Recived on 04.11.2016
Accepted on 24.11.2016

Indian Journal of Agriculture Business
Volume 2 Number 2, July - December 2016
DOI: http://dx.doi.org/10.21088/ijab.2454.7964.2216.3

Review Article

Testing the Efficacy of Organic Biological Inputs for Summer Cucurbits in Sandy Loamy Terai Soil of Gangetic Belt of Garhwal Region

Vijay Sharma*, Ananthanarayana Sharma, Ajay Saini***, Ram Kumar Shukla****, G. Paran Gowda*******

Author Affiliation
*Head, Department (Quality Control & Research & Development), Patanjali Bio Research Institute, Haridwar,
**Ranjit Gupta Centre for Documentation of Action Research, Sholavandan Post, Vadipatti Taluka, Madurai District, Tamilnadu. (Communicating author)
***QC and R&D Department, Patanjali Bio Research Institute, Haridwar.
****Head, Department of Department (Production), Patanjali Bio Research Institute, Haridwar.
***** Director, Patanjali Bio Research Institute, Haridwar.

Reprint Request
Vijay Sharma, Head R&D, QC Laboratory, Patanjali Bio Research Institute, Haridwar – 249407 Uttarakhand.
vijay.sharma@patanjalibio.com

Abstract

A field experiment was conducted to study the efficacy of organic bio-inputs developed by an agricultural biotechnology research institute: for summer cucurbits in loamy sandy soil of Terai plains of Garhwal, irrigated by the Ganges:, during the summer season of 2013. The vegetables experimented on were: Lagenaria siceraria (*bottlegourd*) and Momordica charantia (*bittergourd*). The experiment was conducted at the experimental field of Patanjali Bio Research Institute (PBRI),located in Padartha village, Haridwar district, Uttarakhand, India. The experimental design had one control, four treatments and two crops - bitter gourd and bottle gourd The experiment was laid out in a modified Latin Square design (LSD): with four treatment plots replicated twice, for each crop.. The control plots were replicated four times for both the crops... Seed was procured from a neighbouring village agro input outlet, to simulate actual farming conditions. Two experiments were conducted: the first around germination, and the second around yield of vegetables. In the germination experiment: all the experimental plots received soil treatment of granular compost mixed with amino acid, humic acid, cow urine, and some nutrients. The four soil treatments, consisted of increasing dosage of powdered organic compost ,inoculated with beneficial microbes, mixed with amino acids, with added micronutrients. Using the statistical test of significance of proportions, all the treatments, and the control plots showed significance. However higher dosage seems to have had relatively lesser germination count. Beyond a certain limit, addition of these biological inputs could be counterproductive for germination of summer cucurbits. A pest attack by red pumpkin beetle (Aulacophora foveicollis), was successfully treated with neem oil extract. In the yield experiment, all the four treatments received organic NPK. The first treatment (T1) added amino acid liquid; the second treatment (T2) added vitamin, amino acid growth promoter and Humic acid; the third treatment (T3) added amino acid liquid, vitamin and amino acid based growth promoter, and the fourth treatment (T4) added amino acid liquid, Humic acid, vitamins and amino acid based growth promoter. One way ANOVA (analysis of variance), did not show significance at 10% level of significance. There was a big range of variation in the yields of treatment plots. However incremental analysis, of treatments, again seemed to reveal that the lowest combination of inputs had the highest yields, for both the crops. The preliminary learning seems to indicate that the agricultural economics "Law of Diminishing returns" seems to hold?

Keywords: Cucurbits; Germination Analysis; Vegetable Yield Analysis; Biofertiliser; Biopesticide; Organic Farming; Sandy Loamy Soil; Terai; Gangetic Plains in Garhwal; Bitter Gourd; Bottle Gourd; Summer Crop.

Introduction

Biological Inputs in Agriculture

The strategic imperative for global agriculture seems to be shifting. The demand of the twenty first century seems to be nutritious and safe food for human consumption. This appears to be different from the 20th century agriculture strategic imperatives: of "food security" and "freedom from hunger". One of the reasons, seem to be the indiscriminate use of agro chemicals for improving agricultural productivy, and controlling pathogens. This "chemical inputs" strategy seems to have created the collateral damage of environmental pollution, of agricultural land and water resources: as well as introducing toxicity in the human food chain. As a response, organic farming seems to be emerging as a powerful tool for meeting the global demand for healthy and safe food for human consumption.

However, due to decades of Government and corporate sponsored agricultural extension, the average farmer seems to have become mentally conditioned to believe, that chemical fertilisers and pesticides are essential for farming of food crops for human consumption. Public policy makers also seem to believe that high use of chemical inputs in agriculture is inevitable to meet the growing demand for food in the world. However niche markets seem to have already emerged for organic food products in economically developed country markets and in Indian metropolitan cities. This research experiment was conducted in this wider social and market environment context.

Organic farming, essentially means that conventional chemical pesticides and fertilisers are eliminated from agronomic decision making. The cultivation is completely dependent on bio-fertilizers, for soil conditioning and crop nutrition, and bio pesticides for controlling pathogens. There are different types of micro organisms which are used in the bio-fertilizers. An essential part, of bio fertiliser manufacturing is the preparation of live bacterial / fungal culture of efficient selected beneficial micro organisms / stains of Nitrogen (N_2) Fixing, Phosphorus ('P') solubilizing bacteria. Other plant beneficial micro-organisms are also used for application to seed, soil and / or composting areas with the objective of increasing the population of such stains (micro organisms) in the rhizosphere. The rhizosphere is that region of the soil and the root which pulls in nutrients through enhanced microbial activity [1]. This increases the availability of nutrients that can be easily assimilated by plants [2]. Bio-fertilizer thus plays a vital role in maintaining long term soil fertility: leading to long term environmental sustainability [3].

