitrogen (kg ha^{-1})	118.86	119.62	123.62	128.32	121.24	123.97
Nitrogen uptake (kg ha^{-1})	49.20	70.96	51.60	76.81	50.40	73.88
Available Phosphorous (kg ha^{-1})	17.35	17.75	18.11	19.84	17.73	18.79
Phosphorous uptake (kg ha^{-1})	9.66	10.53	11.41	12.11	10.53	11.32
Available Potassium (kg ha^{-1})	64.50	65.73	64.60	68.60	64.55	67.16
Potassium uptake ((kg ha^{-1})	67.82	123.04	67.55	124.16	67.68	123.60

BF: Bio-accelerated farming; CF: Conventional farming

Table 4: 't'-test on nutrient status in the soil and nutrient uptake by green gram

Nutrients	Available nitrogen (kg ha^{-1})	Nitrogen Uptake (kg ha^{-1})	Available phosphorous (kg ha^{-1})	Phosphorous uptake (kg ha^{-1})	Available potassium (kg ha^{-1})	Potassium uptake (kg ha^{-1})
t-value	-1.68	-17.75	-1.76	-1.69	-1.93	-57.28
Pr>t	0.1042	<.0001	0.0893	0.1005	0.0636	<.0001

addition of organic manure or their different combinations, favored the availability of higher phosphorus in soil (Table 3). The results were compared on‘t’- test analyzing method and it showed that available phosphorous in bio-accelerated farming was non-significant to conventional farming system (Table 4). Available potassium in the soil was also less in the bio-accelerated farming than conventional farming. Pooled data showed that available potassium of 64.55 kg ha^{-1} in bio-accelerated and 67.16 kg ha^{-1} in conventional farming system were recorded (Table 3). Hence, it is confirmed that availability of potassium was non-significant between the treatments after analyzing on‘t’-test statistical analysis i.e. potassium was higher in conventional farming than bio-accelerated farming (Table 4).

3.3.2. Nutrient uptake

Nutrient uptake by the greengram crop was always higher in the conventional farming than bio-accelerated farming which was measured at maturity. The pooled data, nitrogen uptake 50.40 kg ha^{-1} was recorded in bio-accelerated farming while 73.88 kg ha^{-1} in conventional farming system (Table 3). Hence,‘t’-test showed significant variation between the treatments or conventional farming plants showed significantly better uptake of nitrogen than plants of bio-accelerated farming system (Table 4). Uptake of phosphorous was also similar to nitrogen as conventional was higher than bio-accelerated farming. From the pooled data, the uptake of phosphorous was 10.53 kg ha^{-1} in bio-accelerated farming and (11.32 kg ha^{-1}) uptake of phosphorous in conventional farming (Table 3). The results showed that uptake of phosphorous were significantly higher in conventional farming than bio-accelerated farming. ‘t’-test suggested that, uptake of phosphorous was non-significantly higher in conventional farming than bio-accelerated farming (Table 4). The application of different source of organic manures significantly enhances the nitrogen and phosphorus uptake as reported by Bhavya et al. (2018). The average pooled data revealed that the potassium uptake was maximum recorded under the conventional farming (123.60 kg ha^{-1}) than (67.68 kg ha^{-1}) in bio-accelerated farming (Table 3). This might be due the increased growth, nutrient influx and photosynthetic rate resulted in more absorption and translocation of these nutrients to the grain and stem. The‘t’-test results showed that conventional farming uptake of potassium was highly significant than bio-accelerated farming (Table 4). Soil fertility was more or less uniform in both the set of cultivation practices at the beginning of the experiment. Therefore, application of nutrients in the easily available form from inorganic fertilizers recorded more uptake of NPK by the crop as compared to the crops under bio-accelerated farming practices. However, higher fertilizer use efficiency is always associated with low fertilizer rate, cultural practices meant for promoting integrated nutrient management will help to affect saving in the amount of fertilizer applied to the crops and therefore to improve fertilizer use efficiency (Karim and Ramasamy, 2000, Yadav, 2003).

