International Journal of GEOMATE, Dec., 2017, Vol. 13, Issue 40, pp.16 - 23
Special Issue on Science, Engineering & Environment, ISSN: 2186-2990, Japan
DOI: https://doi.org/10.21660/2017.40.2517

INOCULANTS FUNGAL *Trichoderma, Mucor* AND *Bacillus* FOR COMMUNITY DEVELOPMENT BASED ON SUFFICIENCY ECONOMY PHILOSOPHY

*Sukhan Rattanaloeadnusorn[1]

[1] Faculty of Science and Technology, Rajamangala University of Technology Thanyaburi, Thailand

*Corresponding Author, Received: 5 June 2016, Revised: 4 July 2017, Accepted: 25 Sept. 2017

ABSTRACT: His Majesty King Bhumibol Adulyadej of Thailand has conceived and developed a new philosophy to improve the lives of the Thai people and bring them a genuine and lasting happiness. This new philosophy is called "sufficiency economy" or "sufficiency economy philosophy". This research has the objective to create and develop innovation Khok-kham bio-fertilizer for aimed to community development by inoculants *Trichoderma, Mucor* and *Bacillus* based on sufficiency economy philosophy. Khok-kham community in Samut Sakhon province and Khanom community in Nakhon Si Thammarat province were selected for studying the efficiency of innovation Khok-kham bio-fertilizer. Nutrient analysis of innovation Khok-kham bio-fertilizer indicates high macronutrients of Nitrogen, Potassium and Phosphorus with the 84.33% of average value. The planting mangrove tree remove heavy metals such as Lead (Pb), Cadmium (Cd) and Copper (Cu) in soil with the average value of 98.6%. Moreover, it can help speed up 4 times of mangrove tree rate when compared to control case. This can also be applied for recovering mangrove forest area in the condition of limits of times. Innovation Khok-kham bio-fertilizer, can increase rice productivity, reduce costs of 5-6 times and improve soils acid. In summary, innovation Khok-kham bio-fertilizer is very useful for planting mangrove, increasing the productive of organic rice, vegetable and restoring mangrove forest area so that the community is developed based on sufficiency economy philosophy.

Keywords: Inoculants fungal and bacteria, Innovative bio-fertilizer, Sufficiency economic, Mangrove forest

1. INTRODUCTION

In recent years, mangrove forest areas at Khok-kham community in Samut Sakhon and Khanom community in Nakhon Si Thammarat were decreased significantly. There are many causes led to decreasing of mangrove forest areas. For example, the effect of coastal erosion, increasing shrimp farming and salt farming, microbial diseases, waste product from industry, soil acid pH 3-4 etc. [1] and the survival rate of tree less than 30% when plants are grown without Khok-kham bio- fertilizer plant by inoculants *Trichoderma Mucor* and *Bacillus* [2]. Thus, both public and private sectors including the community should be integrated planning and working together for restoring mangrove forest areas and developing community. For sustainable developing community, His Majesty King Bhumibol Adulyadej of Thailand has conceived and developed a new philosophy to improve the lives of the Thai people and bring them a genuine and lasting happiness. This new philosophy is called "sufficiency economy" or "sufficiency economy philosophy". Moreover, His Majesty King Bhumibol had explained a meaning of "sufficiency" in which has three components: moderation, reasonableness, and self-immunity, with two accompanying conditions: appropriate knowledge and ethics & virtues[3]. The sufficiency economy philosophy of His Majesty King Bhumibol as shown in Fig.1 By applying science and technology knowledge based on sufficiency economy of His Majesty King Bhumibol, a process of developing by innovative Khok-kham bio-fertilizer with inoculants *Trichoderma, Mucor* and *Bacillus* from the wastes in community for the sustainable community lead to environmental, society, economy and culture is presented as Fig.2 [4], [5], [6].

This research has the objective to research and developing innovation for developing soils acid in communities. The innovative Khok-kham bio-fertilizer with inoculants *Trichoderma, Mucor* and *Bacillus* from the wastes in community such as hyaline salt (Kigdadnakluea) from salt farming or straw and rice husk from investment on paddy for planting mangrove tree *Rhizophora mucronata* in Khok-kham community, Samut Sakhon province and Khanom community in Nakhon Si Thammarat province and organic rice verities RD. 47 in Nongsoae community, Phathum Thani province, replacement of traditional mangrove tree *Rhizophora mucronata* and organic rice verities RD 47.Which leads to acid soil conservation and development of the communities with inoculants *Trichoderma, Mucor* and *Bacillus* following the philosophy of sufficiency economy.