The Commonly Known Bio Fertilizers are

Rhizobium

These inoculants are known for their ability to fix atmospheric nitrogen in symbiotic association with plants forming nodules in roots. Rhizobium are however limited by their specificity and only certain legumes are benefited from this symbiosis.

Azotobacter

This bacteria is a free living and non-symbiotic nitrogen fixing organism, that produces substances beneficial for the growth of plants and antibodies that suppress many root pathogens. This bacteria has been found beneficial to a wide array of crops like cereals, millets, vegetables, cotton and sugarcane.

Azospirillum

This bacteria is also a nitrogen-fixing micro organism beneficial for non-leguminous plants. Like *Azotobacter*, the benefits transcend nitrogen enrichment, to include production of growth promoting substances.

Blue Green Algae (BGA) & Azolla

BGA are photosynthetic nitrogen fixers and are free living. The algae adds growth-promoting substances including vitamin B12, which improve the soil's aeration and water holding capacity. It also adds to bio mass when decomposed after the life cycle is completed. Azolla is an aquatic fern found in small and shallow water bodies and in rice fields. The fern has a symbiotic relation with BGA and can help rice or other crops in dual cropping or green manuring of soil.

Phosphate Solubilizing (PSB)/Mobilizing Bio-Fertilizer

Phosphorus, both native in soil and applied in inorganic fertilizers becomes mostly unavailable to crops because of its low levels of mobility and solubility and its tendency to become fixed in soil. The PSB are life forms that can help in improving phosphate uptake of plants. The PSB also has the potential to utilize the abundant deposits of rock

phosphates available across the Indian subcontinent, much of which is not enriched [4].

Application of organic fertilisers has been shown to increase physicochemical properties in the rhizosphere region of the soil. The implication of this finding seems to be that, organic fertilisers are able to sustain the soil fertility for a longer period of time. [5]. In a long-term field trial in which organic and conventional agricultural systems were compared, microbial biomass was higher in soils from organic plots [6-9]. A 10-26% increase in microbial biomass under organic management was reported [10]. It is important to note that the Rhizosphere region is crucial to the soil bacterial community. High inputs of agrichemicals lead to an increase of phosphorus level in the soil and a concomitant reduction of the bacterial diversity. This is one of the environmental risks associated with indiscriminate agrichemical usage [11].

Microbiological Theory of Organic Farming

To appreciate the microbiological theory behind organic farming, it is useful to appreciate the "food web" involved in organic farming. The cycle starts with plant residues, which are consumed by bacteria, mycorrhizae and fungi (collectively termed the microflora). These in turn feed bacterial feeding protozoa, bacterial feeding nematodes, fungal feeding nematodes and protozoa. (collectively termed microfauna). These microfauna feed microarthropods, like Collembola and mites.(collectively termed mesofauna). These mesofauna in turn feed, Earthworms, Macroarthropods, and Enchytraeids (collectively termed macrofauna). All these four categories (microflora, microfauna, mesofauna and macrofauna) perform valuable functions to maintain soil health and productivity – like organic matter turnover, nutrient transfer, soil structure improvement, disease prevention, and pollution degradation. It is important to appreciate, that bioinputs add value to these intricate web of life at these microscopic levels: while chemical inputs actively harm and degrade these processes. This is the main "scientific imperative" for agriculture to switch from chemical inputs to biological inputs. The following figure 1 is a pictorial representation of this delicate web of life in the soil which sustains plants.

Context of the Experiment and Choice of Crop

The experiment was to test the efficacy of the some of the manufactured biofertilisers and bio pesticides, in agricultural biotechnology laboratories. Cucurbits were the crop chosen: a common vegetable crop consumed across the Indian subcontinent. This crop is commonly grown in the summer season- across land irrigated by the canals of the Ganges and Jamuna river (Western Uttar pradesh and Terai plains of Garhwal region of Uttarakhand state). Bottlegourd and bittergourd were the cucurbits chosen.

The location of the experiment in the Ganges irrigated tract of the Terai region of Garhwal, was due to proximity: as also to create an experimental model that could be replicated across the Gangetic plains. The Gangetic plains has a very high density of population: which adds to the social relevance of this experiment.

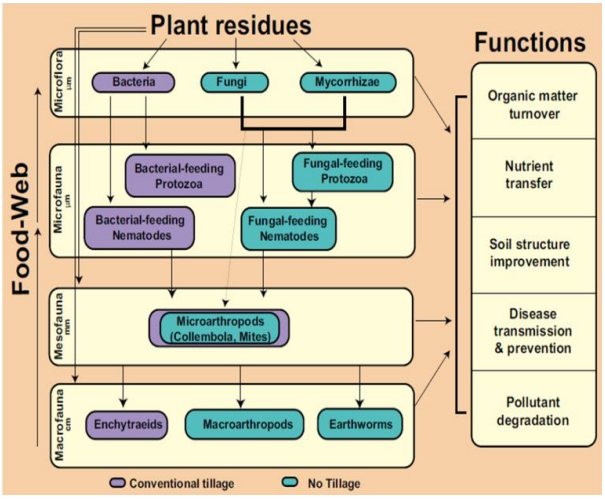

Fig. 1: Microbiological theory of organic farming

Note - The botanical nomenclature of bottle gourd is ***Lagenaria siceraria*** *(synonym Lagenaria vulgaris Ser.)* It is called "Louki" in many North Indian languages and "Sorakkai" in many South Indian languages including Tamil / Malayalam / Telegu. The botanical nomenclature of bitter gourd is ***Momordica charantia***. It is called "Karela" in North Indian languages and "Pavakai" in Tamil / Malayalam.