3.4. Quality parameters

Quality parameters such as phenol and OD phenol also analyses at 30 days after sowing and at maturity of crop. Among the different compounds of phenol and OD phenol was also estimated. Phenol and OD phenol were recorded higher in bio-accelerated than the conventional farming at 30 DAS and at maturity stage. From the pooled data showed 0.24 mg g^{-1} and 0.21 mg g^{-1} of phenol were recorded at 30 DAS in bio-accelerated and conventional farming. At maturity, 7.80 mg g^{-1} and 7.14 mg g^{-1} of phenol were recorded in bio-accelerated and conventional farming system. The highest OD phenol was recorded under bio-accelerated farming (0.05 mg g^{-1}) compared to the conventional farming system (0.04 mg g^{-1}) at 30 DAS. At maturity 0.47 mg g^{-1} and 0.36 mg g^{-1} of OD phenol were recorded at maturity in bio-accelerated and conventional farming (Table 5). ‘t’-test revealed that, phenol and OD phenol were found significantly higher in bio-accelerated farming than conventional farming on all the growth stages except at 30 DAS where phenol showed non-significant difference (Table 6).

Table 5: Estimation of phenol and OD phenol in different cultivation practices (mg g^{-1})

Nutrients	1st year		2nd year		Pooled	
	BF	CF	BF	CF	BF	CF
Phenol (30 DAS)	0.05	0.05	0.44	0.38	0.24	0.21
Phenol (at maturity)	7.26	6.82	8.34	7.46	7.80	7.14
OD Phenol (30 DAS)	0.05	0.03	0.04	0.04	0.05	0.04
OD Phenol (at maturity)	0.49	0.35	0.45	0.37	0.47	0.36

BF: Bio-accelerated farming; CF: Conventional farming

3.5. Estimation of micro-organism (cfu)

The application of organics *i.e.,* jiwanmrita recorded significantly higher number of microbial population in the soil of bio-accelerated farming than the plots in conventional farming. Pooled analysis showed 62.50 microbes in bio-accelerated and 39.75 microbes in conventional farming before sowing which increased up to 97.25 microbes and decreased to 31.94 microbes in bio-accelerated and conventional farming respectively at the stage of maturity

Table 6: 't'-test analysis on phenol and OD phenol estimation in different cultivation practices

Nutri-ents	Phenol (30 DAS)	Phenol (at maturity)	OD phenol (30 DAS)	OD phenol (at maturity)
t-value	-1.68	-17.75	-1.76	-1.69
Pr>t	0.1042	<.0001	0.0893	0.1005

DAS: Days after sowing

(Table 7). This was due to the application of organic manures increased organic matter in soil ultimately enhancing microbial activity which reflected in the possible increase of nutrient status of soil (Reddy et al., 2007). From the't'-test value it was reveled that the microbial population was significantly higher in bio-accelerated farming over conventional farming system. The higher population of microbes helped in better decomposition of organics and mulches, which resulted in better release of nutrients and conservation of more moisture throughout the crop growing period resulted in higher yields as that of conventional treatments (Table 8).

Table 7: Estimation of micro-organism in soil (cfu)

Nutrients	1st year		2nd year		Pooled	
	BF	CF	BF	CF	BF	CF
Microbes (before sowing)	50.63	46.88	74.38	32.63	62.50	39.75
Microbes (at maturity)	87.13	33.13	107.38	30.75	97.25	31.94

BF: Bio-accelerated farming; CF: Conventional farming

Table 8: 't'-test analysis for estimation of micro-organism in soil

Observation	Microbes (before sowing)	Microbes (at maturity)
t-value	7.07	0.90
Pr>t	<.0001	0.3749

