ECONOMIC IMPACT OF MICROBIAL INOCULANTS ON VEGETABLE PRODUCTION IN THIRUVANANTHAPURAM DISTRICT

by

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(2014-11-232)

THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"Economic impact of microbial inoculants on vegetable production in Thiruvananthapuram district"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Place: Vellayani

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Certified that this thesis, entitled **"Economic impact of microbial inoculants on vegetable production in Thiruvananthapuram district"** is a record of research work done independently by **Mr. Jitendra Ajagol** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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Darkness never found me or my path and I know why....The Lord Basava is my almighty, I shall not want......

Jitendra Ajagol

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LIST OF ABBREVIATIONS

APEDA	Agriculture and Processed Food Products Export Development
B:C ratio	Benefit Cost ratio
CSO	Central Statistical Organization
et al.	Co- workers/ co- authors
Fig.	Figure
GOI	Government of India
GOK	Government of Kerala
ha	Hectare
ha^{-1}	Per Hectare
i.e.	that is
KAU	Kerala Agricultural University
Kg	Kilogram
KVK	Krishi Vignana Kendra
MFC	Marginal Factor Cost
MI	Microbial Inoculants
MVP	Marginal Value Product
PGPR	Plant Growth Promoting Rhizobacteria
PSB	Phosphorous Solubilizing Bacteria
R^2	Coefficient of Determination
Rs.	Rupees
Viz.	Namely

LIST OF SYMBOLS

%	Per cent
^{0}	Degree
@	At the rate of
&	And
₹	Indian rupee(s)

Introduction

1. INTRODUCTION

Agriculture, with its allied sectors, is unquestionably the largest livelihood provider in India, more so in the vast rural areas. It also contributes a significant figure to the Gross Domestic Product (GDP). Sustainable agriculture, in terms of food security, rural employment, and environmentally sustainable technologies are essential for holistic rural development. India's diverse climate ensures availability of all varieties of fresh fruits & vegetables. It ranks second in fruits and vegetables production in the world, after China. The area under cultivation of fruits stood at 6.99 million hectares while vegetables were cultivated at 9.61 million hectares. As per National Horticulture Database published by National Horticulture Board, during 2014-15, India produced 86.27 million metric tonnes of fruits and 167.18 million metric tonnes of vegetables. (APEDA, 2015). India is the largest producer of okra among vegetables and ranks second in production of potato, onion, cauliflower, brinjal and cabbage.

Kerala state is blessed with nine agro-climatic regions suitable for growing variety of crops including fruits and vegetables throughout the year. The total cropped area is 26,24,624 ha during the year 2014-15. The net area under cultivation during the year 2014-15 was 20,42,881 ha, which occupies 52.57% of the total area in the State. The area under vegetable cultivation in Kerala during 2014-15 is 44,360 ha. It represents 4.5% area of total food crops (GOK, 2016). The major vegetables cultivated in the state are drumstick, amaranthus, bitter gourd, yard long bean, snake gourd, ladies finger, brinjal, green chillies, bottle gourd, little gourd, ash gourd, pumpkin and cucumber.

Yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt) is one of the most popular and cosmopolitan vegetable crop grown in Kerala. The traditional vernaculars *viz.*, Achingapayar, Kurutholapayar, Vallipayar, Pathinettumaniyan, Asparagus bean and Chinese long bean, used to refer yard long bean indicate that, Kerala is the land of this crop. It is a rich and inexpensive source of vegetable protein and it enriches soil fertility by fixing atmospheric nitrogen. Because of its quick growth habit it has become an essential component of sustainable agriculture in marginal lands of tropics.

Amaranthus (*Amaranthus sps.*) the most popular leafy vegetable of south India is widely cultivated in Kerala. There are approximately 60 species, all are annuals. Amaranthus is a healthy leafy vegetable that is widely consumed all over India. Both the leaves and the seeds of amaranth are valuable in terms of human health. The root also consumed as a root vegetable and has a rich mixture of minerals and nutrients. It can be grown throughout the year. It is an excellent source of bioavailable iron, vitamin 'A' and protein.

Microbial inoculants (MI) are agricultural amendments that use beneficial endophytes (microbes) to promote plant growth. Many of the microbes have a symbiotic relationship with the target crops where both parties benefit (mutualism). Microbial inoculants offer a biological rescue system capable of mobilizing nutrients from non-usable form to usable form and make them available to the plants. The production of bio-inoculants in India is reported as 20,040.35 tons in 2009-10 and Kerala is the third major producer with a share less than 10 per cent (Devi 2014). During 2014-15 the production of MI in the State was 167 metric tons (GOK, 2016). The MI used in the study area are *Pseudomonas, Trichoderma, Rhizobium, Beauveria,* PGPR (Plant growth promoting Rizobacteria) and PSB (Phosphorous Solubilizing Bacteria).

Pseudomonas is a bio-control bacterium that protects the roots of plant species against parasitic fungi such as *Fusarium* and *Pythium*, as well as some phytophagous nematodes.

Trichoderma is a versatile antagonistic fungus. It is used for seed and soil treatment for the suppression of various diseases caused by fungal pathogens. It is found naturally in soil and is effective as a seed dressing in the control of seed and soil-borne diseases.

Rhizobium is the root nodule bacteria which influence the crop growth, yield, and nutrient uptake by different mechanisms. It fixes the atmospheric nitrogen, help in promoting free-living nitrogen-fixing bacteria, increase supply of other nutrients such as, phosphorus and iron, produce plant hormones and controls bacterial and fungal diseases.

Plant growth-promoting rhizobacteria (PGPR) is the soil bacteria that colonize the roots of plants and enhance plant growth. It also controls the plant diseases that are caused by other bacteria and fungi.

Phosphate solubilizing bacteria (PSB) are beneficial bacteria capable of solubilizing inorganic phosphorus from insoluble compounds to soluble form.

Beauveria bassiana is a soil borne entomopathogenic fungus acts as a parasite on various arthropod species, causing white muscardine disease. It is also used as a biological insecticide to control the number of pests such as termites, thrips, whiteflies, aphids and different beetles.

The awareness among the consumers on the deleterious effects of pesticides has been increased recently. Hence, there is a high demand for organically cultivated food produces. This has necessitated the Government to encourage organic farming to ensure poison-free food at affordable price. The Government of Kerala is making effort in cultivating vegetables organically, witnessing the negative effects of chemical fertilizers and pesticides on health and environment. During the budget 2016, 74.34 crores rupees have been earmarked for popularizing organic cultivation.

With a view to sustain the soil health and to thereby maintain the productivity levels of agricultural soils, more emphasis is now being paid on integration of organic inputs with MI, which are the source of nutrients and plant protecting bio agents. Use of such organic materials not only increase the nutrient status of the agricultural soils but also help to improve various physical, chemical and biological properties of soil leading to betterment of soil quality and also to increased fertilizer use efficiency.

The advent of chemical intensive farming and its prevalence in Kerala for the past 50 years have resulted in the decline in micro-organism, loss of soil fertility and vitality, collapse of the sustainable agricultural system, soaring of cost of cultivation, health hazards and challenged food security and food safety (GOK, 2008). So the Kerala farmers are now moving towards sustainable ways of cultivation without harming the ecosystem by adopting organic means. In this context MI can play a major role and hence this study was undertaken with the following objectives:

1. To study the extent of use of microbial inoculants in vegetable cultivation.
2. Work out the economics and efficiency of microbial inoculants in vegetable production.
3. To make a comparative analysis with the conventional vegetable production.

1.1 Scope of the Study

Continuous use of chemical inputs resulted in various types of health hazardous and ecological and environmental imbalances. Hence, it necessitated the use of environmental friendly methods for improving soil fertility, pests and disease control from the point of view of sustainability and cost reduction. Now, the farmers are well aware about the deleterious effects caused by the chemicals and the concept of microbial inoculant enhanced cultivation practices came into the scene. The application of microbial inoculants is seen as being very attractive since it would substantially reduce the use of chemical fertilizers and pesticides and an increasing number of inoculants are being commercialized for various crops. MI plays an important role in agricultural systems, particularly *Trichoderma*, *Pseudomonas*, *Rhizobium*, *Beauveria*, PGPR and PSB in terms of soil, plant and human health. Hence, it is expected that this study would highlight the economics of use of MI in vegetable production, efficiency of MI and constraints in vegetable production.

1.2 Limitations of the Study

Majority of the respondents did not maintain records on the cost and returns from the cultivation of both the crops. Hence, data collected was based on the memory of the respondents. At the time of interview, personal bias of the sample farmers was minimized by convincing them about the genuinely and purpose for which the data were collected.

1.3 Organization of Study

The thesis is presented in five chapters. The first chapter 'Introduction' highlights the back ground of the study, objectives, scope and limitations. The second chapter 'Review of literature' deals with the findings of related studies. The third chapter 'Materials and methods' encompasses the details on selection of the study area, sampling procedure for data collection, methods used in measurement of variables and statistical tools used. The results and discussion of the study are presented in the fourth chapter. The summary and policy implications of the study are presented in the fifth chapter.

Review of Literature

2. REVIEW OF LITERATURE

A critical review of the past work is essential to have a thorough understanding of the topic of research. It is the knowledge of our field which allows us to identify the gap which our research could fill. As the reviews on economic impact of microbial inoculants on vegetable production are meagre, MI on growth and yield of vegetable crops and other perennial horticultural crops were also collected and presented in this chapter. The reviews on past studies collected are presented under the following headings.

2.1 Effect of MI on growth and yield

2.2 MI and economics of production

2.3 Resource use efficiency

2.4 Constraints in vegetable production

2.1 EFFECT OF MI ON GROWTH AND YIELD

Bhagyaraj *et al.* (1980) conducted studies in different locations of Karnataka and found that biofertlizer inoculation increased the yield of black gram, green gram and Bengal gram from 0.4 to 33.00, 1.00 to 162.00 and 0.6 to 119.00 per cent, respectively over untreated.

Parvatham *et al.* (1989) evaluated the effect of Azospirillum on growth and nutrient uptake by okra and reported that plants which received Azospirillum through soil was on par with control and also noticed high growth and yield.

The use of microbial inoculants and organic fertilizers in agricultural production studied by Parr *et al.* (1994) reported that inoculants of mixed cultures of beneficial microorganisms had considerable potential for controlling the soil microbiological equilibrium and thus, providing a more favorable environment for plant growth and protection.

Verma *et al.* (1997) evaluated the effect of bio fertilizers on yield of cabbage and found that bio fertilizers considerably curtailed the quantity of nitrogenous fertilizers to be used in cabbage. Combination of 50 per cent of recommended nitrogen and Azotobacter at 1 kg/ha was found to be superior.

Kumaran *et al.* (1998) evaluated the effect of organic fertilizers on growth, yield and quality of tomato and observed that application of FYM and phosphobacteria combined with recommended dose of inorganic fertilizers showed superior performance in growth and fruit yield of tomato.

Valdenegro *et al.* (2001) studied the effect of *Rhizobium* and PGPR on *Medicago arborea* the result revealed that PGPR increased the growth of a woody legume, and *Rhizobium* acted as source of nutrient and it plays the important role in disease control.

The effect of bio fertilizers and nitrogen levels on growth, yield and quality of Knol-khol was studied by Mathew and Hameed (2002). In the experiment bacterial inoculants were used for seed treatment (500 g/ha), seedling treatment (2kg/ha) and soil application (2.5kg/ha). Results proved that soil application was significantly increased the yield compared to other methods of application.

The effect of integrated nutrient management on growth and yield of cabbage was studied by Vimala and Natrajan (2002). The results observed that curd diameter as well as curd weight were significantly increased by the application of 100% NPK + Bio-fertilizers (PSB at 500 g/ha + *Azospirillum* at 2 kg/ha).

Roberts *et al.* (2005) studied the effect of *Trichoderma* on soil borne pathogens such as, *Rhizoctonia solani, Pythium ultimum,* and *Meloidogyne incognita* in field and greenhouse-grown cucumber and observed that *T. virens* provided the most effective suppression of damping-off caused by *R. solani* in both greenhouse and in field bioassays. Also the high vegetative growth fallowed by high yield was recorded under *T. virens* inoculation.

Spadaro and Gullino (2005) observed that bio inoculants such as *Trichoderma* and *Pseudomonas* were significantly reduced the soil borne diseases in French bean crop; subsequently the yield was more with the same treatment.

Wu *et al.* (2005) evaluated the effects of four bio fertilizers on growth of *Zea mays*. The application of biofertlizers containing mycorrhizal fungus significantly increased the growth of *Zea mays* and the use of bio fertilizer with N-fixer (*Azotobacter chroococcum*) resulted in the highest biomass and seedling height.

The higher growth attributes as well as higher seed (8.14 q/ha) of fenugreek was obtained with *Rhizobium* inoculated crop over control (Bhunia *et al.* 2006).

Cepeda (2006) studied the use of microbial inoculants in the production of strawberry and reported that among the microbial inoculants used PGPR was superior in terms of growth and yield.

The inoculation of soybean with bio fertilizers, application of FYM and recommended dose of fertilizer was studied by Singh *et al.* in 2007. The results observed that plant growth, nodulation, seed and straw yields significantly increased over the control with the application of Rhizobium + Azotobacter + PSB + FYM.

Constantino *et al.* (2008) evaluated the effect of *Azotobacter, Azospirillum* and NPK fertilizer on the growth and yield of chilly. All treatments were applied as single and combined inoculants and reported that combined biofertilisation with NPK increased the nutrient content of the plant leaves and the highest yields were also recorded under the same treatment.

Parmar *et al.* (2008) studied the effect of synthetic macro and micronutrients along with organic manure and microorganisms such as phosphorus solubilizing bacteria and Azotobacter on yield, profitability and quality of potato and found that tuber yield and profit increased respectively by 34.1% and 31.5% with the combined use of organic manure and phosphorus solubilizing bacteria as compared to farmer's practice.

An experiment was conducted to investigate the response of broccoli to integrated nutrient management using organic manure and *Azotobacter* by Sharma *et al.* (2008) and observed that marketable head yield was maximum with the application of half dose of chemical fertilizer + *Azotobacter*.

Kumar *et al.* (2009) studied the effect of *Pseudomonas aeruginosa* on growth and yield of sesame and reported that seed bacterization with *Pseudomonas aeruginosa* + half dose of fertilizer significantly increased the vegetative growth and yield of sesame over non-bacterized seeds. The oil yield increased by 33.3%, while protein yield increased by 47.5% with the same treatment.

The experiment on application of *Trichoderma* to the surface soil of vineyard was conducted by Savazzini *et al.* (2009) and reported that *Trichoderma* had an effect on the soil microflora and it recorded significant disease control with increased yield.

Kachari and Korla (2009) evaluated the effect of four bio fertilizers (Azotobacter, Azospirillum, VAM and PSB) with three levels of recommended dose of inorganic fertilizers on different aspects of growth and development of cauliflower. Inoculation of seedlings with PSB at 2 kg/ha gave significantly higher number of leaves per curd, increased curd size and curd weight.

Onion top weight in organic fertilizer was significantly higher than that of chemical fertilizer and also the marketable yield was 45.9 ton per ha in the organic fertilizer treatment, while it was 40.5 ton in the chemical fertilizer treatment. (Lee, J. 2010).

Raio *et al.* (2011) was conducted the experiment on *Pseudomonas chlororaphis* for its efficacy in controlling the fungus responsible for bark canker of common cypress. The results reported that bacterium was able to completely inhibit the mycelial growth and conidium germination of the fungus and prevented canker induction in field trials with increased yield.

Dey *et al.* 2012 studied the nutrient management with optimum dose of NPK along with seed treatment of *Rhizobium* in vegetable pea, and observed increased seed yield of 5 tons per ha over control.

Gnanamangai and Ponmurugan (2012) studied the efficacy of fungicides and bio control agent *Trichoderma* for the management of bird's eye spot disease in tea plantations. The results observed that *Trichoderma* considerably controls the disease with increased green leaf yield.

Laditi *et al.* (2012) observed that the shoot dry matter and yield of maize was improved with the bio inoculated crop under different soils. The bio-inoculation of *Azospirillum* significantly improved the shoot dry matter yield and nitrogen uptake over control.

Mishra *et al.* (2012) reported that under temperate conditions, inoculation of Rhizobium improved number of pods per plant, number of seed per pod and 1000-seed weight (g) and thereby yielded over the control.

Panda *et al.* (2012) conducted a field experiment to study the effect of organic amendments along with MI such as *Pseudomonas* and *Trichoderma* on growth, nodulation and yield of cowpea. The results found that use of organic amendment such as, poultry manure along with *Pseudomonas* and *Trichoderma* improved the growth, nodulation and yield of cowpea compared to other treatments.