Research Hypothesis of Agricultural Experiment

There were two research hypothesis which were used to conduct this agricultural experiment: related to seed germination, and to yield of cucurbits. Since there were two crops of summer cucurbits, bittergourd and bottlegourd, there were four research hypothesis statements.

Research Hypothesis Related to Germination

1. H_0: There is no significant difference in germination of bittergourd seeds due to bioinput treatments

H_1: There is a significant difference in germination of bittergourd seeds due to bio inputs treatments.

2. H_0: There is no significant difference in germination of bittergourd seeds due to bioinput treatments

   H_1: There is a significant difference in germination of bittergourd seeds due to bio inputs treatments.

Research Hypothesis Related to Yield of Cucurbits

1. H_0: There is no significant difference in yield of bittergourd due to bioinput treatments.

   H_1: There is a significant difference in yield of bittergourd due to bio inputs treatments.

2. H_0: There is no significant difference in yield of bittergourd due to bioinput treatments.

   H_1: There is a significant difference in yield of bittergourd due to bio inputs treatments.

Time and Place of the Experiment

The experiment took place in an agricultural plot of land, near the Patanjali Bioresearch Institute, within the Padartha campus of the Patanjali Food Park: which lies near the Ganges river in, Hardwar district (Garhwal region), Uttarakhand state of India. The experiment was concurrent with the summer agriculture season of Hardwar district, for the financial year 2013-14. Sowing took place on 15th April 2013. Harvesting took place from 12th June 2013 to 8th August 2013.

Design of the Experiment

The experimental design had one control, four treatments (termed as T1, T2, T3, T4) and two crops - bitter gourd and bottle gourd. Each treatment was replicated twice. Thus there were a total of 18 plots: 16 experimental plots and 2 control plots. (That is -4 treatments x two crops x two replications =16 experimental plots + One control plot for Bottle gourd + one control plot for Bitter gourd). The control plots had no treatment. The sixteen experimental plots were distributed as per a Latin Square design- in sixteen plots, laid in four rows. The two control plots were laid alongside and parallel to the experimental plots.

The size of the entire experimental plot was around 64 metres (length) by 36 metres (width) . The plot was oriented north to south. Each column was around 6 metres in width, allowing for six columns to be laid as experimental plots. The first two columns were entirely for the control – one for bitter gourd (on the extreme western end) and the next for bottle gourd. The remaining four columns were divided into four plots each, creating sixteen experimental plots. These sixteen plots were allotted to the four treatments and the two crops. This design of the agricultural experiment, could perhaps be described probably as a rough (modified) Latin Square design. The following is a depiction of the agricultural plots, and the allotment of plots to treatments and crops.

The total extant of the land under the agricultural experiment, was around 2,304 square metres. The land was ploughed and harrowed using manual labour, on 14th April 2013. Six columns were laid - with a 3 metres gap kept between each row. Small earthen bunds, (of around 6 centimetres height and 20 centimetres breadth) were raised to demarcate each row. Each row was around 1.3 metres wide. The distance between the inner parts of each row (the functional area where the plants were to be grown) was around 1.1 metres.

Table 1: Microbiological theory of organic farming

64 metres	Control plot Bitter gourd	Control plot Bottle gourd	Treatment 3 Bitter gourd Treatment 1 Bitter gourd Treatment 4 Bottle gourd Treatment 2 Bottlegourd	Treatment Bottle gourd 1 Treatment Bitter gourd 2 Treatment Bottle gourd 3 Treatment Bitter gourd 4	Treatment 2 Bottle gourd Treatment 4 Bottle gourd Treatment 1 Bitter gourd Treatment 3 Bitter gourd	Treatment Bitter gourd 4 Treatment Bottle gourd 3 Treatment Bitter gourd 2 Treatment Bottle gourd 1	

36 metres

The following approximately depicts the layout of the rows-

inner area for planting	bund	space between rows		bund		inner area for planting	
1.1 metres	0.20 mt.	3.0 metres		0.20		1.1 metres	

Soil Sampling

Using a zig zag method, the top soil of six inches were sampled at five spots. (Termed as S1, S2, S3, S4 and S5). Two samples were a mixture of all the five samples (termed as S6 and S7). The samples were tested at the Uttarakhand State Government Bahadrabad Soil Testing Laboratory (Near Haridwar). The test results data, is as shown in Table 2, (Units in terms of milligrams per kilo of soil)

The soil could be termed nearly neutral in terms of pH. The composition of chemical elements seemed to reveal a medium amount of Phosphorus, Potassium, Carbon, Sulphur, Zinc and a relatively higher amount of Iron, Copper and Manganese.

In terms of relative variance, the experimental plots could be perhaps termed to have very low variation in the parameters of pH, Sulphur (S), Copper (Cu) and Manganese (Mn). The relative variance of Carbon (C), Zinc (Zn), and Iron (Fe), seemed to be medium? The relative variation of Phosphorus (P) and Potassium (K) seemed to be on the higher side. This could be due to previous applications?

Table 2: Soil sampling of experimental plots

Elements	S1	S2	S3	S4	S5	S 6(Mix)	S7 (mix)
pH	7.4	7.2	7.2	7.7	7.8	**7.3**	**7.6**
Symbol							
P	13.5 (L)	27.0 (M)	36.0 (M)	156.8 (M)	27.0 (M)	13.5 (L)	36.0 (M)
K	112 (M)	190.4 (M)	134.4 (M)	31.5 (M)	112.0 (M)	168 (M)	212.8 (M)
C	0.79 (M)	0.720 (M)	0.540(M)	1.02 (H)	0.630 (M)	0.735 (M)	0.675 (M)
S						8.8 (M)	8.9 (M)
Zn						0.419 (M)	0.613 (M)
Fe						11.13 (H)	7.43 (M)
Cu						0.796 (H)	0.840 (H)
Mn						3.317 (H)	3.119 (H)

