Global Advanced Research Journal of Agricultural Science (ISSN: 2315-5094) Vol. 3(7) pp. 179-185, July, 2014.
Available online http://garj.org/garjas/index.htm

Full Length Research Papers

Policy Advocacy for Climate Smart Agriculture in Millets: An Initiative for Ensuring Food Security in Tribal Communities of Koraput Tract, Odisha, India

Chaudhury Shripati Mishra, Trinath Taraputia, Benudhara Suchen

M. S. Swaminathan Research Foundation, Jeypore, Koraput, Odisha, India

Accepted 27 June, 2014

Ensuring food and nutrition security for the fast growing global population is a major challenge for the present agricultural production systems. Finger millet (*Eleusine coracana*) and little millet (*Panicum sumatrense*) serve as major cereal crops in the undulating terrain of Koraput tract of Kundra block, Odisha state, India providing food and nutrition security to native tribal communities. This section of the Eastern Ghat mountain range is inhabited by *Poraja, Kandha* and *Penthia* tribal communities following traditional agronomic practices with low productivity. In recent times, uncertain monsoon, declining soil fertility, lack of irrigation facilities, increased pest and disease incidences, high input costs in agriculture, drudgery in farm operations and lack of necessary support from the State Government of Odisha and the Government of India have threatened millet cultivation and the regional food security in this hilly tract. Realising the challenges associated with sustainability of millet cultivation in the changing agroclimatic and socioeconomic scenarios, research was designed to introduce climate smart agriculture in millet cultivation involving 243 households belonging to three tribal communities. The research initiatives focused on efficient water utilisation, soil fertility management, affordable farm mechanisation and the selection and promotion of climate resilient varieties of millets through participatory field trials over three years. Findings from the benchmark survey, the impact assessment survey and periodic agronomic data highlight the need for promotion and adoption of climate smart agriculture in millets for greater sustainability. Sharing the outcomes of the research initiatives with the scientific as well as the tribal farming communities, policy recommendations were developed and disseminated at regional, national and international levels involving all stakeholders such as not for profit organisations, government agencies, the scientific community, print and electronic media, funding agencies, traders and farmers with a view toward favourable policy formulation to ensure sustainable agriculture while enhancing food and nutrition security in the ancient tribal tracts of Eastern India.

Keywords: Climate smart agriculture, millets, food security.

INTRODUCTION

Ensuring food security for a fast growing global population estimated at 9.1 billion in 2050 and over 10 billion by the end of the twenty first century is a mammoth challenge for the present agricultural production system (UNPFA 2011).

Shrinking average farm size in India and financial constraints for higher investment in agriculture due to 80% farm families belonging to small and marginal farmer categories further heighten the challenge (NCF 2006). For securing food and nutrition security for sizable population, productivity enhancement may provide a vital solution. This involves the adoption of scientific agronomic practices and technologies which promise an augmentation of the productive capacity of traditional agricultural systems. Agronomic practices such as the liberal use of inorganic pesticides and fertilisers during the twentieth century enhanced productivity significantly but undesirable environmental degradation accompanied by increased operational costs in agriculture raised concerns about economic feasibility and sustainability (IAASTD 2009, FAO 2010). About 75% of the adversely affected households belong to rural communities of developing economies whose livelihood is directly or indirectly dependent on agriculture and allied activities (FAO 2009). Unsustainable farming leads to environmental pollution and threatens the livelihood of millions of small farm holders. Strengthening agricultural production systems for greater sustainability and higher economic returns is a vital process for increasing income and food and nutrition security in developing countries (Ravallion & Chen, 2007). Climate smart agriculture attempts to restore environmental depletion while enhancing productivity in a sustainable manner. This involves increase in food production through the adoption of sustainable land management (SLM) technologies, restoration of soil fertility (IFAD 2011), enhancement of the resilience of food crops to counter climate risks (FAO 2010b) and avoidance of further depletion of water resources and soil (World Bank 2006).