The effect of *Trichoderma viride* and *Pseudomonas fluorescens* bio-control agents over commonly used chemicals for seed-treatments on dry root rot of chickpea was studied by Manjunatha *et al.* (2013) and reported that incidence of dry root rot was less with the *Trichoderma* @ 500 g/ha seed treatment + *Pseudomonas* @ 1 kg/ha soil inoculated crop. Maximum germination and high yield of 1.5 tons/ha was also obtained with same treatment compared to chemical seed treated crop.

Rizvi *et al.* (2013) conducted a field experiment to evaluate the effect of oil-seed cakes (viz. neem cake and castor cake) and phosphate solubilizing bacteria (PSB) singly and in various combinations on the growth and productivity of *Trigonella* plant. The results observed that maximum growth and productivity were noticed in the combined inoculation of neem cake + castor cake + PSB as compared to other treatments including inorganic fertilizers and untreated one.

A study conducted by Sateesh and Sivasakthivelan (2013) reported that bio inoculation with *Trichoderma viridae* + *Pseudomonas fluorescence* + *Azotobacter chroococcum* on chilly crop enhanced the growth and yield parameters compared to control.

Toyota *et al.* (2013) studied the effect of five organic sources of plant nutrients and three fertility levels on yield of tomato. Among organic sources, application of FYM @ 2.5 t/ha + *Azotobacter* @ 1 kg/ha has recorded the highest yield of 50 tons per ha.

Vlahova *et al.* (2013) in his study on influence of biofertlizers on pepper cultivation under organic conditions found that the use of biofertlizers led to increase in yield of the pepper by 8% to 39%.

The use of rhizobium inoculants for improvement in N-fixation and productivity of grain legumes viz., soya bean and cowpea was studied by Abdullahi *et al.* (2014) and reported that inoculation with rhizobium increased the yield by 40 - 45% in both the crops compared to control.

Richard (2014) reported that the plant growth-promoting rhizobacteria (PGPR) are non-pathogenic beneficial bacteria that colonized seeds and roots of plants with enhanced plant growth.

2.2 MI AND ECONOMICS OF PRODUCTION

Kolhe *et al.* (1988) studied the effect of Azospirillum alone and in combination with other bio fertilizers on yield of palak. The results indicated that the treatment with *Azospirillum* alone gave significantly higher yield as compared to other treatments and cost incurred for production and gross returns were respectively Rs. 68,000 per ha and Rs. 1,15,000 per ha.

The effect of *Azospirillum* on growth and yield of chilli was studied by Deka *et al.* (1996) and reported that treatment combination of 70 kg N/ha with Azospirillum produced the highest average yield of 136.9 q/ha which was 48 per cent higher than that of control. The cost of cultivation per ha for the same treatment was Rs. 48,500 and the net returns obtained was Rs. 82,800 per ha.

Patel *et al.* (1998) evaluated the effect of bio fertilizers and chemical fertilizers on growth and yield of garden pea. The application of 1 kg Rhizobium + 1 kg prosperous solubilizing bacteria in combination with 50 per cent of N and P boosted number of pods per plant, grains per pod and ultimately pod yield over control. The economics of production showed that cost of cultivation was Rs. 42,000 per ha and gross returns was Rs. 1,10,000 per ha.

Naidu *et al.* (2002) studied the influence of organic manures, chemical and bio fertilizers on growth, yield and economics of brinjal and the results observed that organic manure applied in combination with PSB recorded higher yield of 25 tons per ha. Cost of cultivation estimated was Rs. 82,000 per ha with gross return of Rs. 1,78,000 per ha and benefit cost ratio of 2.17.

The effect of *Azospirillum* and different doses of nitrogen on yield of cabbage was studied by Sharma in 2002. The results observed that azospirillum application significantly increased the number and weight of non-wrapper leaves per plant. Also azospirillum application with 60 kg N/ha resulted in maximum yield of 60 tons per ha. The estimated cost of cultivation was Rs. 85,000 per ha, with a total return Rs. 2,52,000 per ha and benefit: cost ratio of 2.9.

In a study conducted by Perke *et al.* (2003) on cabbage in Pune district of Maharashtra found that among the various treatments, application of poultry manure with Azospirillum produced highest output of 65 tons per ha. Expenditure on production was estimated as Rs. 92,000 per ha and total return was as Rs. 1,59,500 per ha.

The response of field pea to bio fertilizers and chemical fertilizers under rain fed conditions was analyzed by Saraf (2005) and reported that the treatment containing PSB produced significantly higher pod yield of 1.2 tons per ha over control with less cost of cultivation of Rs. 65,000 per ha and net returns of Rs. 1,22,600 per ha.

According to Dass *et al.* (2008) vermicompost with microbial inoculants appeared to be the best soil additive for cabbage cultivation. Use of vermicompost and microbial inoculants produced an yield of 58 tons per ha. The cost of cultivation was estimated as Rs.45,550 ha^{-1} and net returns obtained was Rs. 75,537 ha^{-1}.

Kumar *et al.* (2008) studied the yield parameters and economics of *Withania somnifera* (Ashwagandha) using dual inoculation of *Azotobacter chroococcum* and *Pseudomonas putida*. The crop with the inoculants obtained and a root yield of

1185.6 kg per ha. Cost of cultivation was worked out as Rs. 54,500 per ha and the gross returns estimated was 1,45,000 per ha.

Masanta and Biswas (2009) studied the integrated nutrient management in French bean and observed that application of half dose of chemical fertilizer along with seed inoculation of *Rhizobium* increased the fresh pod yield of French bean (4.7 tons per ha). The cost incurred for the production was 59,000 per ha and the net return obtained was 29,000 per ha.

Sharma (2009) reported that application of recommended dose of nitrogen, phosphorous and potassium in combination with *Azotobacter* and PSB in cauliflower registered higher marketable curd yield of 25 tons per ha over control with maximum net returns of Rs.1,25,000 per ha.

Rather *et al.* (2010) studied the effect of bio fertilizers such as *Rhizobium, Azotobacter* and phosphate solubilizing bacteria (PSB) on growth, yield and economics of field pea. Inoculation of all the three bio-fertilizers produced significantly higher yield as compared to absolute control. Among the treatments less cost of cultivation was incurred by *Rhizobium* inoculated crop (Rs. 57,500 per ha) with highest net return of Rs. 85,000 per ha and B-C ratio of 2.4.

A study on economics of using bio-inoculants in mulberry by Baqual (2013) indicated that approximately Rs 2000 to 4500/ha/year can be saved on the input cost of nitrogen and phosphorus through the application of BF such as phosphate solubilising microorganisms and nitrogen fixing bacteria.

The effect of integrated nutrient management on growth, yield and economics of broccoli was studied by Mohapatra *et al.* (2013). The results showed that curd diameter as well as curd weight were significantly increased by the application of 100% NPK with Bio-fertilizers (*Azotobacter* + *Azospirillum*+ PSB @ 2 kg each/ha).

The cost of cultivation estimated as Rs. 43,508 per ha and gross return of Rs. 1,09,235 per ha for the same treatment with the benefit-cost ratio of 2.5.

Bindra *et al.* (2015) studied the effect of five organic sources of plant nutrients and three fertility levels on productivity and economics of tomato. Among the treatments, higher economic efficiency was achieved with the application of FYM @ 2.5 t/ha + *Azotobacter* @ 1 kg/ha with the fruit yield of 190 quintal/ha and expenditure on various inputs was Rs. 65,500 per ha with net returns of Rs. 72,000 per ha.

2.3 RESOURCE USE EFFICIENCY

The resource use efficiency in rainfed onion production in Gadag Taluk of Dharwad district was studied by Karisomanagoudar (1990) and observed that land and labour inputs significantly increased the gross revenue. The seed variable exercised a significant negative influence on earnings from onion. The variables included in the production function explained 96 per cent of the variation in output

Cobb Douglas production function was used by Sailaja *et al.* (1998) to estimate the production elasticities of resource use on vegetables cultivation in Guntur district of Andhra Pradesh and observed that there was diminishing return to scale for tomato and brinjal, constant returns to scale for cauliflower and increasing returns to scale for coccinia. Regarding production elastcicities, expenditure on human labour was found to have positive and significant effect on the output for all the crops concerned.

A study conducted on farm profitability and resource productivity in production of onion in Bolangir district of Orissa by Mohapatra (2001) using double log production function found that land, seed, fertilizer and labour significantly influenced the yield and income. Also, the returns to scale were found to be constant.

Dileep *et al.* (2002) studied the economics of contract farming in tomato. The ordinary least square estimates of the Cobb Douglas production function showed that the coefficients of plant protection chemicals in the case of contract farmers were negative and significant at five per cent level, indicating excessive use of these inputs. Similarly the coefficients of fertilizer expenses in the case of all the categories of non-contract farmers were positive and significant indicating lesser use of the same. The R^2 values indicated that human labour, machine power, fertilizer expenses, plant protection expenditure and irrigation expenses explained about 54 to 96 per cent of the variations in the production of tomato among different categories of sample farms.

Srinivas and Ramanathan (2005) conducted a study on farm profitability and resource productivity in cultivation of elephant foot yam in Kerala, Andhra Pradesh and Tamil Nadu by fitting Cobb-Douglas production function and found that, in Kerala, planting material and fertilizer significantly influenced the returns.

Haque, T (2006) studied resource use efficiency in various crops spread over different states in India. A double log regression equation was worked out to find out whether farmers in different regions used various inputs in crop production efficiently during 1981-82 to 2002-03. Human labour continued to influence productivity of paddy in Uttar Pradesh quite significantly while machine labour influenced the productivity positively and significantly in Uttar Pradesh. The expenditure on irrigation had negative elasticities in almost all cases. The results indicated that farmers in several instances did not use inputs optimally.

Singla *et al.* (2006) while studying the economics of production of green peas in Punjab analyzed the relative roles of different factors influencing the yield of green peas using regression analysis. The value of adjusted R^2 was found to be 0.95 in small, 0.81 in medium and 0.91 in large growers. The coefficients corresponding to irrigation and human labour were positive and highly significant in small farms. In medium farms, the coefficients of marketing and fertilizers were highly significant and positively affected the yield. In the case of large farms the coefficients of irrigation and pesticides were significant.

According to Suresh and Reddy (2006) the output elasticity of chemical fertilizers, farm yard manure and human labour were positive and significant in paddy cultivation in Peechi command area of Thrissur district of Kerala.

Sharma and Kachroo (2009) studied resource use efficiency and sustainability of maize cultivation in Jammu region of J & K State. Among the seven variables which were tested, factors which contributed significantly to maize output among the farmers were fertilizers, farmyard manure, human labour, capital and seed. The coefficient of multiple determinations (R^2) was 0.51 which meant that the explanatory variables included in the model explained 51 per cent variation in maize production.

2.4 CONSTRAINTS IN VEGETABLE PRODUCTION

Thakur *et al.* (1994) identified the problems encountered by the farmers in marketing of vegetables. They were (1) unorganized marketing and low prices paid to farmers, (2) lack of mechanical grading, packing, and proper storage facilities, (3) malpractices, high and undue marketing margins and costs in markets, (4) lack of village roads, lack of sufficient and low cost transportation facilities, (5) lack of market information and market news and (6) lack of processing units and cooperative societies.

According to Bonny (1996) who studied the constraints on commercial production of vegetable in Pananchery and Puthur, Kerala and reported that increased cost of plant protection chemicals was perceived as the most important constraints by the respondents followed by inadequate market facilities, poor storage and other post-harvest facilities, insufficient capital and high labour costs.

The most important constraints in production and marketing of potato in Kolar district of Karnataka were identified by Nagaraja *et al.* (1999) by assigning the ranks. In production, high cost of seed material and diseases (Rank-I) were the most important constraints followed by frequent power failure (Rank-II), high cost of fertilizers and plant protection chemicals (Rank-III), scarcity and high cost of labourers (Rank-IV) and non-availability of good seed material on time (Rank-V).

Jayapalan and Sushma (2001) reported that among the production constraints of bitter gourd, incidence of pests and diseases ranked first followed by labour scarcity. Non-availability of inputs ranked third followed by weather problems in the fourth position. Among the economic constraints, high cost of material inputs ranked first followed by high labour charge. Price fluctuation of the produce was the third important constraint faced by the bitter gourd farmers.

The most important problems in the production of vegetables in Karnataka reported by Kumar *et al.* (2004) were losses due to insect pest incidence, non-availability of quality seeds, inadequate irrigation facilities, high variations in yield and lack of suitable location specific varieties.

According to Joshi *et al.* (2006) prevailing constraints did not allow smallholders to fully expropriate the emerging opportunities in vegetable production. Major constraints in vegetable production according to him were lack of an assured market and a well-developed seed sector. Since vegetables were perishable in nature, lack of efficient marketing system and appropriate infrastructure resulted in huge post-harvest losses. Further, non-availability of improved and good quality seed reduces the profitability and increases production risk.

Samantaray *et al.* (2009) studied the constraints of vegetable production in Bhubaneswar. The major constraints like lack of postharvest technologies, absence of storage facilities, inadequate training programme and inadequate demonstration of new technology are faced by the growers. Lack of proper follow up service; lack of location specific recommendations, lack of community awareness and lack of effective supervision were also contributed to low production.

The problems related with production of vegetables was reported by Gunwant *et al.* (2012) in Uttarakhand were lack of irrigation, lack of information, manpower, finance/credit, inputs, production levels, insect/pest, diseases, poor linkages with extension agencies inadequate soil testing facilities and risk aversion.

The major constraints in improved tomato production was studied by Jat *et al.* (2012) in Rajasthan and reported that high cost of high yielding varieties, high cost of fertilizers and chemicals, lack of knowledge of disease resistant varieties, lack of knowledge about proper application methods of chemical fertilizers, unavailability of fertilizers in the local market at the time of sowing, lack of knowledge of seed treatment, lower price at harvesting time and lack of knowledge and skills about proper method of tomato production.

According to Sahu *et al.* (2013) major constraints of vegetable production in Uttarakhand were the lack of knowledge about improved variety, seed rate and sowing time (88.33%), lack of knowledge of IPM technologies (85.0%), unavailability of improved seeds of vegetables (83.33%), lack of irrigation facilities (80.0%), non-remunerative price (78.33%), lack of training of scientific vegetable production technology (75.0%), and lack of subsidy (75.0%).

The major constraints in vegetable production were identified by Das *et al.* (2015) in West Bengal were lack of improved package of practice followed by lack of high yielding varieties which are resistant to pests and diseases, improper marketing system, lack of processing facilities, high cost of hybrid seeds and lack of cold storage facilities.

The constraints and farmer's perception on off season green onion production in Maharashtra was studied by Dhital *et al.* (2015) and reported that the seedling raising was the most important problem faced by the off season growers followed by the weed problem, lack of crop insurance facility and diseases and pest incidence.

Dhurwey *et al.* (2015) studied the important constraints in production and marketing of major cole vegetable crops in Bemetara district of Chhattisgarh state and reported that the major constraints in vegetable cultivation are scarcity of labour, problem of high infestation of different insects, pests and diseases in the crop, lack of adequate training facility to farmers, lack of technical knowledge, lack of soil testing facilities and lack of information regarding crop cultivation.

Muttalageri and Mokshapathy. (2015) conducted the survey on constraints in production and marketing of organic vegetable growers in Belagavi district of Karnataka and reported that 100% of the respondents expressed the problem of lack of minimum support price for organically grown vegetables followed by lack of support from the government agencies and other relevant departments in the farm of subsidy and financial assistance (92.50%) and non-availability of market exclusively for organic produce (91.66%). Other major constraints reported were absence of premium price for organic vegetables in local markets (78.33%) and inability to identify marketing networks for organic vegetables (60.83%).

Materials and Methods

3. MATERIALS AND METHODS

Selection of an appropriate methodology is of utmost importance in bringing out meaningful conclusion from research. On the basis of review of literature appropriate methodology was selected for each aspect of the present study. The procedures adopted in the selection of sample, collection of data, analytical techniques employed and the concepts used in the study are briefly described in this chapter.

3.1 Description of the study area

3.2 Selection of sample

3.3 Method of data collection

3.4 Variables and their measurement

3.5 Tools for analysis

3.1 DESCRIPTION OF THE STUDY AREA

3.1.1 Kerala State

Located on the southernmost tip of India, the state of Kerala embraces the coast of Arabian Sea on the west, and is bounded by the Western Ghats in the east. This blissful land of incredible beauty comprises 1.18 per cent area of the country and lies between east longitudes 74° 52' and 72° 22' and north latitudes 8° 18' and 12° 48'. In South India, Kerala with high humidity, low temperature accompanied by good rainfall, has congenial climate for vegetables cultivation. The major vegetables grown in the state are yard long bean, amaranthus, bitter gourd, cucumber, snake guard, ladies finger, Brinjal, green chilly, bottle gourd, little gourd and ash gourd.