Table 3: A simple analysis of the soil sample data

Parameter	Number of samples (n)	Mean	Standard deviation	Coefficient of Variation	Remarks
pH	7	7.46	0.22	2.94	Neutral
Phosphorus (P)	7	44.25	50.48	114.07	Medium
Potassium (K)	7	137.3	60.47	44.04	Medium
Carbon (C)	7	0.73	0.15	20.54	Medium
Sulfur (S)	2	8.85	0.07	0.79	Medium
Zinc (Zn)	2	0.516	0.13	25.19	Medium
Iron (Fe)	2	9.28	2.61	28.12	Medium
Copper (Cu)	2	0.818	0.03	3.66	High
Manganese (Mn)	2	3.218	0.14	4.35	High

Choice of Seed, Treatment and Sowing

To simulate the farming conditions of the district, seed was purchased from a local agri inputs shop in the vicinity. The details of the seed as per the product label is as under –

1. Bottle gourd, F- 1 Roza variety, (truthful label) , (50 grams net weight packet). 160 seed were used which weight came to 24.07 grams.
2. Bitter gourd, F-1 Aanchal Aman, (25 grams net weight packet). 160 seed was used.

The seed, which has a hard coat, was soaked overnight in water, before sowing. The sowing was done on 15th April 2013: immediately after application of the first treatment of the "enriched" organic manure to the soil. As per local, traditional cultivation practise, the seeds were planted in sets of four (locally termed ***thepla).*** Each experimental treatment plot had five sets (theplas), or twenty seed planted (5 seed x 4 theplas).

There were two replications per treatment,: giving a total of 16 treatment plots: eight for bottlegourd and eight for bittergourd.

The control plots each had twenty sets (theplas) planted, which resulted in 80 seeds being sown, for each control plot. This meant that control plots (no treatment) had each four experimental plots each for bottle gourd and bitter gourd.

Soil Treatment

The treatment for the plots started with the soil treatment. The main soil treatment given were two organic manure products manufactured (termed colloquially Khad and Jaivik). The treatments were given on 15th April 2013. Both Khad and Jaivik are manufactured from bio compost: whose origin was

the waste of the food processing units of the Padartha food park. Khad is an elite combination of this organic manure: mixed with humic acid, amino acid, cow urine with some nutrients. The product is in granular form.

Jaivik is this organic manure inoculated with some beneficial microbes like Azotobacter Phospho Solubilising Bacteria (PSB), Potash Mobilising Bacteria (KMP), Pseudomonas, Trichoderma, - and mixed with amino acid, and some micro nutrients like Zinc (Zn), Iron (Fe), Magnesium (Mg), Manganese (Mn) and Boron (Bo). The product is in powdered form.

Each treatment plot had four demarcated spots for sowing the seeds. The demarcated spots for seeding, were given the following dosage, through manual mixing of the manufactured biofertiliser (khad / jaivik), with the top soil. (top soil of three inches dug and mixed). Table 4 details the treatments given. The control plots received no soil treatment.

Germination Count and Analysis

PBRI scientists started the germination count, after the fifth day of sowing. These observations continued for three weeks after seeding. The following table (Table 5) is the final germination count, taken three weeks after seeding.

The data can be represented to allow more meaningful analysis: by analysing each crop separately, with Control also taken as a treatment. Only germination percentage is to be analysed, which data is reproduced from the earlier data.

A graphical representation of the germination, separately for each crop is in Figure 2 and 3.

Table 4: Soil treatment for experimental plots

Treatment	Granular organic compost (Khad)	Powdered organic compost (Jaivik)
T1	500 grams	1 kilo
T2	500 grams	1.5 kilo
T3	500 grams	2.0 kilo
T4	500 grams	2.5 kilo

Table 5: Germination count

	Germination Count Segregated by Crop and Treatment					
	Bottle Gourd			Bitter Gourd		
Treatment	Total germinated	Total sown	%age germinated	Total germinated	Total sown	%age germinated
T1	37	40	92.50%	32	40	80.00%
T2	36	40	90.00%	32	40	80.00%
T3	32	40	80.00%	34	40	85.00%
T4	35	40	87.50%	25	40	62.50%
TOTAL	**140**	**160**	**87.50%**	**123**	**160**	**76.87%**
C (Control)	69	80	86.25%	58	80	72.50%

Table 6: Germination percentage

Treatment	Bottle gourd **%age germinated**	Bitter gourd **%age germinated**
Control(C)	86.25%	72.50%
T1	92.50%	80.00%
T2	90.00%	80.00%
T3	80.00%	85.00%
T4	87.50%	62.50%

In the case of bottle gourd, treatment three had less germination then the control, and treatment four, marginally more. In the case of bitter gourd, clearly treatment four had less germination then the control. A statistical test of "significance of proportions" was applied at 5% level and 1% level of significance, for both the crops [12]. The statistical analysis are in Table 7 and Table 8.

The results of the test of significance is that all the results seem to be significant, calculated at 5% and 1% level of significance?. This seems to show that the differences between the control and the treatments, are NOT that significant, to make a conclusion that treatments have a better germination percentage then the control.