DAS: Days after sowing

3.6. Impact of different insect pest incidence in bio-accelerated and conventional farming system

In view of this, seasonal abundance of some important insect-pests of green gram as well as the role of weather parameters on fluctuation of their populations was studied in the present investigation. Several number of insect-pests was found during the studies namely cutworm (*Agrotis ipsilon* Hufnagel), whitefly (*Bemisia tabaci* Gennadius), leaf folder (*Lamprosema indica* F.), leafminer (*Liriomyza trifolii* Burgess), bihar hairy caterpillar (*Spilosoma oblique* Walker), flea beetle (*Phyllotreta sp*.), pod borers (*Maruca testulalis* Geyer) jassid (*Empoascca kerri* Pruthi) etc. on green gram crop. Among the different insect-pests attacked on green gram cut worm, leaf folder, flea beetle and pod borer were found most predominant and persistently appeared on green gram. However, cutworm generally attacked on the initial stage (seedling stage) of crop growth up to 30-40 DAS (Table 9). However the pest appeared first after 12 days of sowing and damaging symptom persisted for one month. It was revealed that from the pooled data, maximum level of cut worm prevailed more in bio-accelerated farming (1.20 m^{-1}) than conventional farming system (0.60 m^{-1}) respectively on 16th SW. Cutworm existed more in bio-accelerated farming than conventional farming. 't'-test revealed that bio-accelerated farming were infested more by cutworm than conventional farming and significant variation were existed between them (Table 10). Leaf folder incidence was recorded from last week of April (30 DAS or 17th SW) in 1st year and 3rd week of April (15 DAS or 16th SW) in the 2nd year. The pest gradually increased to reach its maximum on 3rd week of May (20th SW) in both the treatments. From the pooled data it was revealed that the maximum leaf folder 1.97 per 10 plants and 1.27 per 10 plants in conventional and bio-accelerated farming and the significant difference between the treatments in almost all standard weeks were observed. 't'-test revealed that apart from 16th and 21st standard week (where non-significant relation existed), all the observations showed significant difference between bio-accelerated and conventional farming in regard to leaf folder population. From the pooled data the incidence of flea beetle existed throughout the crop growth period. The peak population was 3.67 per 10 plants in conventional farming and 1.67 per 10 plants in bio-accelerated farming. The data also suggested the significant variation existence (15th SW and 20th SW were non-significant) between bio-accelerated and conventional farming. 't'-test revealed that, apart from 15th and 20th standard week (where non-significant relation existed between the treatments) all the observations showed significant variation and conventional farming recorded significantly higher pest population as compared to bio-accelerated farming practices. The population of pod borer was initiated from last week of April (30 DAS, 17th SW) in 1st year and 1st week of May (30 DAS, 18th SW) in 2nd year at the period of flower initiation stage (Table 9). The incidence of pod borer attained its peak on 20th SW on pod development stage in both conventional farming and bio-accelerated farming. Pooled mean showed that the highest density of pest population was observed in conventional (13.97 per 10 plants) than bio-accelerated farming practices (9.50 per 10 plants). 't'-test suggested that, pod borer population was recorded significantly higher in conventional farming than bio-accelerated farming on all the observations made (Table 10). The pooled analysis suggested that the jassid population was more in conventional farming than bio-accelerated farming. The maximum population was recorded in conventional farming (3.27 $plant^{-1}$) against bio-accelerated farming (1.60 $plant^{-1}$) in 19th SW. The pest was present till 21SW. Hence, apart from 17th SW all the observation showed significant

Table 9: Effect of cultivation practices of green gram on the incidence of different pests