3.1.2 Thiruvananthapuram

Thiruvananthapuram is the capital city and the southernmost district of Kerala. The district lies between north latitudes 8°17' and 8°54' and east longitudes 76°41' and 77°17'. The total cropped area of the district is 1,62,748 ha and is a traditional vegetable growing district with 3446 ha under vegetables (GOK, 2016). The major vegetables grown in the district are yard long bean, amaranthus, bitter guard, cucumber, bottle guard and ash guard.

3.1.3 Neyyattinkara

Neyyattinkara lies between north latitudes at 8°24′ and 77°05 and east longitudes 8.4° and 77.08°. It has an average elevation of 26 meters (85 feet). The town is situated on the Neyyar River, one of the principal rivers in the district. Topography of the town is rather uneven. Hillock at Aruvippuram is close to Neyyattinkara town. The taluk is sandwiched between the Western Ghats and the Arabian Sea. The nearby sea shore is just 10 km. away to the West, and seven kilometers to the East. The geology is said to be typical of the Kerala soil - the Laterite and Red soil.

3.1.4 Nedumangad

Nedumangad lies between north latitudes at 8°36′ and 77°00′and east longitudes 8.6° and 77.0°. It has an average elevation of 68 metres (223 feet). It lies 18 km from Thiruvananthapuram on the way to Ponmudi hill resort. It is unique for having no coastal belt or railway lines. It is bounded on the west by Thiruvananthapuram taluk, on the east by the State of Tamil Nadu, on the south by Neyyattinkara taluk and on the north by Kollam District.

3.2 SELECTION OF SAMPLE

3.2.1 Sampling Framework

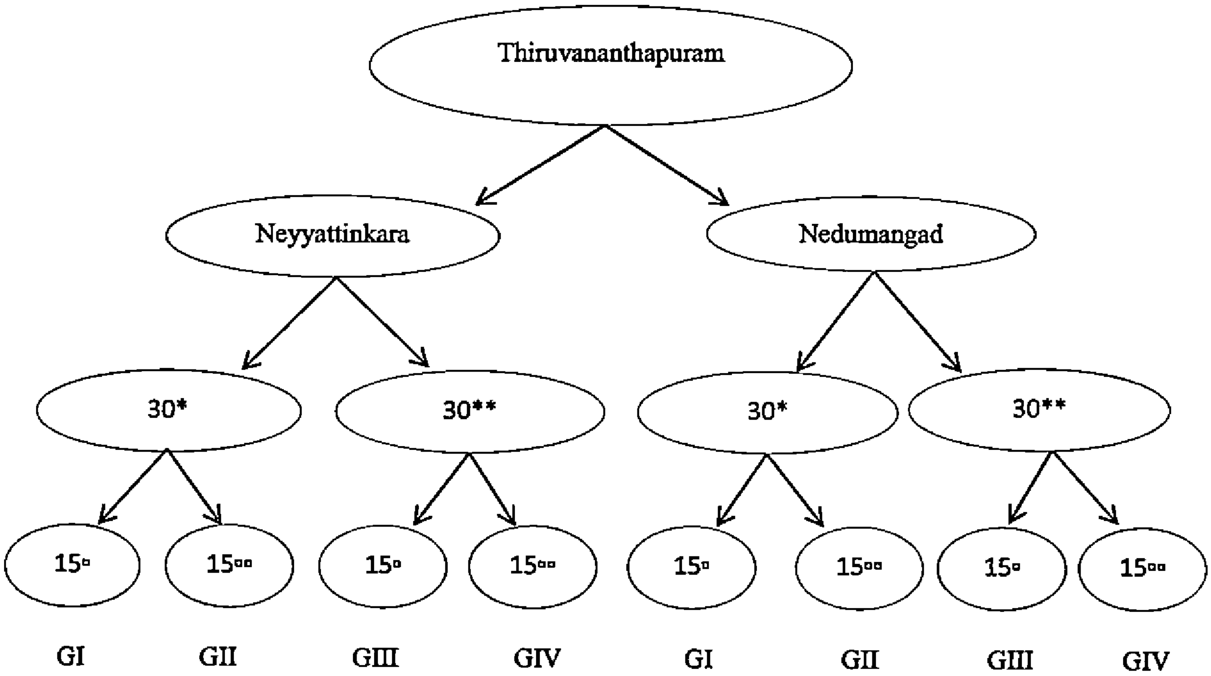
Thiruvananthapuram district was purposively selected for the study being one of the major vegetables producing districts in the southern part of Kerala and due to the prevalence of MI using famers in the district. The study was confined to two taluks of Thiruvananthapuram district namely Neyyattinkara and Nedumangad was also purposively selected due to its proximity to the two institutions doing research and extension activities of MI, namely, Department of Agricultural Microbiology (College of Agriculture, Vellayani) and KVK, Mithraniketan. These two institutions engaged in extending training and popularizing the technology of bio inoculants. Based on the information obtained from these two institutions yard long bean and amaranthus were selected for the study as MI are popularly used in these crops. The total cropped area under yard long bean in the state is 7,298 ha, with 278 ha in Thiruvananthapuram district (out of this Neyyatinkara and Nedumangad shared 118 and 60 ha respectively). The total area under amaranthus cultivation in the state was 1888 ha. Out of this Thiruvananthapuram, Neyyattinkara and Nedumangad shared respectively 241 ha, 150 ha and 21 ha (GOK, 2016).

3.2.2 Sampling Design

Simple random sampling was adopted for selection of sample farmers. A list of vegetable farmers using microbial inoculants were collected from the Department of Agricultural Microbiology, College of Agriculture, Vellayani and Mithranikethan, KVK and the random sample of 15 farmers each cultivating yard long bean and amaranthus were selected. A list of farmers cultivating the same crop conventionally were collected from the krishi bavans of Neyyattinkara and Nedumangad and from the list a random sample of 15 each cultivating yard long bean and amaranthus were selected for the sake of comparison. Thus the total sample size was 120.

The sample farmers were grouped into four groups of 30 each viz., Group I (MI using-yard long bean), Group II (conventional-yard long bean), Group III (MI using-amaranthus) and Group IV (conventional-amaranthus).

Sampling frame



* Yard long bean, ** Amaranthus, ▫ MI using, ▫▫ Conventional. GI–GIV- Group I-IV.

Figure.1 Flow chart showing sample selection

3.3 METHOD OF DATA COLLECTION

3.3.1 Collection of Data

Data on various operations and practices adopted in the cultivation of yard long bean and amaranthus were collected from farmers through personal interview using pre-tested and structured interview schedule. All details on costs, yield and returns with respect to both the crops and problems faced by the farmers were collected. 3 crops of yard long bean and 10 crops of amaranthus were taken per year.

For the purpose of the study all the costs were worked out for one crop with respect to both the crops. The survey was conducted during December 2015 to March 2016.

3.4 VARIABLES AND THEIR MEASUREMENT

3.4.1 Cost of Seeds

In production process, both farm produced and purchased seed materials are used. If the seed material are purchased from outside then it is valuated at purchase rate. If it is a farm produced, a price prevailing in the locality is considered.

3.4.2 Cost of Human Labour

i) Cost of Hired Labour

The actual wage paid to labour engaged in crop production was considered as value of hired human labour. Hired human labour was valued at the prevailing wage rates in the area which ranged from Rs 550-650 for men and Rs 350-450 for women.

ii) Cost of Family Labour

The cost of family labour was imputed based on the prevailing wage rates paid to hired labour in the area.

3.4.3 Cost of Panthal Material

The material cost of stalking was evaluated at the purchasing price. Cost of bamboo poles, wooden stakes and wires were evaluated under the cost of pandal material. Generally the poles are used for three crops and wire for one crop. So the cost of poles for one crop was calculated by dividing the total cost of poles with the number of times it was used to arrive at the cost of poles per crop.

3.4.4 Cost of Manures, Fertilizers and Bio-Inoculants.

Farm produced manure is evaluated as per the prevailing market rates in the study area and fertilizers, bio-inoculants and nonfarm produced manures were evaluated at their purchase price.

3.4.5 Cost of Plant Protection Chemicals

The insecticides and fungicides were evaluated at their purchase price.

3.4.6 Land Revenue

This was taken as the actual rate paid to the revenue department which was calculated as Rs.80 per acre per year. Since the cost of cultivation is calculated per crop hence the total land revenue is divided with the number of times the crops were grown and the rate for one crop was taken for the analysis.

3.4.7 Cost of Maintenance

Annual maintenance charges included total cost incurred for the maintenance of irrigation system, tools and equipments.

3.4.8 Miscellaneous Expenses

These include items such as cost of transporting manures, fertilizers and panthal materials to the farm, rent of sprayer, and purchase of small accessories like basket, gunny bags etc.

3.4.9 Interest on Working Capital

The paid out cost constitutes the working capital. Interest on working capital was worked out for the crop period at the rate of 7 per cent per annum, since it is the rate at which farmers take crop loans from financial institutions.

3.4.10 Rental Value of Leased in Land

It is evaluated on the basis of what the farmer paid to land owner as rent of the leased in land. Since the selected crops can be grown more than once in a year, the rental value of leased in land was computed by dividing it with the number of times crop were grown.

3.4.11 Rental Value of Owned Land

Rental value of own land was computed by taking the rental value prevalent in the study area.

3.5 TOOLS FOR ANALYSIS

Analytical tools employed for the primary data are given below.

3.5.1 Percentages and Averages

Percentages and averages were used to examine the socio- economic characteristics of the farmers such as age, educational status, gender, family size, land holding, annual income of the sample farmers and in working out cost of cultivation.

3.5.2 Cost of Cultivation

Cost of cultivation was worked out as the sum total of cost incurred on various inputs that are used in the production of the commodity. In this study ABC cost concepts were also used to workout the cost of cultivation. For the present analysis costs and returns were worked out per crop.

3.5.2.1 A B C Cost Concepts

ABC cost concepts (CSO, 2008) was adopted for working out cost of cultivation. Cost A was divided into cost A_1 and cost A_2.

Cost A1

The cost A_1 includes

a) Cost of hired human labour
b) Cost of manures and fertilizers
c) Cost of microbial inoculants
d) Cost of plant protection chemicals
e) Cost of pandal material
f) Land revenue
g) Maintenance cost of equipments and machineries
h) Miscellaneous cost
i) Interest on working capital

Cost A_2

Cost A_1 + rent paid for leased-in land.

Cost B

Cost A_2 + rental value of owned land (net of land revenue) & interest on owned fixed capital excluding land.

Cost C

Cost B + imputed value of family labour.

3.5.3 Cost of Production

Cost of production refers to the cost of producing one Kg of the vegetable.

3.5.4 Returns

Gross return was worked out as the total value of products at the prevailing market price. Net income was derived by subtracting the total cost from the gross income.

3.5.5 Benefit-Cost Ratio

It was calculated by dividing the total benefits by total expenditure incurred for production.

3.5.6 Resource Use Efficiency

Cobb-Douglas production function has been fitted to the collected data in order to describe the relationship between the output and various inputs used in production. From the production function, elasticities of production of inputs were worked out.

The algebraic form of Cobb- Douglas production function is

$$Y = a\prod_{i=1}^{5}(X_i^{b_i})e$$

The functional form of production function fitted for the study is

$$Y = a.\ X_1^{b1}\ X_2^{\ b2}\ X_3^{b3} X_4^{b4} X_5^{b5} e$$

This is modified into a log linear model by the application of logarithms to either side resulting in

$$\text{Log } Y = \log a + b_1\log X_1 + b_2\log X_2 + b_3\log X_3 + b_4\log X_4 + b_5\log X_5 + \log e$$

Where,

Y= value of output (Rupees)

a = Intercept

X1= Area (cents)

X2= Expenditure on seed/hired labour/family labour (Rupees)

X3= Expenditure on manures/miscellaneous/hired labour (Rupees)

X4= Expenditure on MI (Rupees) for group I & III.

X5= Expenditure on family labour (Rupees)

$b_1 \ldots\ldots b_5$= Regression coefficients of explanatory variables.

e = Error term

The Cobb-Douglas function was estimated by using OLS method assuming the error term (e) to be randomly and normally distributed. Coefficient of multiple determination (R^2) was tested for its significance by applying F test. The regression coefficients (b_i) were tested for their significance using 't' test at chosen level of significance.

$$t = \frac{bi}{\text{Standard error of } b_i}$$

3.5.7 Estimation of Marginal Products and Marginal Value Products

In the present study marginal product (MP) and marginal value product (MVP) were also calculated by comparing the MVP of each resource with marginal factor cost (MFC).

The marginal products were calculated at the geometric mean levels of variables by using following formula

$$\text{Marginal product of input } (MP_i) = bi \times \frac{\overline{Y}}{\overline{X_i}}$$

Where

$\overline{Y}$ = geometric mean of out put

$\overline{X_i}$ = geometric mean of i^{th} independent variable.

b_i = the regression coefficient of the i^{th} independent variable.

The marginal value product of each resource was calculated by multiplying the marginal product of the resource by the price of the product.

The formula used for calculating the MVP was;

$$\text{Marginal value productivity of } X_i = b_i P_Y \frac{\overline{Y}}{\overline{X_i}} = P_Y \times MP_i$$

Where

P_Y = price of yard long bean or amaranthus

The comparison of ratios (MVP/MFC= k) for judging efficiencies are

$k > 1$ indicating under use or sub optimal use of resources

$k = 1$ optimum use of resources (allocative efficiency)

$k < 1$ indicating excess use of resources.

Farm specific input level were calculated by equating MVP of an input with its price. In this study since the cost of inputs are considered for the calculation of allocative efficiency of input, price of input i.e. MFC is taken as unity.

3.5.8 Constraints Analysis

The problems in production were analysed using the Garrett's scoring technique (Garret, 1969). The respondents were asked to rank the factors or problems in production of yard long bean and amaranthus and these ranks were converted into per cent position by using the formula.

$$\text{Per cent position} = \frac{100 \times (R_{ij} - 0.5)}{Nj}$$

Where,

R_{ij} = Ranking given to i^{th} factor by j^{th} individual

Nj = Number of factors ranked by the j^{th} individual.

By referring to the Garrett's table, the percentage positions estimated were converted into scores. Thus, for each constraint, the scores of various respondents were added and the mean value was estimated. The means thus obtained for each of the constraint were arranged in descending order. The attributes with the highest mean value was considered as most important one and the others followed in that order.

Results and Discussion

4. RESULTS AND DISCUSSION

In the previous chapters, a brief review of the past studies, relevant methodology adopted and the general description of the study area were presented. The data collected during the survey were tabulated with that background and analyzed in relation to each specific objective of the study. In this chapter, the results of the analysis are presented and discussed under fallowing headings.

4.1. General characteristics of sample farmers

4.2. Adoption of MI

4.3. Economics of production

4.4. Resource use efficiency

4.5. Constraints in vegetable production

4.1 GENERAL CHARACTERISTICS OF SAMPLE FARMERS

4.1.1 Age

The distribution of respondents with respect to age is given in Table.1. The respondents were divided into four age groups, < 30 years (youth), 30-45 years (adulthood), 45-60 years (middle adulthood), and > 60 years (old aged) (Newman and Newman, 1999). Maximum number of farmers was in the age group of 30-45 years which accounted to 70.83 per cent. The respondents in the age group of below 30 years and 45-60 years were less than 15 percent. This indicates the interest and involvement of younger generation in vegetables cultivation. The average age of groups was 38.97, which also underlines the above observation.

Table.1 Age-wise distribution of the respondent farmers

Particulars	Age (years)				Total	Average age
	< 30	30-45	45-60	> 60		
Group I	2 (6.60)	24 (80.00)	3 (10.00)	1 (3.40)	30 (100)	39.80
Group II	4 (13.30)	21 (70.00)	5 (16.60)	0 (0)	30 (100)	39.40
Group III	8 (26.60)	19 (63.30)	2 (6.60)	1 (3.40)	30 (100)	36.50
Group IV	3 (10.00)	21 (70.00)	6 (20.00)	0 (0)	30 (100)	40.16
Total	17 (14.16)	85 (70.83)	16 (13.30)	2 (1.60)	120 (100)	38.97

Figures in parentheses denote percentages to total

Table.2 Distribution of respondent farmers according to the educational status

Particulars	Educational status				Total
	Primary	High school	Pre-Degree	Graduation	
Group I	5 (16.66)	9 (30.00)	8 (26.66)	8 (26.67)	30 (100)
Group II	10 (33.33)	10 (33.33)	7 (23.33)	3 (10.00)	30 (100)
Group III	4 (13.33)	8 (26.67)	9 (30.00)	9 (30.00)	30 (100)
Group IV	9 (30.00)	10 (33.33)	7 (23.34)	4 (13.33)	30 (100)
Total	28 (23.33)	37 (30.83)	31 (25.83)	24 (20.00)	120 (100)

Figures in parenthesis denote percentages to total

Table.3 Distribution of the respondents according to family size

Particulars	Family size			Average size of the family
	≤ 4 (Nuclear)	5-8 (Joint)	Total	
Group I	18 (60.00)	12 (40.00)	30 (100)	4.30
Group II	12 (40.00)	18 (60.00)	30 (100)	4.73
Group III	13 (43.33)	17 (56.66)	30 (100)	4.66
Group IV	10 (33.33)	20 (66.67)	30 (100)	5.06
Total	53 (44.16)	67 (55.83)	120 (100)	4.68

Figures in parentheses denote percentages to total

4.1.2 Education

The study observed 100 per cent literacy in the study area (Table.2). Majority of the farmers (30.83 per cent) were having high school level of education. It was also observed that about 25.83 per cent of the farmers were educated up to pre-degree level followed by primary education (23.33 per cent). Farmers with graduation level of education were also found among the samples, which was 28.33 per cent in MI using farmers it indicates the highly educated farmers using MI in the study area. Group wise analysis also showed that maximum percentage in all groups except group III farmers were educated up to high school level. This analysis concludes that majority of the vegetable growers in the study area were highly educated.