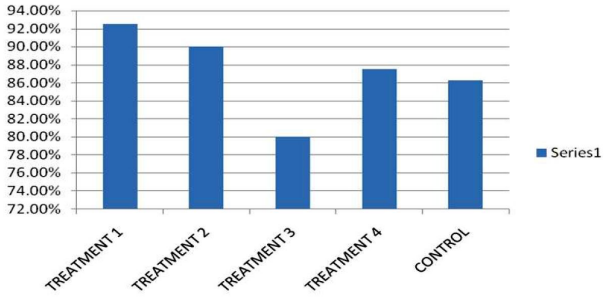

Fig. 2: Germination percentage of Bottlegourds

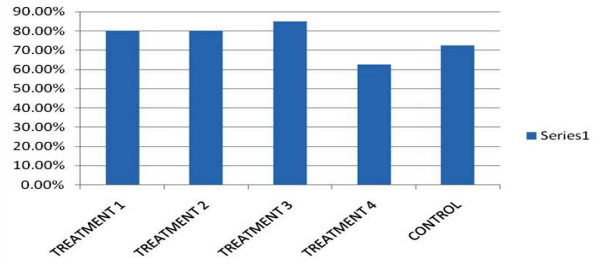

Fig. 3: Bitter gourd germination percentage

The results of the test of significance for bottle gourd is as under –

Table 7: Testing of significance of proportions (bottelgourd)

Treatment	Seed planted (n)	Seed germinated	Proportion germinated (p)	Proportion not germinated (q =1-p)	Standard error = Square root of pq/n
Control (C)	80	69	0.86	0.14	0.038794
T1	40	37	0.92	0.08	0.042895
T2	40	36	0.90	0.1	0.047434
T3	40	32	0.80	0.2	0.063246
T4	40	35	0.87	0.13	0.053174

Test of significance at 5% level

Treatment	1.96 S.E.	Proportion germinated (p)	p +/-1.96 s.e.	Significance range	Significant
Control (C)	0.076037	0.86	0.784-0.936	63-75	YES
T1	0.084075	0.92	0.836-1.000	33-40	YES
T2	0.092971	0.90	0.807-0.993	32-40	YES
T3	0.123961	0.80	0.676-0.924	27-37	YES
T4	0.104222	0.87	0.766-0.974	31-39	YES

Test of significance at 1% level

Treatment	2.58 S.E.	Proportion germinated (p)	p +/- 2.58 s.e.	Significance range	Significant
Control (C)	0.100089	0.86	0.76-0.96	61-77	YES
T1	0.11067	0.92	0.809-1.000	32-40	YES
T2	0.12238	0.90	0.778-1.000	31-40	YES
T3	0.163174	0.80	0.637-0.963	25-38	YES
T4	0.13719	0.87	0.733-1.000	29-40	YES

The results of the test of significance for bitter gourd is as under –

Table 8: Testing of Significance of Proportions (Bitter gourd)

CROP	Seed planted (n)	Seed germinated	Proportion germinated (p)	Proportion not germinated (q =1-p)	Standard error = Square root of pq/n
Control (C)	80	58	0.725	0.275	0.049922
T1	40	32	0.800	0.200	0.063246
T2	40	32	0.800	0.200	0.063246
T3	40	34	0.850	0.150	0.056458
T4	40	25	0.625	0.375	0.076547

Test of significance at 5% level

Treatment	1.96 S.E.	Proportion germinated (p)	p +/-1.96 s.e.	Significance range	Significant
Control (C))	0.097847	0.73	0.627-0.823	50-66	YES
T1	0.123961	0.80	0.676-0.924	27-36	YES
T2	0.123961	0.80	0.676-0.924	27-36	YES
T3	0.110658	0.85	0.739-0.961	30-38	YES
T4	0.150031	0.63	0.475-0.775	19-31	YES

Test of significance at 1% level

Table 8: (continued) Testing of Significance of Proportions (Bitter gourd)

Treatment	2.58 S.E.	Proportion germinated (p)	p +/- 2.58 s.e.	Significance range	Significant
Control (C)	0.128798	0.73	0.596-0.853	48-68	YES
T1	0.163174	0.80	0.637-0.963	25-39	YES
T2	0.163174	0.80	0.637-0.963	25-39	YES
T3	0.145662	0.85	0.704-0.995	28-40	YES
T4	0.19749	0.63	0.428-0.822	17-33	YES

However, the germination results for Treatment.(3) for bitter gourd, and Treatment (4) for bittergourd is less then control? Taken together, Treatment (1) and (2) seem to perform better then Treatment (3) and (4). It can perhaps be inferred, that beyond a certain point, application of biofertilisers for germination could be counterproductive.?

With the limited data available from this study, it appears; that these organic composted biofertilisers, inoculated with beneficial microbes with amino acids and nutrients added: should be applied in lower dosages for cucurbits. The exact calibration of inputs needs to be assessed with reference to nutrient conditions of the soil: and the vigour of the seed?

Crop Management

Irrigation

A ninety feet deep bore well with five horse power irrigation engine, and a four inch diameter outlet pipe, existed next to the summer cucurbits experimental plots. Two irrigations were done for the summer on the following days -

- *24 April 2013*- for 180 minutes, from 11.00 to 14.00 hours. (8 days after sowing)
- *10 May 2013*- for 180 minutes, from 17.00 to 20.00 hours. (25 days after sowing and 9 days after end of germination).

There was heavy rainfall in the region, since the first week of June. Due to copious available of rain water, irrigation was discontinued.

Pesticide Application

There was a pest attack immediately after germination. Informal examination by PBRI scientists seemed to suggest that pest was the red pumpkin beetle, (entomological identification - *Aulacophora foveicollis (Lucas)*. A photographic image of the beetle is as below.

This pathogen was treated with an in house neem oil based liquid pesticide. 15 ml of the neem oil solution was mixed with ten litres of water, and sprayed on all the experimental plot plants. This spraying was done on 1st May 2013. Approximately 1015 millilitres of water was sprayed on 163 plants, giving an approximated application of 1015 / 163 = 6.22 millilitres per plant.

This treatment eliminated the pathogen from the experimental plots: which seems to show the efficacy of neem oil for pest control: in cucurbuts specifically and perhaps vegetable crops in general?

Fig. 4: Aulacophora foveicollis (Lucas)

Intermediate Application of Fertilisers and Growth Promoters to All Treatment Plots

After completion of one month after sowing, intermediate application of fertilizers was done.