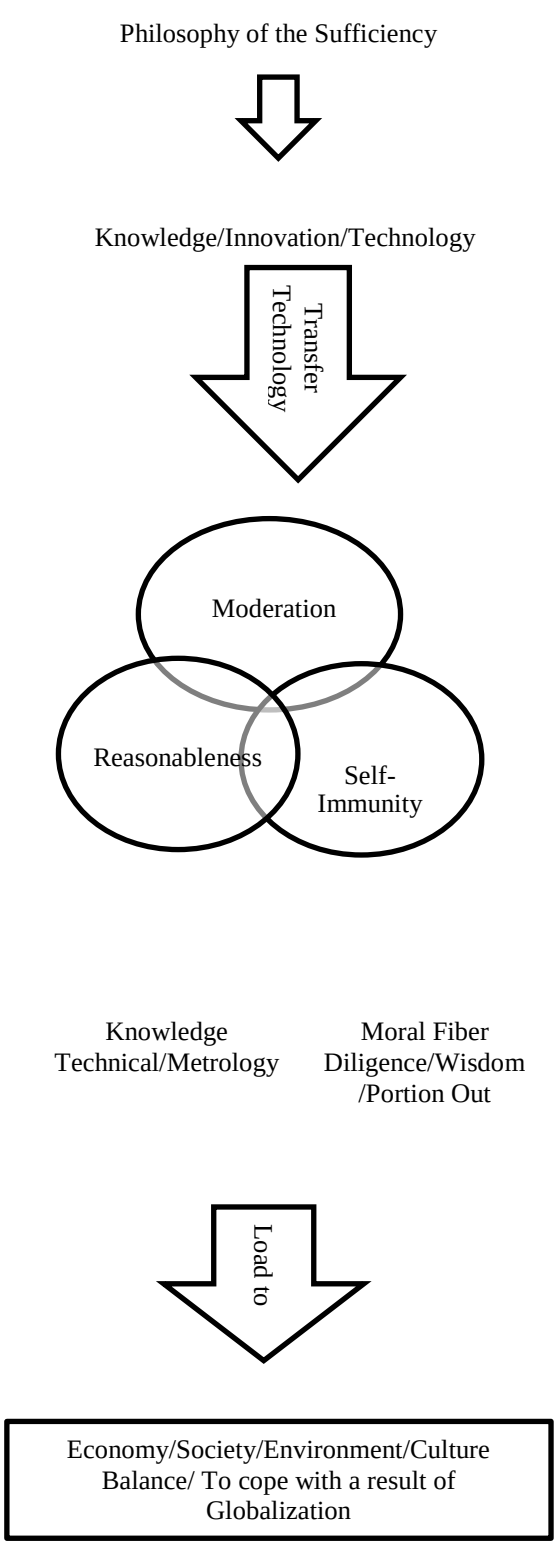

Fig.1 Sufficiency economy philosophy of His Majesty King Bhumibol Adulyadej. [3]