The hilly tract of the Eastern Ghat mountain range in Koraput district of Odisha state, India possesses rich agrobiodiversity. The native tribal population belonging to *Poraja, Kandha* and *Penthia* communities follow traditional agronomic practices. Finger millet (*Eleusine coracana*) and little millet (*Panicum sumatrense*) are widely cultivated cereal crops in this mountainous tract and contribute significantly towards food and nutrition security of tribal communities. Improper soil fertility management, imbalanced use of inorganic fertilizers, diminishing organic carbon content in soil, cultivation of less climate resilient varieties of millets, unscientific agronomic practices, absence of crop rotation and crop intensification under rainfed agroclimatic conditions limited the productivity of nutritious millets in this undulating terrain. Limited access to scientific knowledge and information on improved agronomic practices posed major obstacles to improve food security in these tribal communities. Although overall millet production accounted for 15% of the total food grain production in India in 2009-2010, it suffered from negative growth during the period 1980 to 2012 due to the lack of technological innovation, shifts to more profitable crops and the discontinuation of agriculture in comparatively dry areas leaving the land fallow (Swaminathan and Bhavani 2013). The area under finger millet and other small millets cultivation in Odisha state has significantly reduced from 336000 and 362000 hectares in 1980 to 169000 and 17000 hectares in 2012 respectively (Government of Odisha, 2012). Similarly the cultivation of finger millet, the most widely cultivated millet in the mountainous terrain of the Eastern Ghat mountain range, has been threatened by a sharp decline in the land area under finger millet farming in Koraput district from 144480 hectares in 1980 to 74280 hectare in 2008 (Government of Odisha, 2008). Irregular monsoons with irrigation facility available in only 9.24% agricultural land under millet cultivation in Koraput district (Government of Odisha, 2008) further limited millet farming and highlighted the need for the introduction of climate-smart agricultural systems in this rainfed hilly tract for greater agricultural sustainability to counter endemic hunger and hidden hunger.

*Corresponding Author's Email: csmishra2009@gmail.com

Objectives

The present study attempts to assess the impact of adoption of climate smart agricultural practices in millet cultivation on sustainability of agriculture and productivity in the Koraput tract. This research is based on the findings in this region over a period of three years from 2011 to 2013. An effort is made to develop suitable policy recommendations for promotion of climate smart agriculture in millet cultivation on consultation with the farming community and the social and agricultural scientists. This endeavour is aimed at drawing attention of policy makers at different tiers of governance by disseminating the research outcomes through print and electronic media, national and international conferences and policy meets for inclusion and modification of policies towards promotion of sustainable millet cultivation.

MATERIALS AND METHODS

The study was conducted in six villages of Kundra block in Koraput district, Odisha state. It involved 243 households belonging to the *Penthia*, *Kandha* and *Poraja* tribes in the villages of Kaudiaguda, Bhadraguda, Heruguda, Pipalguda, Narakenduguda and Chendiajhilligaon. A benchmark survey was carried out in the same 243 households using a scheduled questionnaire in 2010 to record traditional agronomic practices and socioeconomic status.

Based on the findings from the benchmark survey, detailed research initiatives were designed in consultation with agricultural and social scientists and the native farming community. For impact assessment, a structured questionnaire was used in 2013. The effect of the research initiatives was examined using both qualitative and quantitative data and the findings were shared with scientific community and male and female farmers belonging to the tribal communities associated with the study. The study on the application of vermicompost was carried out with thirty farmers practising organic finger millet farming. The effect of improved agronomic practices was studied with sixty five men and women farmers carrying out millet cultivation under rainfed agricultural system for consecutive three years. The total experimental agricultural land area for millet cultivation was 14 hectares with half of the land under improved agronomic practices and the other half under traditional farming practice. Taking into consideration the research outcomes, key policy recommendations were outlined in participatory mode with the communities and were communicated to the regional and district level government departments and planning agencies, the print and the electronic media and other stakeholders for policy advocacy on climate smart agriculture in millet cultivation to promote sustainable agriculture with food and nutritional security in less developed tribal communities.