Soil treatment around the root zone was done for all the plants in the treatment plots.

This soil treatment involved application of a mixture of the following -

- 250 ml of pseudomonas and trichoderma solution, mixed in ten liters of water, and then mixed in fifty kilos of bio inoculated and nutritionally enhanced organic manure.
- 250 ml of Azotobacter solution mixed in ten liters of water, and then mixed in in fifty kilos of of bio inoculated and nutritionally enhanced organic manure.
- 250 ml of Phosphate solubilizing Bacteria (PSB) solution, mixed in ten litres of water, and then mixed in in fifty kilos of of bio inoculated and nutritionally enhanced organic manure.

- 250 ml of Potash mobilizing bacteria solution (KMB) mixed in ten litres of water, and then mixed in fifty kilos of of bio inoculated and nutritionally enhanced organic manure.

The four batches of fifty kilo organic manure, were then thoroughly remixed.

This mixture was spread equally around the root zone (within six inch radius from the plants) of all the 263 experimental plants. Each plant would have received around 1.23 kilos (200kilos / 163 plants) of this bioproduct mixture.

Application of Treatment

Treatment of the experimental plots started around three weeks (22 days to be exact) after sowing.

The Table 9 are the details the various treatments for the experimental plots: with classification of specific bioinputs.

Flowering started a few days after the treatment was administered. Fruiting started from 6th June 2013 (51 days after sowing): or 19 days after this treatment. Fruiting continued till 8th August 2013: 130 days after sowing.

Yield Observations

The agricultural field assistant started collection of the bitter gourd from 12th June to 6th August, and bottlegourd from 14th June to 8th August. The vegetables were brought to the PBRI laboratory and individually weighed. The number of vegetables harvested, with the weight of each vegetable was individually recorded on an observation sheet. This observation sheets had data segregated by actual plot from which the harvest was made. The Table 10 and Table 11 is the yield data, presented with a simple analysis from 6th June till 8th August 2013.

Table 9: Treatment of experimental plots after germination

Treatment	Amino acid Liquid	Organic NPK	Vitamin	Amino acid growth promoter	Humic acid
T1	25 ml	15 ml	No	No	No
T2	No	15 ml	1 ml	1 ml	25 ml
T3	25 ml	15 ml	1 ml	1 ml	No
T4	5 ml	15 ml	1 ml	1 ml	25 ml

Table 10: Yield of bottlegourd

Crop and experimental plot	Seeds planted	Seeds germinated	Total weight of vegetables (In Kilos, grams)	Total number of vegetables	Total weight /number of seeds germinated (In Kilos, grams)	Total number /number of seeds germinated	Average weight /vegetable (In gm/Kg)
T1	40	37	93,670	147	2531.62	3.97	637.21
T2	40	36	122,927	204	3414.64	5.67	602.58
T3	40	32	45,960	81	1436.25	2.53	567.41
T4	40	35	55,660	97	1590.29	2.77	573.81
C (Control)	80	69	97,580	164	1414.20	2.38	595.00

Table 11: Yield of bittergourd

Crop and experimental plot	Seeds planted	Seeds germinated	Total weight of vegetables (In Kilos, grams)	Total number of vegetables	Total weight /number of seeds germinated (In Kilos, grams)	Total number /number of seeds germinated	Average weight /vegetable (In gm/Kg)
T1	40	32	15,252	355	476.63	11.09	42.96
T2	40	32	13,283	306	415.09	9.56	43.41
T3	40	34	8,872	201	260.94	5.91	44.14
T4	40	25	10,828	291	433.12	11.64	37.21
C (Control)	80	58	6,313	184	108.84	3.17	34.31

Analysis of Variance (ANOVA)

A one way test of Analysis of Variance (ANOVA) was used for appreciating the significance of the yield, with various treatments [13]. The data was originally sorted by treatments and yield.

The ANOVA calculations have been presented separately for bottle gourd,(Table 12 and 13) and bitter gourd (Table 14 and 15). The yield data sorted by treatment, for bottlegourd is presented below in Table 12.

The One Way Analysis of Variance (ANOVA) for bottlegourd is as under –

Table 12: Bottle Gourd – Yield in Grams, Sorted by Treatments

Treatment	Plot 1	Plot 2	Total
Treatment 1(T1)	459,200	48,900	508,100
Treatment 2(T2)	109,820	12,637	122,457
Treatment 3(T3)	261,600	19,800	281,400
Treatment 4 (T4)	28,700	28,410	57,110
Control(C) (4 plots)			105,346
TOTAL			1,074,413

Table 13: Analysis of Variance for Bottle Gourds

	Treatment 1 (T1)	Treatment 2 (T2)	Treatment 3 (T3)	Treatment 4 (T4)	Control (C) (4 plots)	TOTAL
Plot 1	459,200	109,820	261,600	28,700		
Plot 2	48,900	12,637	19,800	28,410		
Plot 3						
Plot 4						
Total yield of treatments	508,100	122,457	281,400	57,110	105,346	1,074,413
Number of Observations (n)	2	2	2	2	4	12
Mean Yield ($\bar{x}$)	254,050.00	61,228.50	140,700.00	28,555.00	26,336.50	89,534.42
Sum of squares	213,255,850,000	12,220,126,169	68,826,600,000	1,630,818,100	11,097,779,716	**307,031,173,985**
Correction Factor	$(1074,413)^2$ / 12	=1,154,363,294,569 / 12		**=96,196,941,214**		
Total Sum of Squares	= Sum of squares - Correction Factor			**=210,834,232,771**		
Sum of squares between samples	= (Sum of Each column total / n) - CF			=(180,578,293,354) - 96,196,941,214		**84,381,352,140**
Sum of squares within samples	= Total Sum of Squares -Sum of squares between samples			=(210,834,232,771) - (84,381,352,140)		**126,452,880,631**