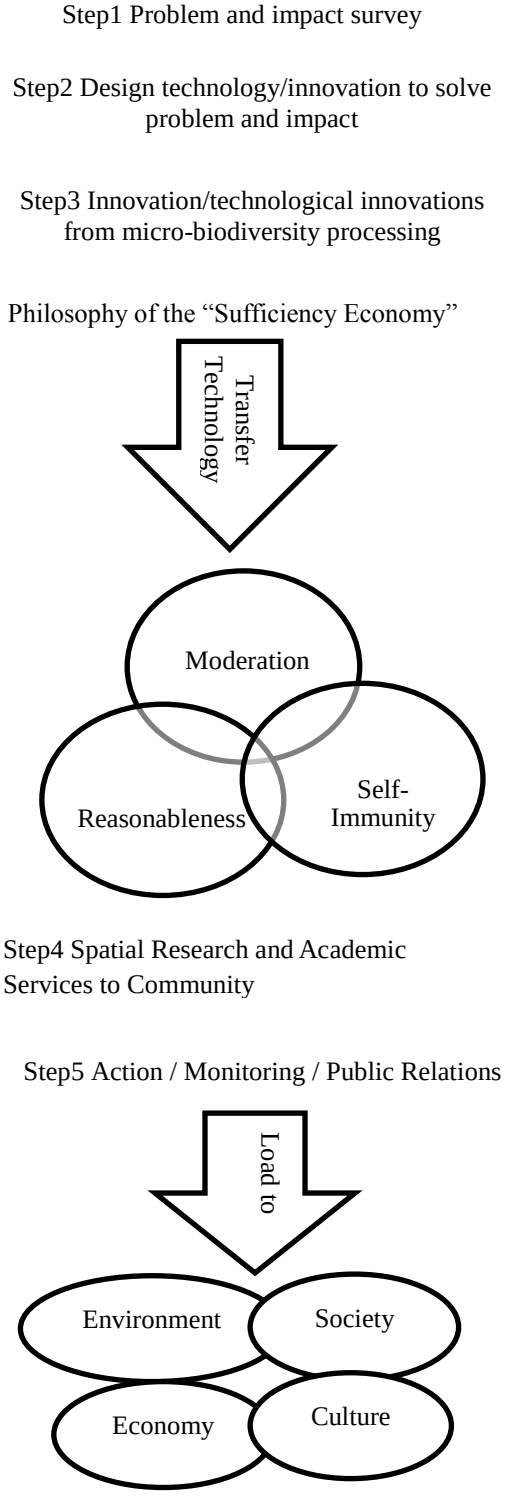

Fig.2 Process of community developing by innovative Khok-kham bio-fertilizer with inoculants *Trichoderma*, *Mucor* and *Bacillus* based on sufficiency economy philosophy of King Bhumibol Adulyadej.

2. RESEARCH METHODOLOGY

2.1 STUDY AREA

Khok-kham community, Samut Sakhon province (A) and Khanom community in Nakhon Si Thammarat province (B) and Nongsoae community, Phathum Thani province. Fig. 3

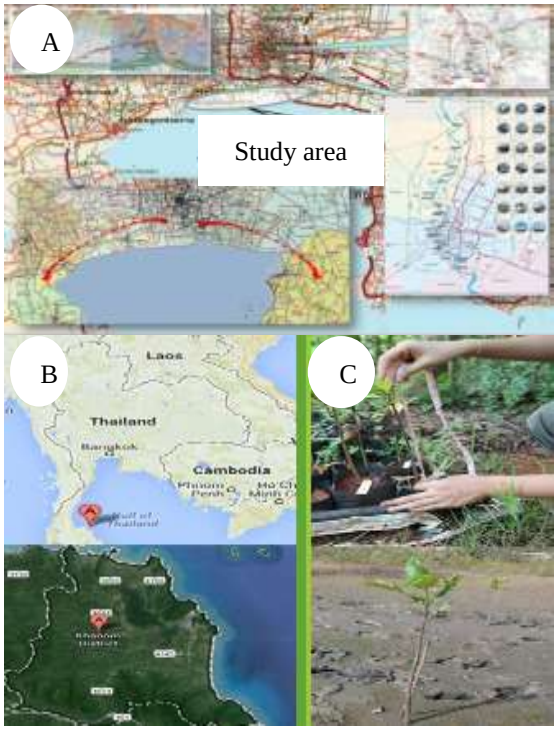

Fig.3 Area mangrove planting with Khok-kham bio-fertilizer associated by innovations inoculants *Trichoderma*, *Mucor* and *Bacillus*, (A) Samut Sakhon province and (B) Nakhon Si Thammarat province (C) Monitor the growth of mangrove plants

2.2 METHODOLOGY

Research driven community development engagements by explored problems and of the community. First integrate bio- technology to solutions and eliminate waste and garbage of community to Khok-kham bio-fertilizer with innovations inoculants *Trichoderma*, *Mucor* and *Bacillus* from biodiversity of antagonistic fungal and bacteria. Make Khok-kham bio- fertilizer with inoculants *Trichoderma*, *Mucor* and *Bacillus* from the wastes of communities for use in seeding and mangrove planting in soil acid, Samut Sakhon province and Nakhon Si Thammarat province and organic rice and vegetables developments in soil acid, Phathum Thani province Thailand. Following steps of driven community research or process of corporate social responsibility (CSR) were 5 steps as Fig. 4

1) Community problem and impact surveyed in area Khokkham, Samut Sakorn province and Khanom, Nakhorn Si Thammarat Thailand.

2) Wastes and garbage of the community were rhizo-degraded with innovation by antagonistic *Trichoderma*, *Mucor* and *Bacillus* in semisolid's tanks in during time 28-30 days.