Std. Wk.	Cutworm M^{-2}						Leaf folder $10pl^{-1}$						Flea beetle $10pl^{-1}$					
	1st year		2nd year		Pooled		1st year		2nd year		Pooled		1st year		2nd year		Pooled	
	BF	CF	BF	CF	BF	CF	BF	CF	BF	CF	BF	CF	BF	CF	BF	CF	BF	CF
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
15	0.20	0.00	1.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.13
	0.84	0.71	1.23	0.71	1.05	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.88	0.71	0.80
16	2.07	0.93	0.33	0.27	1.20	0.60	0.00	0.00	0.73	1.87	0.37	0.93	1.73	1.80	1.33	2.47	1.53	2.13
	1.61	1.20	0.92	0.88	1.31	1.05	0.71	0.71	1.11	1.54	0.94	1.20	1.50	1.52	1.36	1.73	1.43	1.62
17	0.67	0.00	0.27	0.00	0.47	0.00	1.00	1.93	1.53	2.00	1.27	1.97	1.33	1.87	2.00	4.47	1.67	3.17
	1.09	0.71	0.88	0.71	0.99	0.71	1.23	1.56	1.43	1.58	1.33	1.57	1.36	1.54	1.58	2.23	1.48	1.92
18	0.47	0.00	0.07	0.00	0.27	0.00	0.00	0.73	1.73	3.33	0.87	2.03	1.27	1.80	2.00	2.87	1.63	2.33
	0.99	0.71	0.76	0.71	0.88	0.71	0.71	1.11	1.50	1.96	1.17	1.59	1.33	1.52	1.58	1.84	1.46	1.69
19	0.00	0.00	0.00	0.00	0.00	0.00	0.73	1.27	0.53	0.93	0.63	1.10	1.47	1.93	1.07	3.13	1.27	2.53
	0.71	0.71	0.71	0.71	0.71	0.71	1.11	1.33	1.02	1.20	1.07	1.27	1.41	1.56	1.26	1.91	1.33	1.74
20	0.00	0.00	0.00	0.00	0.00	0.00	1.33	2.07	0.80	1.40	1.07	1.73	0.33	0.60	3.87	6.54	2.10	3.57
	0.71	0.71	0.71	0.71	0.71	0.71	1.36	1.61	1.14	1.38	1.26	1.50	0.92	1.05	2.09	2.66	1.62	2.02
21	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.60	0.47	0.67	0.33	0.63	0.27	0.67	0.67	1.73	0.47	1.20
	0.71	0.71	0.71	0.71	0.71	0.71	0.84	1.05	0.99	1.09	0.92	1.07	0.88	1.09	1.09	1.50	0.99	1.31
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.67	0.00	0.47	0.27	1.27	0.67	2.07	0.47	1.67
	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.88	0.71	1.09	0.71	0.99	0.88	1.33	1.09	1.61	0.99	1.48
Mean					0.28	0.07					0.50	0.98					1.02	1.86
					0.88	0.75					1.00	1.22					1.23	1.54

Table 9: Continue...

Std. Wk.	Pod borer $10pl^{-1}$						Jassid pl^{-1}					
	1st year		2nd year		Pooled		1st year		2nd year		Pooled	
	BF	CF	BF	CF	BF	CF	BF	CF	BF	CF	BF	CF
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
17	0.53	2.13	0.00	0.00	0.27	1.07	0.00	0.00	0.00	0.07	0.00	0.03
	1.02	1.62	0.71	0.71	0.88	1.26	0.71	0.71	0.71	0.76	0.71	0.73
18	1.67	4.93	1.53	3.67	1.60	4.30	0.60	1.53	0.47	2.07	0.53	1.80
	1.48	2.33	1.43	2.04	1.45	2.19	1.05	1.43	0.99	1.61	1.02	1.52
19	7.27	12.27	2.13	4.40	4.70	8.33	2.07	3.73	1.13	2.80	1.60	3.27
	2.79	3.57	1.62	2.22	2.28	2.97	1.61	2.06	1.28	1.82	1.45	1.94
20	8.60	11.93	10.40	16.00	9.50	13.97	0.47	2.20	0.07	2.00	0.27	2.10
	3.02	3.53	3.30	4.06	3.16	3.81	0.99	1.65	0.76	1.58	0.88	1.62

Table 9: Continue...

Std. Wk.	Pod borer 10pl^{-1}						Jassid pl^{-1}					
	1st year		2nd year		Pooled		1st year		2nd year		Pooled	
	BF	CF	BF	CF	BF	CF	BF	CF	BF	CF	BF	CF
21	5.33	7.73	4.80	7.00	5.07	7.37	0.00	0.00	0.00	0.13	0.00	0.07
	2.42	2.87	2.30	2.74	2.36	2.81	0.71	0.71	0.71	0.80	0.71	0.76
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Mean					2.35	3.89					0.27	0.81
					1.69	2.10					0.88	1.14

BF: Bio-accelerated farming; CF: Conventional farming; DAS: Days after sowing; Figure in parentheses are square root transformed values

Table 10: 't'-test analysis on effect of cultivation practices of green gram on the incidence of different pest