Source of variation	Sum of Squares	Degrees of Freedom	Mean Sum of Squares
Between samples	84,381,352,140	5-1=4	**21,095,338,035**
Within samples	126,452,880,631	12-5=7	**18,064,697,233**
Calculated F Value	= (21,095,338,035) / (18,064,697,233)		**1.168**

Table value of F, at 10% level of significance, for (4,7) degrees of freedom is 2.96. Since Calculated value is less then Table value, Null Hypothesis is accepted. There is no significant difference in yields due to treatments for bottle gourds

The One Way Analysis of Variance (Anova) for Bittergourd is as under-

Table 14: Bitter Gourd – Yield in grams, sorted by treatments

Treatment	Plot 1	Plot 2	Total
Treatment 1(T1)	7,474	7,265	**14,739**
Treatment 2(T2)	8,020	6,348	**14,368**
Treatment 3(T3)	2,946	6,690	**9,636**
Treatment 4 (T4)	8,838	3,007	**11,845**
Control(C) (4 plots)			**7,529**
TOTAL			**58117**

Table 15: Analysis of variance for bitter gourds: (Meaurement unit = Kilos, grams)

Yield Observations - Bitter gourd (in kilos and grams)						
	Treatment 1 (T1)	**Treatment 2 (T2)**	**Treatment 3 (T3)**	**Treatment 4 (T4)**	**Control(C) (4 plots)**	**Total**
Plot 1	7,474	8,020	2,946	8,838		
Plot 2	7,265	6,348	6,690	3,007		
Plot 3						
Plot 4						
Total yield of treatments	14,739	14,368	9,636	11,845	7,529	58,117
Number of Observations (n)	2	2	2	2	4	12
Mean Yield ($\bar{x}$)	7,369.50	7,184.00	4,818.00	5,922.50	1,882.25	4,843.08
Sum of squares	108,640,901	104,617,504	53,435,016	87,152,293	56,685,841	410,531,555

Correction Factor	$(58,117)^2 / 12$ =3377,585,689 / 12	**=281,465,474**	
Total Sum of Squares	= Sum of squares - Correction Factor	=129,066,081	
Sum of squares between samples	=(Sum of Each column total)^2 / n - CF	=342,588,493 - 281,465,474	**=61,123,019**
Sum of squares within samples	= Total Sum of Squares -Sum of squares between samples	= 129,066,081 - 61,123,019	**=67,943,062**

Source of variation	**Sum of Squares**	**Degrees of Freedom**	**Mean Sum of Squares**
Between samples	61,123,019	5-1=4	15,280,755
Within samples	67,943,062	12-5=7	9,706,152
Calculated F Value	=15,280,755 / 9,706,152		**1.574**

Table value of F, at 10% level of significance, for (4,7) degrees of freedom is 2.96. Since calculated value is less then Table value, Null Hypothesis is accepted. There is no significant difference in yields due to treatments for bitter gourds.

Table 16: Incremental yield over control

Mean yield	**Bottlegourd**	**%age increase over control**	**Bittergourd**	**%age increase over control**	**Remarks**
Control	26,336		1,882		
Treatment 1	254,050	964.64%	7,369	391.55%	Highest increase
Treatment 2	61,228	232.48%	7,184	381.72%	
Treatment 3	140,770	534.51%	4,818	256.00%	Lowest increase for bittergourd
Treatment 4	28,555	108.42%	5,922	314.66%	Lowest increase for bottlegourd

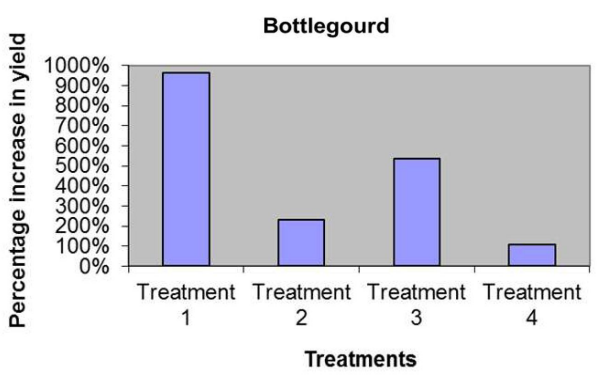

Fig. 5: Incremental Yields over Control -Bottlegourd

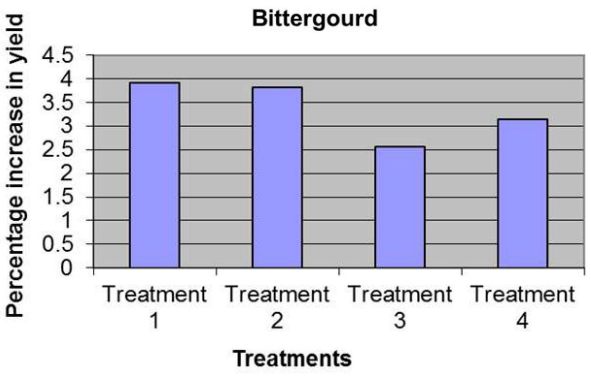

Fig. 6: Incremental yield over control -bittergourd

Incremental Analysis of Treatment Yield over Control

The inference from the ANOVA analysis, that there is no significant difference due to treatments, does not seem to do justice, to obvious increases in yield from some treatments. There seems to exist a wide variance in the yield: – specifically, Treatment 4 for bottlegourd and Treatment 3 for bittergourd; which could have, probably skewed the results. However Treatment 1 had uniformly very high yield across both the crops. It would be useful to do a simple calculation of yield benchmarked to control in terms of percentage increase. Table 16 is the incremental analysis with the graphical representation in Figures 5 and 6.