3) Quality control the bio- fertilizer products follows Standard bio-fertilizer products [2].

4) Utilization and analysis data after the bio fertilizer products with inoculants *Trichoderma*, *Mucor* and *Bacillus*, it using mangrove restoration and organic planting development compared with non-using the bio fertilizer products in soils acid. It is analysis about increase percent of growth rate tree *Rhizophora mucronata* and percent productivity yields and reducing costs to restored at shrimp abandoned area and organic rice agriculture developments by new innovation with inoculants *Trichoderma*, *Mucor* and *Bacillus* in soils acid.

5) Bio-technology transfer for the development of community based on sufficiency economic philosophy in to sustainable restore the nature balance and organic rice developments.

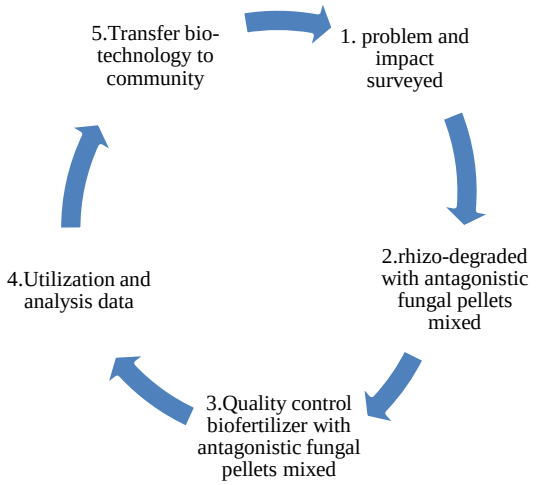

Fig.4 Process of research driven community development engagement through by innovation with inoculants *Trichoderma*, *Mucor* and *Bacillus*.

3. RESULTS

Based on sufficiency economic philosophy, a researcher transferred bio-technology into the community to sustainable nature balance, increase mangrove forest area and organic rice and vegetables. The communities can produce innovative Khok-kham bio-fertilizer with inoculants *Trichoderma*, *Mucor* and *Bacillus* from

the wastes in community Fig.5-6. We found innovative Khok-kham bio-fertilizer have macronutrient and micronutrient higher than the standard bio-fertilizer up to 84.33 percent. Moreover, it also can removal of heavy metals, such as cadmium (Cd) and copper (Cu) in soils up to 98.6 percent. While when the inoculants only *Trichoderma* has detected major nutrient 66 percent, inoculants *Bacillus* has detected major nutrient 59 percent. Reduced the amount of heavy metals is 93.6 and 93.1 percent respectively.

Rice husk

Kigdadnakluea

Inoculants fungal

Khok-kham bio- fertilizer

Fig.5 Khok-kham bio- fertilizer with inoculants *Trichoderma, Mucor* and *Bacillus* from the wastes in community.(A) Rice husk (B) Kigdadnakluea (C)Inoculants fungal (D) Khok-kham bio- fertilizer

Production bio- fertilizer with inoculants

Khok-kham bio- fertilizer with inoculants

Planting by Khok-kham bio- fertilizer

Monitoring growth after mangrove planting with Khok-kham bio-fertilizer

Fig.6 Transfer bio technologies to community developments for producing Khok-kham bio-fertilizer with inoculants *Trichoderma, Mucor* and *Bacillus* from the wastes in community.
(A)Production of bio- fertilizer with inoculants
(B) Khok-kham bio- fertilizer with inoculant
(C) Planting by Khok-kham bio- fertilizer
(D)Monitoring growth after mangrove planting with Khok-kham bio-fertilizer.[6]

Found that the community has higher productivity yields at when they use the Khok-kham bio- fertilizer with inoculants *Trichoderma*, *Mucor* and *Bacillus* instead of bio- fertilizer with *Trichoderma* or bio-fertilizer with *Bacillus* for restoration in abandoned shrimp farms to natural balance within 5 years. Normal restoration of shrimp abandoned without Khok-kham bio-fertilizer associated with inoculants *Trichoderma*, *Mucor* and *Bacillus* rehabilitation time required for 10-15 years [1], [8]. The growth rate of mangrove tree *Rhizophora mucronata* increasing up to 4 times, and the survival rate of more than 95% when the plants are grown by Khok-kham bio-fertilizer with inoculants *Trichoderma Mucor* and *Bacillus* as shown in Fig .7 and Table 1 [2].