4.1.3 Family Size

Analysis of family size presented in Table.3 revealed that, out of 120 farmers 56 per cent had family size of 5-8 (joint family) members and 44 per cent possessed nuclear families with a family size of 4 members. In the group level the maximum percentage of nuclear families was observed in group I (60 per cent) followed by group III (43 per cent). The average size of family was 4.68 and the maximum family size of 5.06 was observed in group IV and minimum size of 4.30 in group I.

4.1.4 Gender

Classification of sample vegetable growers based on gender showed that more than 84 per cent of the growers were males. There was wide variation in gender involvement among four groups and maximum involvement of females was noticed in group III (23 per cent) and minimum of 7 per cent in group II (Table.4).

4.1.5 Major Occupation

Classification of vegetable growers according to their main occupation presented in Table.5 showed that agriculture was the main occupation of 65 per cent of vegetable growers followed by own business (19 per cent).

Table.4 Gender wise distribution of respondent farmers

Particulars	Gender		Total
	Male	Female	
Group I	26 (86.66)	4 (13.33)	30 (100)
Group II	28 (93.33)	2 (6.64)	30 (100)
Group III	23 (76.66)	7 (23.34)	30 (100)
Group IV	24 (80.00)	6 (20.00)	30 (100)
Total	101 (84.16)	19 (15.84)	120 (100)

Figures in parenthesis denote percentages to total

Table.5 Occupational status of the respondent farmers

Particulars	Agriculture as main	Agriculture as sub		Total
		Service	Own business	
Group I	17 (56.66)	5 (16.67)	8 (26.66)	30 (100)
Group II	20 (66.66)	3 (10.00)	7 (23.34)	30 (100)
Group III	20 (66.66)	5 (16.67)	5 (16.67)	30 (100)
Group IV	21 (70.00)	6 (20.00)	3 (10.00)	30 (100)
Total	78 (65.00)	19 (15.83)	23 (19.16)	120 (100)

Figures in parentheses denote percentages to total

Table.6 Distribution of respondents according to the total size of holding

Particulars	Size of holding (cents)			Total	Average size of holding (cents)
	< 50	50-100	> 100		
Group I	23 (76.66)	5 (16.66)	2 (6.66)	30 (100)	47.36
Group II	20 (66.66)	8 (26.60)	2 (6.66)	30 (100)	43.93
Group III	23 (76.66)	5 (16.66)	2 (6.66)	30 (100)	43.53
Group IV	21 (70.00)	5 (16.66)	4 (13.34)	30 (100)	49.33
Total	87 (72.50)	23 (19.16)	10 (8.34)	120 (100)	46.03

Figures in parentheses denote percentages to total

It can also be noted that 16 per cent of the growers were employed either in government sector or private sector.

4.1.6 Size of Holding

The average land holding observed in the study area was 46.03 cents (Table. 6). Average land holding size of MI using farmers varied from 43.53 cents in group III to 47.36 per cent in group I. It was also observed that 73 per cent of the respondents had holding size of only less than 50 cents.

4.1.7 Cropping Pattern

Details presented in Table.7 revealed that, mixed cropping system was observed in study area. Annual crops like vegetables, tapioca and banana and perennial crop like coconut were cultivated along with yard long bean and amaranthus. About 28 per cent of respondent farmers were cultivating other vegetables such as bitter guard, okra, snake guard and cucumber.

4.1.8 Annual Income

The average annual income at the aggregate level was Rs. 1,03,337/- (Table.8). About 8 per cent of the respondents were only having an annual income of less than Rs. 50,000/-. Majority of farmers were observed in the second income group of Rs. 50,000-1,00,000, followed by third income group.

4.1.9 Area under Selected Vegetables

It could be seen from Table.9 that about 93 per cent of the respondent farmers possessed an area of less than 20 cents under the selected crops. More than 50 cents area under selected crops was observed only among 2 per cent of the farmers.

Table.7 Cropping pattern of respondent farmers

Particulars	Group name				Total
	Group I	Group II	Group III	Group IV	
Banana	5 (16.66)	8 (26.66)	3 (10.00)	8 (26.66)	24 (20.00)
Tapioca	6 (20.00)	5 (16.66)	8 (26.66)	6 (20.00)	25 (20.83)
Coconut+tapioka	4 (13.33)	4 (13.33)	6 (20.00)	4 (13.33)	18 (15.00)
Banana+coconut	5 (16.66)	6 (20.00)	4 (13.33)	5 (16.60)	20 (16.66)
Other vegetables	10 (33.34)	7 (23.33)	9 (30.00)	7 (23.33)	33 (27.50)
Total	30 (100)	30 (100)	30 (100)	30 (100)	120 (100)

Figures in parentheses denote percentages to total

Table.8 Annual income of respondent farmers

Particulars	Annual income (Rs)				Total	Average annual income (Rs)
	< 50000	50000-100000	100000-200000	>200000		
Group I	1 (3.33)	9 (30.00)	15 (50.00)	5 (16.67)	30 (100)	1,15,333/-
Group II	3 (3.00)	16 (53.33)	7 (23.33)	4 (13.33)	30 (100)	96,666/-
Group III	2 (6.66)	11 (36.66)	14 (46.66)	3 (10.00)	30 (100)	1,08,350/-
Group IV	4 (13.33)	17 (56.66)	6 (20.00)	3 (10.00)	30 (100)	93,000/-
Total	10 (8.34)	53 (44.16)	42 (35.00)	15 (12.50)	120 (100)	1,03,337/-

Figures in parentheses denote percentages to total

Table.9 Distribution of respondents according to area under selected vegetables

Particulars	Area under selected crop (in cents)				Average area (cents)
	1-20	21-50	> 50	Total	
Group I	25 (83.33)	3 (10)	2 (6.66)	30 (100)	17.43
Group II	28 (93.33)	2 (6.67)	0 (0)	30 (100)	11.56
Group III	28 (93.33)	2 (6.67)	0 (0)	30 (100)	10.83
Group IV	30 (100)	0 (0)	0 (0)	30 (100)	6.86
Total	111 (92.50)	7 (5.83)	2 (1.66)	120 (100)	11.67

Figures in parentheses denote percentages to total

4.2 ADOPTION OF MI

4.2.1 Type of MI Used

A perusal of the Table.10 showed that most commonly used MI were *Pseudomonas* and *Trichoderma* in the study area. *Pseudomonas* was used by more than 38 per cent and *Trichoderma* by 35 per cent. It clearly indicates that majority of the farmers are using microbial inoculants for disease control.

Table.10 Distribution of respondent farmers according to type of MI used

Particulars	*Pseudomonas*	*Trichoderma*	PSB	*Beauveria*	Rhizobium	PGPR I & II	Total
Group I	10 (33.33)	5 (16.66)	3 (10.00)	1 (3.33)	6 (20.00)	5 (16.66)	30 (100)
Group III	13 (43.33)	16 (53.34)	0 (0)	0 (0)	0 (0)	1 (3.33)	30 (100)
Total	23 (38.33)	21 (35.00)	3 (5.00)	1 (1.66)	6 (10.00)	6 (10.00)	60 (100)

Figures in parentheses denote percentages to total

4.2.2 Purpose of Use of MI

Here the MI using farmers are classified into three categories according to the purpose of use of inoculants. More than 73 per cent of farmers were used inoculants for disease control followed by nutritional purpose (25 per cent) and only 2 percentages of farmers used inoculants for pest control (Table.11).

Table.11 Distribution of respondent farmers according to purpose of use of MI

Particulars	Purpose			Total
	Disease control	Pest control	Nutrition	
Group I	15 (50.00)	1 (3.34)	14 (46.66)	30 (100)
Group III	29 (96.66)	0 (0.00)	1 (3.34)	30 (100)
Total	44 (73.33)	1 (1.66)	15 (25.00)	60 (100)

Figures in parentheses denote percentages to total

4.2.3 Source of MI

The respondent farmers who are all using MI are classified according to source from where they purchased MI and is presented in Table.12. The respondent farmers are classified under three categories, based on the source of purchase of MI; KVK, College of Agriculture and Agro shop. Fifty per cent of respondent farmers purchased MI from College of Agricultural, followed by about 42 per cent from KVK and around 8 per cent from agro shops. The above result clearly indicates the role played by College of Agriculture and KVK in popularizing the MI technology in study area.

Table.12 Distribution of respondent farmers according to source of MI

Particulars	KVK	Agricultural college	Agro shops	Total
Group I	15 (50.00)	15 (50.00)	0 (0.00)	30 (100)
Group III	10 (33.33)	15 (50.00)	5 (16.66)	30 (100)
Total	25 (41.66)	30 (50.00)	5 (8.33)	60 (100)

Figures in parentheses denote percentages to total

4.2.4 Adoption of MI for Seed Treatment

In case of yard long bean, only about 27 per cent of the respondent farmers were found to be adopting MI for seed treatment (Table.13). More than 73 per cent of the respondents were not treating seeds with MI before sowing, but were applied directly to soil.

In the case of amaranthus, only 20 per cent of the farmers were found to be treating the seeds with MI and the remaining 80 per cent of the respondents were applying MI directly to soil.

Table.13 Adoption of MI for seed treatment

Particulars	Yard long bean	Amaranthus
Treated	8 (26.66)	6 (20.00)
Untreated	22 (73.34)	24 (80.00)
Total	30 (100)	30 (100)

Figures in parentheses denote percentages to total

Even though there is a recommendation by KAU (Kerala Agricultural University) for seed treatment with MI, very few farmers were followed the recommendation. This is because of the unaware of the technology and due to the fear that may cause damage to seeds.

4.2.5 Distribution of Respondents Based on Extent of Use of MI

The extent of use of MI in the study area is given in Table.14. In case of yard long bean, only 27 per cent of the respondents were following the recommended rate. More than 56 per cent of the farmers were applying MI above the recommended rate and about 17 per cent of them were applied below recommended rate.

In the case of amaranthus, only about 17 per cent of the respondents were following recommended rate. Seventy per cent of the respondents applied above recommendation and about 13 per cent were below recommended rate.

From the above analysis it is clear that most of the farmers applying MI above the recommended rate. The main reason is that MI's are available in 1 kilogram packets and entire quantity is applied to the soil irrespective of area cultivated. Another reason is that they are not aware of recommended rate and the shelf life of MI.

Table.14 Distribution of respondents based on extent of use of MI

Particulars	Yard long bean							Amaranthus			
	Pseudomonas	*Trichoderma*	Rhizobium	PGPR	PSB	*Beauveria*	Total	*Pseudomonas*	*Trichoderma*	PGPR	Total
Below recommended	1 (10.00)	3 (60.00)	1 (16.60)	0	0	0	5 (16.60)	0	4 (25.00)	0	4 (13.33)
Recommended	2 (20.00)	0	3 (50.00)	3(60.00)	0	0	8 (26.66)	3 (23.07)	2 (12.50)	0	5 (16.60)
Above recommended	7 (70.00)	2 (40.00)	2 (33.40)	2(40.00)	3(100)	1 (100)	17 (56.66)	10 (76.92)	10 (62.50)	1 (100)	21 (70.00)
Total	10 (33.34)	5 (16.66)	6 (20.00)	5(16.66)	3 (10.00)	1 (3.33)	30 (100)	13 (43.33)	16 (53.33)	1 (3.33)	30 (100)

Figures in parentheses denote percentages to total

4.2.6 Average Adoption of MI

Using the collected data average adoption of the different MI's per ha was worked and compared the same with the recommendation of KAU (Table. 15). In the case of yard long bean, for seed treatment *Pseudomonas* (300 g/ha) was used above recommended rate of 250 g/ha and *Trichoderma* (220 g/ha) and Rhizobium (310 g/ha) were below the recommended rates of 250 g/ha and 350 g/ha respectively. With respect to soil application also all the MI's except *Beauveria* was used 8 to 11 times more over the recommendation.

In the case of amaranthus the *Pseudomonas* and *Trichoderma* were used below the recommended rate for seed treatment. For soil application the inoculants used are *Pseudomonas, Trichoderma* and PGPR I & II, which are used above recommended level are.

From the above analysis it can be seen that the farmers are wasting MI and money by applying large quantity of MI to the soil. This shows the necessity of more extension activities among farmers for the proper adoption of MI.

Table.15 Average adoption of MI

Particulars	Recommendation		Average adoption per ha			
			Yard long bean		Amaranthus	
	Seed treatment (g/ha)	Soil application (kg per ha)	Seed treatment (g/ha)	Soil application (kg/ha)	Seed treatment (g/ha)	Soil application (kg/ha)
Pseudomonas	250	1-2	300	11.47	240	8.27
Trichoderma	250	1-2	220	10.29	270	7.92
Rhizobium	350	-	310	0	0	0
PGPR- I & II	0	1	0	14.13	0	10.5
PSB	0	1-2	0	8.75	0	0
Beauveria	0	1-1.5 (Foliar application)	0	1.71	0	0

(KAU, 2012).

4.3. ECONOMICS OF PRODUCTION

The data on cost of cultivation and returns are of special interest since they reveal the profitability of the enterprise and bring out the differences in unit cost and returns incurred by the less efficient and more efficient farms. Thus economics of production is a main criterion to compare the performances of MI using and conventional farmers of yard long bean and amaranthus.

4.3.1. Cost of Cultivation of Yard Long Bean

The cost of cultivation of yard long bean per ha was estimated and presented in Table 16. Cost A_1 for MI using farmers was worked out as Rs 1,24,611.02 ha^{-1}, of which cost of hired labour accounted for 56.31 per cent followed by cost of panthal materials (23.92 per cent) and interest on working capital (6.56 per cent), this results are in harmony with the results obtained by Patel *et al.* (1998) on garden pea. MI accounted for only 1.72 per cent of cost A_1. Cost A_2, cost B, and cost C were respectively Rs 1,65,444.41 ha^{-1}, Rs 2,09,027.41 ha^{-1} and Rs 2,39,860.74 ha^{-1}.

The cost of cultivation of conventional yard long bean showed that, cost A_1 for conventional yard long bean was Rs 1,42,016.72 ha^{-1}. Hired labour accounted for 57.20 per cent followed by cost of panthaling materials (19.96 per cent) and interest on working capital (6.26 per cent). Cost A_2, cost B and cost C were respectively Rs 1,77,019.88 ha^{-1}, Rs 2,22,186.54 ha^{-1} and Rs 2,60,493.94 ha^{-1}.

From the analyses of data, it could be seen that, conventional farmers incurred thirteen per cent more cost than that of the MI using farmers. This is in terms of hired labour (split application of fertilizers and plant protection chemicals) and high cost of fertilizers and plant protection chemicals. It was coincide with the study conducted by Rather *et al.* (2010) on field pea in Uttar Pradesh.