Treatment 1, seems to have recorded the highest yield both for bottlegourd and for bittergourd. Similarly Treatment 4, seems to have recorded very low yield for bottlegourd, and a lower yield for bittergourd. It is useful to appreciate that Treatment 1, had the least combination of inputs (15 ml of Organic NPK and 25 ml of Amino Acid liquid): while Treatment 4 had the highest combination of inputs (15 ml of organic NPK, with 5 ml of amino acid liquid, 1 ml of vitamin, 1 ml of Amino acid growth promoter, and 25 ml of Humic acid. "Less seems to be more": as far as biological inputs are concerned for agriculture?

Conclusion

Both the germination percentage and the yield data seem to indicate that the treatment with the lowest dosage seemed to have had a better performance then the treatment with the highest dosage? This seems to be probably in conformity with an old law, of agricultural economics – the law of diminishing marginal returns?

This law states that "We will get less and less extra output when we add additional doses of an input while holding other inputs fixed." "In other words, the marginal product of each unit of input will decline as the amount of that input increases, holding all other inputs constant"[14].

As a recommendation, one conclusion could be that that basal dosage: of granular compost (Khad) with humic acid, amino acid, cow urine with some nutrients and powdered compost (Jaivik) enriched with beneficial microbes, micronutrients & amino Acid: should be calibrated. An approximate dosage could be 500 grams of granular compost and between 1to1.5 kg of powdered compost: for a plot size around 16 square metres: which can be planted with five sets (theplas) of twenty seed.

The possible conclusion, is that calibration of biological inputs is required, for increasing germination and yield of summer cucurbits in the loamy sandy soil of the Gangetic plains in Garhwal. However this being a pilot experiment, these results needs to be treated with caution. The experiment needs to be replicated, with the same seed, crops and land / water conditions: to establish definitive causal relationships; between biological inputs and increasing germination and yield.

Acknowledgments

The authors gratefully acknowledge the support received from Shri Acharya Balkrishna (Vice Chancellor, University of Patanjali) for carrying out this research work. We also gratefully acknowledge PBRI agricultural microbiologist, Dr.(Smt) Sadhana Singh, for her effective supervision of field agricultural operations. Also acknowledge with gratitude, field staff Mr. Bhupendra Kumar, Mr. Ankit Kumar, Mr. Lokesh Kumar, Mr. Pankaj Kumar and the various technical & non-technical staff of PBRI, Patanjali Ayurved Limited and Patanjali Food & Herbal Park for assistance during different stages of field trial studies.

References

1. Hiltner, L. Uberneuererfahrungen undprobleme auf demgabiet der bodenbak teriologie and unterbesonderer berucksichtingung dergrun-dungung und brache. Arb.Dtsch. Landwirt. Ges., 1904; 98:59-78.
2. Venkatashwarlu B. Role of bio-fertilizers in organic farming: Organic farming in rain fed agriculture: Central institute for dry land agriculture*, Hyderabad*, 2008.p.85-95.
3. Mishra D.J.1, Singh Rajvir2, Mishra U.K.3 and Shahi Sudhir Kumar4, Role of Bio-Fertilizer in Organic Agriculture: A Review, Research Journal of Recent Sciences, 2013; 2(ISC-2012):39-41.
4. Promoting Bio-fertilizers in Indian Agriculture, Nilabja Ghosh, Institute of Economic Growth, University Enclave, Delhi 110007, India.
5. Bibhuti B. Das and M.S. Dkhar. Rhizosphere Microbial Populations and Physico Chemical Properties as Affected by Organic and Inorganic Farming Practices, American-Eurasian J. Agric. & Environ. Sci., 2011; 10(2):140-150.
6. Gelsomino, C.C., A. Ambrosoli, R. Minati and P. Ruggiero. Functional and molecular responses of soil microbial communities under differing soil management practice. Soil Biol. Biochem., 2004; 36: 1873-1883. Soil Use Manage, 2004; 18:274-283.

7. Tu, C., J.B. Ristaino and S. Hu. Soil microbial biomass and activity in organic tomato farming systems: effects of organic inputs and surface mulching. Soil Biol. Biochem., 2005; 37:1-9.
8. Hu, S., D.C. Coleman, C.R. Carroll, P.F. Hendrix and M.H. Beare. Labile soil carbon pools in subtropical forest and agricultural ecosystems as influenced by management practices and vegetation types. Agric. Ecosys. Environ., 1997; 65:69-78.
9. Liu, B., C. Tu, S. Hu, M.L. Gumpertz and J.B. Ristaino. Longterm effects of organic and synthetic soils fertility amendments on soil microbial communities and the development of southern blight. Soil Biol. Biochem., 2007; 39:2302-2316.
10. Fraser, P.M., R.J. Haynes and P.H. Williams. Effects of pasture improvement and intensive cultivation on microbial biomass, enzyme activities and composition and size of earthworm population. Biol. Fertil. Soils, 1994; 17:185-190.
11. H. Tan, M. Barret, O. Rice, D.N. Dowling, J. Burke, J.P. Morrissey, F. O'Gara, Long-term agrichemical use leads to alterations in bacterial community diversity, Plant Soil Environ. 2012; 58(10): 452–458.
12. Srivastava, U.K, Shenoy, G.V.,Sharma S.C. Quantitative techniques for managerial decisions. (2002 edition) p.229. 11. New Age International (P) ltd. New Delhi.
13. Rao K.Viswesara.Biostatistics – a manual of statistical methods for use in Health, Nutrition and Anthropology. (2009 edition) 2009.p.226-259. Jaypee Brothers Medical Publishers. New Delhi.
14. Samuelson Paul and William Nordhaus, Economics, - 18th edition. 2005. p.09. 11. Tata McGraw-Hill Publishers, New Delhi.