PEST	Std.Wk.	15	16	17	18	19	20	21	22
Cutworm	t-value	4.65	2.01	3.39	3.05	-	-	-	-
	Pr>t	<.0001	0.0536	0.0004	0.0048	-	-	-	-
Leaf folder	t-value	-	-1.61	-2.79	-2.59	-2.85	-3.35	-1.74	-4.17
	Pr>t	-	0.1180	0.009	0.0145	0.0079	0.0022	0.0925	0.0002
Flea beetle	t-value	-1.97	-2.41	-3.46	-2.31	-5.35	-1.31	-3.35	-5.45
	Pr>t	0.058	0.0221	0.0016	0.0282	<.0001	0.2013	0.0022	<.0001
Pod borer	t-value	-	-	-2.40	-8.52	-2.69	-4.51	-4.92	-
	Pr>t	-	-	0.0230	<.0001	0.0115	<.0001	<.0001	-
Jassid	t-value	-	-	-1.56	-5.49	-5.75	-10.52	-2.15	-
	Pr>t	-	-	0.1295	<.0001	<.0001	<.0001	0.0401	-

Std. Wk.: standard week

variation between the treatments (Table 9). This might be due to the high humidity, moderate to high temperature and low rainfalls are found to be conducive for growth and multiplication of jassid. 't'-test revealed that conventional farming were attacked more by the pest than bio-accelerated farming and had significant variation between them on all the observations from 18th standard week to 21st standard week except 17th standard where non-significant relation existed between the treatments (Table 10). However this might be due to the conventional farming system (high cropping intensity, HYVs, increased use of fertilizers) has boosted the crop growth but at the same time it invited a level of pest to the crops. A general trend to use high dose of N fertilizers than P, K accordingly by the farmers increased the succulency of greengram plants resulting the attack of large number of insect-pests. On the contrary, bio-accelerated farming maintained the optimum growth of the plant by improving the soil physico-chemical properties and enhances microbial activity through use of organic mulching, cowdung and cow urine etc (jiwamrita) and these process provided resistance to the respective crop against pest infestation. The results on the incidence of rice insect-pests are in conformity with the findings of many workers (Fang and Huanchao, 2007; Mulumba and Rattan 2008; Goswami and Das, 2009).

1.7. Impact of abiotic factors on the incidence of different insect pest on green gram

The highest cutworm population was found in the green gram plant on 15th, 16th, 17th and 18th standard week when the average temperature ranges from 28.37 °C to 28.95 °C; the temperature gradient from 8.57 to 11.57; average rh (76.50% to 77.96%) and rh gradient (5.00% to 13.57%). The rainfall was moderate when the cutworm population reached the peak as 4.49 mm of rainfall was recorded during 16th standard week. Hence, it can be said that, high humidity, moderate temperature and low rainfall are found to be conducive for growth and multiplication of cutworm. The population of leaf folder was found during 16th, 17th, 18th, 19th, 20th, 21st and 22nd standards weeks with the average range temperature of 28.37 °C – 30.52 °C; temperature gradient range of 7.71 °C - 10.15 °C; average relative humidity of 76.50% – 81.60% and relative humidity gradient of 3.75 – 11.24. 3.75 mm of rainfall was recorded during the peak infestation period. Hence, it can be concluded that, moderate to high temperature, high humidity and low rainfall are conducive for the growth and multiplication of leaf folder. It was revealed from the Table 11 that the flea beetle population was found in the green gram from 15th to 22nd standard week when the average temperature ranges from 28.40 °C to 30.52 °C; the temperature gradient from 7.71 to 11.57; average rh (76.50% to 81.60%) and rh gradient (5.00% to 13.57%). The rainfall was moderate when the flea beetle population reached the peak as 11.24 mm of rainfall was recorded during 20th standard week. Therefore, it can be said that, high humidity, moderate to high temperature and moderate rainfall are found to be conducive for growth and multiplication of flea beetle population. The pod borer population was found on 17th, 18th, 19th, 20th, 21th and 22nd standard week in greengram when the average temperature ranges from 28.40 °C to 30.52 °C; the temperature gradient from 7.71 to 9.57; average rh (76.50% to 81.60%) and rh gradient (5.00% to 12.14%). The rainfall was moderate when the pod borer population reached the peak as 11.24 mm of rainfall was recorded during 20th standard week. Therefore, it can be said that, high humidity, moderate to high temperature and moderate rainfall are found to be conducive for growth and multiplication of pod borer population. It was recorded that the jassid population was found in greengram plant on 17th, 18th, 19th, 20th and 21st standard week when the average temperature ranges from 28.40 °C to 30.19 °C; the temperature gradient from 7.71 to 9.57; average rh (76.50% to 79.94%) and rh gradient (5.00% to 12.14%). The rainfall was the minimum of 3.75 mm during 19th SW when the jassid population reached the peak.