Moreover, when Khok-kham bio-fertilizer associated with *Trichoderma*, *Mucor* and *Bacillus* for develop organic rice and vegetable cultivation in acid soils, Pathum Thani, Thailand found that many farmers have increased productivity yields and reduced costs 5-6 times (from 7,000 baths to 1,800 baths) [6] as much neutral soil condition (pH 6-7), increased survival rate, reduced the amount of heavy metals in soil, biodiversity antagonistic fungi increased, Control of Pathogens [6], [7], [9]. Table1 and Fig.8

Table 1 Comparison percent increasing nutrients, increasing productivity yields, reducing heavy metal, reducing costs of innovative (times) with mixed inoculants *Trichoderma*, *Mucor* and *Bacillus* and only *Trichoderma* or *Bacillus* (control)

Lists	Percent efficiency of inoculants (%)		
	Trichoderma Mucor and *Bacillus*	*Tricho-derma*	*Bacillus*
Nitrogen (N)	80	50	43
Potassium (K)	93	74	74
	80	75	60
% increasing nutrients	84.33	66	59
Pb (Lead)	100	95	85
Cd (Cadmium)	100	100	100
Cu (Copper)	96	98	97
% reducing heavy metal	98.6	97.6	93.1
increasing productivity yields, reducing costs of rice	5-6 times	2-3 times	1.5 times
increasing growth rate of *R. mucronata*	4 times	2 times	1 times

Seedlings and the roots of the plants cultivated by Khok-kham bio-fertilizer with mixed microorganism.

Testing group with Khok-kham bio-fertilizer with mixed microorganism, 1 year

Testing group with Khok-kham bio-fertilizer with mixed microorganism, 2 years

Control group without Khok-kham bio-fertilizer with mixed microorganism, 2 years

Fig.7 Restored mangrove forest by innovative Khok-kham bio- fertilizer associated with inoculants *Trichoderma*, *Mucor* and *Bacillus*
(A) Seeding and root of *R. mucronata* seeding by Khok-kham bio-fertilizer with inoculants *Trichoderma*, *Mucor*, *Bacillus* and only *Trichoderma* and *Bacillus*.(B)Inducing growth *R. mucronata* with mixed antagonistic pellets at abandoned shrimp farms in 1 year.(C) Inducing growth *R. mucronata* with mixed antagonistic pellets at abandoned shrimp farms in 2 year. 4.3 folds (D) Growth *R. mucronata* without mixed antagonistic pellets at abandoned shrimp farms in 2 year (Control)

Due to antagonistic microorganism in inoculants with *Trichoderma*, *Mucor* and *Bacillus* products produced extra-enzyme such as hemicellulase, peroxidase, phosphatase laccase etc. to accelerated degradation of the organic and inorganic to the macronutrients and micronutrients will been uptake through the root system, removal of heavy metal, pretreatment soil pH. Which the fungal accelerated the organic wastes degradation to the bio-fertilizer in the appropriate form, The bio-fertilizer from the waste of the community's ratio of nutrients, phosphate, potassium etc. or sources of carbon (C) ratio more than the nutrients nitrogen (N) or source of nitrogen (C≥N ratio), increase sugars, amino acid, humic acid, fulvic acid and hormone, which the substance is extracted from the fungal, will accelerate the flowering of the off-season fruit. The nutrients gradually release to the roots. Reduce the loss of nutrients to the environment. The farmers can reduce the use of fertilizer less than usual.Sugars, amino acid, humic acid, fulvic acid helps to stimulate root formation, and seed germination and enhance the absorption of minerals, plants.The gibberellin hormone to accelerate of the root, stem, leaves, flower, and fruits, stickier flower stalk. cytokines hormone help to extend the shelf life of the crop after harvest, resulting in farmers in the community [7]. There are mangrove areas and the productivity of rice and vegetables increase.When they were planted mangrove forest areas, rice and vegetation with the innovative inoculants *Trichoderma*, *Mucor* and *Bacillus*. The farmers can reduce costs and increase profitability when they plant mangrove forest, rice and vegetables with innovative inoculants *Trichoderma Mucor* and *Bacillus* replace mangrove planting, Rice and vegetables without using innovative inoculants *Trichoderma*, *Mucor* and *Bacillus* to address community problems and impacts, about environment, society, economy and culture follow base on the philosophy of sufficiency economy sustainability [2], [3], [5], [6], [7], [9].