Capacity building for the tribal communities within the research initiatives was organised in order to conduct the participatory field trials effectively. Training programmes on the organisation of farmers clubs, soil health management, nursery development, quality seed production, vermin composting and integrated disease and pest management were organised to cover all households under study.

In Participatory Variety Selection trials, a score card was developed by male and female farmers taking into account twelve attributes for each variety namely plant appearance, plant height, crop duration, pest and disease incidence, shape of the panicle, size of the panicle, grain size, grain taste, grain colour, shattering of grains at the time of harvest, market value and relevance for preparation of traditional recipes. The evaluation of the overall performance of each variety was based on crop duration, pest and disease incidence, plant height, plant canopy, lodging susceptibility, number of tillers per plant, length and shape of the panicle, grain yield per panicle, number of fingers per panicle, number of irregularly shaped fingers per plot, grain weight, straw weight and performance under aberrant monsoon. Agronomic data were collected from field trials in two different villages for consecutive three years. Combining the observations of the scientists and the farming community, the ranking of each variety was determined. The land area for each variety under PVS field trial was 5 meter x 5 meter with three replications receiving the same treatment. In total, 5 finger millet landraces (traditional varieties), 9 improved varieties of finger millet, 3 improved varieties of little millet and one little millet landrace were considered for the participatory variety selection. These varieties were planted in farmers' fields following randomized block design (RBD) in two villages.

RESULTS AND DISCUSSION

Demonstration of Climate Smart Agricultural practices in participatory mode

1. Identification of climate resilient millet varieties through Participatory Variety Selection (PVS) Trials.

The objective of the participatory research by agronomists and farmers is to facilitate the selection of most suitable millet varieties for higher productivity and climate resilience taking into consideration scientific observations, culinary properties, regional preferences and other agronomic attributes relevant for the local agro-climatic conditions.

The results showed precise correlation between the ranking of varieties based on visual selection and grain yield. While the visual scoring identified GPU 67 and GPU 45 as the best two varieties, the yield based selection data showed that GPU 67 and GPU 48 are the best two in that order. Among the local landraces of finger millet, Telengamandia received the highest score whereas Dasaramandia emerged as the best based on visual scoring. These varieties were found to be most climate resilient due to their hardiness, resistance to moisture stress, disease and pest incidence, aberrant monsoons and adaptation to regional agro-ecological conditions on the Eastern Ghat Mountain Range.

2. Soil fertility management

The soil sample analysis from sixty five agricultural land sites under millet cultivation revealed low organic carbon content in soil. Low nitrogen content and high acidity of the soil highlighted the need for adoption of sustainable soil fertility management practices. High acidity makes the soil deficient in nutrients such as magnesium, calcium, phosphorus, nitrate-nitrogen, molybdenum and boron (Smith and Doran 1996). To enhance organic carbon content, application of vermicompost was promoted at the dose rate of 2 tonnes/hectare. Vermicomposting is a process of composting in which preferably non-burrowing species of earthworms and microorganisms are employed to hasten the process of conversion of organic waste to an enriched organic fertilizer with high microbial activity, plant nutrients and growth regulators. The buffering action of vermicompost further helps in managing the soil pH balance promoting the assimilation of nutrients from the soil by plants. Field studies have established the fact that the plant uptake of nitrogen, phosphorus and potassium increases significantly when inorganic fertilizer is applied in combination with vermicompost (Jadhav et al. 1997). The species of earthworm used for vermicomposting in the study was *Eudrilus eugenae*. The average pH of vermicompost was found to be 6.8±0.2. After three consecutive years of vermicompost application, the soil sample analysis from thirty sites under organic millet