Table.16 Cost of cultivation of yard long bean per crop

Particulars	MI using yard long bean		Conventional yard long bean	
	Cost Rs/ha	**Per cent to cost A_1**	**Cost Rs/ha**	**Per cent to cost A_1**
Hired labour	70178.23	56.31	81235.58	57.20
Seed	4744.70	3.80	5795.84	4.08
Fertilizer	0.00	-	4060.69	2.85
Manures	5804.43	4.65	3078.14	2.16
Microbial inoculants	2143.54	1.72	0.00	-
Panthal material	29816.96	23.92	28355.30	19.96
Chemical plant protection	0.00	-	4282.00	3.01
Maintenance cost	445.56	0.35	616.34	0.43
Land revenue	66.66	0.05	66.66	0.04
Miscellaneous	3227.36	2.58	5622.83	3.95
Interest on working capital	8183.58	6.56	8903.34	6.26
Cost A1	1,24,611.02	100	1,42,016.72	100
Rent of leased in land	40833.39		35003.16	
Cost A2	1,65,444.41		1,77,019.88	
Rent of owned land	43583.00		45166.66	
Cost B	2,09,027.41		2,22,186.54	
family labour	30833.33		38307.40	
Cost C	2,39,860.74		2,60,493.94	

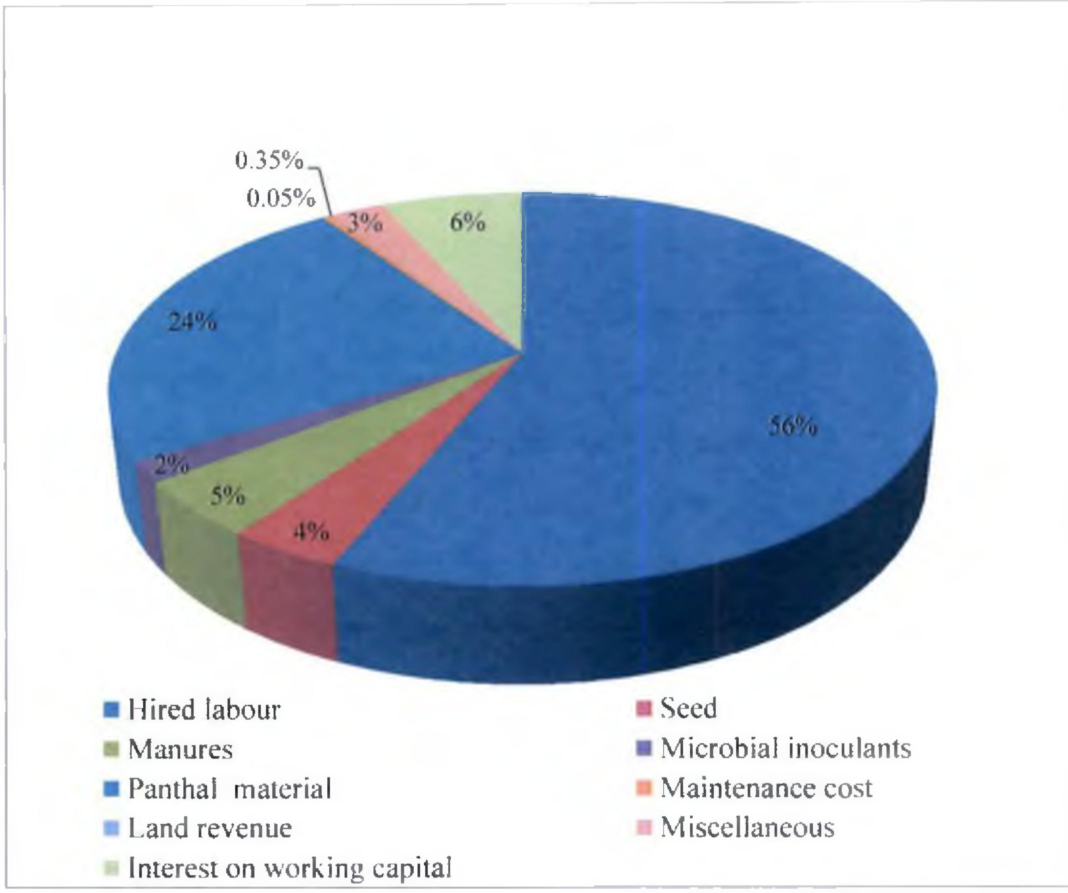


Figure 2. Cost A_1 of MI using yard long bean

4.3.2 Returns from Yard Long Bean

Returns from MI using and conventional yard long bean were presented in table 17.

The MI using yard long bean farmers obtained total yield of 6498.43 kg ha^{-1}, which was 7.15 per cent more than that of conventional farmers (6098.62 kg ha^{-1}).

Table.17 Returns from yard long bean

Particulars	Returns	
	MI using	**Conventional**
Yield (kg/ha)	6,498.43	6,098.62
Price (Rs/kg)	55.06	52.33
Gross return (Rs/ha)	3,62,577.10	3,19,244.00
Net returns at cost A_1 (Rs/ha)	2,37,966.10	1,69,549.30
Net returns at cost A_2 (Rs/ha)	1,97,132.70	1,34,546.10
Net returns at cost B (Rs/ha)	1,53,549.70	89,379.48
Net returns at cost C (Rs/ha)	1,22,716.40	51072.08

The gross returns obtained from yard long bean using MI were Rs.3,62,577 ha^{-1}, which is twelve per cent more than that of conventional farmers (Rs. 3,19,244 ha^{-1}). The market price observed in the area was Rs 55.06 per kg for MI using farmers and for conventional farmers it was 52.33 per kg.

The net returns at cost A_1 were Rs 2,37,966.10 ha^{-1} for MI using farmers and for conventional farmers it was Rs 1,69,549.30 ha^{-1}.

From the analysis it was observed that the net returns obtained by MI using farmers were 58 per cent more than that of conventional farmers. The main reason for this was high cost incurred by the conventional farmers in the production. It was in lines with the results observed by Saraf (2005) on field pea in Haryana.

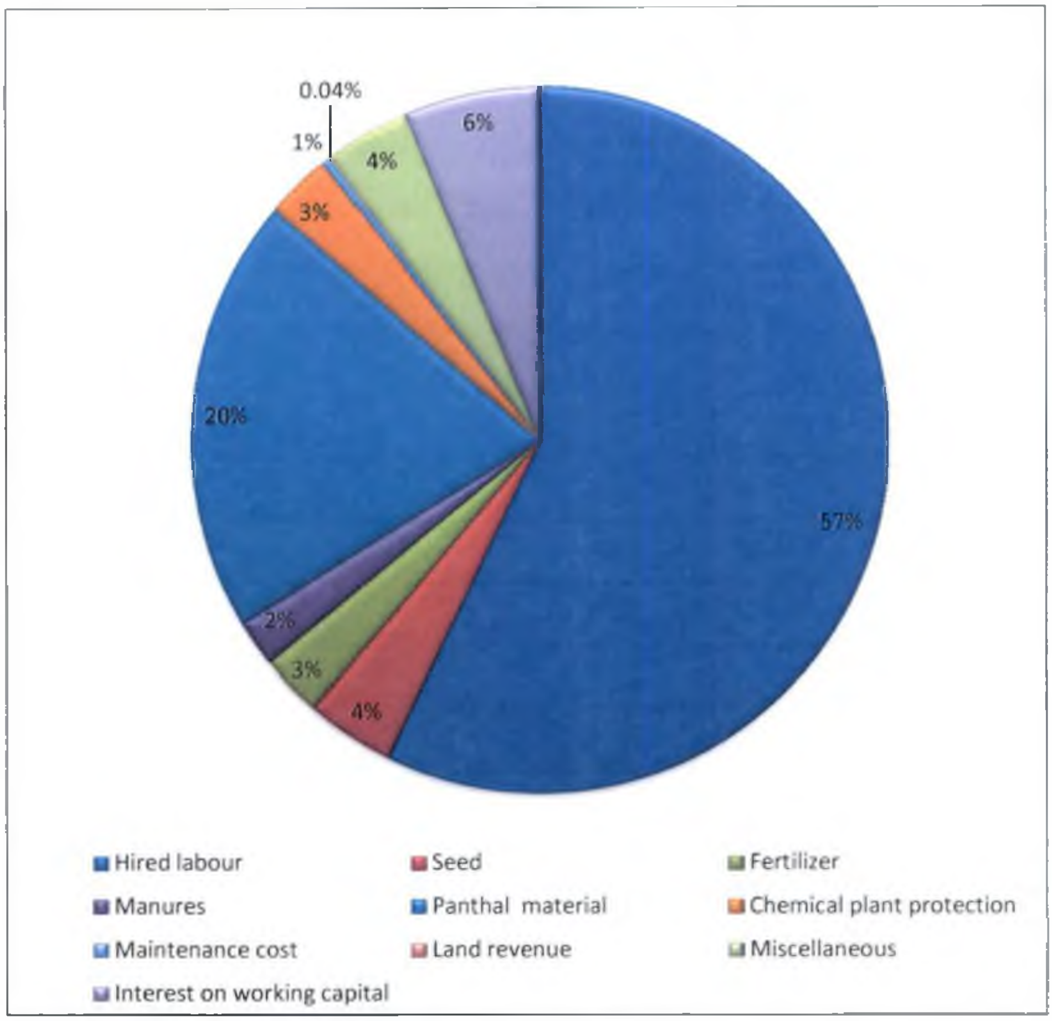


Figure 3. Cost A_1 of conventional yard long bean

4.3.3 Benefit Cost Ratio and Cost of Production of Yard Long Bean

B-C ratio and cost of production on different cost concepts were calculated and presented in Table.18.

Benefit cost ratio indicates value of output per rupee of input cost. This ratio will serve as a measure which would indicate as to whether the costs incurred commensurate with the returns obtained.

Returns generated per rupee invested were found to be more (2.90) for MI using farmers and it was 2.19 for conventional farmers at cost A_1. This was due to a low cost A_1 owing to the maximum usage of manures without the use of chemicals such as fertilizers and plant protection materials. The higher yield of MI using farmers was also contributed to the high benefit cost ratio when compared to conventional farmers. However the benefit cost ratio at cost C was also more than 1 for both the categories of farmers.

Table.18 B-C ratio and cost of production of yard long bean

Particulars	MI using		Conventional	
	B-C ratio	Cost of production (Rs/Kg)	B-C ratio	Cost of production (Rs/Kg)
Cost A1	2.90	19.17	2.19	23.28
Cost A2	2.19	25.45	1.76	29.02
Cost B	1.73	32.16	1.40	36.43
Cost C	1.51	36.91	1.19	42.71

Cost of production at cost A_1 were respectively Rs 19.17 and Rs 23.28 per kilogram for MI using and conventional farmers.

Cost of production per ha of yard long bean at cost C was more for conventional farmers (Rs. 42.71) than that of MI using farmers (Rs. 36.91).

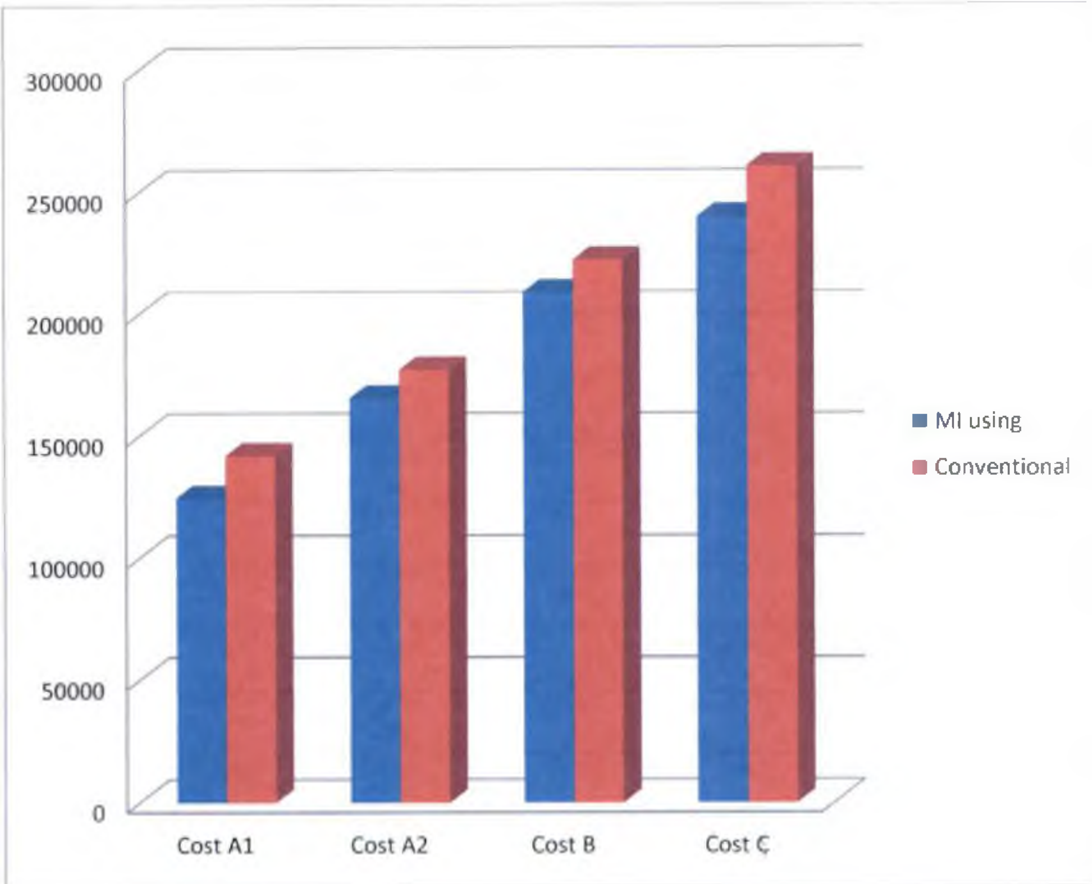


Figure4. Comparison of ABC cost (Yard long bean)

4.3.4 Comparison between the two Groups of Farmers

Analysis of covariance (ANCOVA) of returns was done by taking area as covariate to make comparison between the two types of farmers and is presented in Table 19.

Table.19 Analysis of covariance for yard long bean

Particulars	Adjusted mean of returns (In Rs.)	t-stat
MI using	3,61,905.40	14.25**
Conventional	3,09,213.80	
Difference	52,691.60	

** Significance at 1 per cent level.

The results showed that there was significant difference between MI using and conventional farmers as the t-value (14.25) is significant at 1 per cent level. The MI using farmers obtained Rs. 52,692 ha^{-1} more profit than that of conventional farmers.

4.3.5 Cost of Cultivation of Amaranthus

The cost of cultivation of amaranthus per ha was estimated and presented in Table 20.

Cost A_1 for MI using farmers was worked out as Rs 61,730.24 ha^{-1}, of which cost of hired labour accounted for 68.99 per cent followed by seed cost (7.18 per cent) and manures (6.97 per cent), this was agree with the results obtained by Kohle *et al.* (1988) on palak. Cost A_2, cost B, and cost C respectively were Rs 71,605.24 ha^{-1}, 81,705.24 $ha^{-1}$and Rs 1,05,597.21 ha^{-1}.