4. CONCLUSION

Community development by innovation inoculants *Trichoderma*, *Mucor* and *Bacillus* as Khok-kham bio- fertilizer products from the wastes in community those are better than the usual standard bio- fertilizer products. This Khok-kham bio- fertilizer were using for development of mangrove reforestation and development of organic agriculture. To answer problems and impact of the community and environmental, social economic development base on the philosophy of sufficiency economy sustainability.

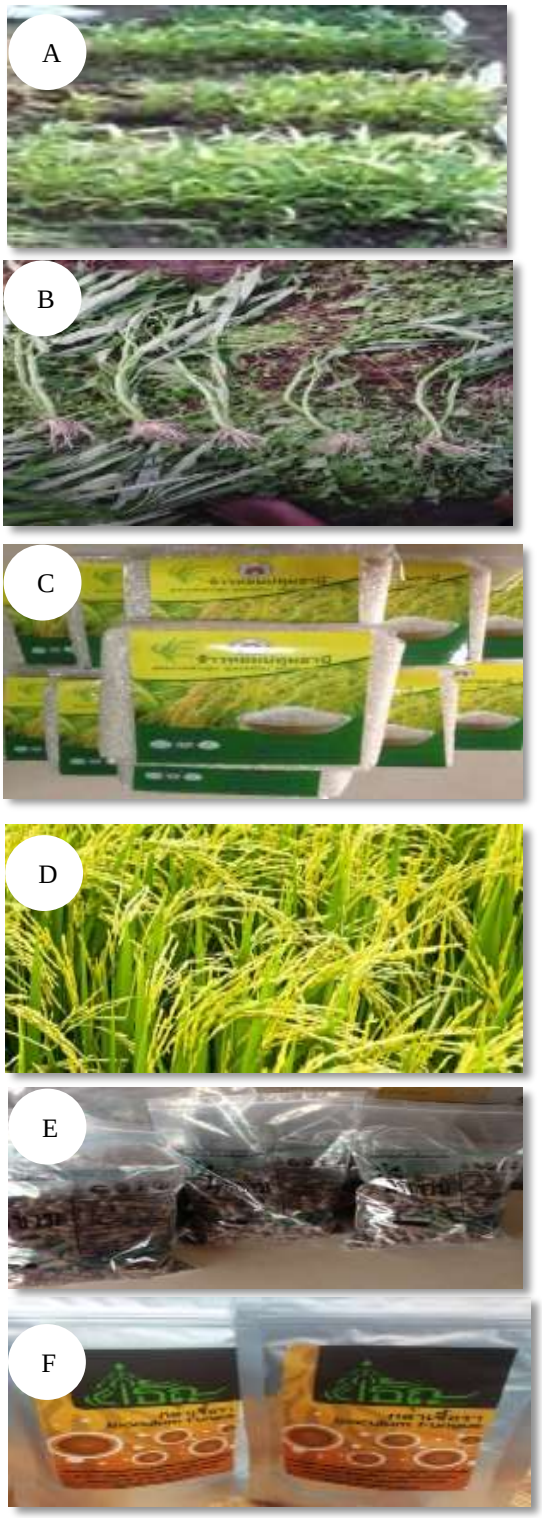

Fig.8 Organic rice and vegetable developments by Khok-kham bio-fertilizer with inoculants *Trichoderma*, *Mucor* and *Bacillus* for increase the productivity yields, reducing costs 5-6 folds instead of bio- fertilizer with inoculant only *Trichoderma* or bio- fertilizer with inoculant *Bacillus*.(control) (A-B) Comparison of *Ipomoea aquatica* Forsk. growth by bio-fertilizer (left) and chemical fertilizer(right) (C)Organic brown rice (D)

Rice growth with the bio fertilizers (E) Khok-kham bio-fertilizer (F) innovative inoculants