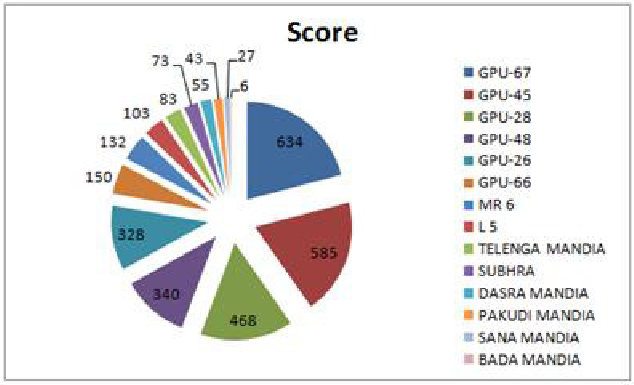

Figure 1. Score card for selection of finger millet and little millet varieties by farmers in two PVS trials in 2012. GPU 67, GPU 45 and GPU 28 were selected as the three most suitable finger millet varieties.

Table 1. Result of PVS ranking of finger millet and little millet varieties in Kundra block in 2011, 2012 and 2013

Variety	Rank in 2011	Rank in 2012	Rank in 2013	Overall rank	Desirable Traits
GPU-67	I	III	I	I	Good panicle shape, medium duration, no grain shattering.
GPU-45	II	I	II	II	Medium duration, good panicle shape (compact grain filling), bigger grain size.
GPU-28	III	II	III	III	Long finger shaped panicles, good tillering ability, good panicle shape, tall plants.
GPU-48	IV	IV	V	IV	Compact panicle, good tillering ability, tall plants.
GPU-26	V	V	VII	V	Medium duration, good plant type (tillering ability)
GPU-66	VIII	VI	IV	VI	Long finger shapes, bigger grain size, no grain shattering
MR 6	VI	VIII	VI	VII	Bigger and longer panicle shape, compact grain filling, late duration.
L 5	VII	X	X	VIII	Long duration, tastier, compact panicle
Telenga Mandia	X	VII	VIII	IX	Tall plants, open panicle
Subhra	XII	IX	IX	X	Medium duration, whitish grain colour
Dasara Mandia	IX	XII	XII	XI	Medium duration, imparts good taste in the beverages.
Pakudi Mandia	XIII	XI	XI	XII	Late duration
Sana Mandia	XI	XIII	XIII	XIII	Early maturing variety, good for beverage preparation.
Bada Mandia	XIV	XIV	XII	XIV	Late duration.

Table 2. Average nutrient composition of vermicompost and soil before and after vermicompost application

Nutrient element	Vermicompost	Soil (in 2010)	Soil (in 2013)
Organic carbon	12.7 %	0.45 %	1.05 %
Nitrogen	1.24 %	86.8 kg/ acre	87.1 kg/ acre
Phosphorus	0.89 %	21.01 kg/ acre	20.69 kg/ acre
Potassium	0.65 %	35.19 kg/ acre	37.88 kg/ acre

Table 3. Microbial populations in vermicompost and compost

	Actinomycetes (CFU/g)	Bacteria (CFU/g)	Fungi (CFU/g)
Vermicompost	1.2×10^4	48×10^6	6.5×10^4
Compost from organic waste	0.8×10^4	39×10^6	9×10^4
Soil (at 3 to 4 cm depth)	0.1×10^4	3.2×10^6	1.4×10^4

cultivation showed a gradual shift of the soil pH from high acidity (4.87) towards relatively neutral pH range (4.92).

The microbial population in vermicompost has been reported to be higher than that of organic waste and compost (Parmelee 1998). Samples of vermicompost and decomposed organic waste prepared by composting were analysed for microbial population. After collection of samples in sterile petri dishes, dilution plate technique was employed using a complex media using Potato Dextrose Agar, Nutrient Agar and Actinomycetes Isolation Agar-HI Media. The total population of actinomycetes, bacteria and fungi was expressed in colony forming units (CFU) per gm of sample.

