Prospects of Effective Microorganisms (EM) for the sustainable agricultural development in the Hindu-Kush Himalayan Region

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Abstract

Mountains are not only homelands for the mountain peoples, but also provide timber, minerals, meat, hydroelectric power, fresh water supply for the peoples in lowlands. The sustainable mountain development, therefore, becomes imperative not only for the mountain peoples but also for the peoples of the lowlands. However, mountain peoples are facing several problems that have impeded the development of the mountains. These problems include land degradation (soil erosion, fertility decline, acidification, compaction, contamination), environmental degradation (deforestation, desertification, hazards, etc.), poverty, underdevelopment, and some others. Agriculture in the mountains has become dependent on chemicals (fertilizers and pesticides), and agricultural investment has increased greatly. Due to excessive use of chemical fertilizers, pesticides and commercial animal feed, the agricultural, horticultural and animal husbandry products have become more or less unsafe to human beings. Hence it is imperative to change from chemical-based, high-cost farming systems to more sustainable and more safe kinds of agriculture. The mountain problems and characteristics necessitate development of new technology and option to achieve sustainable and safe mountain development. Any technologies for mountain development should be environmentally non-degrading, technically appropriate, economically viable and socially acceptable.

Effective microorganisms (EM) is one of such technology and has been shown to be able to improve soil quality, growth of agricultural crops and horticultural plants, to improve quality of agricultural, horticultural and animal husbandry products, and to increase yield of agricultural crops and horticultural plants. It has also been shown effective in drinking water treatment and environment improvement. It has, therefore, high potentials for application in the sustainable mountain agriculture in crop production, animal husbandry, horticultural production, soil quality improvement and in other fields. However, the problems and characteristics in the mountains should be taken into consideration for the introduction and extension of the technology to the mountain peoples. As a biological product, it needs careful testing and demonstration before extending to farmers' levels.

1. Introduction

The Hindu-Kush Himalayan (HKH) region is the largest, most populated, highest, and youngest but also the most fragile mountain ecosystem in the world. This region is the habitat of about 120 million people of diverse natural and cultural diversity in countries Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. Most of the population in the region are engaged in various agricultural activities including crop production, horticulture, forest and animal husbandry. However, during recent years, agriculture in the Hindu Kush Himalayan (HKH) region has been exhibiting trends of increasing un-sustainability in terms of increased pressures on the land, declining agricultural productivity, declining resource generating and land degradation. The basic issues facing mountain agriculture are those of low productivity caused by soil degradation, inadequate access to appropriate technology, lack of marketing facilities, inadequate credit, weak community organizations, small landholdings, and natural calamities. Among all these issues, declining productivity, soil erosion, and declining fertility of agricultural lands and trend of increasing

un-safety of agricultural production have become very serious throughout the HKH region.

One important area of focus has been the need for technologies that can enhance crop yields, improve quality of produces and soil, maintain or improve soil fertility, and can reduce soil erosion to an acceptable level (l0-12 tons/ha/year), and is simple, cheap, effective, and acceptable to hill farmers. Of the various technologies screened, some technologies and practices have been selected and are being tested and carefully evaluated in the HKH region, such as the Sloping Agricultural Land Technology (SALT), plastic film technology, development of eco-tourism.

Effective Microorganisms (EM) technology is another such technology that has been shown high potentials for the development of sustainable mountain agriculture in the HKH region. Testing and demonstration of EM application in agriculture, horticulture, animal husbandry, environment improvement and protection, and in some other fields, have started in most countries of HKH region.

2. Understanding Mountains

Mountains make up 20 per cent of the earth's landscape and are home to at least 10 per cent of the world's population. Homelands of mountain peoples serve as storehouses of timber, minerals, meat, hydroelectric power, and other resources for the surging populations below them. Mountain watersheds are also the irreplaceable sources of fresh water supplies for at least half of the world population. The expanding economic pressures are degrading mountain ecosystems while confronting mountain peoples with increasing poverty, cultural assimilation and political disempowerment. Therefore the sustainable mountain development becomes imperative not only for the mountain peoples but also for the peoples of the lowlands

Compared to the two dimensional spatiality of the plains, mountain habitats are characterized by three dimensional spatiality. This additional dimension is the altitude, which usually obstructs the applicability of developmental or other experiences of plains to the mountains. Meanwhile, this additional dimension also provides specifically potential advantages and opportunities for the mountain development. The strategies for the mountain sustainable development should be different from those for the plain areas.

