

## Technology Fact Sheet for Adaptation

### VI. Development of drought resistant and pest resistant varieties of crops <sup>i</sup>

#### Introduction

Climate change creates greater uncertainty and unpredictability in the environment due to which the traditional farming practices and crop breeds are increasingly becoming unviable for the farmers, thereby rendering them economically vulnerable.

It has been recognized world-wide that traditional knowledge in crop-breeding as well as careful use of the molecular breeding tools are required to develop new breeds that can be resistant to less availability of water as well as emergence of pests which are expected to spread to newer areas due to warming of climate.

#### Technology characteristics

Breeding new and improved crop varieties enhances the resistance of plants to a variety of stresses that could result from climate change. These potential stresses include water and heat stress and the emergence of new pests. Varieties that are developed to resist these conditions will help to ensure that agricultural production can continue and even improve despite uncertainties about future impacts of climate change. Breeding for improved performance under environmental stresses involves activities which accumulate favorable alleles (different forms of a gene) contributing to stress tolerance<sup>1</sup>.

Development of new crop varieties requires both traditional knowledge in gene-pool as well as utilization of modern biotechnological processes like transgenic crops and molecular breeding. Conventional breeding requires the identification of genetic variability to drought among crop varieties and introducing this tolerance into lines with suitable agronomic characteristics. Although conventional breeding for drought tolerance has and continues to have some success, it is a slow process that is limited by the availability of suitable genes for breeding and largely limited to exploiting the existing genetic variation in crop plants and their very close relatives.

The development of tolerant crops by genetic engineering, on the other hand, requires the identification of key genetic determinants underlying stress tolerance in plants, and introducing these genes into crops. The physiological response of plants to water stress is accompanied by the activation of genes involved in the perception of drought stress and in the transmission of the stress signal. These set of genes are targeted for replication and amplification of their expression in the new breeds. A major reason for the relatively slow progress in conventional breeding responses to the stresses related to climate change arises from the fact that plant adaptations are not likely to be single gene changes and whole metabolic pathways are likely to be involved.

#### Country specific applicability and potential

Agriculture in Bhutan is especially vulnerable to rainfall variability and emergence of new pests due to warming. Erratic weather patterns and temperature and humidity changes have resulted in a dramatic rise in pest and disease outbreaks in many crops, raising worries about domestic food production<sup>2</sup>. Given that the staple crops in Bhutan like maize and rice are amenable to genetic engineering and crop breeding and the fact that these constitute about 90% of crop production in Bhutan, these crops should be taken up on a priority basis. Given the highly fluctuating nature of crop production in Bhutan<sup>3</sup>, breeding of climate resilient varieties of maize and rice will contribute to food security in the country.

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<sup>1</sup> Clements R J, Hagggar A, Quezada and J. Torres, 2011, Technologies for Climate Change Adaptation – Agriculture Sector, X. Zhu (Ed.), UNEP Risø Centre, Roskilde.

<sup>2</sup> Administrator, 2011, HAPPINESS DRYING UP, Bhutan Today, available at [http://www.bhutantoday.bt/index.php?option=com\\_content&view=article&id=1433:happiness-drying-up](http://www.bhutantoday.bt/index.php?option=com_content&view=article&id=1433:happiness-drying-up), accessed on 4 May 2012.

<sup>3</sup> <http://www.tradingeconomics.com/bhutan/crop-production-index-1999-2001--100-wb-data.html>, accessed on 4 May 2012

## Status of technology in country

Crop breeding has been practiced traditionally in Bhutan. But of late it has been taken up on a systematic basis in partnership with Indian Agricultural Research Institute (IARI).