Table.20 Cost of cultivation of amaranthus per crop

Particulars	MI using amaranthus		Conventional amaranthus	
	Cost Rs/ha	Per cent to cost A_1	Cost Rs/ha	Per cent to cost A_1
Hired labour	42590.03	68.99	50109.33	67.61
Seed	4435.98	7.18	5102.04	6.88
Fertilizer	0.00	-	4522.59	6.10
Manures	4305.17	6.97	2514.57	3.39
Microbial inoculants	2781.62	4.50	0.00	-
Chemical plant protection	0.00	-	3577.50	4.82
Maintenance cost	430.90	0.69	552.72	0.74
Land revenue	20.00	0.03	20.00	0.02
Miscellaneous	3116.34	5.04	2854.71	3.85
Interest on working capital	4050.20	6.56	4860.35	6.55
Cost A1	61,730.24	100	74,113.81	100
Rent of leased in land	9875.00		10625.00	
Cost A2	71,605.24		84,738.81	
Rent of owned land	10100.00		9900.00	
Cost B	81,705.24		94,638.81	
family labour	23891.97		30308.55	
Cost C	1,05,597.21		1,24,947.36	

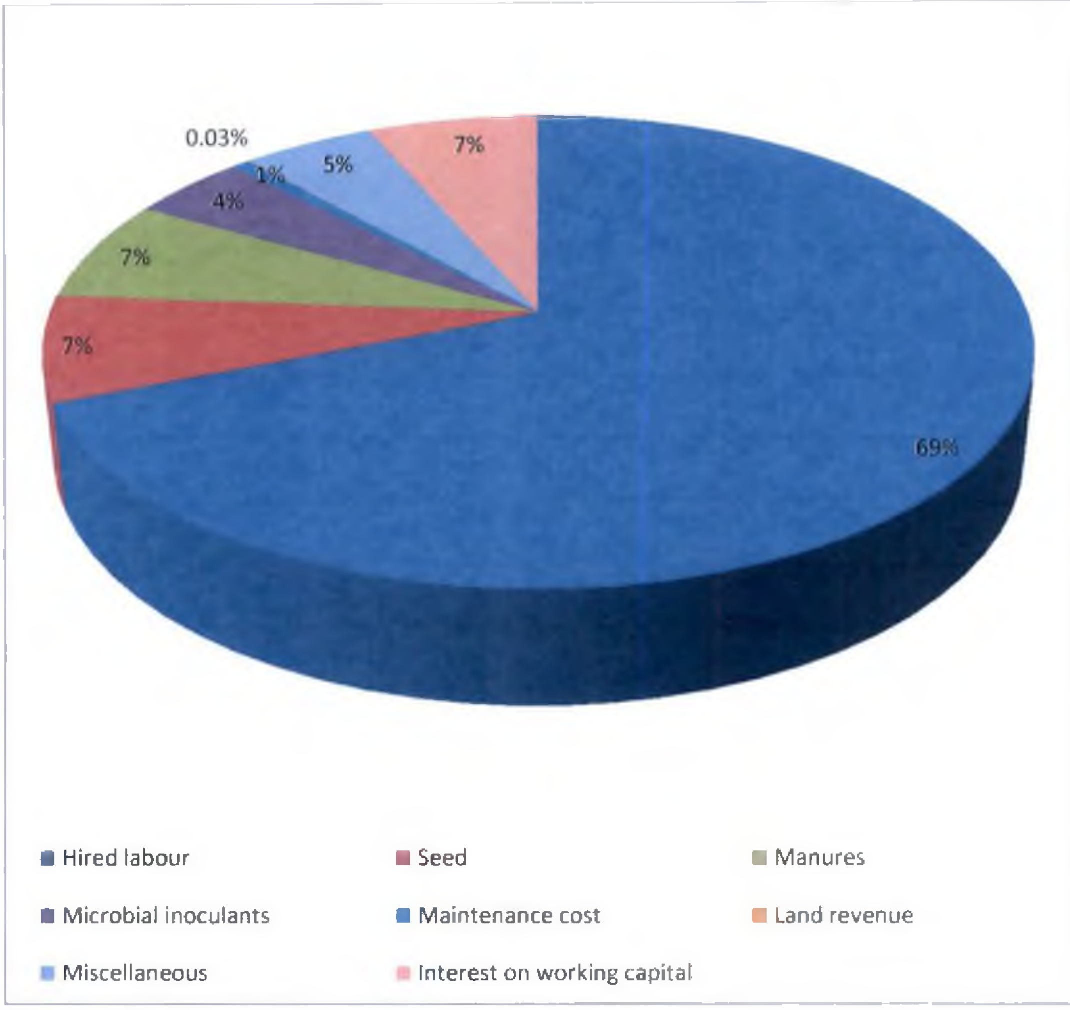


Figure 5. Cost A_1 of MI using amaranthus

For conventional amaranthus cost A_1 was estimated as Rs 74,113.81 ha^{-1}. Hired labour accounted for highest share of 67.61 per cent followed by seed cost (6.88 per cent) and interest on working capital (6.55 per cent). Cost A_2, cost B and cost C respectively were Rs 84,738.81 ha^{-1}, Rs 94,638.81 $ha^{-1}$and Rs1,24,947.36 ha^{-1}.

From the analyses of data, it could be seen that, conventional farmers incurred eighteen per cent more cost than that of the MI using farmers. This is in terms of hired labour (split application of fertilizers and plant protection chemicals) and high cost of fertilizers and plant protection chemicals.

4.3.6 Returns from Amaranthus

Returns from MI using and conventional amaranthus were presented in table 21.

Table.21 Returns from amaranthus

Particulars	Returns	
	MI using	Conventional
Yield (kg/ha)	7,835.10	7,306.85
Price (Rs/kg)	20.46	20.06
Gross return (Rs/ha)	1,54,439.80	1,46,416.40
Net returns at cost A_1 (Rs/ha)	92,709.56	72,302.59
Net returns at cost A_2 (Rs/ha)	82,834.56	61,677.59
Net returns at cost B (Rs/ha)	72,734.56	51,777.59
Net returns at cost C (Rs/ha)	48,662.59	21,469.04

The MI using amaranthus farmers obtained total yield of 7,835.10 kg ha^{-1}, which was 7 per cent more than that of conventional farmers (7,306.85 kg ha^{-1}).

Gross returns obtained by MI using farmers were Rs 1,54,439.80 ha^{-1}, which is five per cent more than that of conventional farmers (Rs 1,46,416.80 ha^{-1}). The

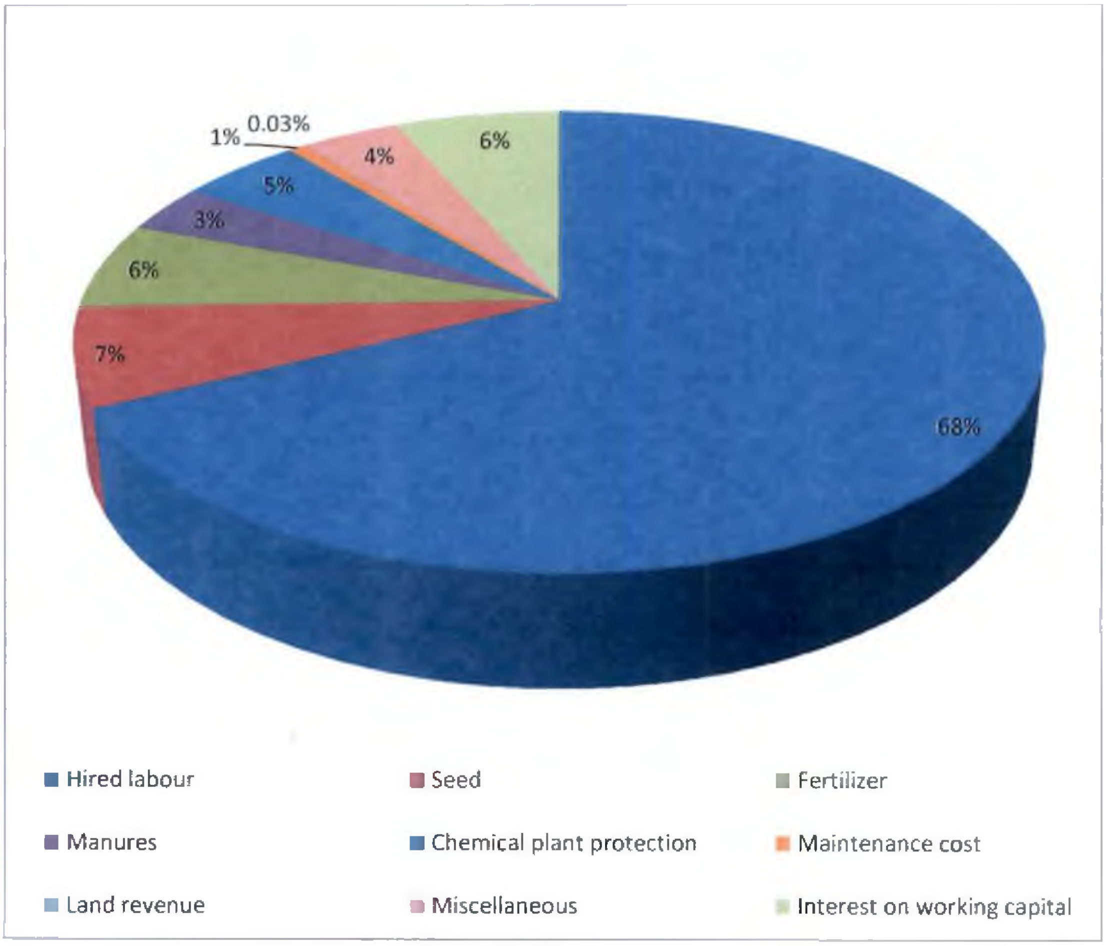


Figure 6. Cost A_1 of conventional amaranthus

market price observed in the area was respectively Rs 20.46 per kg and Rs 20.06 per kg for MI using farmers and for conventional farmers.

The net returns at cost A_1 were Rs 92,709.56 ha^{-1} for MI using farmers and for conventional farmers it was Rs 72,302.59 ha^{-1}.

From the analysis it was observed that the net returns obtained by MI using farmers were 45 per cent more than that of conventional farmers. The main reason for this was high cost incurred by the conventional farmers in the production.

4.3.7 Benefit Cost Ratio and Cost of Production of Amaranthus

B-C ratio and cost of production on different cost concepts were calculated and presented in Table.22.

Returns generated per rupee invested were found to be more (2.50) for MI using farmers and it was 1.97 for conventional farmers on cost A_1 basis. This was due to a low cost A_1 owing to the maximum usage of manures and no use of chemicals such as fertilizers and plant protections. The higher yield of MI using farmers was also contributed to a large benefit cost ratio when compared to conventional farmers. However the benefit cost ratio on cost C basis was more than one for both the categories of farmers.

Table.22 B-C ratio and cost of production of amaranthus

Particulars	MI using		Conventional	
	B-C ratio	Cost of production (Rs/Kg)	B-C ratio	Cost of production (Rs/Kg)
Cost A1	2.50	7.87	1.97	10.14
Cost A2	2.15	9.13	1.72	11.59
Cost B	1.89	10.42	1.54	12.95
Cost C	1.46	13.47	1.17	17.10

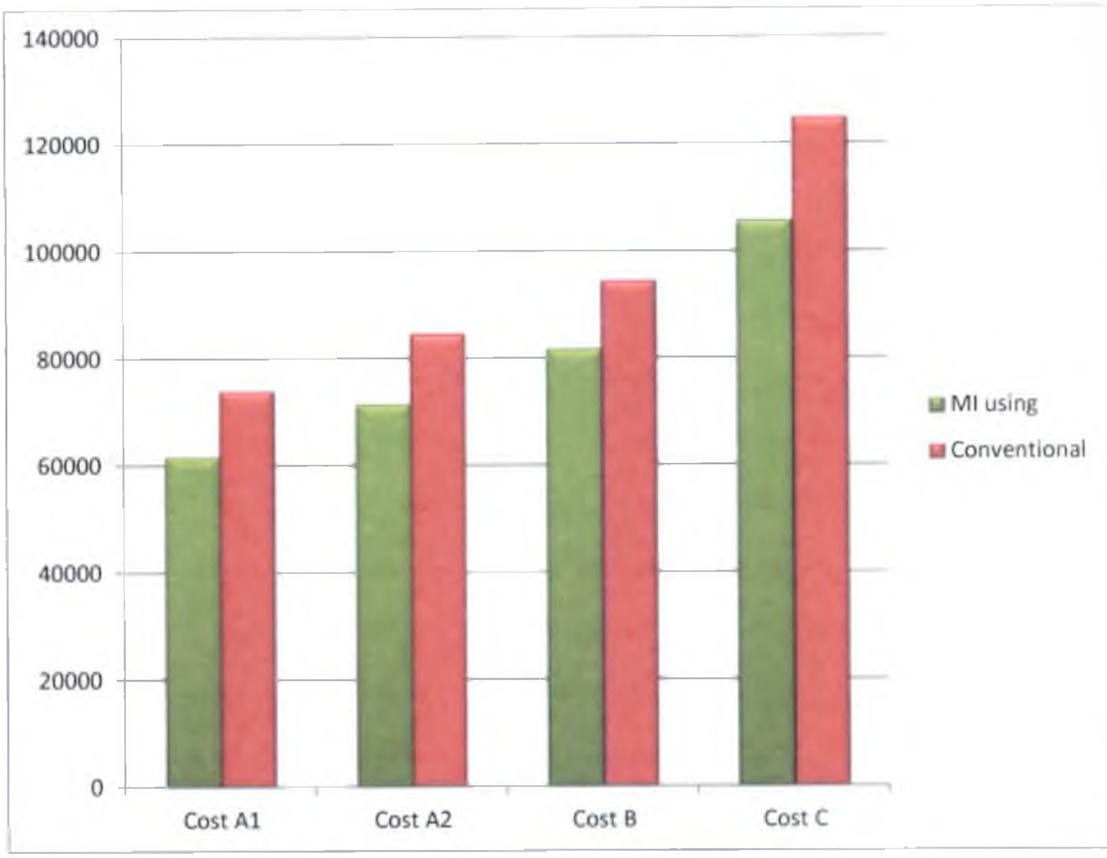


Figure 7. Comparison of ABC cost (Amaranthus)

Cost of production at cost A1 was Rs 7.87 and Rs 10.14 per kilogram respectively for MI using and conventional farmers.

Cost of production per ha of amaranthus at cost C was more for conventional farmers (Rs. 17.10) than that of MI using farmers (Rs. 13.47).

4.3.8 Comparison between the two Groups of Farmers

Analysis of covariance (ANCOVA) of was done by taking area as covariate to make comparison between the two types of farmers and presented in Table 23.

Table.23 Analysis of covariance for amaranthus

Particulars	Adjusted mean of returns (In Rs.)	t-stat
MI using	1,88,941.21	19.02**
Conventional	1,13,544.35	
Difference	75,397.14	

** Significance at 1 per cent level.

The results showed that there was significant difference between MI using and conventional farmers as the t-value (19.02) is significant at 1 per cent level. The MI using farmers obtained Rs. 75,397.14 ha^{-1} more profit than that of conventional farmers.

4.4. RESOURCE USE EFFICIENCY

Production function is defined as the relationship between physical inputs and physical output of a farm. It is useful in providing yardsticks of how efficiently resources are being used on a farm under given conditions (Dhondyal, 1997). The productivities of individual resources can be derived from the production function which indicates the efficiency of those resources at various levels.

In the present study, Cobb-Douglas production function was used for studying the dependence of output on the various inputs used. Cobb Douglas production function was used since it is the best method of determining the nature of inputs used in agriculture. For both, MI using and conventional farmers of yard long bean and amaranthus, Cobb-Douglas production function was fitted separately. As the farmers used different kinds of organic manures and plant protection chemicals, the actual physical quantity of this could not be elicited from them. Hence monetary value of variables except area was included in the production function analysis. The specification of the function fitted for yard long bean is:

$$Y = a\, X_1^{b1}\, X_2^{b2}\, X_3^{b3}\, X_4^{b4}\, X_5^{b5} e$$

Where,

Y = value of output (Rupees)

X_1 = area in cents

X_2 = Expenditure on seed (For MI using)/ hired labour (For conventional)

X_3 = Expenditure on manure (Rupees)

X_4 = Expenditure on MI (For MI using)/ maintenance (For conventional)

X_5 = Expenditure on family labour

a = Intercept

$b_1 \ldots . b_5$ = Regression coefficients of explanatory variables.

The coefficient of determination (R^2) explains the proportion of variation in the dependent variable (Y) explained by the independent variables included in the function. The estimated regression coefficients (b_i) of independent variables are the production elasticities of the respective factors (X_i). The regression coefficient 'b_i'

indicates the percentage by which the returns (Y) would change if input 'X_i' changes by one unit while all other factors remain constant at their geometric mean levels.

4.4.1 Resource Use Efficiency in Yard Long Bean Cultivation

A perusal of Table.24 revealed that R^2 was 0.88 for MI using farmers, which means that 88 per cent of the variation in dependent variable (value of output) was explained by the independent variables included in the function. Only area in cents was found to have a positive and significant impact on returns. The elasticity coefficient for area in cents was 1.34 which meant that 1 per cent increase in expenditure on this input would raise the returns by 1.34 per cent. The expenditure on MI was found to have a negative and significant elasticity coefficient which shows excess use of microbial inoculants in the production process, this is evident from the Table. 15, that farmer using MI 8- 10 times more than that of recommended rate. The expenditure on seed was found to be positive but non-significant. The elasticity coefficients for expenditure on manure and family labour were found to be negative and non-significant, which meant that any further expenditure on these inputs would reduce the returns. In other words, these inputs were over utilized in the production of yard long bean and reduction of these may result in improved production.

In case of conventional farmers, the explanatory variables included in the production function could explain 94 per cent (Table.25) of the variation in the dependent variables as indicated by the adjusted R^2. Area was found to have an elasticity co efficient of 0.86, which was significant at 1 per cent level. This meant that a one per cent increase in area would increase returns by 0.86 per cent. Other inputs such as expenditure on hired labour, manure and maintenance had positive impact on output as indicated by their elasticity coefficients but were statistically non-significant.

Table.24 Estimated production function for MI using yard long bean farmers

Sl No.	Particulars	Coefficients	Standard Error	P value
1	Intercept	3.93	0.63	>0.0001**
2	Area in cents (X_1)	1.34	0.39	0.002429**
3	Expenditure on seed (X_2)	0.17	0.12	0.187896
4	Expenditure on manure (X_3)	-0.24	0.13	0.086749
5	Expenditure on MI (X_4)	-0.01	0.11	0.034844*
6	Expenditure on family labour (X_5)	-0.25	0.18	0.180255
7	R^2	0.88		
8	$\overline{R^2}$	0.86		
9	F	36.68**		
10	$\sum bi$	1.01		
11	No. of observations	30.00		

* Significance at 5 per cent level

** Significance at 1 per cent level

Note: The coefficients are obtained with log value

Table.25 Estimated production function for conventional yard long bean farmers

Sl No.	Particulars	Coefficients	Standard Error	P value
1	Intercept	2.44	0.32	>0.0001**
2	Area in cents (X_1)	0.86	0.14	>0.0001**
3	Expenditure on hired labour (X_2)	0.12	0.10	0.239553
4	Expenditure on manure (X_3)	0.06	0.04	0.194106
5	Expenditure on maintenance (X_4)	0.12	0.18	0.502525
6	R^2	0.94		
7	$\overline{R^2}$	0.93		
8	F	98.48**		
9	$\sum bi$	1.18		
10	No. of observations	30.00		

* Significance at 5 per cent level

** Significance at 1 per cent level

Note: The coefficients are obtained with log values

Thus the results of production function analysis suggested that an increase in cultivated area would increase returns for both the farmers. MI using farmers must reduce the excess use of MI, manure and family labour to increase returns.