So innovative Khok-kham bio-fertilizer with inoculants *Trichoderma*, *Mucor* and *Bacillus* were been used in the development of bio- fertilizer from the wastes in community. It found that the volume of macronutrient and the micronutrient in bio- fertilizer higher than the standard 84.33 percent. Moreover, the removal of heavy metals such as cadmium (Cd) and copper (Cu) contamination in soil are at high rate of 98.6 percent.When we lead new bio-fertilizer with inoculants *Trichoderma*, *Mucor* and *Bacillus* development to planting *R. mucronata* in acid soils. The rate of growth 4 folds higher than growing traditional, survive rate more than 95% and the farmers have higher productivity yields and lower costs at 5-6 times when they use this new bio- fertilizer with inoculants *Trichoderma*, *Mucor* and *Bacillus*. Instead of bio-fertilizer with inoculants only *Trichoderma* 2-3 times or bio-fertilizer with inoculants *Bacillus* 1.5 times in soils acid. Due to antagonistic microorganism in inoculants *Trichoderma*, *Mucor* and *Bacillus* products produced extra-enzyme such as cellulase, peroxidase, phosphatase etc. to accelerated degradation of the organic and inorganic to the macronutrients and micronutrients, sugars, amino acid, humic acid and hormone will been uptake through the root system, removal of heavy metal, pretreatment soil pH. The plants grow better than grown without the use of innovative inoculants *Trichoderma*, *Mucor* and *Bacillus*. From the results of the implementation of community development projects by innovation Khok-kham bio-fertiizer with inoculants *Trichoderma*, *Mucor* and *Bacillus*, it found that the results is better than development restoring mangrove forest, organic rice and vegetable by only *Trichoderma* inoculants.

5. ACKNOWLEDGEMENTS

This research was supported by research grants from the NSTDA, Ministry of Science and Technology, and thanks to RMUTT engagement, community Moo 3 Tambon Khok Kham, Samut Sakorn, and Nakornsri Thamarat and Nongsoae community, Phathum Thani province Thailand to cooperate in this research

6. REFERENCES

[1] Aksornkoae, S., & Khemnark, C. Nutrient Cycling in Mangrove Forest of Thailand. In E. Soepadmo, A. N. Rao, & D. J. Macintosh (Eds.), Proceedings of the Asian Symposium on Mangrove Environment Research and Management. Kuala Lumpur: University of Malaya. 1984, pp. 545-557.

[2] Rattanaloeadnusorn S., Pongswat S. and Rattanaloeadnusorn A., Antagonistic Fungal Pellets for Community Development based Sufficiency Economy Philosophy. The 2 nd Asia Engage Regional Conference 2014: Innovation and Creativity: collaboration with Communities to tackle problems across ASEAN, Asia and Beyond, 17 – 20 November 2014 at Hotel Grand Nikko, Nusa Dua Bali Indonesia.2014, p.23.

[3] http://www.thaiembassy.ca/en/about-embassy/news/the-royal-initiative-of-the Philosophy-of-sufficiency-economy)

[4] Rattanaloeadnusorn S., 2013. Fungal Pellets, Patents IP 1201000319

[5] Rattanaloeadnusorn S., Sronkwan T., Sujaya Ritthisor S. and Pongswat S. Biofertilizer from Stock Fungus and Natural Material for Sufficiency Economy Philosophy Community Development, *st International Symposium on Local Wisdom and Improving Quality of Life*, in 8-11 August 2012 Chai mai, Thailand. 2012. pp.49-56.

[6] Rattanaloeadnusorn S. Inoculants Fungal *Trichoderma* and *Bacillus* for Improving Acidic Soils and Community Development Based on Philosophy of Sufficiency Economy, Proceeding 2015 International Conference on Science and Technology TICST 2015, November 4 - November 6, 2015 Faculty of Science and Technology,Rajamagala University of Technology Thanyaburi Pathumtani, Thailand. 2015. p.24.

[7] Kucey,R.M.N..,H.H. Janzen and M.E. Leggett. Microbially mediated increases in plant available phosphorus. Advances in Agronomy.42: 1989, pp.199-227.

[8] Lacambra, C., Friess, D., Spencer, T., & Moller I., Bio shields: mangrove Ecosystems as resilient natural coastal defenses. In F. Renaud, K. Sudmeier-Rieux, &M. Estrella (Eds.), the role of ecosystems. 2013, pp. 82-108.

[9] Liu, Q. Loganathan P. and. Hedley M. J., Influence of ectomycorrhizal hyphae on Phosphate fractions and dissolution of Phosphate rock in rhizosphere soils of *Pinus radiate*. Journal of Plant Nutrition. 28: 2005, pp.1525-1540.

[10] Intana, W., Chamswang. C., Intanoo, W., Hongprayoo, C and Sivasithamparam, K., Use of mutantstrain for improved Efficacy of *Trichodrema* for controlling Cucumber damping-off. Thai Journal of Agricultural Science.36 (3): 2003, pp.45-50.