In Bhutan, the Biodiversity Use and Conservation in Asia Programme <sup>4</sup>(BUCAP), coordinated by the National Biodiversity Centre of the Ministry of Agriculture, in partnership with the agricultural research institutions and the agricultural extension agencies introduced the Participatory Plant Breeding (PPB) model to utilize the traditional knowledge of farmers as well as introduce new scientific methods in the grassroots level in 2002. It involved farmers directly in participatory varietal selection (PVS), and focused on the selection of rice blast resistant varieties. This focus was inserted into the PVS activities following a severe outbreak of rice blast at high altitude (1800-2700m) production environment in 1995. Parents were selected in the basis of the farmers' feedback. The collaborative programme works with farming communities in different valleys of Bhutan. The programme has thus far succeeded in increasing the diversity of blast resistant varieties in farmers' fields, and has released two improved local blast resistant rice varieties, namely Yusirep Maap and Yusirey Kaap. Besides, the BUCAP is also concentrating on developing new strains of maize.

National Field Crop Research Strategy Programme (2008-13) has also identified continuous crop breeding efforts as essential for sustainable agriculture output in Bhutan<sup>5</sup>

## Benefits to economic / social and environmental development

Agriculture in Bhutan is increasingly being threatened by the fall outs of climate change. Crop-loss due to drought and damage by hitherto unknown pests are taking a major toll on the economic condition of farmers. In 2007, the maize harvest loss by the farmers at about 1800m above mean sea level is recorded at more than 50% because of the outbreak of northern corn blight disease<sup>6</sup>. Thus crop breeding and development of climate resilient varieties has become a prerogative for the agriculture sector. The improved varieties, as one maize variety introduced by CIMMYT<sup>7</sup>, also helps in enhancing crop yield and farmers' incomes. But whilst fast tracking the process of crop breeding, it is essential that focus is not entirely on improved crop varieties but on further enrichment of gene pool which will help in resisting climate variability linked hazards in crop production. As HYV varieties entail a very narrow genetic base, concentrating entirely on such varieties as a means of increasing crop productivity may not be sustainable in the long term.

Thus achieving environmental development through improved crop varieties entails a tight-rope walk between encouraging indigenous multiple varieties of traditional strains which may have comparatively lower yield but are resistant to environmental challenges and adaptation of HYV varieties based on a narrow gene pool and establishing high cost-high return genetically uniform monocultures which may expose the sector to even more environmental risks going ahead.

## Climate change adaptation benefits

Extreme fluctuation in agriculture production due to drought and pest attack is expected to aggravate poverty, threaten food security, and cause out-migration of people from rural areas. Breeding of climate change resilient varieties will help in bringing stability in crop production and protecting the livelihood of farmers. Stability of crop production is one of the major challenged in the face of climate change especially given that the population of Bhutan is increasing steadily and there is a growing pressure on the natural resources in the country.

## Financial requirements and costs

The cost of developing new crop varieties depends on the type of crop, the method followed and the technologies involved. Whilst major crop variety development has been taken up by government sponsored

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<sup>4</sup> <http://www.cdic.wur.nl/NR/rdonlyres/DFDA8928-9664-4EF3-A593-C5E3023D3164/71905/CHAPTER4.pdf>

<sup>5</sup> <http://www.rcbajo.gov.bt/publication/files/dwn8uy3433mh.pdf>

<sup>6</sup> National Environment Commission, 2011, Second National Communication to the UNFCCC, National Environment Commission, Royal Government of Bhutan, Bhutan

<sup>7</sup> <http://www.cimmyt.org/en/newsletter/37-2008/106-improved-maize-varieties-and-partnerships-welcomed-in-bhutan>

institutions and the costs being borne by them, many corporate too are developing new varieties but in the latter case, farmers have to share the burden of development and intellectual property rights that increases the cost of seeds manifold. Such a situation is implausible in a country like Bhutan. Thus farmers should only pay for the initial adoption in new crop varieties that may initially require different seed bases but can be multiplied by the farmer themselves rather than corporations withholding the crop varieties for profit.

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<sup>i</sup> **This fact sheet has been extracted from TNA Report – Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation – Bhutan. You can access the complete report from the TNA project website <http://tech-action.org/>**