Higher microbial population of bacteria and actinomycetes in vermicompost contributes towards greater breakdown of complex elements to simpler nutrients resulting in higher absorption of nutrients from soil by the plants. In addition to this initiative, awareness was created among the farmers to apply inorganic fertilizers in the soil at the recommended NPK dose rate of 40:20:20 kg/hectare in millet cultivation (TNAU 2013) taking into consideration the existing nutrient content of soil determined through periodic soil analysis. This avoided the over and under-supplementation of soil nutrients preventing the imbalance of soil pH and nutrient ratio. Thus it further reduced the cost associated with integrated nutrient management.

3. Crop intensification in rainfed agricultural system

Traditionally broadcast sowing is practised in case of millets resulting in uneven interplant distance. This leads to unequal nutrient availability to plants and difficulty in weeding. Line sowing with recommended inter-row and interplant distances of 22.5 cm and 10 cm respectively was introduced in finger millet and little millet cultivation (Bioversity International 2008) using multi furrow row markers. This row marker facilitated marking eight rows simultaneously maintaining an inter-row distance of 22.5 cm. Line sowing helped in introducing mechanical weeding using a kono weeder due to suitable availability of inter-row spacing. This further reduced the drudgery of farm women who are traditionally engaged in weeding operation in millet cultivation. Mechanical weeding played a vital role in bringing down the intercultural operational cost by reducing the expenditure associated with manual weeding. This research initiative also increased the soil nutrient availability to the crops by lessening the weed population by 47% in comparison to control plots following farmers' practice in sixty five field trial sites.

Crop intensification enhanced the efficient utilisation of water in finger millet cultivation under the rainfed agricultural system by enhancing productivity by 80.6%. The average yield following improved agronomic practices was 10.69 quintals/hectare whereas finger millet farming with farmers' practice yielded on average 5.92 quintals/hectare. The cost benefit ratio for millet cultivation under field conditions in participatory mode was found to be 1:1.23 and 1:1.16 following improved agronomic practices and farmers' practice respectively.

Policy recommendations

One of the major objectives of this research initiative is the development of favourable policy recommendations for greater sustainability of millet cultivation with adoption of climate smart agronomic practices and policy advocacy in different forums for effective communication with policy makers. This involved the sharing of the findings from the research initiatives with farming and scientific communities to formulate policy recommendations. These recommendations addressed four aspects of millet farming such as cultivation, consumption, commerce and conservation. These policy recommendations integrated the concept of climate smart agriculture with millet cultivation for greater sustainability.

1. Cultivation: Minimum support prices for millets can be fixed by the Government to provide an assured return to millet growers. Millet cultivation can be promoted by providing technical and physical support by the State Agriculture Universities and Agriculture Departments with focus on soil health management, integrated nutrient management, quality seed production and farm mechanisation. These promotions will enhance the productivity as well as profitability of this crop encouraging millet producers. Identification, development and promotion of climate resilient varieties of millets under specific agro-climatic conditions may be taken up by agricultural research organisations to promote suitable varieties for different terrains. Agricultural subsidies covering challenging aspects of millet cultivation can be extended to the farming community by the government to facilitate millet farming. Farm mechanisation can be encouraged by providing agricultural equipments customised for millet

cultivation, such as row markers, mechanical weeders, seed cum fertilizer drill and ploughing implements at a fair price.

Harvesting is exclusively carried out by farm women in millet cultivation. This involves collection of panicles one by one by cutting with a sharp instrument which is time consuming and adds drudgery to women. A suitable mechanical device can be developed or promoted to address this issue.

Organic farming of millet cultivation can be introduced with required certification and marketing facilities to provide a premium price to the organic millet growers. To enhance sustainability, organic farming and the application of organic fertilizers such as vermicompost can be promoted by extending financial and technical support. This will further popularise organic farming of millets in a sustainable manner. Intercropping of millets with leguminous crops significantly improves soil fertility due to nitrogen fixation in soil. This practice may be promoted on a large scale with agricultural input and technical support.