4.4.2 Marginal Productivity Analysis in Yard Long Bean Production

Marginal productivity is the measure of the increase in total product, for the addition of one unit of a particular resource above its mean level while other resources are held constant at their respective mean levels. Marginal value product is the marginal physical product represented in its value terms. The resource use efficiency has been judged on the basis of criterion that each factor of production is paid according to its marginal productivity. A significant difference between marginal value product and market price of individual input indicate whether the farmers are using on an average, their factors of production efficiently or inefficiently (Thakur *et al.* 1990).

In the present study, marginal value products of all inputs were worked out at their geometric mean levels. For efficient and optimum use of one input in the existing production situation, marginal value product to factor price ratio (MVP_{Xi}/MFC_{Xi}) should be equal to one or in other words MVP_{Xi} should be equal to price of X_i, where X_i is the i^{th} input. Marginal value productivity to factor cost ratios significantly different from unity would indicate whether the resources are used efficiently or not. The marginal value productivities of both the categories of farmers of yard long bean production are given in Table.26.

For MI using farmers, the MVP/MFC ratios of inputs such as seed, manures, panthalling materials and family labour were more than one which indicated the sub optimal use of these resources. The MVP/MFC ratio of hired labour and MI were less than one which indicated the overutilization of these resources, it was also in

Table.26 Marginal value product and marginal factor cost of different inputs in yard long bean production

Particulars	MI using		Conventional		MFC	MVP/MFC = k	
	Geometric mean	MVP	Geometric mean	MVP		MI using	Conventional
Returns	4.30	-	4.08	-	-	-	-
Hired labour	3.43	- 3.58	3.49	9.87	1.00	- 3.58	9.87
Seed	2.41	23.45	2.33	56.63	1.00	23.45	56.63
Manure	2.09	1.46	1.54	3.50	1.00	1.46	3.50
Panthal materials	3.22	2.35	2.17	8.17	1.00	2.35	8.17
MI	2.04	- 2.87	-	-	1.00	- 2.87	-
Fertilizers	-	-	2.90	6.07	1.00	-	6.07
Plant protection chemicals	-	-	2.24	- 4.20	1.00	-	- 4.20
Family labour	3.71	19.33	3.21	- 3.75	1.00	19.33	- 3.75

harmony with production function analysis. By reducing the use of hired labour and MI production could be shifted from a stage of negative returns (third stage of production) to a profitable region (second stage of production).

In case of conventional farmers, inputs such as hired labour, seed, panthalling materials and fertilizers had MVP/MFC ratios greater than one which indicated the underutilization of these resources. Other inputs like plant protection chemicals and family labour, the MVP/MFC ratio was less than one which indicated the excessive use of these inputs. So expenditure on these inputs must be reduced.

From the above analysis it was observed that MI using yard long bean farmers should reduce expense on hired labour and MI to increase returns whereas conventional farmers must reduce expenditure on plant protection chemicals and family labour to enhance returns.

4.4.3 Resource Use Efficiency in Amaranthus Cultivation

The production function fitted for the amaranthus is

$$Y = a X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} e$$

Where,

Y = value of output (Rupees)

X_1 = area in cents

X_2 = Expenditure on family labour (Rupees)

X_3 = Expenditure on MI (For MI using)/ hired labour (For conventional)

Table.27 Estimated production function for MI using amaranthus farmers

Sl No.	Particulars	Coefficients	Standard Error	P value
1	Intercept	2.67	0.23	>0.0001**
2	Area in cents (X_1)	0.87	0.07	>0.0001**
3	Expenditure on family labour (X_2)	0.24	0.13	0.232978
4	Expenditure on MI (X_3)	-0.18	0.05	0.000865*
5	R^2	0.92		
6	$\overline{R^2}$	0.92		
7	F	114.20**		
8	$\sum bi$	0.88		
9	No. of observations	30.00		

* Significance at 5 per cent level

** Significance at 1 per cent level

Note: The coefficients are obtained with log value

X_4 = Expenditure on maintenance (Rupees)

a = Intercept

$b_1 \ldots b_4$ = Regression coefficients of explanatory variables.

For MI using farmers, the production function fitted had an adjusted R^2 value of 0.92 which meant that 92 per cent of the variation in the dependent variable is explained by the explanatory variables included in the function (Table 27). With regard to inputs used, area had an elasticity coefficient of 0.83 and was significant which indicates the positive impact of area on returns. Expenditure on MI had a negative and significant impact on returns as indicated by their elasticity coefficients, which shows excess use of microbial inoculants in the production process.

In case of conventional farmers, the explanatory variables included in the production function could explain 85 per cent (Table.28) of the variation in the dependent variables as indicated by the adjusted R^2. Area was found to have an elasticity coefficient of 0.79 which was significant at 1 per cent level of probability. The expenditure on family labour had negative elasticity coefficient but statistically significant. Other inputs such as maintenance cost had positive impact and hired labour had negative impact on returns as indicated by their elasticity coefficients, but they are statistically non-significant.

Thus the results of production function analysis indicated that MI using farmers and conventional farmers can increase returns by increasing the area under cultivation. MI using farmers must reduce the excess use of MI to increase returns at less cost.

4.4.4. Marginal Value Productivity Analysis in Amaranthus Production

From Table.29, it can be observed that MVP/MFC ratios were more than one for the inputs such as seed, manure and family labour which indicated the underutilization of these resources. But hired labour and MI were excessively used in cultivation. This was clearly observed from the production function analysis also.

But in the case of conventional farmers, hired labour, seed, manure, fertilizers and plant protection chemicals were used sub optimally. Other input (family labour) had MVP/MFC ratios less than one which indicated their overutilization. These results agree with the conclusions drawn by Sharma and Kachroo (2009) that labour, seed, fertilizers and plant protection chemicals were sub optimally utilized in maize cultivation in Jammu.

4.5 CONSTRAINTS ANALYSIS

A clear understanding of constraints helps to formulate research and to suggest suitable policy options. The constraints were grouped into three categories, production constraints, marketing constraints and technological constraints. The plausible constraints were ranked by vegetable growers and scores were obtained using the Garrett's ranking techniques were presented in tables 30, 31, 32 and 33 respectively.

4.5.1 Production Constraints

High price of seeds was the most serious constraints faced by the MI using farmers followed by the lack of availability of quality seeds; Most of the farmers purchased the seeds from college of agriculture, Vellayani and local agro shops, they raised the problem of poor germination, which according to them was less than 70 per cent of germination. Another important problem faced by the MI using yard long

Table.28 Estimated production function for conventional amaranthus farmers

Sl No.	Particulars	Coefficients	Standard Error	P value
1	Intercept	2.99	0.19	>0.0001**
2	Area in cents (X_1)	0.79	0.13	>0.0001**
3	Expenditure on family labour (X_2)	-0.19	0.08	0.025437*
4	Expenditure on hired labour (X_3)	-0.10	0.06	0.094467
5	Expenditure on maintenance (X_4)	0.14	0.09	0.131161
6	R^2	0.85		
7	$\overline{R^2}$	0.83		
8	F	37.35**		
9	$\sum bi$	0.85		
10	No. of Observations	30.00		

* Significance at 5 per cent level

** Significance at 1 per cent level

Note: The coefficients are obtained with log value

bean farmers was high cost of panthal materials, even though the panthal materials can be used more than once.

In case of conventional vegetable farmers high incidence of pest and disease was the most serious problem, followed by the high price of the seeds. High cost of panthal materials was the third important constraint faced by the conventional farmers.

4.5.2 Marketing Constraints

Marketing constraints had been identified as the most crucial problem in both categories of farmers. MI using farmers are very few and scattered with less marketable surplus, since the commodities are highly perishable in nature they could not transport it to distant organic markets to get good price for their produce. Unorganized markets and the absence of separate market for selling the organic produce was the major problems faced by the MI using farmers, the result is in harmony with the study conducted by Joshi *et al.* in 2006. But in case of conventional farmers most serious problem was frequent changes in taste and preference of consumer.

Lack of demand from local households and the inability of small farmers to find to find market for their produce were the other major constraints faced by the MI using farmers.

4.5.3 Technological Constraints

In case of technological constraints lack of standardized practice to fallow, followed by lack of new varieties for cultivation were most serious problems faced by both the categories of farmers. In the case of MI using farmers lack of knowledge about MI and absence of practical training about the use of MI were also observed as the other important constraints.

Table.29 Marginal value product and marginal factor cost of different inputs in amaranthus production

Particulars	MI using		Conventional		MFC	MVP/MFC = k	
	Geometric mean	MVP	Geometric mean	MVP		MI using	Conventional
Returns	3.76	-	3.57	-	-	-	-
Hired labour	3.17	- 4.79	3.00	5.36	1.00	- 4.79	5.86
Seed	2.17	20.37	2.11	1.98	1.00	20.37	1.98
Manure	1.86	1.11	1.51	3.56	1.00	1.11	3.56
MI	2.01	- 3.25	-	-	1.00	- 3.25	-
Fertilizers	-	-	2.03	7.27	1.00	-	7.27
Plant protection chemicals	-	-	1.93	2.46	1.00	-	2.46
Family labour	2.92	9.53	2.86	-1.03	1.00	9.53	- 1.03

Table.30 Production constraints of MI using farmers

Sl No.	Constraints	MI using	
		Garrett's score	Rank
1	Lack of availability of quality seeds	63.41	2
2	High price of seeds	70.36	1
3	Less availability of microbial inoculants	51.68	5
4	High incidence of pest and disease	53.30	4
5	Slow effect of MI	46.98	7
6	Difficulty in identifying pest and diseases	47.96	6
7	Difficulty in availing institutional credit	37.95	8
8	Lack of knowledge about method and time of application of MI	34.41	9
9	High price of MI	30.71	10
10	High cost of panthal materials	60.54	3

Table.31 Production constraints of conventional farmers

Sl No.	Constraints	Conventional	
		Garrett's score	Rank
1	Lack of availability of quality seeds	50.13	5
2	High price of seeds	62.66	2
3	High incidence of pest and disease	73.06	1
4	High cost of plant protection chemicals	53.28	4
5	Difficulty in identifying pest and diseases	43.73	6
6	Difficulty in availing institutional credit	40.08	7
7	High cost of panthal materials	60.54	3

Table.32 Marketing constraints

Sl No.	Constraints	MI using		Conventional	
		Garrett's score	Rank	Garrett's score	Rank
1	Lack of coordination among vegetable growers	46.11	5	50.13	4
2	Unhealthy competition among growers	37.15	6	62.66	2
3	Frequent changes in taste and preference of consumer	48.86	4	73.06	1
4	Marketing problems	75.35	1	53.28	3
5	Inability of small growers to find market	54.13	3	43.73	5
6	Lack of demand from local households	60.76	2	40.08	6
7	Delay in payment of sale proceeds	27.70	7	28.76	7

Table.33 Technological constraints

Sl No.	Constraints	MI using		Conventional	
		Garrett's score	Rank	Garrett's score	Rank
1	Absence of practical training About MI	39.55	4	-	-
2	Lack of knowledge about MI	49.75	3	-	-
3	No standardized practice to fallow	63.71	1	64.34	1
4	Lack of research for developing new varieties	57.71	2	63.74	2
5	Lack of technical expertise on MI	38.85	5	-	-

Summary

5. SUMMARY

Thiruvananthapuram district is one of the major vegetable producing district in the Kerala state. The district also has a more number of vegetable growing farmers using MI. The present study is an attempt to understand the impact of MI on vegetable production in the district taken up with the following objectives:

To study the extent of use of microbial inoculants in vegetable cultivation, work out the economics and efficiency of microbial inoculants in vegetable production and to make a comparative analysis with the conventional vegetable production.

This study was done in Ncyyattinkara and Nedumangad taluks of Thiruvananthapuram district. Data on the general characteristics of the farmers such as age, education, family size, gender, major occupation, size of holding, cropping pattern, annual income and area under selected vegetables were collected and analyzed using percentages and averages. Cost of cultivation was worked out using the A B C cost concepts. Resource use efficiency was estimated using Cobb-Douglas production function and marginal productivity analysis was also calculated. Farmers are asked to rank the constraints faced by them according to severity and final rank for each constraint was arrived using Garret's ranking techniques.

The analysis of socio-economic characteristics of respondents revealed that involvement of younger generation was more in vegetable cultivation. All the farmers in the study area were literates. They are educated up to graduate level. There was wide variation in gender involvement and maximum involvement of females was noted in MI using amaranthus farmers (23 per cent). The average size of family was 4.68 and the maximum family size of 5.06 was observed in conventional amaranthus farmers. Agriculture was the main occupation of 65 per cent of vegetable growers and the average land holding observed in the study area was 46.03 cents. Average annual income at the aggregate level was Rs. 1,03,337/- per household.

About 93 per cent of the respondent farmers possessed an area of less than 20 cents under the selected crops.

The most commonly used MI were *Pseudomonas* and *Trichoderma* in the study area. *Pseudomonas* was used by more than 38 per cent and *Trichoderma* by 35 per cent of the respondents. More than 73 per cent of farmers were used inoculants for disease control. Fifty per cent of respondent farmers purchased MI from College of Agricultural and about 42 per cent from KVK. This indicates the role played by college of agriculture and KVK in popularizing the MI technology in the study area.

MI for seed treatment was found to be adopted by 27 per cent and 20 per cent respectively of the respondent farmers in the case of yard long bean and amaranthus. Most of the farmers are applying MI above the recommended rate. The farmers are wasting MI and money by applying large quantity of MI to the soil. This shows the necessity of more extension activities among farmers for the proper adoption of MI.

Cost A_1 for MI using yard long bean farmers was worked out as Rs 1,24,611.02 ha^{-1}, of which cost of hired labour accounted for 56.31 per cent followed by cost of panthaling materials (23.92 per cent) and interest on working capital (6.56 per cent). MI accounted for only 1.72 per cent of cost A_1. Cost A_2,cost B, and cost C were respectively Rs 1,65,444.41 ha^{-1}, Rs 2,09,027.41 ha^{-1} and Rs 2,39,860.74 ha^{-1}.

Cost A_1 for conventional yard long bean was Rs 1,42,016.72 ha^{-1}. Hired labour accounted for 57.20 per cent followed by cost of panthaling materials (19.96 per cent) and interest on working capital (6.26 per cent). Cost A_2, cost B and cost C were respectively Rs 1,77,019.88 ha^{-1}, Rs 2,22,186.54 ha^{-1} and Rs 2,60,493.94 ha^{-1}.

The MI using yard long bean farmers obtained total yield of 6498.43 kg ha^{-1}, which was 7.15 per cent more than that obtained by conventional farmers (6098.62 kg ha^{-1}). The gross returns obtained from yard long bean using MI were Rs.3,62,577 ha^{-1}, which is twelve per cent more than that of conventional farmers (Rs. 3,19,244

ha^{-1}). The net returns obtained by MI using yard long bean farmers were 58 per cent more than that of conventional farmers. The main reason for this was high cost incurred by the conventional farmers in the production. B-C ratios at cost A_1 were found to be more (2.90) for MI using yard long bean farmers and it was 2.19 for conventional farmers. Cost of production at cost A1 were respectively Rs 19.17 and Rs 23.28 per kilogram for MI using and conventional farmers.

Analysis of covariance (ANCOVA) showed that there was significant difference between MI using and conventional yard long bean farmers. The MI using farmers obtained Rs. 52,692 ha^{-1} more profit than that of conventional farmers.

The estimated cost A_1 for MI using amaranthus farmers was worked out as Rs 61,730.24 ha^{-1}, of which cost of hired labour accounted for 68.99 per cent, seed cost (7.18 per cent) and manures (6.97 per cent). Cost A_2, cost B, and cost C were respectively Rs 71,605.24 ha^{-1}, 81,705.24 $ha^{-1}$and Rs 1,05,597.21 ha^{-1}.

For conventional amaranthus, cost A_1 estimated was Rs 74,113.81 ha^{-1}. Hired labour accounted for the highest share of 67.61 per cent followed by seed cost (6.88 per cent) and interest on working capital (6.55 per cent). Cost A_2, cost B and cost C respectively were Rs 84,738.81 ha^{-1}, Rs 94,638.81 $ha^{-1}$and Rs 1,24,947.36 ha^{-1}.