Mountains, especially the HKH region, exhibit some specific characteristics, which should be taken into consideration. Some of these characteristics have been barriers for the development, and some are of highly potentials for development. The major characteristics include:

Inaccessibility: Due to slope, altitude, overall terrain conditions, and periodical seasonal hazards (e.g., landslides, snow, storms etc.), inaccessibility is the most known feature of mountain areas (Price 1981; Allan 1986; Hewitt 1988). Its concrete manifestations are isolation, distance, poor communication, and limited mobility. Besides the dominant physical dimension, it has socio-cultural and economic dimensions that are reflected by socio-economic differentiation and inequity of access to resources, information and opportunities. Inaccessibility exaggerates other conditions such as marginality and diversity.

Fragility: Mountain areas are known for their fragility. This fragility is due to altitude and steep slopes, in association with geologic, edaphic, and biotic factors, and intensive and over-exploitation human activities.

Marginality: Due to remoteness and physical isolation, fragility and low-productivity resources, and several man-made handicaps, mountains become marginal and usually outside of mainstream pattern of activities.

Diversity: Very rich physical, biological, and culture diversity occurs in the mountain regions. This is the advantages and is of highly potential for the development in the mountain regions, though sometimes it becomes also condition that may have negative effect on development.

The above conditions, or characteristics, certainly are not specific to mountains, but they can be applied to almost all mountain regions.

3. Problems of Mountain Farmers

The mountain conditions, especially the back development in infrastructure has led to farmers' inaccess to market and new technologies. The mountain peoples are facing many problems, which have become the major barriers of the economic development. Some of the major problems include:

Fast growth of population: Though population growth is not a problem only for mountains, the most part of the increased population is in the mountains. During the past four decades, population in the mountains have doubled, while the farming lands have decreased gradually. The population growth and decrease in farming lands have forced mountain peoples extend various agricultural activities to more steep sloping lands and to adopt more intensive practices in order to produce enough food for themselves and their livestock.

Deforestation and degraded mountain environment: Forests in the mountains have been under logging mostly by or for the consumers from the lowlands. Degradation of mountain environment is the result of many activities, but mainly of deforestation/devegetation, over-exploitation of natural resources, and excessive use of chemicals (fertilizers and pesticides, etc.) for great increase in agricultural and horticultural yields.

Soil degradation: Soil is the single most important non-renewable resource for farming. However, the agricultural soils are being degraded. More lands are abandoned due to land degradation, which include:

Soil erosion: Soil erosion is basically a human-induced result by the over-exploitation of forest, intensive farming activities, and cultivation of steep sloping lands, etc. Substantial areas of cultivated land throughout the world, particularly the mountain areas, have been seriously affected by soil erosion. Soil nutrients are also being lost through soil erosion, which results in declining land productivity.

Soil fertility decline: Mainly due to soil erosion, improper management practices, and leaching of nutrients resulting from soil erosion, soil fertility decline has become a major constraint for food production. The direct response for the fertility decline is, as recommended by agronomist and other scientists, to apply chemical fertilizers. However, utilization of great amount of chemical fertilizers has led to changes of soil microflora and soil fauna, which in turn have affected soil property and efficiency of chemical fertilizers.

Acidification and compaction: Largely due to use of great amount chemicals, improper management activities, and excessive uptake and removal of nutrients and biomass from soil, soils in most HKH region have become acid, and compact.

Food safety and human health: Various intensive and improper farming practices have led and are leading to excessive soil erosion by wind and water, depletion of soil organic matter, and exhaustion of soil fertility. All of this has contributed to an alarming decline in soil productivity. As yields of crops, horticultural crops, and animal husbandry decrease, more and more chemical fertilizers and pesticides have been applied in an effort to sustain production. This, of course, has contributed considerably to the pollution of our soil, water and air, and has raised serious questions relative to food safety and quality, and human and animal health.

Shortage of energy for daily life: Mountains are rich in renewable resources. However, the approaches for the sustainable use of renewable energy resources are not accessible or not acceptable to the mountain peoples. Accordingly the mountain peoples have to depend on the forests for fuels and fodder of their livestock in their everyday life. This leads to the deforestation as well, which, in turn, has very unfavorable effects on microclimate, soil physical and chemical properties, and soil conservation.

Underdevelopment and poverty: This is the result of all the related causes of both natural and social origins.

Of all the above problems some are closely related to farming activities. It is well known that agriculture is the only dominant sector of the economy in the mountain region. Moreover, the sustainable mountain development will depend on whether or not sustainable mountain agriculture can be achieved. Therefore, the development of sustainable mountain agriculture becomes the main concern of many development agencies and governmental organizations throughout the world.

4. Sustainable Mountain Agriculture

As defined by FAO, sustainable agricultural development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development conserves or increases land capacity to produce agricultural goods, water availability, plant genetic resources, and is environmentally non-degrading, technically appropriate, economically viable and socially acceptable. The ultimate goal of sustainable agriculture is to develop farming systems that are productive, profitable, energy-conserving, environmentally sound, conserving of natural resources, and that ensure food safety and quality.