2. Consumption: The health and nutritional benefits of millets can be communicated efficiently to consumers using print and electronic media. Videos and posters can be used as effective modes of communication for communities with low literacy rate. Interactive media creating awareness on nutritional benefits of millets can be introduced through academic curriculum in schools for promotion of healthy dietary habits among children. Nutritious millet grains can be included under the public distribution system (PDS) which is a social welfare initiative by the Government of India for ensuring minimum food security for the socially and economically weaker sections of the society. Millet based nutritious ready-to-cook and ready-to-eat food may be introduced for children, adolescent girls, pregnant and lactating women through *Anganwari* centres under Integrated Child Development Services scheme (ICDS). These village level pre-school education and healthcare centres implement government sponsored social welfare programmes for children and women welfare programmes which include provision of balanced food for children up to six years of age, adolescent girls, pregnant and lactating women.

3. Commerce: Official procurement of millets by the government for food grain distribution under food security programmes will certainly boost millet cultivation. Introduction of organic certification and initiatives for marketing of organically grown millets through private and public sector owned food outlets, fair trade shops and super markets may be organised to promote organic farming by providing a premium price to the growers. Strategic planning for marketing of organic millets may be targeted with awareness creation on beneficial effects of organic food. Value addition to millets can be encouraged by providing technical, financial and marketing support to both male and female entrepreneurs to increase the diversity of millet based healthy foods to consumers. This will enhance not only the consumption but also the acceptance of millets across various age groups of consumers. Value addition to millets may be promoted through community based organisations (CBOs) generating additional income in producer communities. Proportionate participation of women may be encouraged focusing on strengthening of these CBOs with promising market linkages. Inclusion of millet based ready-to-cook and ready-to-eat food in ICDS programme and procurement of these value added nutritious food prepared through regional CBOs may be proposed for promotion of millet consumption and employment generation in rural areas.

4. Conservation: Community based organisations (CBOs) may be organised in participation with farmers to conserve the local genetic diversity of millets. The unique genetic pool of millets needs to be conserved for safeguarding regional biodiversity. Reward and recognitions may be introduced to encourage CBOs to contribute towards conservation of landraces and efficient natural resource management.

Intercommunity learning and sharing of knowledge and experiences may be promoted by federating the community based organisations. This will facilitate knowledge dissemination and strengthen marketing network.

The findings of the study and the policy recommendations were shared with various stakeholders in different forums. This collective action involved publication of research papers, oral presentations, posters and videos targeting policy makers from the Government sector and self governance bodies through national and international level seminars, conferences and policy meets. The print and electronic media were employed as a vehicle for creating awareness among scholars, scientific communities and farmers and dissemination of results.

CONCLUSION

Enhancing food and nutrition security of tribal households through integration of innovative agronomic practices may serve as a vital step towards socioeconomic and knowledge empowerment of tribal communities. Promotion of climate smart agriculture for sustainable food grain production under challenging agro climatic conditions in high altitudes is an endeavour aiming at self-sustainability of primitive communities in terms of food security. Policy advocacy for climate smart agriculture in millets is an integrated approach striving for employment generation, enhancement of agricultural productivity, sustainable management of natural resources and endorsement of nutritious millet farming. Effective policy planning and advocacy necessitates cooperation and perseverance of all the stakeholders to offset the adverse effects of climate change on sustainable agriculture and food security in mountainous tracts of Eastern India. A comprehensive planning with favourable policy formulation assures of a healthier community practicing sustainable agriculture in one of the renowned agro-biodiversity hotspots of India.

ACKNOWLEDGEMENT

We are highly grateful to the farmers of project intervention villages of Kundra block, Odisha for their kind cooperation and active participation in all activities. The financial support from the Department for Foreign Affairs, Trade and Development (DFATD), Canada and International Development Research Centre (IDRC), Canada and the regional project coordination by M. S. Swaminathan Research Foundation, India, are duly acknowledged.

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