The different insect pests such as cutworm, leaf roller, flea beetle, pod borer and jassid were found infesting greengram. The multiple regression equation (Table 11) showed that weather parameters, in most of the cases had no significant impact on the population of these pests. Only temperature average and temperature gradient revealed significant negative impact against leaf roller and flea beetle in both bio-accelerated and conventional farming system. Impact of weather parameters in together was found 86.7% and 75.5% against leaf roller in bio-accelerated and conventional farming respectively whereas 89.9% and 88.6% contribution of weather factors in total were noticed against flea beetle in both the farming system (Table 11). In other insect pests, weather parameters had no significant impact on their population development.

Table 11: Regression analyses of different weather parameters with pest

Sl. No.	Pest	Treatments	Equation	R^2
1	Cut worm	Bio-accelerated farming	$Y=4.198 -0.312_{x1}+0.075_{x2}+0.058_{x3}-0.005_{x4}+0.004_{x5}$	0.470
		Conventional farming	$Y=0.388 -0.103_{x1}+0.067_{x2}+0.028_{x3}-0.022_{x4}+0.010_{x5}$	0.347
2	Leaf roller	Bio-accelerated farming	$Y=14.428 -0.500_{x1}^{**}-0.389_{x2}^{**}+ 0.056_{x3}+0.023_{x4}-0.041_{x5}$	0.867
		Conventional farming	$Y=16.514 -0.765_{x1}^{*}-0.614_{x2}^{*}+0.162_{x3}+ 0.042_{x4}-0.085_{x5}$	0.755
3	Flea beetle	Bio-accelerated farming	$Y=13.680 -0.907_{x1}^{**} -0.505_{x2}^{*} + 0.243_{x3}^{*} -0.009_{x4}-0.068_{x5}$	0.899
		Conventional farming	$Y=11.520 -1.229_{x1}^{*} -0.848_{x2}^{*} + 0.450_{x3}^{*} -0.034_{x4}-0.135_{x5}$	0.886
4	Pod borer	Bio-accelerated farming	$Y=12.132 -1.141_{x1}-1.651_{x2}+0.534_{x3}-0.226_{x4}-0.206_{x5}$	0.629
		Conventional farming	$Y=23.955-1.808_{x1}-2.902_{x2}+0.817_{x3} -0.247_{x4}-0.405_{x5}$	0.671
5	Jassid	Bio-accelerated farming	$Y=-2.386+0.024_{x1}-0.266_{x2}+0.063_{x3}-0.004_{x4}-0.067_{x5}$	0.470
		Conventional farming	$Y=-0.688-0.367_{x1}-0.757_{x2}+ 0.259_{x3}+ 0.005_{x4}-0.156_{x5}$	0.572

Where, x_1: Average temperature; x_2: Temperature gradient; x_3: Average relative humidity; x_4: relative humidity gradient; x_5: Rainfall

4. Conclusion

The adoption of bio-accelerated against conventional farming system produces the quality crop restoring the quality of soil health and better grain quality, apart from facilitating the dynamics of organic matter decomposition and plant nutrient availability. The better economic returns in bio-accelerated farming system also proved its superiority. Bio-accelerated farming system enhanced the plant growth; yield response as well as qualitative development of soil especially micro floral attributes indicated the relevance of comprehensive organic approach towards reversal of the imperiled sustainability in agriculture.

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