Clearly, agriculture and its development are far from sustainability in many parts of the world, but in particular in mountain areas.

The mountain conditions and problems necessitate great needs of development or introduction of new technologies and options to achieve sustainable mountain development. It is imperative to change from chemical-based, conventional farming systems to more sustainable kinds of agriculture.

5. Effective Microorganisms and its potentials in the HKH region

Effective Microorganisms (EM) has been shown to be able to improve soil quality and crop growth, to enhance crop yield and production, conserve natural resources and ultimately create a more sustainable agriculture and environment (Higa and Parr, 1994) and useful in eliminating problems associated with the use of chemical fertilizers and pesticides (Higa, 1991).

According to the classification of Higa (Higa, 1991; 1994), Effective micro-organisms are the mixture of the Beneficial Microorganisms, which have following functions:

- fixation of atmospheric nitrogen
- decomposition of organic wastes and residues
- suppression of soil-borne pathogens
- recycling and increased availability of plant nutrients
- degradation of toxicants including pesticides
- production of antibiotics and other bioactive compounds
- production of simple organic molecules for plant uptake
- complexation of heavy metals to limit plant uptake
- solubilization of insoluble nutrient sources
- production of polysaccharides to improve soil aggregation

Based on their functions, it implies that EM can be applied in many fields of the mountain development. However, based on literature and other information, EM may be applied in the following specific fields.

Yield increase : Based on experimentation and testing of EM in some areas (Tang 1996), EM is effective on yield increase of majority of cereal and cash crops, such as maize, wheat, sweet

potato, tomato, peanut, sugarcane, vegetables, and some others.

Improvement of soil quality: Through shifting the soil microbiological equilibrium, and achieving the balance of soil microflora, soil quality can be improved greatly by applying EM.

Improvement of growth of agricultural crops and horticultural plants: This is again to enhance production. EM has also been shown effective in keeping fruits fresh for a quite long time. This would be very helpful for transportation of mountain produce to main markets.

Pest and insect control: Pest and insect control has been a concern of agronomist and farmers for long time. The effective practice at present is the application of chemical pesticides that have contaminate our environment. Great efforts have been made to look for replacements. EM has also been shown promising in pest and insect control and may play a role in this field though EM is not a real pesticide.

Composting: Composting making is still one of common traditional practices of nutrient management in the HKH region. The application of EM in composting making in some of the regions indicates that it can shorten the period of decomposition and improvement of composting efficiency.

Soil erosion: Primary results are also promising in minimizing soil erosion. This may be achieved by improving soil filtration, soil water holding capacity, and flourishing growth of crops.

Animal husbandry: Animal husbandry in the HKH region is largely traditional and the productivity is quite low. EM may be used for disease control and improvement of growth condition and ultimately improving productivity.

Environmental cleaning: Though this is not directly associated with agriculture, it is very important for the agricultural development. EM treated living organic matters can become important sources of organic fertilizers for crops in both agricultural and horticultural productions. EM treatment of poultry, goat and pig raising farms will be equally important for the sustainable development of the industry and improvement of income generating.

6. Conclusion and Suggestions for Extension in HKH Region

Microorganisms have been used in medical industry, food processing, environmental protection, agricultural biotechnology, and effective treatment of agricultural and organic wastes for many years. However, its importance has not been widely recognized due to various reasons, but largely due to inappropriate extension mechanisms.

EM has been shown very promising in various agricultural fields to increase production yield, improve growth, control pests, improve quality, and to protect environment. Therefore it has very high potentials for the sustainable development of HKH region, especially in agricultural development. However, the success of EM in the region may depend on several factors, but testing, demonstration and extension in particular.

Following are some suggestions for extension of EM:

As a biological product, EM has exhibited numerous beneficial effects in application. However, as its application is closely related to human beings, careful testing and experimentation are necessary to explore all of its effects, including positive as well as its negative effect. To some extent, the latter is more important. It should be made certain that it is not too late for any correction.

On the basis of the above consideration, how much EM is accepted by people becomes crucial for the successful achievement of the final goals. Hence, appropriate methodology of testing and demonstration is imperative. The former experiences of testing and demonstration on EM

(Parr et al., 1994) imply that purely scientific and laboratory types of testing and demonstration need reconsideration. Farmers are keen to learn and practice new technologies, but they only accept what they have seen and believed. Accordingly, community-based testing and demonstration and participatory approaches may be helpful.

Access to people is another important factor in terms of price and availability. If people cannot afford to buy, or it is beyond availability of people, it will not function no matter how nice it is.

For HKH region in particular, testing and demonstration should be planned and conducted in different agro-ecological zones in order to have enough information about the performance of EM under different conditions.

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