The MI using amaranthus farmers obtained yield of 7835.10 kg ha^{-1} which was 7 per cent more than that obtained by conventional farmers (7306.85 kg ha^{-1}). Gross returns obtained by MI using farmers were Rs 1,54,439.80 ha^{-1}, which is five per cent more than that of conventional farmers (Rs 1,46,416.80 ha^{-1}) and the net returns obtained by MI using farmers were 45 per cent more than that of conventional farmers. B-C ratios at cost A_1 were found to be more (2.50) for MI using amaranthus farmers and it was 1.97 for conventional farmers. Cost of production at cost A_1 was respectively Rs 7.87 and Rs 10.14 per kilogram for MI using and conventional amaranthus farmers.

Analysis of covariance (ANCOVA) showed that the MI using amaranthus farmers obtained Rs. 75,397.14 ha^{-1} more profit than that of conventional farmers.

Production function analysis of yard long bean revealed that an increase in cultivated area would increase returns for both the categories of farmers. For MI using farmer's expenditure on MI was found to have a negative and significant elasticity coefficient, which shows excess use of MI. All other inputs were negative and non-significant. For conventional farmers other inputs such as expenditure on hired labour, manure and maintenance cost were found to had positive impact but statistically non-significant.

Production function analysis of amaranthus revealed that an increase in cultivated area would increase returns for both the categories of farmers. For MI using farmer's expenditure on MI had a negative and significant impact on returns. In case of conventional farmers expenditure on family labour was found to be had negative coefficient but statistically significant.

From the allocative efficiency analysis of both the crops, it was observed that MI using farmers should reduce expense on hired labour and MI to increase returns whereas conventional farmers must reduce expenditure on plant protection chemicals and family labour to enhance returns.

High price of seeds was the most serious production constraints faced by the MI using farmers whereas, high incidence of pest and disease was the most serious problem faced by conventional farmers.

Unorganized markets and the absence of separate market for selling the organic produce was the major marketing constraints faced by the MI using farmers, while in case of conventional farmers the most serious marketing problem was, frequent changes in taste and preference of consumer.

Lack of standardized practice to cultivate the vegetable and lack of new varieties for cultivation were most serious technological constraints faced by both the categories of farmers.

5.1 Conclusion

The yield, returns and B: C ratios of MI using yard long bean and amaranthus farmers were more with less expenditure when compared to conventional farmers: Hence MI can be used for sustainable crop production. Over adoption of MI was observed in the study area due to lack of awareness regarding the correct dose of MI and seed treatment with MI was not a common practice, extension machinery must be strengthened to give proper guidance to the farmers on the application of recommended dose of MI, which would enhance the returns of farmers at less cost.

From the production function analysis it was understood that an increase in cultivated area would increase returns for both the crops. MI using farmers must reduce the excess use of MI to increase returns. Allocative efficiency also revealed the same results. So MI can be used as an alternative for chemical inputs, which would enhance the yield and net profit of farmers.

5.2 Policy Options

The study revealed that over adoption of MI. The main reason is that MI are available in 1 kilogram packets, so MI should made available in small packets, which will help the farmers cultivating in small holding.

The research work to link the use of MI on the quality of agricultural produce is to be given focus in view of the rising consumer demand for organic products in domestic and export market.

The farmers are unaware of the recommended rate and shelf life of MI. Hence, action should be taken to extend practical training regarding exact recommendations of MI.

More than 60 per cent of the respondents opined that they got poor germination, which according to them was less than 70 per cent. Hence action should be taken to supply quality seeds.

The supply chain arrangements (retail outlets) for MI are very inadequate. The material is not available in sufficient quantity, at time and place. Hence action should be taken to supply quality MI at required time.

The MI and organic manures are perceived as same, by many farmers. The beneficial effect of MI and its application pattern and needed technical information is not appropriately passed on. This creates a situation of unscientific use of MI. The public extension system may focus on this aspect.

The government should provide premium and support prices for the vegetables especially organic vegetables in order to create incentive among farmer to enhance vegetable cultivation. Institutional credit and incentives to be given to the women and unemployed youth for enhancing vegetable production by adopting new technologies and using MI.

Training programmes should be organized to keep the vegetable growers well versed of the improved production methods.

The government should take initiatives to start separate markets for organic vegetable products at premium prices.

The farmers often compare the effects of MI with that of chemicals to which they are familiar. The convincing effect of chemicals on crop growth is a motivation for farmers to adopt the technology. Lack of such immediate visible effects for MI limits the scope for adoption. This underlines the need for massive extension strategy for popularizing the technology in the walk of increasing emphasis by State and Central governments for a shift towards organic agriculture.

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Appendix I

Appendix I

SCHEDULE

KERALA AGRICULTURAL UNIVERSITY

College of Agriculture, Vellayani, Thiruvananthapuram- 695522

Department of Agricultural Economics

Title: Economic impact of microbial inoculants on vegetable production in Thiruvananthapuram district.

Name of Interviewer: - Date:-

1. **General information**

1. Name of the farmer: 2. Taluk:

3. Panchayath: 4. Village: 5.Contact No:

2. Particulars of family: Nuclear family / Joint family:

Sl. No	Family members name	Relation with head	Age (years)	Education level	Main Occupation	Income (Rs.)
1.						
2.						
3.						
4.						
5						

3. Land holding Details:

Sl. No	Type of land	Owned (cents)	Leased in.		Leased out		Total area (cents)	Price/ unit	Total value(Rs)
			Area	Value (Rs)	Area	Value (Rs)			
1.	Wet land								
2.	Garden								
	a) Irrigated								
	b) Rain fed								
3.	Total								

4. ASSETS POSITION

a. Farm assets

PARTICULARS	No.	Purchase value	Year of purchase	Present value
A. Farm buildings				
1.Farm house				
2.Cattle shed				
3.Pump house				
4.Poultry shed				
5.Others(specify)				
B. Farm machinery & equipment				
1. Tractor				
2. Power Tiller				
3. Bullock Cart				
4. Others(specify)				
C. Other implements.				
1.Spade				
2.Sickle				
3.Others(specify)				

5. **Cropping pattern**

a) Wet land

Sl. No	Crops	Area (cents)	Total (Cents)
1.			
2.			
3.			

b) Garden land

Sl. No	Crops	Irrigated (Cents)	Rain fed(cents)	Total (cents)
1.				
2.				
3.				

6. Whether you are using microbial inoculants-Yes/No

   i) If yes for what purpose-
      a) Pest control
      b) Disease control
      c) Nutrition purpose
      d) Others

   ii) Why?
      a) It increases crop yield
      b) Easily available and eco-friendly
      c) Any other reason

7. Whether these inoculants are available in your place - Yes/No
   a) If yes specify source-
   b) Name of the inoculant-

c) Since from how many years you are using-

8. From whom do you usually get information on microbial inoculants-

1	Agricultural department	Yes/No
2	Krishi Vignana Kendra (Specify)	Yes/No
3	Agricultural university	Yes/No
4	Public media (e.g. Radio, Newspaper, Magazines, TV)	Yes/No
5	Others(specify)	

9. What are all the microbial inoculants you are using -

Sl. No	Name	Crops	Quantity	Price/unit	Source	Purpose
1.	*Trichoderma*					
2.	*Azotobacter*					
3.	*Rhizobium*					
4.	*Pseudomonas*					
5.	P solubilizes					
6.	*Metarhizium*					
7.	*Beauveria*					
8.	*Lecanicillium*					
9.	*Paecilomyces*					
10.	Other(specify)					

10. Which one you feel to be more effective:

a) Why?

11. If you are using bio-inoculants in which manner you are using–

	Type	Quantity
a)	Seed treatment	
b)	Seedling treatment	
c)	Soil application	
d)	Foliar spray	
e)	Any other	

12. Do you know about recommendations - Yes/NO

a) If yes specify-

13. Do you think bio-inoculants are safe to use- Yes/No

14. Which is more cost effective - Chemicals / bio-inoculants

a) To what extent:
b) At what time you are applying these agents-
   i) Morning
   ii) Afternoon
   iii) Evening

15. Are you using any chemicals along with bio inoculants Y/N

16. Do you feel any yield advantage over chemicals- Y/N

a) If yes to what extent:

17. Do you feel any quality difference on microbial inoculants from different sources:

a) If yes, how?

18. Costs and returns from crop—————————

Crop: Variety: Area (acres):

Season: Irrigated/Rain fed:

Source of irrigation:

Wage rate (Rs): M: F: Bullock pair: Machine (Rs/ hrs/day):

19. Labour Requirement for crop production (days/hrs)

No.	Operations	Labour			Machine labour (Hrs)	Total
		Men	Women	family		
1	Land preparation					
2	Transportation of manures					
3	FYM application					
4	Preparation of sowing seeds with microbial inoculants					
5	Sowing/transplanting					
6	Panthal material					
7	Irrigation					
8	Fertilizer application					
9	Weeding					
10	Inter cultivation					
11	Spraying					
	Insecticide-					
	Fungicide-					
	Bio pesticides-					
12	Harvesting					
13	Post-harvest handling					
14	Others					

20. Material input requirement and their costs for crop Area:

Sl. No.	Particulars	Units	Quantity	Unit Price (Rs)	Total cost (Rs)	Remarks
1.	Planting materials /seeds					
2.	Seed treatment					
	a.					
	b.					
3.	Manures					
4.	Fertilizer					
	a.					
	b.					
	c.					
5.	Panthal material					
	a. Cost of standards					
	b. Cost of ropes					
6.	Plant protection chemical					
	a.					
	b.					
	c.					
7.	Irrigation charges (if water is purchased from neighbours)					

B. Marketing			
8	Cleaning and packing		
	Loading and Un-loading		
	Transportation charges		
9	Commission		
10	Market fees/Taxes		
11	Other charges, if any(refreshment)		

21. Returns (Crops)

S.N.	Particulars	Units	price per unit (Rs)	Total Value (Rs)
1.	Main Product			
2.	By Product (Specify)			

22. Constraints faced by vegetable growing farmers:

Sl.No		Constraints	Rank
1		**Production constraints**	
	1	Lack of availability of quality seeds	
	2	High price of seeds	
	3	Less availability of microbial inoculants	
	4	High incidence of pest and disease	
	5	Slow effect of MI	
	6	High cost of PP chemicals	
	7	Difficulty in identifying pest and diseases	
	8	Difficulty in availing institutional credit	
	9	High cost of panthal materials	
	10	High price of MI	
	11	Lack of knowledge about method and time of application of MI	
2		**Marketing constraints**	
	1	Lack of coordination among vegetable growers	
	2	Unhealthy competition among growers	
	3	Frequent changes in taste and preference of consumer	

	4	Unorganized marketing channels	
	5	Inability of small growers to find market	
	6	Lack of demand from local households	
	7	Delay in payment of sale proceeds	
3		**Technological constraints**	
	1	Absence of practical training About MI	
	2	Lack of knowledge about MI	
	3	No standardized practice to fallow	
	4	Lack of research for developing new varieties	
	5	Lack of technical expertise on MI	
4		Others (specify)	

Appendix II

Appendix II

GARRETT RANKING CONVERSION TABLE

The conversion of orders of merits into units of amount of "scores"

Percent	Score	Percent	Score	Percent	Score
0.09	99	22.32	65	83.31	31
0.20	98	23.88	64	84.56	30
0.32	97	25.48	63	85.75	29
0.45	96	27.15	62	86.89	28
0.61	95	28.86	61	87.96	27
0.78	94	30.61	60	88.97	26
0.97	93	32.42	59	89.94	25
1.18	92	34.25	58	90.83	24
1.42	91	36.15	57	91.67	23
1.68	90	38.06	56	92.45	22
1.96	89	40.01	55	93.19	21
2.28	88	41.97	54	93.86	20
2.69	87	43.97	53	94.49	19
3.01	86	45.97	52	95.08	18
3.43	85	47.98	51	95.62	17
3.89	84	50.00	50	96.11	16
4.38	83	52.02	49	96.57	15
4.92	82	54.03	48	96.99	14
5.51	81	56.03	47	97.37	13
6.14	80	58.03	46	97.72	12
6.81	79	59.99	45	98.04	11
7.55	78	61.94	44	98.32	10
8.33	77	63.85	43	98.58	9
9.17	76	65.75	42	98.82	8
10.06	75	67.48	41	99.03	7
11.03	74	69.39	40	99.22	6
12.04	73	71.14	39	99.39	5
13.11	72	72.85	38	99.55	4
14.25	71	74.52	37	99.68	3
15.44	70	76.12	36	99.80	2
16.69	69	77.68	35	99.91	1
18.01	68	79.17	34	100.00	0
19.39	67	80.61	33	-	-
20.93	66	81.99	32	-	-

Abstract

ECONOMIC IMPACT OF MICROBIAL INOCULANTS ON VEGETABLE PRODUCTION IN THIRUVANANTHAPURAM DISTRICT

by

JITENDRA AJAGOL

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Abstract of the thesis
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2016

ABSTRACT

The research entitled "Economic impact of microbial inoculants on vegetable production in Thiruvananthapuram district" was undertaken in Neyyattinkara and Nedumangad taluks. The objectives were to study the extent of use of microbial inoculants (MI) in vegetable cultivation, to work out the economics and efficiency of microbial inoculants in vegetable production and to make a comparative analysis with the conventional vegetable production. The crops selected for study were yard long bean and amaranthus. The required information was collected from 30 each of MI using and conventional farmers of yard long bean and amaranthus by simple random sampling so that the sample size became 120. Percentage analysis was used to measure extent of use of MI and economics of vegetable production. Resource use efficiency was estimated using Cobb-Douglas production function and constraints were ranked using Garrett's ranking technique.

A mixed cropping system was observed in study area. Annual crops like vegetables, tapioca and banana and perennial crop like coconut were cultivated along with yard long bean and amaranthus. Average size of holding of the selected farmers was 46.03 cents. The average area under yard long bean was 17.46 cents and 11.56 cents respectively for MI using and conventional farmers. In case of amaranthus, average area for MI using farmers was 10.83 cents and for conventional farmers it was 6.86 cents. Fifty per cent of respondent farmers purchased MI from agricultural college and about 42 per cent from KVK.

Analysis of the extent of use of MI revealed that only 27 and 17 per cent of the respondents were following the recommended rate respectively in yard long bean and amaranthus, whereas, 53 and 70 per cent were applying MI above the recommended rate.

The total cost of cultivation of yard long bean per hectare was more for conventional farmers than that of MI using farmers. Cost A_1 was estimated as Rs.

1,42,016 ha^{-1} and Rs. 1,24,611 ha^{-1} respectively for conventional and MI using farmers and cost C was Rs. 2,60,493 ha^{-1} and Rs. 2,39,860 ha^{-1} respectively. The corresponding B-C ratios were 1.46 and 1.51 and net returns were Rs. 51,072 ha^{-1} and Rs. 1,22,716 ha^{-1} respectively. Major share of the cost was accounted for hired labour which was 57 and 56 per cent respectively of cost A_1 for conventional and MI using farmers. In the case of amaranthus, cost A_1 estimated for conventional farmers was Rs. 74,113 ha^{-1} and for MI using farmers it was Rs. 61,730 ha^{-1} and cost C was Rs. 1,24,947 ha^{-1} and Rs. 1,05,597 ha^{-1} respectively. The corresponding B-C ratios were 1.17 and 1.19 and net returns were Rs. 21,469 ha^{-1} and Rs. 48,662 ha^{-1} respectively for conventional and MI using farmers. Here also hired labour occupied the highest share for both the categories of farmers which accounted for 68 and 69 per cent respectively of cost A_1.

The yield of yard long bean was found to be more for MI using farmers (6498 kg ha^{-1}) and it was 6098 kg ha^{-1} for conventional farmers. The corresponding cost of production was Rs. 19 per kg and Rs. 23 per kg respectively at cost A_1. In case of amaranthus also, MI using farmers obtained more yield (7835 kg ha^{-1}) compared to conventional farmers (7306 kg ha^{-1}) and the respective cost of production were Rs. 7 per kg and Rs. 10 per kg at cost A_1.

The production function analysis revealed that area had positive and significant impact on returns in all the cases. Expenditure on MI showed a negative and significant impact on returns, which may be due to over adoption of MI. Cost of seeds, cost of panthal material and pest and disease incidence were identified as major constraints in vegetable production.

Present study revealed that by using MI, cost of cultivation per hectare of yard long bean and amaranthus can be reduced considerably when compared to conventional cultivation and profits can be increased. Since over adoption of MI was observed among respondents, extension machinery must be strengthened to give proper guidance to the farmers on the application of recommended dose of MI.